Autism's Genetic Roots | Nobels 2010 | Materials Go Cosmic

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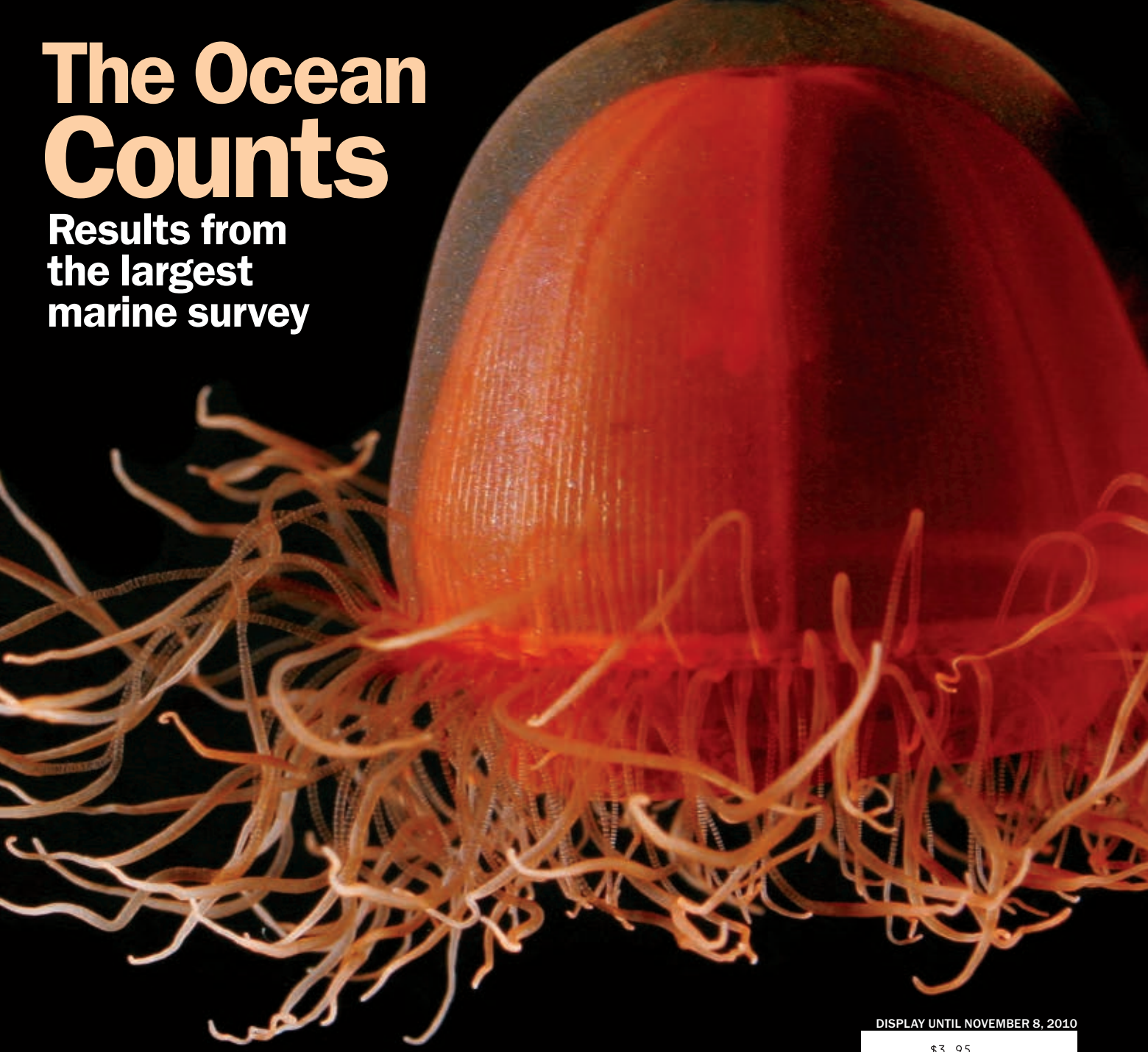
ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ OCTOBER 23, 2010

The Ocean Counts

Results from the largest marine survey



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Discovered: Three Kings Silver Coin from the Time of Jesus's Birth

Imagine holding in the palm of your hand an ancient silver coin minted by of one the three kings who sent his emissaries to witness the birth of the baby Jesus. Imagine owning a coin that was touched by the people who walked among Jesus during his years on earth. Today, through an exclusive release by GovMint.com you can own an authentic Silver Drachma, saved from destruction and preserved for over 2,000 years!

Miraculous Find Garners Worldwide Attention

Finding an ancient Silver Drachma coin anywhere in the world is a noteworthy event. Finding one issued by one of the "Three Kings" of the Bible, a coin produced by the King of Persia from 35 BC to 5 AD and used throughout the life of Jesus Christ, is cause for true excitement. Intricately designed, it is a miniature work of art. In ancient times the Silver Drachma was struck by hand, one at a time, so no two are exactly alike. This was a coin that could have easily been used to purchase the gifts presented to the Christ Child and has been historically proven to have circulated in Jesus' lifetime.

A Gift That Will Be Treasured!

The Parable of the Lost Drachma

The Silver Drachma was a coin well known to Jesus and his followers. In one of his parables Jesus says, "Or what woman, having ten drachmas, if she loses one, does not light a candle and sweep the house and look diligently till she finds it? And after she has found it, she calls in her friends and says, Rejoice with me, for I have found the drachma that I lost" (Luke 15:8-9).

A Precious Christmas Gift

Your Silver "Kings" Drachma from the time of Christ will arrive housed in a deluxe presentation album together with historical information detailing this coin's amazing journey. A signed certificate of authenticity guarantees the coin is from the time of Christ and is sure to be cherished by friends and family.

Very Limited at this Low Price —

This special offer of ancient Silver Drachmas from the time of Christ is made possible by a recent discovery. The quantity is strictly limited and once they are gone, there is no telling when, or if, any more will ever be found. This coin has sold nationally for $129.95, but while our supply lasts you can own this ancient Silver "Three Kings" Drachma for just $49.95. Additional savings are available for multiple coin orders (see details).

Specifications

Years of Issue: 35 BC — 5 AD
Composition: Silver
Design: King Azes II on Horseback
Weight: 9.65 grams (approx.)
Diameter: 15 mm

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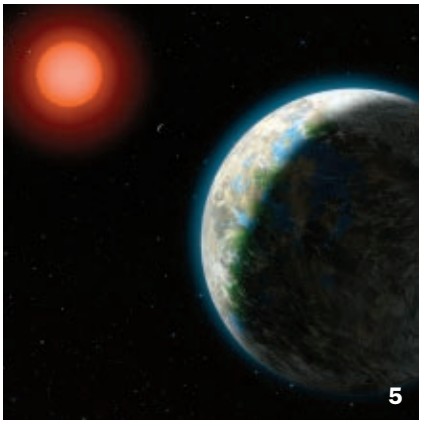

ScienceNews

In The News

Photo Essay

Features

Departments

COVER The jellyfish *Crossota norvegica* was collected 1,600 meters below the Arctic ice during one of 540-plus research expeditions undertaken for the Census of Marine Life. *© Kevin Raskoff*

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FROM THE EDITOR

Seeking subtle simplicity in science's complexities

Science is all about finding simplicity amid subtleties and complexities.

It's a good thing, too. Otherwise it would be hopeless to try to understand the brain. No realm of nature exhibits more complexity, and in no realm do accurate explanations require more subtlety. That's especially the case when the brain malfunctions. It's hard enough to explain how the brain works when it's working properly. When things go awry, the subtleties and complexities are magnified.

Efforts to understand autism spectrum disorder, for example, have met with bewildering evidence from genetics studies. Autism and its related afflictions clearly reflect genetic problems—perhaps 90 percent of all cases have at least some genetic component. Yet no single gene or small set of genes appears to be responsible for a substantial fraction of those cases. Dozens or even hundreds of rare genetic variants seem to contribute to the disorder, as contributing correspondent Susan Gaidos notes in this issue (Page 18). Autism must be the product of some elaborate neurological complexity.

But identifying subtleties in autistic brains can help scientists perceive underlying simplicity. While many genes are involved, they may exert their influence in similar ways. In fact, certain neural circuits and processes seem especially relevant to autism's symptoms. Proteins produced from the numerous suspect genes may converge in just a few brain networks, and that may someday enable a picture of autism to emerge that is simple enough to suggest effective treatments.

Of course, science must also deal with other complexities: the multiplicity of life-forms in the oceans, for example. Progress in a census of marine life (visually summarized in this issue with descriptions by Susan Milius, Page 22) will help scientists discern subtle features of oceanic biology. And modern theories have added new layers of complexity to the universe itself—in the form of countless siblings to the single spacetime bubble that humans occupy. It will be easier to find simpler explanations of such a complicated cosmos, perhaps, if subtle features in strange substances known as metamaterials can be studied in the lab, as Elizabeth Quill notes (Page 28).

All in all, there's no avoiding the complexity of the world. But illuminating the subtleties that reveal simplicity can help humans navigate through that complexity more safely. Science is the only reliable way of doing that.

—Tom Siegfried, Editor in Chief

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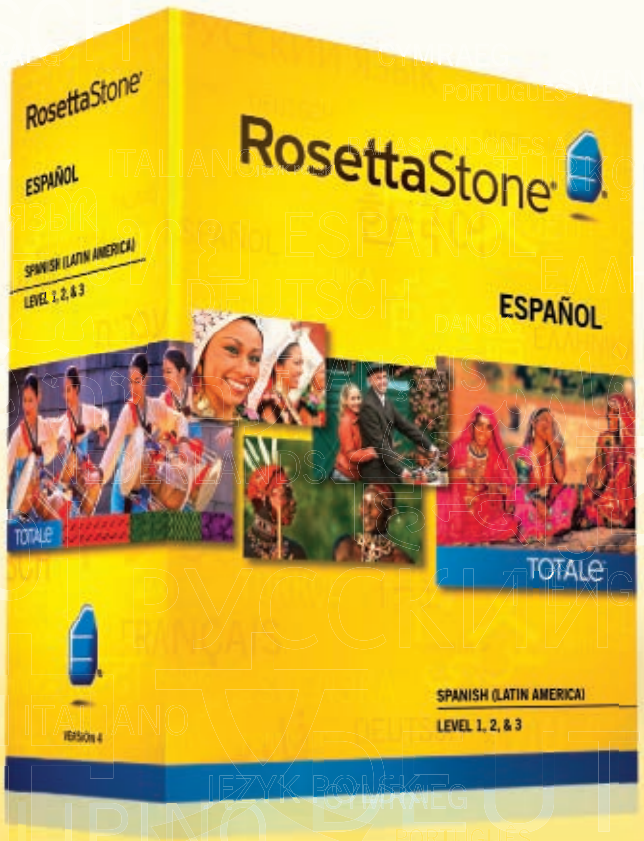

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Scientific Observations

"At first glance, the causes of wildlife declines in a protected area may seem obvious. Excessive hunting, for instance, effectively extirpated wolves, mountain lions, and other large carnivores from Yellowstone National Park. Modern extinctions in protected areas, however, are seldom so easily attributed to one cause. Recent studies link them to an array of threats that vary, often unpredictably, across time and space. They range from global phenomena such as climate change and atmospheric pollution, to regional issues such as shifts in fire regimes, disease dynamics, or invasive species, to more localized threats such as overharvest, habitat conversion, and the effects of isolation. These threats can interact both additively and synergistically to create syndromes of extinction that confound diagnosis and remedy." —**ECOLOGIST JUSTIN S. BRASHARES OF THE UNIVERSITY OF CALIFORNIA, BERKELEY, IN THE JULY 23 *SCIENCE***

Science Past | FROM THE ISSUE OF OCTOBER 22, 1960

WORLD TV VIA SATELLITES SET AT $170,000,000 — Fifty improved courier-type communications satellites would provide world-wide telephone and television facilities for a mere $170,000,000: $100,000,000 for the satellites and $70,000,000 for the ground stations. These are the figures the American Telephone and Telegraph Company estimated for the Federal Communications Commission in Washington, D.C. Without the luxury of television facilities, the telephone system alone would cost only $115,000,000. AT&T also estimated the cost of an economy system to link America, Europe and Hawaii with 30 active repeater satellites. The price for 600 telephone circuits and a two-way TV channel: $82,000,000.

Science Future

October 28–30
National Science Teachers Association holds its Kansas City area conference on science education. Go to www.nsta.org/conferences/2010kan

November 1
Slated launch date for shuttle *Discovery*'s final spaceflight. See www.nasa.gov/missions

November 5
Nomination deadline for the 15th Annual Carnegie Science Awards. Go to www.carnegiesciencecenter.org

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GENES & CELLS
Some liver cells have a strange number of chromosomes, but instead of signaling cancer this quirk may make cells stronger. Read "Vital flaw."

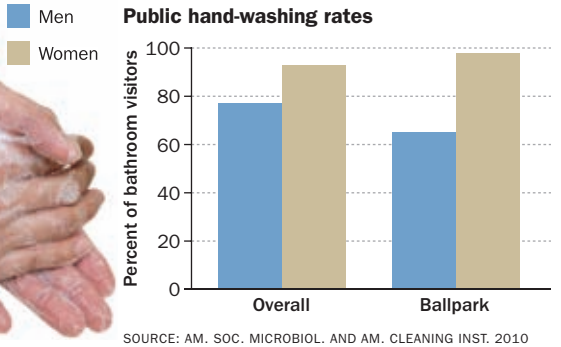
LIFE
New data counter old about where mosquitoes picked up malaria. See "Main malaria parasite came to humans from gorillas, not chimps."

ATOM & COSMOS
Astronomers combined hours of Cassini spacecraft data into a video of Saturn's auroras. Read "Glowing auroras ring Saturn."

Unexpected pairings of energetic particles are perplexing Large Hadron Collider physicists. See "Particles in cahoots."

Science Stats | MANLY HYGIENE

More than three-quarters of men wash their hands publicly, but rates fall at the ballpark, one study found.



SOURCE: AM. SOC. MICROBIOL. AND AM. CLEANING INST. 2010

Firsts

Scientists have made the first measurements of flying fish aerodynamics. Mechanical engineers Hyungmin Park and Haecheon Choi of Seoul National University stuffed freshly dead darkedged-wing flying fish (*Cypselurus hiraii*) with their fins in three different positions and put the fish in a wind tunnel. The scientists analyzed airflow around the fins and body and found that the flying fish's gliding performance in air is comparable to a bird's. The data confirm that the fish control aerodynamic forces by altering the angle of their pectoral fins, which changes the effective "wingspan" and the lift force. Gliding low over the water with the body parallel to the surface minimizes drag, too. The results appear in the September *Journal of Experimental Biology*.

CLOCKWISE, TOP LEFT: W.C. BRASHARES; IAN NICHOLS, NATIONAL GEOGRAPHIC SOCIETY; DEVONYU/ISTOCKPHOTO

“My own personal feeling is that the chances of life on this planet are 100 percent.” —STEVEN VOGT

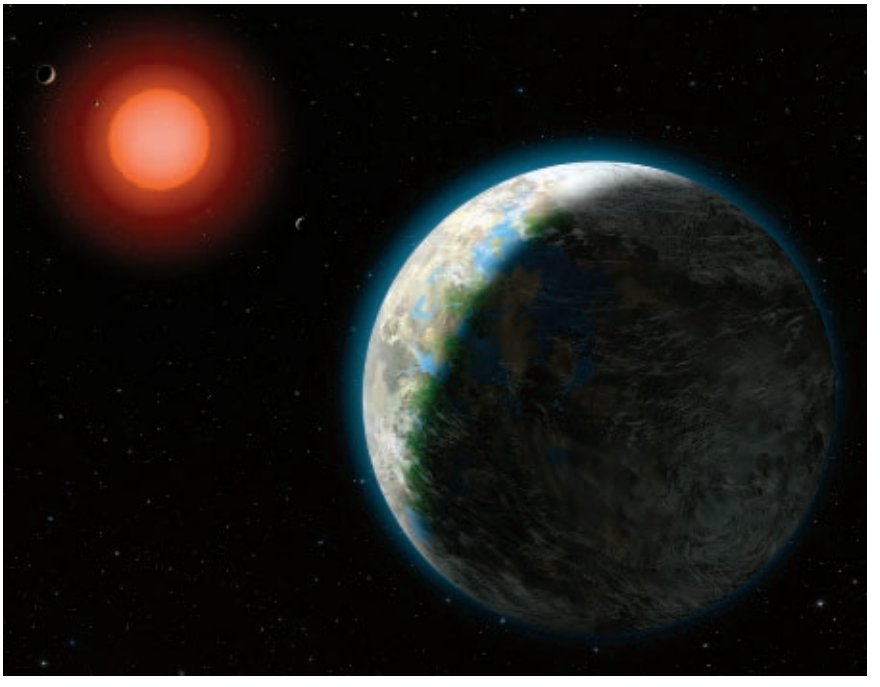
In the News

STORY ONE

A little wobble spurs hope for finding life on distant worlds

Extrasolar planet is in the right location to be habitable

By Laura Sanders



Gliese 581 (upper left in this artist’s depiction) has six confirmed planets, including one (foreground) that orbits the star at a distance hospitable to life.

LYNETTE COOK

Scientists have spotted an Earth doppelgänger that may have the right specs to harbor life, just 20 light-years distant in the direction of the constellation Libra.

Although details about conditions on the planet’s surface remain a mystery, the find suggests that many more potentially habitable worlds are likely to be found. The discovery was reported online September 29 at arXiv.org and will be described in an upcoming *Astrophysical Journal*.

Finding the planet so nearby and so soon after extrasolar planets were first discovered suggests that the galaxy is teeming with Earthlike worlds, said coauthor Paul Butler of the Carnegie Institution for Science in Washington, D.C. He noted that it has been only 15 years since astronomers first located a planet orbiting a sunlike star beyond the solar system.

“This is the first one, but the threshold has now been crossed,” Butler said in a September 29 press briefing. “Over the next 10 years I would be shocked if there weren’t many tens of these things.” The body is one of two newly discovered planets orbiting the red dwarf star Gliese 581 — setting the current record at six for the most planets circling a star other than the sun.

“It’s kind of a mini-version of our own solar system,” said study coauthor Steven Vogt of the University of California, Santa Cruz.

Vogt and his colleagues used more than 200 nights’ worth of data to track tiny wobbles of Gliese 581 caused by the gravitational tug of orbiting planets. Astronomers can use these wobbles not only to detect unseen planets, but also to determine their masses and orbital paths.

The researchers found that the planet Gliese 581g, estimated to be about three times more massive than Earth, orbits its star about once every 37 days. The average surface temperature is estimated to range from -24 degrees to 10 degrees Fahrenheit, but may vary greatly.

Just as the moon always keeps the same face toward Earth, one side of the planet always faces its parent star. But the planet’s temperature range may not be as extreme as the moon’s, where the difference between the dark and illuminated sides can be more than 500 degrees Fahrenheit. Modeling experiments suggest that winds could help distribute heat on Gliese 581g, moderating extreme temperatures. “It would be quite a benign, comfortable place to live,” Vogt said, and one with “a lot of different niches for different kinds of life to evolve stably.”

The result is “fantastic news,” said Franck Selsis, an astrophysicist at the

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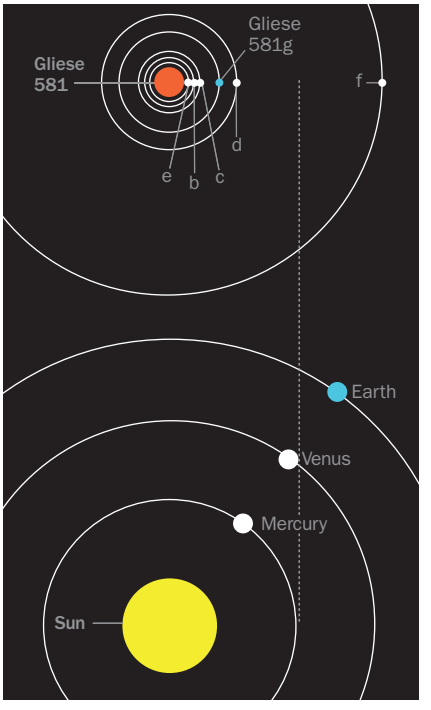
Laboratoire d'Astrophysique de Bordeaux in France. Selsis and his colleagues have proposed that two other Gliese-orbiting planets might be habitable. Recent studies, Selsis said, show that the habitability zone of Gliese 581 extends farther than originally thought, placing planet Gliese 581d, which flanks Gliese 581g on the side farther from the star, in the habitability zone, too. More extensive modeling of Gliese 581d suggests that its bigger mass (about 7.1 times more massive than Earth) could have accumulated an atmosphere large enough to keep the planet warm, making liquid water a possibility there too.

A surface temperature that allows liquid water is considered necessary for life. "At this point, we can't say anything about the physical conditions on the planet," Butler said of Gliese 581g. "We can't say anything for sure about the atmosphere. We can't say anything sure about water."

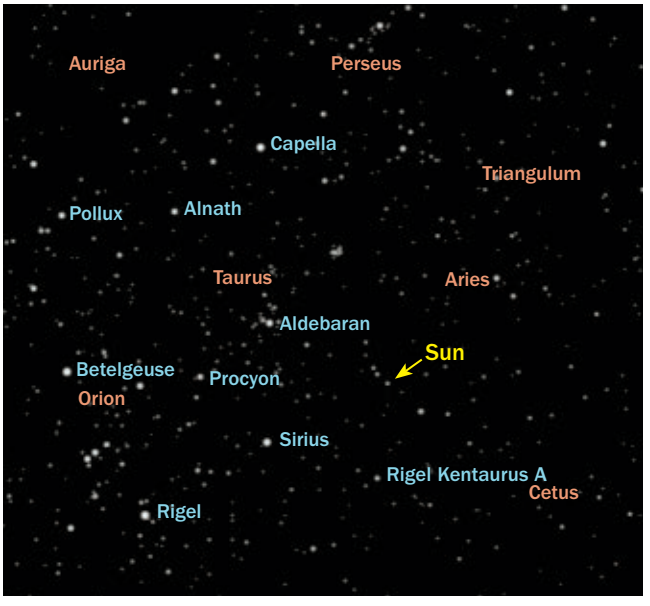
Vogt points out that water is abundant in the galaxy, so it is hard to imagine that Gliese 581g wouldn't have any. "Given the ubiquity and propensity of life to flourish wherever it can ... my own personal feeling is that the chances of life on this planet are 100 percent," Vogt said. "I have almost no doubt about it."

But Selsis cautions that being in the all-important "habitability zone" where temperatures are right for life as we know it is "necessary, but certainly not sufficient." The planet could have formed without any water. It could be regularly bombarded with objects capable of wiping out any life that develops. Or it could have such a heavy atmosphere that its surface would be extremely hot.

Astrophysicist and planetary scientist Sara Seager of MIT said that the authors don't yet know if the greenhouse effect would be too strong on Gliese 581g for life to survive. For astronomers to get accurate atmospheric data, the planet would have to pass between its star and Earth, which Gliese 581g doesn't do. Another option would be to launch equipment into space to image the planet directly, but even a nuclear-powered probe would take more than 200 years to get close enough. ■



On the small side All but one of Gliese 581's planets (top) hug the parent star closer than Mercury orbits the sun (bottom). But Gliese 581 is substantially dimmer than the sun, so planet g could still have liquid water on its surface—considered a requisite for life.



From Gliese 581g, you could see the Earth's sun, about 20 light-years distant, and many of the stars (blue labels) and constellations (orange labels) visible from Earth.

Back Story | YOU ARE HERE

What would it be like to live on Gliese 581g?

Eternal sunshine The rocky planet is tidally locked to its star, so one side is perpetually sunny and the other is always dark and cold. There wouldn't be time-dependent seasons, and a person sitting at a given longitude would experience the same temperature and weather patterns year-round.

Weighed down The gravity of the planet is estimated to be slightly stronger than that of Earth. A 130-pound Earth woman would weigh between 143 and 221 pounds on Gliese 581g.

Big orange ball Gliese 581g's parent star would appear about twice as large as the sun appears to an Earth observer, and, depending on the atmosphere, the star might appear orange. The quality of the light on the surface of Gliese 581g, however, would probably appear whitish.

Visible planets The three inner planets in the Gliese system would be visible with the naked eye from the surface, and they would have phases, similar to the progression of the moon cycle as seen from Earth.

Howdy neighbor A person on Gliese 581g could see Earth's sun with the naked eye. But red dwarfs don't burn as brightly, so Earthlings must use a telescope to see Gliese 581.

Time to burn Red dwarfs can persist for hundreds of billions of years—a life span much longer than other types of stars, including the sun. That means that any life on Gliese 581g will have a very long time to evolve.

FROM TOP: E. FELICIANO; D. NASH, WWW.ASTRONEXUS.COM, ADAPTED BY T. DUBÉ

Inform

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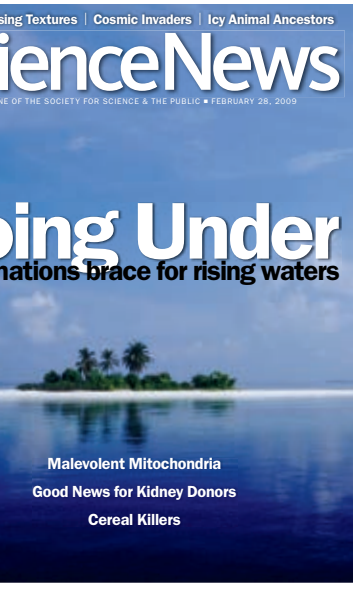

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Technology

480,000 years — Estimated total time wasted in traffic by U.S. drivers in 2007

$87.2 billion — Estimated cost of traffic congestion in U.S. in 2007

3-D X-rays show nanosized details

High-resolution technology exposes a material's insides

By Gwyneth Dickey

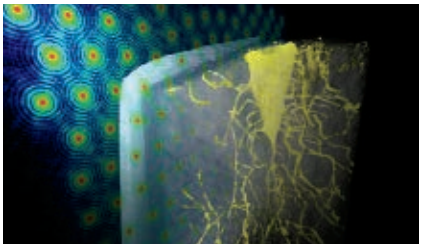
A new X-ray microscope technique gives a super-detailed look inside small samples, and does it in 3-D.

An international team of scientists used the method to examine a tiny piece of mouse bone and reveal inner details as small as 100 nanometers, such as hideyholes for cells in the bone matrix and connecting channels between those pockets.

The technique, published in the Sept. 23 *Nature*, rolls several new technologies into one. A powerful X-ray source sends a beam through a sample to a sensitive photon-counting detector without the need for an image-forming lens.

On their way through the object, X-rays are slightly scattered by variations in the density of the material. The detector measures the pattern of the scattered waves, and a powerful computer program uses that information to reconstruct a two-dimensional image of the sample.

After an image is made at each degree in a 180-degree view of the material, a computer program puts all the images together into a 3-D image, similar to the way a CT brain scan is created.



A fragment of mouse bone visualized by a new technique that creates 3-D X-rays of features as small as 100 nanometers.

M. DIEROLF, P. THIBAULT AND F. PFEIFFER/TECHNICAL UNIV. OF MUNICH

The Tao of traffic: Go with the flow

If stoplights bend to cars, a study says, the way grows clearer

By Rachel Ehrenberg

Traffic lights that act locally can cut travel time globally, new research suggests. By minimizing congestion, the approach could save money, reduce emissions and perhaps even quash the road rage of frustrated drivers.

The new approach makes traffic lights go with the flow, rather than enslaving drivers to the tyranny of timed signals. By tracking vehicle flow through each intersection as it occurs and coordinating lights with only their nearest neighbors, a systemwide smoothness emerges, scientists report in a Santa Fe Institute working paper posted online in September.

> "The traffic flow controls the traffic light rather than the other way around."
>
> DIRK HELBING

Traffic lights usually are controlled from the top down, operating on an "optimal" cycle that maximizes the flow of traffic expected for particular times of day, such as rush hour. But even for a typical time on a typical day, there's so much variability in the number of cars at each light and the direction each car takes leaving an intersection that roads can fill up. Combine this condition with overzealous drivers, and intersections easily become gridlocked. Equally frustrating is the opposite extreme, where a driver sits at a red light for minutes even though there's no car in sight to take advantage of the intersecting green.

"It is actually not optimal control, because that average situation never occurs," says complex-systems scientist Dirk Helbing of the Swiss Federal Institute of Technology in Zurich, a coauthor of the new study. He and Stefan Lämmer from the Dresden Technical University in Germany decided to scrap the top-down approach and start at the bottom. They noted that when crowds of people are trying to move through a narrow space, such as through a door connecting two hallways, there's a natural oscillation: A mass of people from one side will move through while the other people wait, then suddenly the flow switches direction.

"It looks like maybe there's a traffic light, but there's not. It's actually the buildup of pressure on the side where people have to wait that eventually turns the flow direction," says Helbing. "We thought we could maybe apply the same principle to intersections; that is, the traffic flow controls the traffic light rather than the other way around."

The arrangement puts two sensors at each intersection: One measures incoming flow and one measures outgoing flow. Lights are coordinated with every neighboring light, such that one light alerts the next, "Hey, heavy load coming through."

"The approach is adaptive and the system can react," says mechanical engineer Gábor Orosz of the University of Michigan in Ann Arbor. "That's how it should be."

The researchers simulated the approach for part of downtown Dresden. The flexible self-control approach reduced time stuck waiting in traffic by 56 percent for trams and buses, 9 percent for cars and trucks and 36 percent for pedestrians crossing intersections. Dresden is now close to implementing the new system, says Helbing, and Zurich is also considering the approach.

"In general these algorithms improve traffic, but maybe not as much as they do on paper because we are still human," Orosz says. "It is still humans driving the cars."

Environment

"All of a sudden, boom, it drains right down. It sucked all the water out of our hole." —JOEL HARPER

Florida cats rescued by western kin

Lone Star imports boost genetic diversity of rare panthers

By Susan Milius

Plenty of people hated the idea in 1995, but borrowing some genes from Texas has improved the prospects of endangered Florida panthers, a new report says.

Hybrids that mix Florida cats with Texas cousins of the same species have twice the genetic variety and far fewer of the genetic defects seen in Florida panthers before the introduction, says geneticist Warren Johnson of the National Cancer Institute in Frederick, Md.

When biologists first proposed importing eight females to south Florida, wildlife managers had doubts about whether adding genetic variety would help much. Also, this was the iconic Florida panther, not the Floritexan panther.

Now, panther kittens of mixed-state background have about half the mortality risk of pure Floridian kittens, and adults face lower risks too. Thanks to the genetic infusion and other measures, Florida's adult panther population has tripled, Johnson and his colleagues report in the Sept. 24 *Science*. Wildlife managers put adult panther numbers in the 90s.

"This work can be a good model for other severely depleted populations of carnivores," says longtime cat conservation biologist Howard Quigley, based in Bozeman, Mont. But Florida's panthers are far from safe, he points out.

Among the big remaining questions is whether Florida will find enough habitat for a population to survive. A mere hundred Florida panthers isn't a viable population in the long term.

"The Florida panther represents the increasing reality for many large carnivores in the world today: small, isolated populations," Johnson says.

Florida panther kittens have been healthier since eight Texan panthers arrived.

While drilling holes in Alaska's Bench Glacier, scientists discovered dozens of huge cracks that could affect melting.

Glacier found to be deeply cracked

Alaska fissures raise questions about future ice movement

By Rachel Ehrenberg

Pressure and stress can lead to a crack-up, or several, if you are a glacier. Researchers have discovered a system of deep cracks in the ice of southern Alaska's Bench Glacier. The crevasses are described in the Sept. 30 *Nature*.

Scientists aren't certain how widespread such cracks are, how long the fissures persist or how glacier movement is influenced. The cracks, some of which extend 80 meters from the glacier's bottom, hold a considerable amount of water and could help scientists better predict how glaciers move and melt, which in turn could affect forecasts of sea level changes.

Water pressure below the glacier and stress from the enormous weight above probably produced the cracks, the researchers say. The gaps could allow the glacier to absorb, sponge-style, a sudden inrush of water from melting or rain. That buffering may prevent the glacier from sliding and lurching if water floods the bed of soil and rock below. But under certain conditions the cracks might suddenly drain, spilling water into the bed and sending a glacier sliding.

"Water is tricky business," says Jack Kohler of the Norwegian Polar Institute in Tromsø, who was not involved with the research. "Water is at the heart of really all the dynamic behavior of a glacier."

The researchers weren't looking for cracks. Led by Joel Harper of the University of Montana in Missoula, the team set out to drill holes through the glacier's roughly 200 meters of ice to see how the holes would drain. Because the drill used hot water, each bore hole stayed filled to the brim — until the drillers hit a crack.

"Then all of a sudden, boom, it drains right down," says Harper. "It sucked all the water out of our hole."

Within the cracks was enough water to cover the entire glacier bed to a depth of 10 centimeters, the team reports. Research suggests that just 4 centimeters of water can increase the typically plodding pace of a glacier by a factor of five.

FROM TOP: SCIENCE/AAAS; J. HARPER

Matter & Energy

"People tend to just ignore relativistic effects, but relativistic effects are everywhere." —JAMES CHIN-WEN CHOU

It isn't just for astronauts anymore

Physicists demonstrate relativity in the down-to-Earth realm

By Rachel Ehrenberg

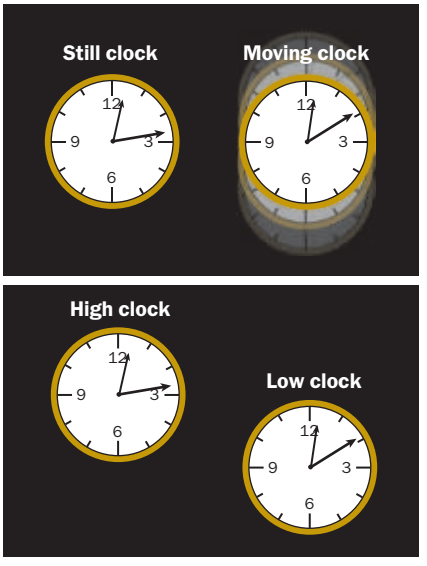
Probing the peculiar effects of Einstein's relativity is no longer rocket science. Tabletop experiments in a Colorado lab have illustrated the odd behavior of time, a strangeness typically examined with space travel and jet planes.

Using superprecise atomic clocks, scientists have witnessed time dilation — the bizarre slowing of time described by Einstein's theories of relativity. The experiments are presented in the Sept. 24 *Science*.

"Modern technology has gotten so precise you can see these exotic effects in the range of your living room," says physicist Clifford Will of Washington University in St. Louis. The experiments don't reveal any new physics, Will says, but "what makes it cute and pretty cool is they have done it on a tabletop."

Time dilation arises in two situations. In one, time appears to move more slowly the closer you are to a massive object, such as the Earth. So a person hovering in a hot-air balloon, for example, actually ages faster than someone standing below.

Time also goes faster for someone at rest relative to someone moving — one 25-year-old twin traveling in a rocket near the speed of light for what he perceives as a few months would return to Earth to find that the other had reached middle age.



Let's do the time warp Relativity causes clocks in motion to tick slower than stationary clocks (top); clocks that are nearer to a massive object such as Earth also run slower (bottom).

Previous experiments with rockets and airplanes have demonstrated these odd aspects of general and special relativity. The notion of time running slower closer to Earth has even been tested in a multistory physics building at Harvard.

The Colorado researchers used two optical atomic clocks in neighboring labs at the National Institute of Standards and Technology in Boulder. Each clock has an electrically charged aluminum atom, or ion, that vibrates between two energy levels more than a million billion times per second. A 75-meter-long optical cable connects the clocks, allowing the team to compare the instruments' timekeeping.

In the first experiment, physicist James Chin-wen Chou and his colleagues raised one of the clocks 33 centimeters, or about a foot. Sure enough, the lower clock ran more slowly than the elevated one — at the rate of a 90-billionth of a second in 79 years. In a second experiment the team applied an electric field to one clock, sending the aluminum ion moving back and forth. As predicted, the moving clock was slower than the clock that was at rest.

The experiments have more implications for precision instrumentation than they do for relativity, notes Chou. But they are a nice reminder that relativity is always at hand. "People tend to just ignore relativistic effects, but relativistic effects are everywhere," he says. "Every day, people are moving; they are doing things like climbing stairs."

And, Chou asks, what about frequent fliers? Are they aging more slowly, because they move so much? Or faster, because they spend so much time in the air?

A compass that lights its own way

Instrument senses magnetic field's direction using optics

By Laura Sanders

A compass made of light shot through a blob of rubidium atoms can directly and reliably measure the size and orientation of a magnetic field, physicists report in the Sept. 13 *Physical Review A*.

Highly sensitive compasses are needed for oil discovery, earthquake detection and other applications. These compasses typically include a built-in reference magnetic field that allows the instrument to reconstruct the terrestrial magnetic field, but the data can vary in quality, says study coauthor Alexander Zibrov of Harvard.

He and his colleagues trapped rubidium-87 atoms at 45° Celsius in a domino-sized chip and shined linearly polarized laser light into the atoms.

In a magnetic field, the atoms' orientation changed in a way that could be detected in the light that came through the atom cloud. This change allowed the researchers to measure the precise size and direction of the field.

Other compasses based on lasers and atoms exist, Zibrov says, but those require fancy mathematical models to reconstruct the magnetic field after the measurement has been taken.

The compass detected fields with a strength between 0.1 gauss, which is less than the Earth's magnetic field, and 200 gauss, which is stronger than a small iron magnet.

CHOU *ET AL*/*SCIENCE*, ADAPTED BY E. FELICIANO

Molecules

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

Primordial soup served up cold

Icy baths may have nurtured earliest replicating molecules

By Rachel Ehrenberg

The hot spot for life on early Earth may have been very cold. Tiny pockets that form inside ice can contain and protect replicating molecules, researchers report September 21 in *Nature Communications*.

The paper suggests that life could have sprung from icy slush covering a freshwater lake, rather than a boiling deep-sea hydrothermal vent or the "warm little pond" proposed by Charles Darwin. And perhaps the frigid, icy surfaces of other planets are not as barren as they appear, proposes the research team from the MRC Laboratory of Molecular Biology in Cambridge, England.

Previous work had shown that nooks and tiny crevices within ice could provide a cozy, safe place for the construction of RNA, the molecule that many think served as the basis of the earliest life. As ice forms, pure water becomes crystallized, while salts and other bits of debris accumulate in watery pockets. These impurities lower the water's freezing point, and the little pockets may remain unfrozen within an otherwise solid chunk.

To see if RNA could replicate in these pockets, a team led by chemical biologist Philipp Holliger took test tubes of water and added salts and one of life's presumed starter ingredients — an RNA molecule that can make reactions go, known as a ribozyme — and the building blocks this molecule would need to make a full copy of itself. Then the researchers cooled the tubes to a range of temperatures.

Not only did the ribozymes go about their business of building RNA strands, but the reactions continued for much longer in the icy test tubes than at higher temperatures, the team reports.

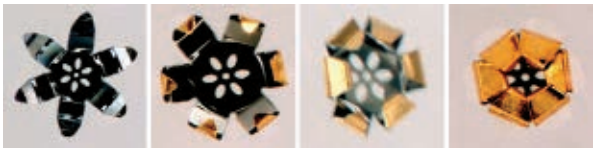
"It's a little like the tortoise and the hare," says Holliger. The reactions go faster at higher temperatures, he explained, but soon stop. At colder temperatures the reactions proceed more slowly but last longer, ultimately making more progress.

While the experiments suggest the reactions necessary for life can proceed in ice, "we are some distance from self-replication," cautions Holliger. The team got strands that were 32 building blocks long, while the full-length ribozyme is 190.

Tiny tools could have medical uses

Enzyme-triggered devices could deliver drugs, take biopsies

By Rachel Ehrenberg



The tools are built in an open position (far left) but snap shut when triggered by certain enzymes (left to right).

N. BASSIK *ET AL/JACS* 2010

Researchers have created millimeter-sized metal tools that contort on command, clamping shut or popping open in response to specific chemical cues. The devices, described online September 17 in the *Journal of the American Chemical Society*, may one day be used to biopsy a liver, prop open an artery or deliver drugs to a target site.

It took some doing to make devices that could respond to chemicals in the right time and place, yet remain friendly inside the body. David Gracias of Johns Hopkins University in Baltimore and his team began with thin silicon wafers and coated them with layers of chromium, nickel and gold. Using a high-tech version of a stencil, the researchers patterned the metal layers into parts that looked like a flower or the open palm of a hand. Adding hinges enabled the open hand to clamp shut.

Then the team added layers of biologically friendly polymers that break down in the presence of certain enzymes. By layering these polymers just right the researchers could selectively degrade the layers, prompting the device to spring shut or pop open.

One polymer was derived from collagen, the connective tissue that holds much of the body together. The other came from cellulose, the stuff of plant cell walls.

Both collagen and cellulose get chewed up by specific enzymes. Cellulases, which are made by fungi and bacteria, destroy cellulose and allow termites to chew through wood.

Proteases, which help break down meat in human stomachs, take apart collagen. Certain tumors are protease factories, Gracias says, raising the possibility that minimachines could be designed to trigger automatically upon reaching diseased tissue.

"It is very creative work," says biomedical engineer Kam Leong of Duke University in Durham, N.C., who was not part of the research. "The proof of principle is fascinating."

To test their invention, the researchers made some fake innards from resin and embedded hard-to-reach bird liver tissue inside. Using a magnet, the scientists piloted a device through the faux bile duct and into the liver, then added cellulase with a syringe. The device closed around the bit of bird tissue, and the team piloted the sample back out with a magnet, having performed a rough version of a biopsy.

"The ultimate test will be in vivo, but this is an important contribution," says Leong.

Humans

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Neandertals taken out by volcanoes

Modern humans may have thrived thanks to luck, not wits

By Bruce Bower

Neandertals didn't get dumped on prehistory's ash heap — it got dumped on them. At least three volcanic eruptions about 40,000 years ago devastated Neandertals' western Asian and European homelands, spurring a rapid demise of these humanlike hominids, says a team led by archaeologist Liubov Golovanova of the ANO Laboratory of Prehistory in St. Petersburg, Russia.

Animal-tooth pendants made by modern humans were found in a cave where Neandertals once lived.

Modern humans survived because they lived in Africa and on the tip of southwestern Asia at that time, safely outside the range of volcanic ash clouds, the researchers propose in the October *Current Anthropology*. If that scenario pans out, then geographic good luck allowed *Homo sapiens* to move into Neandertals' former haunts after a couple thousand years without having to compete for food and other resources, as many researchers have assumed.

"For the first time, we have identified evidence that the disappearance of Neandertals in the Caucasus coincides with a volcanic eruption approximately 40,000 years ago," Golovanova says. Signs of Neandertal activity at Mezmaiskaya Cave in southwestern Russia declined sharply after the first eruption and disappeared after a second, the team says. By 40,000 years ago, cave sediment contains no bones of hunted animals or Neandertal-made stone tools. Advances in stone tool-making and other cultural innovations by modern humans shortly after that time supported their survival in harsh post-volcanic habitats, the team hypothesizes.

Chemical analyses of soil layers in the cave identified two types of volcanic ash denoting separate eruptions in western Asia between 45,000 and 40,000 years ago. Plant pollen in the cave indicates that extremely cold, dry conditions prevailed around that time.

In a comment published with the new study, archaeologist Paul Pettitt of the University of Sheffield in England agrees that Neandertals disappeared near Mezmaiskaya Cave shortly after volcanic eruptions. But the timing of Neandertals' and modern humans' presence over at least 10,000 years in an area of tens of thousands of square kilometers remains poorly understood, he cautions.

Remains of child sacrifices found

Buried bodies and artifacts offer glimpse of Inca practice

By Bruce Bower

The ancient remains of seven children apparently killed in a ritual have given scientists new views of the sketchily understood Inca practice of sacrificing select children in elaborate ceremonies.

The children were buried together beneath a 500- to 600-year-old building in Peru's Cuzco Valley, apparently after they were killed in a sacrificial rite honoring Inca deities and promoting political unity across the far-flung empire, say anthropologist Valerie Andrushko of Southern Connecticut State University in New Haven and her colleagues.

Analyses of strontium levels in bones at the site indicate that at least two of the children came from distant parts of the Inca realm, Andrushko's group reports online September 15 in the *Journal of Archaeological Science*.

Accounts of Inca life written by Spanish conquerors describe a ritual in which children from throughout the kingdom were selected for sacrifice based on their physical perfection. They were brought to the capital city of Cuzco for special ceremonies and then sacrificed, sometimes in distant locations.

Most other archaeological evidence of Inca child sacrifices has come from youngsters' naturally mummified bodies found frozen on several Andean peaks. "It was surprising that figurines and other artifacts found with children buried at this low-altitude site are nearly identical to finds at high-altitude child sacrifices," Andrushko says. Items surrounding the remains in the Inca structure included fancy pottery and clothing covered in gilded metal discs as well as figurines of people and llamas made of gold, silver and red shell.

A male figurine made of silver was found among precious objects buried with children killed in an Inca ritual.

Based on their tooth development, the children ranged in age from 3 to 12. Not enough skeletal material survived to make sex determinations.

Such investigations are rare, says anthropologist Tamara Bray of Wayne State University in Detroit. "We have so little scientific information about who these children were or where they may have come from," she says.

FROM TOP: L. GOLOVANOVA; G. MCEWAN/WAGNER COLLEGE

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Life

"What surprised me is the beauty." —JESSE AUSUBEL

First census of marine life reveals there's plenty new under the sea

Decade-long study highlights how much more is left to discover

By Susan Milius

A 10-year international project called the Census of Marine Life has come to an end with what has to be one of the strangest census reports ever.

At the project's finale in London October 4, a summary of the work by 2,700 scientists from more than 600 institutions around the world highlighted their own undercounts and the vast realms they had missed. That, however, was the point.

Census photographers captured this hydrozoan jellyfish in Australia's Great Barrier Reef, a diversity wonderland.

"There's a lot of ocean left to explore," says census cofounder Jesse Ausubel, an environmental scientist with the Alfred P. Sloan Foundation in New York City. The water world covers the majority of the planet, feeds people far inland, offers exotic compounds for drugs and manufacturing, regulates the planet's climate and provides half its oxygen, but its inhabitants remain largely unknown.

How many fish in the sea? The census didn't aim for a full count, since scientists haven't even finished naming known species of marine fish. According to the census, the tally of 16,764 fish species formally named as of early 2010 probably falls short by an estimated 5,000 species.

And fish aren't the half of it. They account for perhaps just 12 percent of total marine species, the census estimates. Crustaceans and mollusks each include more species than fish, and researchers report evidence of major undercounts in those groups too.

Overall at least 750,000 marine species, not including microbes, still await discovery, census teams predict.

For microbes, the census researchers report boggling diversity. Analyzing a liter of seawater revealed 38,000 kinds of microbes, and DNA sequencing in diverse habitats has turned up specimens from more than 100 phyla. Such breadth approaches three times the number of phyla known in the animal kingdom. Estimates for the total kinds of marine microbes run as high as a billion.

Undersampling afflicts oceans everywhere, the researchers say. Perhaps 80 percent of nonmicrobial species around Australia remain undescribed. In the Mediterranean, 75 percent of deep-sea species do not yet have names.

Deep waters are so underexplored below 200 meters that their life-forms constitute "biodiversity's big wet secret," says the census's chief scientist, Ron O'Dor of Dalhousie University in Halifax, Canada. Fewer than 10 percent of records of marine life come from abyssal plains between 4,000 and 6,000 meters deep, yet that zone accounts for half the oceans' area.

Even though census scientists point out how much remains to be discovered, they did a lot of exploring in 10 years. Of the 17 teams that make up the census, 14 emphasized field expeditions, logging more than 9,000 days at sea.

The new explorations particularly boosted knowledge of life at the poles, which aren't easy places to study, Ausubel says. Sending a ship to Antarctica costs about $125,000 a day.

Among all the discoveries from the field, "what surprised me is the beauty," Ausubel says. Census projects encouraged photography, and the stream of pictures has introduced a wide public to the charms of deepwater crabs and free-swimming sea cucumbers (see Page 22).

The census also organized records and made them widely available. The Ocean Biogeographic Information System database now allows anyone to look up what species have been found where. And more than 80,000 species now have their own Web pages in the Encyclopedia of Life.

Census workers also assessed how human activities such as fishing have changed marine populations. Delving into documents such as old tax files and monastery records, researchers found effects as far back as Roman times. O'Dor, however, points out that the census also documents recoveries from human impact. "Under the right circumstances, the ocean is resilient," he says.

Themes of great undiscovered diversity at risk aren't unique to the sea, says Peter Raven, president emeritus of the Missouri Botanical Garden in St. Louis. "The Census of Marine Life certainly ought to be replicated on land," he says. "This is basically an unknown planet when it comes to living organisms."

1 million+
Estimated number of species in the oceans*

about 250,000
Number of marine species described to date*

1,200+
New species described by Census of Marine Life*

5,000+
Possible new species found by census but not yet confirmed*

100–150
Average new marine fish species described per year

*EXCLUDES MICROBES

GARY CRANITCH/QUEENSLAND MUSEUM

Genes & Cells

79 inches Average height of NBA basketball players

73 inches Average height of Major League baseball players

64 inches Average height of Thoroughbred racing jockeys

Tails grow back with dash of salt

Sodium needed to stimulate limb regeneration in tadpoles

By Laura Sanders

Researchers have hit on a winning recipe for regrowing limbs: Add a pinch of salt to a tailless tadpole; let sit for one hour. Yield: one perfectly formed tail, complete with nerves, muscles, blood vessels and other tissues.

It's not quite that simple, but results published in the Sept. 29 *Journal of Neuroscience* extend the time that tadpoles can regrow a tail, raising the possibility that salt's surprise role in amphibian regeneration may ultimately lead to ways to coax human tissue into regrowing severed limbs and damaged organs.

Tadpoles can completely regrow appendages after an injury. Humans retain some of this ability: Until about age 11, children can regrow fingertips under the right conditions.

In the new study, researchers led by Michael Levin of Tufts University in Medford, Mass., found that tadpoles engineered so that they couldn't shuttle salt into their cells couldn't regrow a tail, while normal tadpoles were perfectly able to.

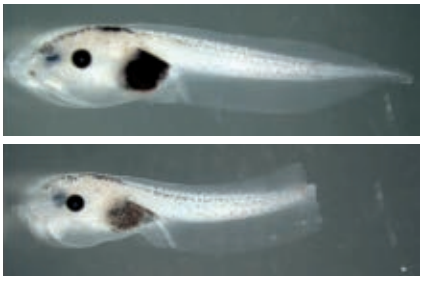
Tadpole tails don't usually grow back more than about 18 hours after an injury, when scarlike tissue has formed around the amputated limb. But salt imported into cells near the wound can stimulate regeneration even after this scarlike tissue is established, Levin's team reports.

A salty environment alone isn't enough to cause the tail to regrow. The salt has to be ushered into the cells near the wound. One particular salt-importing channel, called NaV1.2, was required for tail regrowth, the team found. Such channels are well-known for their roles in brain cell communication and heart cell beating, but scientists had no idea one might be important for regeneration.

The NaV1.2 channel is just one of salt's avenues into a cell. There are other ways in, Levin says, raising the possibility of simpler treatments. "It really doesn't matter how the sodium gets in there," he says.

One way to salt cells is with a small molecule called monensin that shuttles sodium into cells. A one-hour treatment with monensin induced tail regeneration in tadpoles with wounds that had already formed scarlike tissue. "This simple signal kick-starts a remarkably complex process," Levin says.

The hope is that one day a simple salt signal might turn out to be useful in coaxing human appendages to regrow.



Normally, tadpoles can regrow their tails after an injury (top). Keeping sodium out of cells blocks this process (bottom).

"All studies up until now had to treat animals before wounding," Levin says. "You can't go to a doctor and get treated before you have your accident."

AI-SUN TSENG, M. LEVIN/TUFTS UNIV.

Heaps of genes have hand in height

Study finds hundreds of genetic variants influencing stature

By Tina Hesman Saey

Geneticists are getting to the long and short of the genes that control how tall a person will grow. The short answer is that at least 180 common genetic variants are involved; the long, that up to a thousand variants may control human height.

Scanning the genetic blueprints of more than 100,000 people, scientists have turned up at least 180 different genetic variants involved in determining human height, the researchers report online September 29 in *Nature*. That may sound impressive, but each of the genes involved has a small effect, and researchers are still able to account for only about 10 percent of the genetic contributions that give rise to the wide diversity seen in height.

"It's a lot more complicated than we originally thought, and there may be thousands of variants with subtle effects," says Michael Weedon, a geneticist at Peninsula College of Medicine & Dentistry in Exeter, England. Weedon is one of 293 coauthors of the new study, which reanalyzed data from more than 50 previous genome-wide association studies to find genes that affect growth in people.

Some of the genes pinpointed in the new study were already known to affect height, but others are involved in biological processes that were not previously suspected to control growth.

While height itself is usually not of great medical significance, the new study may provide insight into the ways that many genes influence the development of some diseases, says Jeffrey Barrett, a statistical geneticist at the Wellcome Trust Sanger Institute near Cambridge, England. "This tells us something about the architecture of other human traits," he says.

Larger studies might uncover even more genetic variants associated with height. Assuming all variants have the same modest effects as the ones in this study — each affecting height by a millimeter or so — the researchers calculate that between 483 and 1,040 different variants may be involved, accounting for almost 20 percent of the genetic components that determine height. Scientists are still debating where the remaining genetic components are likely to be found.

Science & Society

For longer stories on the Nobel Prizes, visit **www.sciencenews.org/Nobels2010**

2010 Nobels recognize potential of basic science to shape the world

Prizes go to IVF, graphene and 'carbon chemistry at its best'

A technology that has brought 4 million babies into the world over the past three decades has been recognized with a Nobel Prize, along with two innovations that promise to revolutionize how those children live in the 21st century.

The 2010 Nobel Prize in physiology or medicine went to Robert Edwards of the University of Cambridge in England for pioneering in vitro fertilization, a process that overcomes many causes of infertility by creating embryos outside the body and implanting them in a prospective mother's uterus.

Edwards began research on IVF in the 1950s and later worked with gynecologist Patrick Steptoe. In the late 1960s Edwards was the first to try human egg removal and fertilization in vitro, a Latin term meaning "in glass."

"By a brilliant combination of basic and applied medical research, Edwards overcame one technical hurdle after another in his persistence to discover a method that would help to alleviate infertility," the Nobel Assembly of the Karolinska Institute stated in announcing the prize.

Ultimately, Edwards' efforts gave rise to both a medical breakthrough and a now-outdated term — test-tube baby. The first test-tube baby, Louise Brown, was born July 25, 1978.

One winner of the 2010 Nobel Prize in physics, Konstantin Novoselov, was little more than a toddler at the time. Now 36, he and Andre Geim, both of the University of Manchester in England, published their Nobel-winning discovery just six years ago in *Science* (*SN: 10/23/04, p. 259*). Since then almost 50,000 research papers have been published on graphene, the material the pair isolated from graphite using ordinary adhesive tape.

Graphene is made of carbon atoms arranged in a honeycomb pattern, forming a single layer so thin that it's nearly see-through. For such a humble material, graphene displays some remarkable properties: It conducts electrons with extremely low resistance, can conduct heat 10 times better than copper and exhibits strange quantum effects. Graphene is also flexible and stronger than steel. The substance could form the basis for new kinds of electronics, transparent displays, efficient solar panels or lightweight plastic composite materials for use in aerospace and other applications.

"When you couple it with all of the applications, that's what whips physicists into a frenzy," says Joseph Stroscio of the National Institute of Standards and Technology's Gaithersburg, Md., campus. "It's an amazing little material."

The winners of the chemistry prize developed ways to use another amazing material, the precious metal palladium, as a catalyst to build large molecules out of carbon atoms. The techniques the trio developed are already used in producing thin-screen displays and a host of drugs, including antibiotics, chemotherapy agents and the anti-inflammatory naproxen. More applications are bound to come as chemists continue to refine the technique, the Royal Swedish Academy of Sciences said in naming the winners: Richard Heck, who retired in 1989 from the University of Delaware in Newark; Ei-ichi Negishi of Purdue University in West Lafayette, Ind.; and Akira Suzuki of Hokkaido University in Sapporo, Japan.

All three figured out ways to make chemical reactions go by using palladium to disconnect and connect particular atoms with speed and efficiency. Known as palladium-catalyzed cross-coupling reactions, different versions of the process already bear the names of each Nobel winner and are familiar to organic chemistry students, as well as those in industry and academia. The research that led to the prizes began back in the 1950s and has become part of the standard toolkit of chemists.

"This is fundamental carbon chemistry at its best," says Joseph Francisco, a Purdue chemist and president of the American Chemical Society.

This year's Nobel Prizes are worth 10 million Swedish kronor each, or about $1.5 million. Geim and Novoselov will split their prize evenly, as will Heck, Negishi and Suzuki. —*Nathan Seppa, Laura Sanders, Rachel Ehrenberg*

2010 NOBEL LAUREATES

Robert G. Edwards
Physiology or Medicine
For the development of in vitro fertilization

Andre Geim
Physics
For the discovery of graphene and related experiments

Konstantin Novoselov
Physics
For the discovery of graphene and related experiments

Richard F. Heck
Chemistry
For palladium-catalyzed reactions that combine carbon atoms

Ei-ichi Negishi
Chemistry
For palladium-catalyzed reactions that combine carbon atoms

Akira Suzuki
Chemistry
For palladium-catalyzed reactions that combine carbon atoms

FROM TOP: © BOURN HALL; SERGEOM/WIKIMEDIA COMMONS; RUSSELL HART; UNIV. OF DELAWARE; PURDUE UNIV.; HOKKAIDO UNIV.

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

Richard W. Wetherill
1906-1989

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

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

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

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

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

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

WHOEVER OR WHATEVER IS THE CREATOR revealed this behavioral law to the mind of Richard W. Wetherill in 1929 in answer to his fervent appeal for an understanding of humanity's plight. And although Wetherill took no credit for identifying this law, his efforts to inform people of the flaw in their approach to life met with an almost impenetrable wall of resistance and opposition until he published his book, *Tower of Babel*, on January 2, 1952. Then small study groups were formed near several large cities in America. Later all the members who were able to relocate came together under Wetherill's direction in southeastern Pennsylvania.

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

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

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

Visit our colorful Website www.alphapub.com where several essays and seven books describe the changes called for by whoever or whatever created nature's law of absolute right. The material can be read, downloaded, and/or printed FREE.
This public-service message is from a self-financed, nonprofit group of former students of the late Mr. Wetherill. Please help by directing others to our Website so that they can learn that obeying this natural law provides a ***life that is both fair and well worth living****.*

A boy diagnosed with autism makes eye contact with a therapist while working on his social and communication skills.

DREW PERINE/AP PHOTO/THE NEWS TRIBUNE

The unusual suspects

With no obvious culprit in sight, geneticists do broader sweeps to identify autism's causes

By Susan Gaidos

It's a high-stakes version of the board game Clue. Scientist-detectives probing the origins of autism must contend with an enormous cast of characters. Within the past year, researchers have found dozens, possibly hundreds, of rare genetic mutations that may contribute to the disorder, and a handful of common mutations may also be involved.

Faced with this staggering lineup of genetic suspects, scientists have turned to new DNA sequencing technologies and other methods to track clues within the brain and pin down the who, where and how underlying autism.

Nobody expects to find Colonel Mustard in the kitchen with a knife. The latest clues have made it clear that with autism, there will turn out to be multiple culprits.

"There's not going to be a simple explanation for autism," says neurogeneticist Daniel Geschwind of the University of California, Los Angeles. "The genetics are very complex, and there are likely to be many different genetic and biological mechanisms involved."

Researchers have long known that genes play a role in autism, a disorder marked by impaired social interaction and communication. Studies of twins suggest that as many as 90 percent of autism cases may have a genetic link. The problem, in many cases, is that scientists don't know what to make of those findings.

"What you hope for is that you find a mutation and then every time you see the mutation, a person's got some evidence of autism," says Yale University neurogeneticist Matthew State.

But that's not what scientists see. Studies have linked a handful of common gene variants to autism, but most of the genetic mutations implicated in the disorder are rare. In many cases, the mutations found in kids with autism are also seen in kids without autism. And some of the gene variants that raise the risk of autism have also been linked to other psychiatric disorders, such as manic-depressive illness or schizophrenia.

To try to untangle these complications, researchers are using the genetic findings as a starting point, followed up by studies to see how and where the products of these potentially rogue genes work in the brain. Lately a more complete picture has begun to emerge.

"What genetics is doing for us is telling us where to look and what are the fundamental processes that are involved," State says.

Identifying common MOs

While it's still early in the game, recent findings tie many of the rare mutations to genes in common biological pathways and networks — most of which help control the way the brain develops and functions. Some of the genes belong to pathways used by brain cells to communicate, while others are involved in the growth of nerve cells, anchoring cells together or signaling within a cell.

Such findings provide targets for new treatments and approaches, the scientists

say. Already, some labs are working to find chemical markers of the disorder that could be used for early diagnosis.

Other laboratories are using new technologies to sequence all protein-coding regions and even all of a person's DNA to identify parts of the genome that diverge in people with autism and healthy subjects. As researchers home in on genomic differences that can predispose an individual to autism, ways to tailor treatments and interventions may emerge.

"It's someplace where we've been 30 or 50 years behind other areas of medicine," says State, a specialist in child psychiatric disorders. "If you go to a cardiologist, they understand the pathology that they look at in the clinic at a molecular and cellular level. In autism and other child psychiatric disorders, we have not had that."

Multiple rare syndromes

Autism is not one disorder, but a spectrum of disorders. People with autism often have great difficulty with communication and social interaction. Some cannot speak or maintain eye contact. Many have repetitive routines. A common trait is obsessive attention to certain details. Symptoms can be mild to severe, and about half of kids with autism have some kind of intellectual disability. In the United States, an estimated one in 110 children has an autism spectrum disorder.

For years, most studies focused on finding common variations in a handful of genes. While researchers found a few genetic variants linked to autism, the cumulative effects were disappointingly small, accounting for just a fraction of cases.

"The hypothesis had been that in order for a common disease to arise, you would need to have common genetic variations in perhaps just a few genes," says Stephen Scherer, director of the Center for Applied Genomics at the Hospital for Sick Children in Toronto. "But that idea is shifting."

One reason for the shift: Following the completion of the Human Genome Project in 2003, it became apparent that the genome is much more variable than previously thought. Studies showed that the number of copies of a particular gene differs from one individual to the next. Many of these variations involve either segments of DNA that are entirely missing from the genome or the same segment repeated several times.

Through such gains or losses, called copy number variations, whole stretches of DNA can be erased or repeated (*SN: 7/3/10, p. 12*). Most copy number variants appear to be harmless. But some can remove parts or all of a gene. Studies have implicated copy number mutations in a number of diseases, including schizophrenia. And in 2007, researchers at Cold Spring Harbor Laboratory in New York found evidence that such anomalies may also be associated with the symptoms of autism spectrum disorders.

Researchers then began looking for rare variants in autism — and found them. In a widely acclaimed study in the July 15 *Nature*, an international group of researchers compared genomes of nearly 1,000 autistic people and about 1,300 healthy controls. The scientists found dozens of genes were involved. Most of the variants were sections of DNA that were either duplicated or missing. Some of the genetic changes were inherited from the kids' parents, while other variants were new, arising from alterations of DNA in the egg or sperm of one of the parents, or in the offspring themselves.

Those findings support an emerging consensus within the scientific community, says Scherer, who coauthored the study. Namely, that autism, instead of having just one or two genetic risk factors, probably has hundreds.

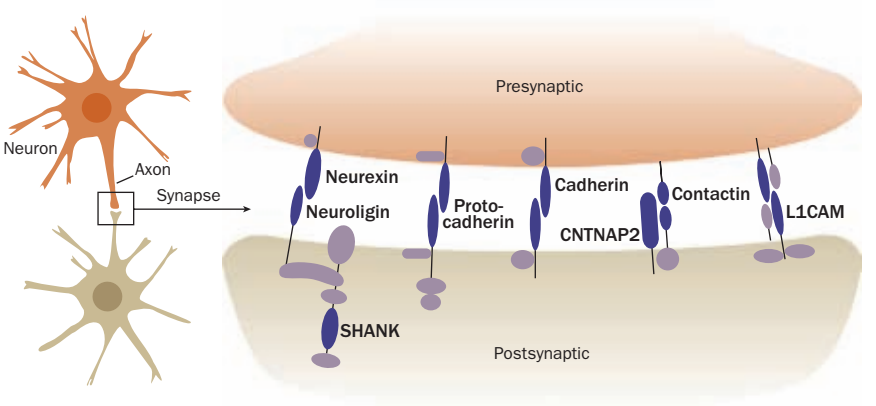
"I think it says something fundamental about autism, that you can think of it as a collection of rare syndromes," he says.

Scientists now suspect that, while the number of different genes involved is large, the protein products of these genes participate in a much smaller number of common pathways that regulate brain development and function. Two genes may encode two proteins that seem totally unrelated but, in fact, interact closely in a particular pathway. A deficiency in either's function could result in the same outward defect.

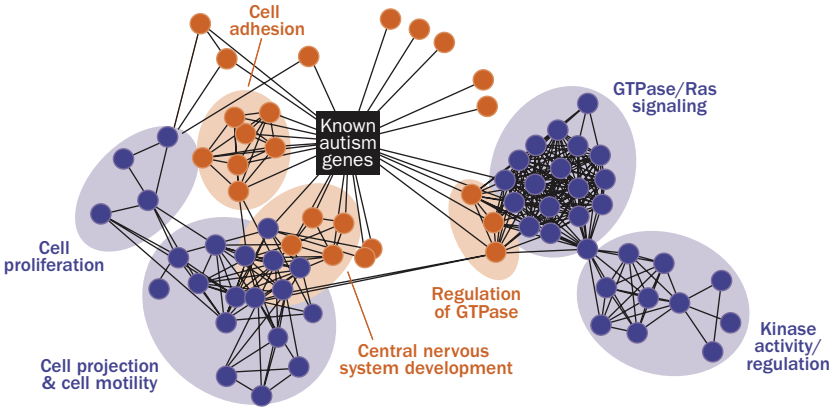
That seems to be what's happening, Scherer says. While each of the variants may account for only a small fraction of autism cases — no single variant can be said to account for more than 1 percent — collectively the rare variants may account for a large fraction of the cases.

Scientists are now working to identify all of the genes involved and create a catalog of autism risk genes. Studies to date have already identified 100 or so strong candidate genes. And Scherer and his colleagues recently completed a second study with an additional 1,500 families, with analysis of the data now underway.

Getting the message Projections called axons transmit messages from one nerve cell to another (left) at the synapse (right), a junction between nerve cells held in place with the aid of various cell-adhesion molecules. Studies have linked autism with mutations in a number of genes involved in cell adhesion at the synapse. A disruption in any one of the proteins (dark purple) that these genes code for may throw off the system so that nerve cells don't connect normally.



C. BETANCUR *ET AL/TRENDS IN NEUROSCIENCES*, ADAPTED BY E. FELICIANO



Getting networked Some people with autism may be missing all or parts of genes involved in brain development and function. Newly discovered genes affected by these deletions (purple) work in networks with other genes (orange) that have already been linked to autism. These networks help guide important cell functions, including cell proliferation and central nervous system development.
SOURCE: DALILA PINTO/THE HOSPITAL FOR SICK CHILDREN

Even closer scrutiny

Researchers also are working to find even more subtle mutations. Scientists at the Broad Institute in Cambridge, Mass., are using next-generation DNA technologies to compare the genomes of autistic individuals with those of healthy controls. The method will allow the researchers to read each gene in every region of the genome, making it possible to pick up on variations that are much more rare and to detect submicroscopic insertions and deletions that contribute to autism.

"It's clear that there is a lot more to discover," says Mark Daly, who oversees the DNA sequencing studies at the Broad Institute, a genetic research center operated by Harvard University and the Massachusetts Institute of Technology.

For example, scientists have yet to find a single autism-related mutation capable of disabling any one copy of a gene in a systematic way. Nor have they figured out ways to interpret the effects of copy number variants, which can take out dozens of genes in a single deletion.

"It's been challenging to extract really specific biological insights from those observations because we don't know which, or which sets, of a 25-gene deletion is relevant to autism," Daly says.

Such discoveries may soon emerge. By searching for single changes in the DNA, called individual point mutations, scientists hope to "fill out" the rest of the genetic components that contribute to autism risk, Daly says. "It's not that we didn't know that this is what we wanted to look for. We never had the technical ability to search for these types of mutations in a systematic and unbiased fashion."

Other scientists are looking at differences in gene activity to find biochemical markers for early diagnosis. Geneticist Stephen T. Warren of Emory University in Atlanta says genes active in white blood cells may reflect what's happening in the brain. Using blood samples from twin brothers — one with autism and one without — his group is looking at more than a dozen sites in white blood cells where DNA is chemically altered, or methylated, affecting whether a gene is turned "on." Such differences may serve as a genetic signature for some cases of autism.

Warren's group is now investigating whether any of the markers are present before the onset of autism. If so, the irregular gene activity patterns might be used to help identify high-risk children as infants, instead of at age 2 or 3, and allow early intervention therapies to be initiated. Studies show that the younger the child, the more flexible the brain. With intense behavioral intervention, new mental pathways might be created to overcome some of autism's effects.

Finding conspirators

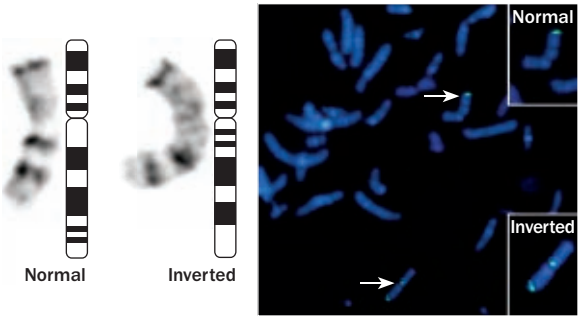
As for the genes themselves, researchers have found dozens over the past few years that appear to raise the risk of autism. Many of the genes can be tied to common biological pathways and networks, providing insight into what the genes do and how they operate to control — or interfere with — specific brain processes. Scientists are treating such findings as possible signposts that can help navigate the many potential routes to autism.

For example, many of the studies point to molecules that help form and maintain brain connections. Other findings point to the processes used by nerve cells to pass signals to one another. Mutations in genes with names such as *SHANK3*, *SHANK2* and *NRXN1* have been linked to autism. All of these implicated genes code for proteins found at synapses, the junctions where one nerve cell releases chemical signals to communicate with another, and are crucial for normal signaling between nerve cells.

As the list of genetic suspects grows, the challenge lies in unraveling how problems in any one of the genes could send the brain's circuits awry. To find answers, scientists are looking at a handful of rare syndromes where autism patients share a common mutation leading to the same outcome.

Four years ago, scientists found one such example. Researchers studying a

Shuffling DNA Autism often arises in low-risk families via mutations that show up in a child but are not present in the parents' DNA. A chromosome inversion, where a single chromosome undergoes breakage and rearranges itself (left), is one example. The autism-related gene *CNTNAP2* (highlighted at right by a fluorescent probe) is split in an inverted chromosome.



BOTTOM: NICOLE WRIGHT/YALE SCHOOL OF MEDICINE, *AMERICAN JOURNAL OF HUMAN GENETICS*

rare mutation that causes an epileptic disorder in Old Order Amish children observed that all the children with two copies of a recessive gene — called contactin associated protein-like 2, or *CNTNAP2* — developed frequent seizures in early childhood, followed by features of autism.

Further studies followed, linking *CNTNAP2* and autism. In January 2008, three groups of researchers independently reported that they had identified defects in the gene in larger groups of subjects. The three groups used different strategies and different populations to look for possible autism links, and found different mutations — some common and some rare. Still, the labs arrived at the same conclusion: Variations in *CNTNAP2* predisposed carriers to autism.

State's group is now pursuing studies to figure out exactly how. *CNTNAP2* normally makes a type of protein called a neurexin, which is located in neurons. The protein helps brain cells link up during the development of the nervous system. It also appears to help growing cells adapt and alter axons, projections through which brain cells send electrical impulses essential for normal brain function.

In test-tube experiments and in zebra fish, State's team is engineering cells that lack the gene completely. "If we can find out what goes wrong in the protein that we know leads to this rare syndrome of bad seizures and autism, then we can use that as a benchmark and can begin to ask questions of the mutations that we are seeing in other people," he says.

Tracing lines of evidence

Meanwhile, Geschwind and his group are working to catch the gene suspects in action. Studies show that during early development, *CNTNAP2* is highly active in parts of the human brain important for language processing. Other studies have implicated *CNTNAP2* in certain language disorders. Together, the studies suggest that a disrupted version of the gene could throw a monkey wrench into the works during the earliest stages of development.

Using functional MRI, the scientists are looking to see whether the brains of people with and without autism activate differently in specific regions during language-related tasks. The next step will be to see whether activation patterns can be linked to genetic variations. Other labs are using similar approaches to show how autism-associated genes might work on distinct brain regions.

Still, solving the puzzle of autism will be daunting. The fact that identical twins do not always share the disorder suggests that environmental factors as well as genes are at play, Geschwind says. The task is made even more difficult because the genetic aberrations that have been implicated in autism do not present a clear, one-to-one relationship with patients' symptoms or abilities. Some of the submicroscopic changes found in autistic children, for example, are also seen in one of their parents, though the parent may have only mild symptoms or no symptoms at all. Other mutations found in autistic children are seen in kids without autism as well.

And new questions will arise. As research pieces together a more complete picture of the various genes involved — showing which they are, where they work and how they control brain circuits — it may reveal ways to tie particular features of autism to specific derangements in DNA. Like the movie version of Clue — which had multiple endings with different killers committing the same crime — the findings will probably finger multiple molecular missteps leading to the same behaviors and outcomes.

Understanding how the brain functioning of one child with autism differs from that of another could help in developing treatments tailored to specific behaviors or problems. Whether kids with similar symptoms but different genetic variations will respond to the same treatments is unknown, Geschwind says. "But that's a question that we have to ask and begin to look at." ■

Explore more

- NIH autism fact sheet: www.ninds.nih.gov/disorders/autism

Autism spectrum disorders

Autism is often used as a catchall phrase to describe a spectrum, or range, of disorders that affect a person's ability to communicate and interact socially. Autism spectrum disorders include conditions with a wide variety of symptoms that range in severity and come in many different combinations. The autism spectrum disorders include:

Autistic disorder:

Also known as "classic autism," this disorder affects a person's ability to communicate, form relationships and respond appropriately to the environment. Some people with autistic disorder are high-functioning and can speak and interact, while others are more severely affected and nonverbal.

Asperger syndrome:

Individuals with Asperger syndrome do not have a delay in spoken language development, but they can have serious deficits in social and communication skills. People with Asperger syndrome often have obsessive, repetitive routines and preoccupations with a particular subject, such as trains.

Childhood disintegrative disorder:

Children with this disorder typically develop normally for two to four years before the condition, which resembles autistic disorder, arises. Previously mastered language, social and toileting skills may be lost.

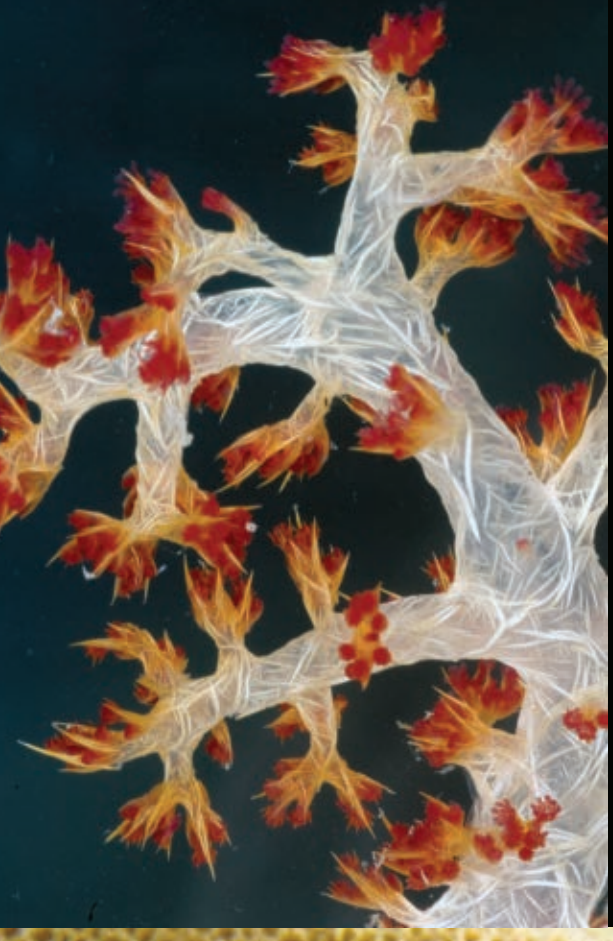
Rett syndrome:

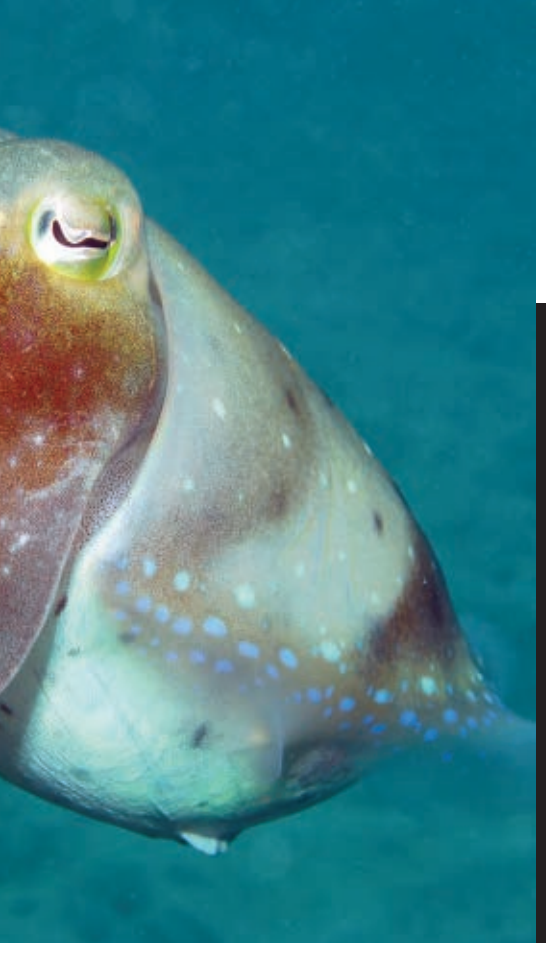
This disorder almost always affects girls. Babies with Rett syndrome develop normally until 6 to 18 months of age, when development slows and their heads no longer grow normally. Affected children don't develop normal speech and may exhibit unusual hand movements and walking patterns.

Pervasive developmental disorder/not otherwise specified:

Also known as atypical autism, this diagnosis is often used when some, but not all, of the symptoms of classic autism or another disorder are seen. Like other autism spectrum disorders, it is characterized by social and speech problems.

SOURCES: NIH, NATIONAL RETT SYNDROME FOUNDATION





An oceanic endeavor

Marine census catalogs creatures that roam all corners of the seas

Calling a 10-year plan for ocean research a "Census of Marine Life" was from the beginning a splendid ambition, but perhaps a little loony. Scientists didn't have names for, and may never have seen, thousands of marine critters. Nor had anyone sampled 99.9 percent of the ocean volume where the knowns and unknowns might dwell.

Yet something in seawater nourishes big schemes and dreams. In 2000, researchers began collaborating in a network that has now grown to involve at least 2,700 scientists from more than 80 nations. The coalition tackled "three grand questions," in the words of Jesse Ausubel of the Alfred P. Sloan Foundation, an environmental scientist and cofounder of the census. The goal, as Ausubel put it, was to discover what has lived in the ocean, what lives there now and what will live there in the future.

To take on such a big task, census participants mined historical records, made more than 540 field expeditions, wrote upwards of 2,600 publications, discovered at least 1,200 new species (with more on the way), created a whale of a worldwide database for marine species records and spent $650 million.

New technologies bloomed. A novel approach to sonar gave a view wide enough to detect 250 million herring massing into a school the size of Manhattan. Tagging top predators revealed a previously unrecognized gathering point in the Pacific, dubbed the White Shark Café. And troubles loomed. Concerns over ocean resources encouraged research into the health of fishing stocks. In one dramatic report, scientists warned that unless something changes, fisheries could collapse by 2050.

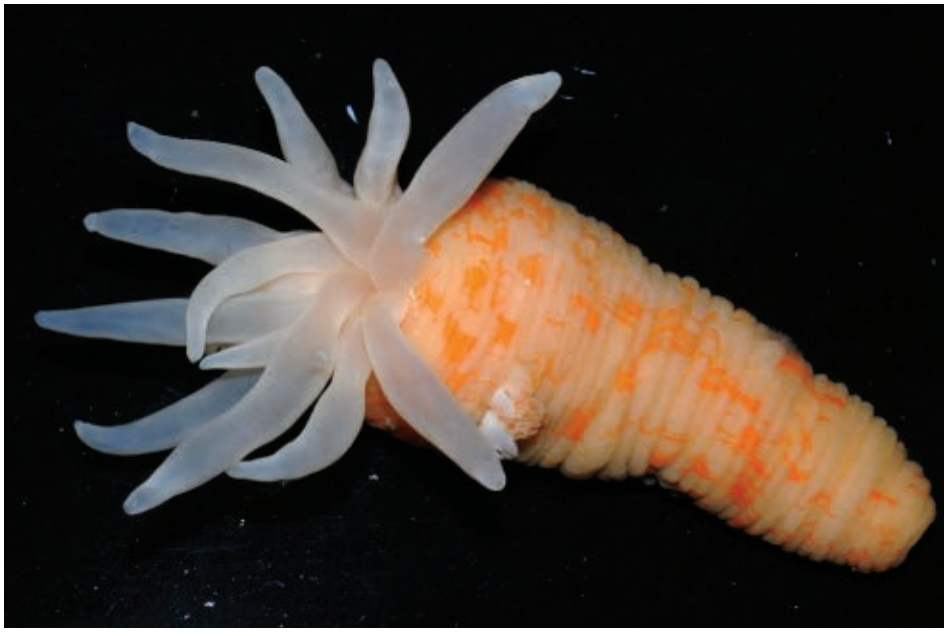
Shipboard researchers collected specimens for basic taxonomy as well as for understanding patterns in past and future biodiversity. But the census portraits, a sampling of which are found on the following pages, are what really leads to oohing and ahhing over the seas' spectacles.

A newly discovered crab boasts legs covered in pale, shaggy fur. Worms waggle more head ornaments than an Easter hat and the membranes of jellyfish flutter like moths. After 10 years, a new age of discovery has barely begun. —*Susan Milius*

SPINELESS MARVELS

A new species nicknamed the yeti crab looked photoshopped to a startled public when researchers first released an image (top right) of the deep-dwelling invertebrate. The specimen, belonging to the species now called *Kiwa hirsuta*, came from 2,228 meters down in the South Pacific. A wrap-up analysis put out by Census of Marine Life researchers concludes that most marine diversity lies not in fish but in life-forms without backbones. Other invertebrates shown include (clockwise from the yeti crab) a cuttlefish, Christmas-tree worm and soft coral.

CLOCKWISE FROM TOP RIGHT: COURTESY IFREMER, A. FIFIS 2006; NEXT TWO: JOHN HUISMAN; GARY CRANITCH/QUEENSLAND MUSEUM 2008



LIVING COLOR **Though scientists had previously described the Antarctic sea anemone *Stephanthus antarcticus*, they observed a living specimen with its carrot-orange color for the first time during a 2006–07 census survey. Two field projects focused on the polar oceans, where exploration has lagged because of forbidding conditions. Census researchers on their way to Antarctic study sites endured 16-meter waves, and those working on ice at the northern end of the Earth posted an armed guard to watch for polar bears.**
PABLO J. LOPEZ-GONZALEZ/UNIV. DE SEVILLA, CAML

DEEP WORMS The deep ocean accounts for much of the living space on Planet Earth, but scientists hardly ever visit there. Given the chance to explore these regions, researchers uncovered much that was new, including this species of acorn worm. Of interest to evolutionary biologists, these creatures have a pair of gills like fish do. The worms also have head ends and tail ends, the beginnings of a vertebrate-like body plan.
COURTESY OF DAVID SHALE

SMALL PLATES A copepod collected from the depths of the Atlantic (considerably magnified here) plays an important role in an unsung part of oceanic food webs. These tiny crustaceans typically graze on microscopic cells bobbing in the thin soup of ocean water. In turn, fish larvae or other (relatively) large creatures feed on the copepods. The census's legacy includes an ambitious, ongoing effort to document the huge food web of the North Atlantic.
© BÜNTZOW/CORGOSINHO

BOMBER FAMILY A new species of polychaete worm was found about 2,800 meters down in the Celebes Sea, south of the Philippines. The worm belongs to a new family that swims through open water. Flashier family members, nicknamed "green bombers," release little globes if poked by a scientist or, presumably, if approached by a predator. The globes explode in a burst of green light that might dazzle a pursuer for a few vital seconds.
PHOTO BY LARRY MADIN/WHOI

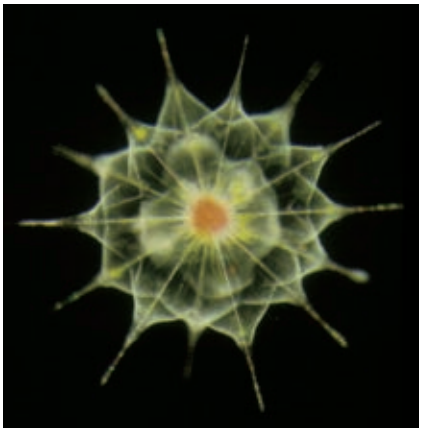
FILM STARS Census photographers captured remarkable images of delicate, filmy creatures that less sensitive sampling methods often mangle. A new species of narcomedusa jellyfish dubbed *Bathykorus bouilloni* (far left) was collected in the Arctic Ocean and shows off its dainty bell.
KEVIN RASKOFF

NO DUMMY A new dumbo (near left), a close relative of octopuses, extends rounded flaps that researchers suspect are important for swimming. Unlike octopuses lurking in crevices, the deep-water dumbos move through open water. Census researchers encountered this specimen during trips to the Mid-Atlantic Ridge.
COURTESY OF DAVID SHALE

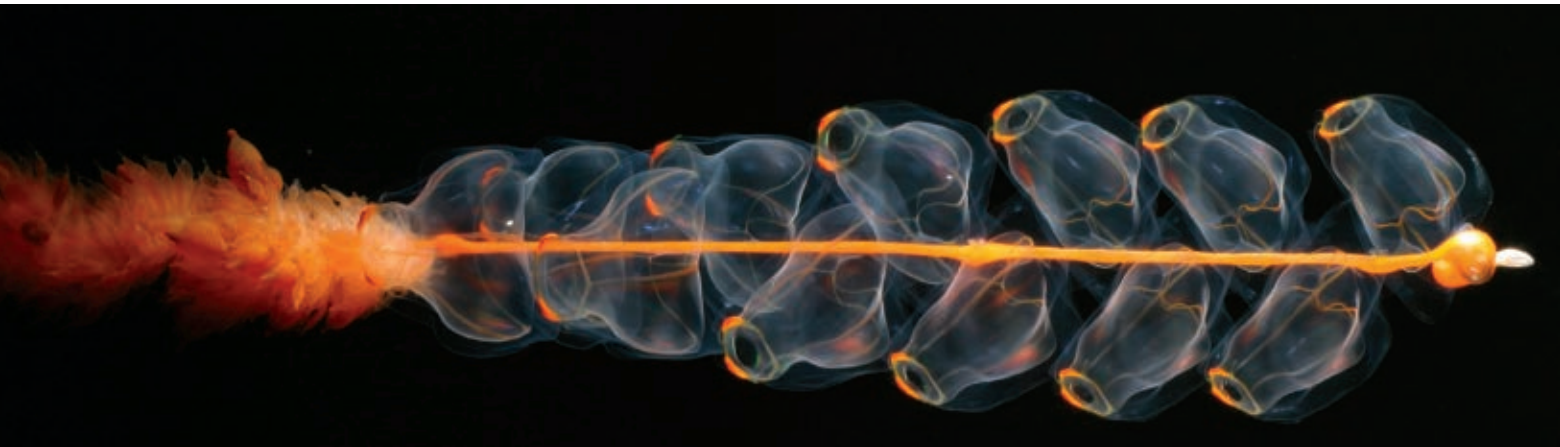
COOL CUKE This pink marvel really is a sea cucumber, though very different from the fat, dark sluggish forms nudging along in tide pools. The Celebes Sea beauty, *Enypniastes eximia*, ranks among the small group of sea cucumbers that can leave the ocean floor and swim gracefully, if slowly. By undulating its collarlike structure, *E. eximia* can move dozens of meters up into the water column. Census researchers found the cuke some 2,500 meters below the surface of the Celebes Sea. Dropping down to more than 5,000 meters in places, the Celebes has several deep, chilly basins. Yet it also sits within the Coral Triangle, a region famed for shallow, warm wonderlands of reefs. A census expedition that went to the Celebes will help researchers address such broad questions as whether the deep basins mirror the richness of life found in the surrounding shallows.
PHOTO BY LARRY MADIN/WHOI

LOADED Despite its airy looks, this nemertean is built to hunt. A tonguelike projection coils around a dart within the ribbon worm, ready to shoot out at prey. A see-through body reveals a yellow, branching stomach. Collected on an Antarctic research expedition, this *Pelagonemertes rollestoni* specimen measures about 3 centimeters long. Census analyses compared species living in the Antarctic and Arctic. Although many of the finds were a world apart, more than 200 kinds of Antarctic organisms had look-alikes at the other pole, either the same species or a close relative. RUSS HOPCROFT/UNIV. OF ALASKA FAIRBANKS

DEEP FREEZE With new data, scientists have found that Antarctica, where the juvenile octopus shown here resides, periodically enriches the cast of animal characters in seas to the north. As the continent's glaciers have expanded and retreated through time, some octopus lineages have taken refuge in deep Antarctic waters. From there the octopuses adventure into northern oceans, giving rise to new species there. Sea spiders and isopods, among other groups, may also have edged northward in time with these glacial cycles. M. RAUSCHERT



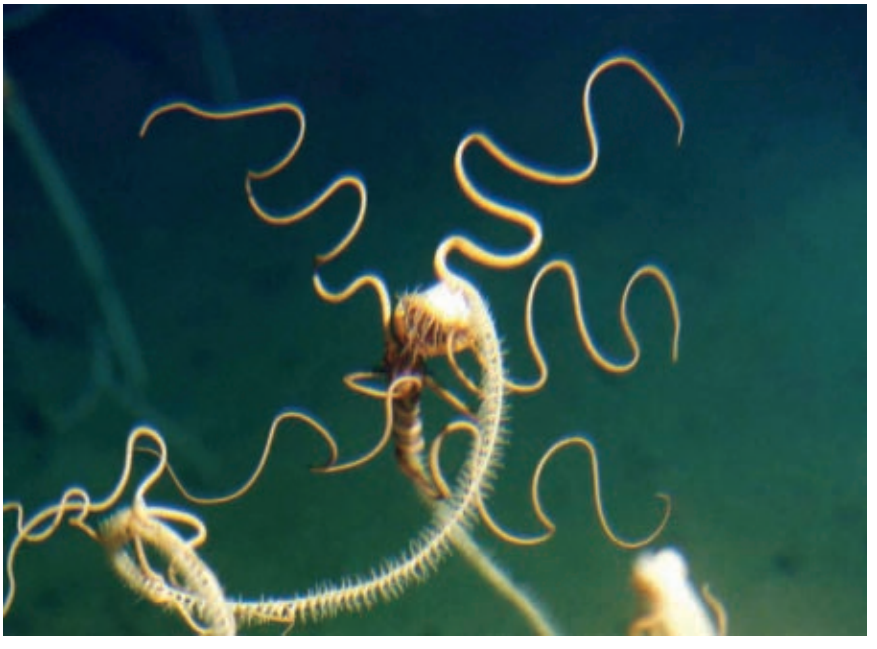
SMALL POINTS Microbial residents of the seas called acantharians (one shown here) form skeletons of strontium sulfate, which dissolve when the cell dies. Census researchers took advantage of advances in DNA sequencing to explore the diversity of marine microbes, analyzing water samples from 1,200 sites worldwide. All this little stuff adds up to a majority of the biomass of the oceans, researchers report. Wafting cells could collectively weigh as much as 240 billion African elephants. That's 35 elephants' worth of microbes for every person living on the planet.
LINDA AMARAL ZETTLER, UNDER LICENSE TO MBL (MICRO*SCOPE)



COLONIAL STYLE Collected—gently—in the Arctic Ocean, a siphonophore strings out its delicate clones. Individual zooids, as the component clones are called, specialize and cooperate to swim and hunt together as a single creature. Species of siphonophore can grow 40 meters or more in length, ranking as the longest known animals. The one shown here is a third of a meter, but can reach six times that length while feeding. KEVIN RASKOFF

WHATSIT The census's many research cruises turned up more unfamiliar creatures than scientists have had time to analyze and name. This specimen from the Arctic is probably a new species of comb jelly. (Unlike true jellyfish, in the phylum Cnidaria, comb jellies don't have stinging cells.) Census participants have lamented the current shortage of experts able to classify the vast numbers of organisms that have been pulled from the seas in the past decade. KEVIN RASKOFF

JAWS Sharp teeth protrude even from the tongue of this dragonfish. As environmental scientist and census participant Paul Waggoner describes members of the species shown here, "they would be terrifying animals if they weren't the size of a banana." Though invertebrate species overwhelm vertebrate species in census tallies, dividing the organisms into smaller groups offers a different perspective. Fish rank third in numbers of known species, after crustaceans and mollusks. Fish account for about 12 percent of known marine organisms, not a huge chunk but still a dozen times the proportion of sea squirts and other tunicates. JULIAN FINN, MUSEUM VICTORIA



A STAR SURVEY Because of the census's accomplishments, today biologists can easily find records of the brittle star *Asteronyx loveni* living in European waters, off the coast of South Africa and off New Zealand. There's a greater sense of what lives where in the oceans now. A study done in 1995 by the National Research Council found that hardly any nation could list the species living off its shores. Today a database created by the census allows any nation, or anybody doodling around on the Web, to enumerate some of the local wonders of the seas. © JAMSTEC

Explore more

- Visit the Census of Marine Life website: www.coml.org

Cosmic dioramas

Metamaterials may offer windows into other worlds

By Elizabeth Quill

Move over Harry Potter, and take your invisibility cloak with you. Alice's looking glass may be the latest bit of literary magic worthy of physics laboratories.

Rather than using substances known as metamaterials to hide objects in plain sight, some scientists instead want to use the strange materials to build windows into worlds with fundamentally different physics. Peering in may reveal how other universes operate and how this universe — the one that avid J.K. Rowling and Lewis Carroll readers reside in — could have begun.

Metamaterials can be engineered to have features very different from those of everyday matter. By altering electric and magnetic properties, scientists can make metamaterials that bend, twist or otherwise manipulate light. The power to turn light in unusual ways brought about a cloaking craze and introduced the possibility of superlenses with unprecedented focusing power.

Last year, a group of physicists at the University of California, Berkeley proposed a type of metamaterial that, if built, could trap light the way a black hole does (*SN: 10/10/09, p. 10*). The math describing processes in that material resembles the equations governing black holes.

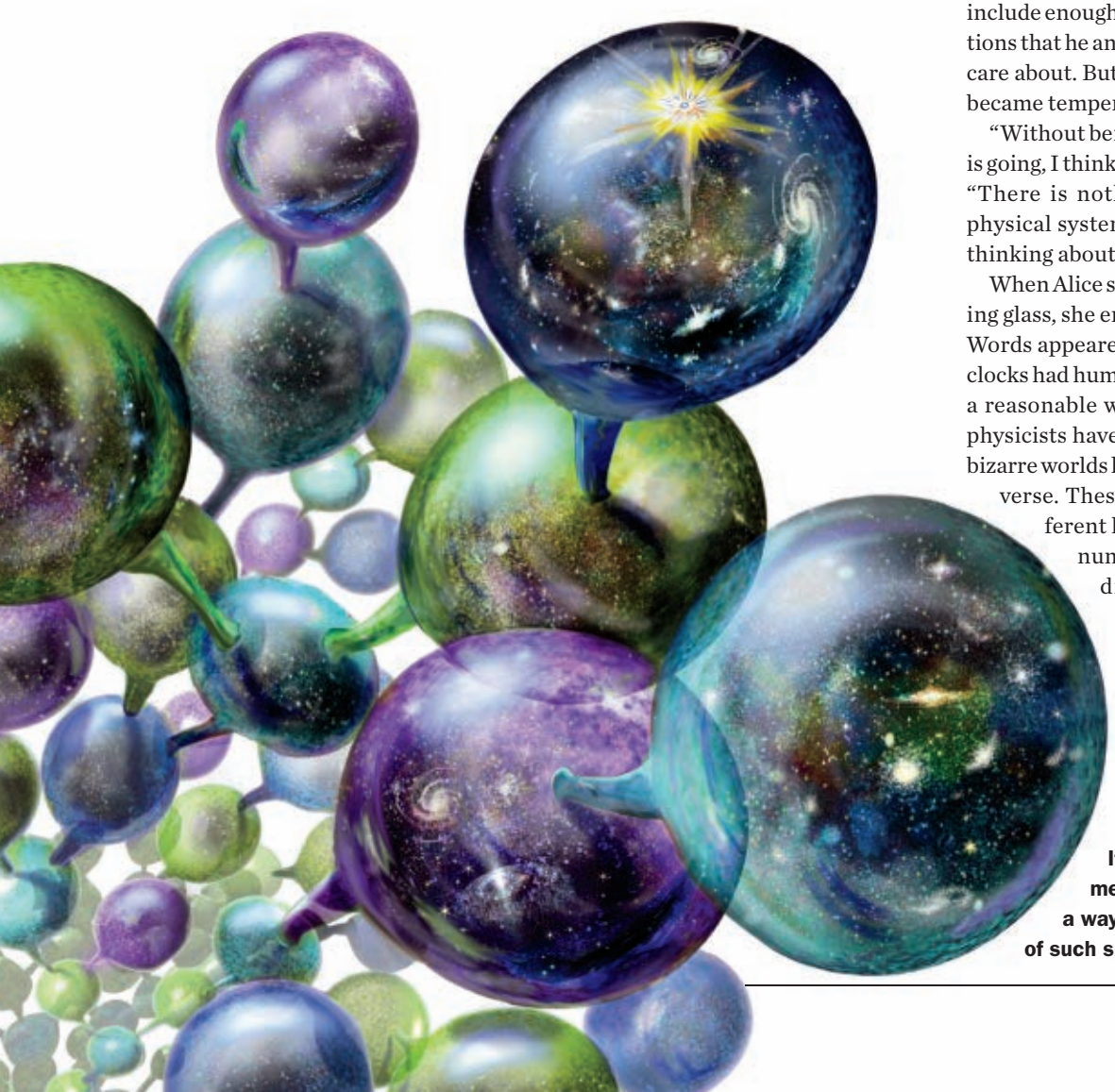
Now Igor Smolyaninov of the University of Maryland in College Park has developed additional "strange schemes," as he calls them. Metamaterials, it turns out, can serve as broader cosmic dioramas, manipulating light to replicate the shape of spacetime.

"In metamaterials, we have a situation in which we have optical spacetime," Smolyaninov says. "And we can engineer the properties of spacetime."

Joseph Polchinski of the University of California, Santa Barbara's Kavli Institute for Theoretical Physics says he was skeptical after first reading about the work. He is not convinced that the analogs Smolyaninov proposes would include enough detail to probe the questions that he and others in his field really care about. But Polchinski's doubt soon became tempered by curiosity.

"Without being able to say where this is going, I think it is interesting," he says. "There is nothing like having a real physical system in your hands to start thinking about things in a new way."

When Alice stepped through her looking glass, she entered a distorted world. Words appeared backward on the page, clocks had human faces and floating was a reasonable way to get around. Some physicists have proposed that far more bizarre worlds lie beyond the visible universe. These worlds could have different laws of physics, different numbers of dimensions and different curvatures of spacetime surfaces. But because these multiple universes (known collectively as the multiverse) aren't visible, they would be hard to study.



If many universes exist, metamaterials may offer a way to study the properties of such spaces in the laboratory.

NICOLLE RAGER FULLER

Smolyaninov suggests a solution online at arXiv.org and in an upcoming *Journal of Optics*. Metamaterials, he claims, can be made to mimic the multiverse. He says the idea is straightforward: Pockets with different properties could be designed to replicate adjacent universes. The pockets could be created so light can't escape — as in the black hole scenario — or so that light can move among them.

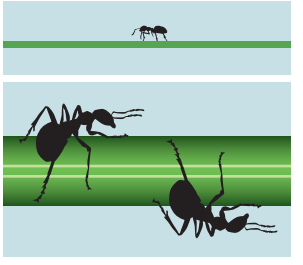
And just as some physicists believe that some dimensions of the visible universe could be compactified — shrunk down really small — the same could be emulated for dimensions in other universes. One pocket universe with two compactified and two extended dimensions could sit next to a space with three compactified dimensions and one extended dimension, for example.

Analog systems have been beneficial to theorists over and over again, says metamaterials expert Ulf Leonhardt of the University of St. Andrews in Scotland. He suspects that something could be gleaned from this system too. "In some areas of theoretical astrophysics, people are just relying on theory," he says. "They have been relying on theory for a very long time."

The idea that space can have compactified dimensions has been around for a while. In the 1920s, Polish mathematician and physicist Theodor Kaluza proposed that an extra dimension might exist beyond the three of space and one of time that are typically experienced. Soon after, Swedish physicist Oskar Klein proposed that such an additional dimension of space could be wrapped up into a small loop. Because it would be too tiny to see, the dimension wouldn't be like those that people know and love, the ones that allow moving forward or back, up or down and side-to-side. Yet particles would notice it. Adding the extra dimension did for electromagnetism what general relativity did for gravity — it gave the field a geometric underpinning.

A common way to think about a compactified dimension is to consider an ant walking along a garden hose. From far away, the garden hose appears one-dimensional — the ant can move only along its length. But zoom in closer, and it becomes obvious that the ant can also loop around the hose's circumference, so a second dimension is available. Just as this second dimension is hidden from a distant observer, an extra curled-up dimension may be hidden from people in the real world.

Smolyaninov calls the Kaluza-Klein idea "a stone of theoretical physics." And although his original proposal for a metamaterial multiverse focused on universes with fewer dimensions, he reports online September 6 at arXiv.org that metamaterials could mimic a world with five or more dimensions. Simulating higher dimensional spaces could make the analogs more interesting to string theorists, who propose the existence of many dimensions too small to see.



From afar, an ant on a hose seems able to move in only one dimension. Close-up, another dimension appears.

In the materials that Smolyaninov dreams of creating, photons can occupy an infinite number of quantum states. Some type of change, in temperature perhaps, could make the unusual material — if constructed just right — revert to a state in which photons can't occupy so many positions. When this transformation happens, the particles have to be emitted, like a bunch of kids getting kicked out of a game of musical chairs all at once. Those emitted photons would create a flash of light.

"It looks like a Big Bang situation," Smolyaninov says. Such a flash could emulate the birth of the universe.

And the flash could be made in a second way, Smolyaninov argues. Consider the dimensions that people experience (leaving Kaluza-Klein out of the picture for now). There are three of space and one of time; the time dimension behaves differently, so it gets its own special math to describe it. But when what's called a metric signature change occurs, a timelike dimension can take on spacelike qualities, or vice versa. Metamaterials could also replicate the math behind this type of transformation, Smolyaninov and Evgenii Narimanov of Purdue University in West Lafayette, Ind., propose in the Aug. 6 *Physical Review Letters*.

Smolyaninov notes that theorists have discussed the idea of two timelike dimensions before. But, says Leonhardt, these ideas remain controversial in cosmology. "There's no consensus about what would happen if one spatial dimension became a timelike dimension," he says. In some ways, this uncertainty makes the proposed analog more exciting. "You can go ahead and try it and see what happens."

Polchinski agrees: Very few people think that a metric signature change occurred during the Big Bang, and differential equations don't seem to have meaningful solutions in a world with two times. Still, he notes, if the system can be built, the math must work out.

So can you build it? Christopher Davis, a colleague of Smolyaninov's at the University of Maryland, says no: "You cannot build what he talks about from real materials."

Smolyaninov responds, "not yet." He is betting on advances in nanofabrication and hoping to drum up some excitement for new optical technologies until then.

While the new technologies may lead to practical devices, the metamaterial multiverse is more speculative.

Smolyaninov is careful to emphasize that the similarities he sees between spacetime and metamaterials are mathematical, not necessarily physical. He doesn't know whether what lies on the other side of his proposed looking glass accurately represents reality.

"Maybe the whole universe is built in the same way," Smolyaninov says. "If it is true or not, you just don't know." ■

Explore more

- Shing-Tung Yau and Steve Nadis. *The Shape of Inner Space*. Basic Books, 2010.

T. DUBÉ, ANT IMAGE: POTAPOV ALEXANDER/SHUTTERSTOCK

The Weather of the Future

Heidi Cullen

The forecast for Earth is in, and it's not good. So writes Cullen, a climatologist formerly of the Weather Channel, in her new book subtitled *Heat Waves, Extreme Storms, and Other Scenes from a Climate-Changed Planet*. If trends continue, she says, by the middle of this century — a mere 40 years from now — no place on Earth will experience the same weather that it does today.

In the first part of this provocative book, Cullen recounts the near century-long history of weather prediction and how that science serves as the foundation for modern climate projections. Climate simulations, she points out, rely on the same laws of physics used in weather forecasts and give scientists the closest tool they have to a crystal ball.

Cullen then draws on recent research to conjure an image of future climate for seven locales that could be especially hard-hit. Models suggest that in densely populated, low-lying Bangladesh, for example, rising sea levels will boost storm surges and flood coasts, submerging as much as a quarter of the nation and driving millions to become climate refugees. And in Australia, warmer water temperatures and acidifying seas could kill corals in large parts of the Great Barrier Reef, which attracts more than 2 million tourists and boosts local economies by about $6.9 billion a year.

Much of the blame for these changes can be pinned on humans, Cullen argues. No climate model that includes only natural influences like solar variability and volcanic eruptions — not a single one — yields results that match actual temperature trends of the past century. Only if heat-trapping carbon dioxide emissions are included can the observed climate be reproduced.

For people to avoid a dismal climate future, Cullen's prescription is to trust climate forecasts and substantially trim carbon dioxide emissions, beginning soon. In the meantime, places that will be most affected by climate change would do well to begin adapting to a new and warmer climate. If you don't start sandbagging until flood waters are up to your waist, she warns, it's already too late. *—Sid Perkins*

Harper, 2010, 329 p., $25.99.

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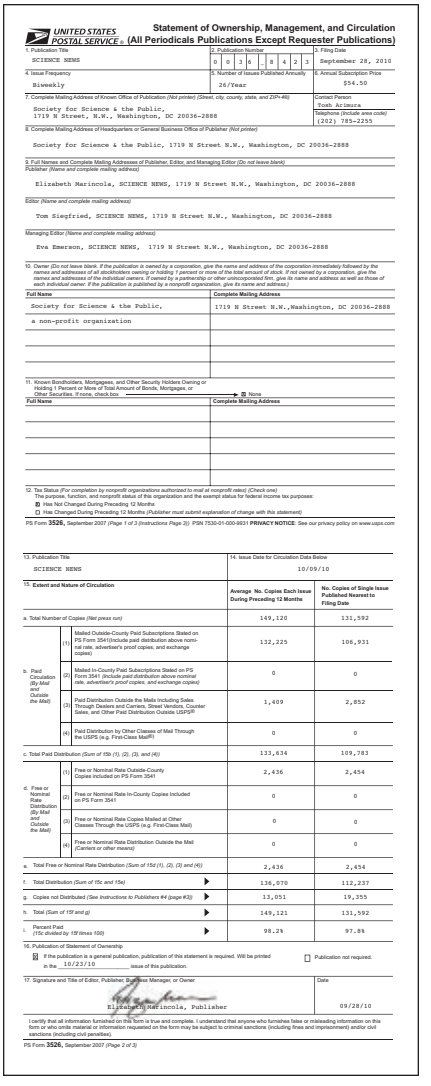

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Music on the mind

Common experience confirms that music serves language ("A mind for music," *SN: 8/14/10, p. 17*). A person unfamiliar with, say, the musical *South Pacific* has only to listen to its songs a few times to sing the lyrics from memory. Another who tries to memorize the lyrics by just hearing them recited a few times will not succeed nearly as well. Now, why?

H. Charles Romesburg, Logan, Utah

Thanks for the special issue on music. Does music soothe the savage breast? I can't say, but I'm pretty sure it has played a large role in keeping me (a life-long musician) sane for the last 25 years of incarceration, and it serves the entire prison community by keeping dozens of creative, purpose-lacking minds occupied with an activity that keeps us largely out of further trouble. As Ian Cross mentioned ("Whatever music is, it's a basic part of being human," *SN: 8/14/10, p. 36*), music programs in schools often get the ax when money's tight. Angered parents sometimes look for an opportunity to pass along the misfortune. Here in Pennsylvania state prisons, the authorities recently decided to end all music programs, even though funding came exclusively from profits earned by selling inmates munchies and cosmetics. Luckily, inmates may still buy and keep personal guitars and keyboards, purchase radios and borrow cassette tapes from the library. It might be interesting for some sociologist to study the difference a lack of formal music programming has on the correctional environment that used to have band room access. Keep up the great work. Not only do I love your magazine, but so do the uncounted guys to whom it gets passed when I'm done.

Paul Schlueter III, Dallas, Pa.

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

Michael Holick

For more Comment, visit Columns at **www.sciencenews.org**

Vitamin D is essential to the modern indoor lifestyle

It's known that vitamin D is necessary for proper bone formation and maintenance. But recent decades have seen a torrent of studies suggesting that vitamin D can also affect many other aspects of health; some scientists have come to consider the daily recommended intake of 400 international units of vitamin D far too low. Michael Holick is a biochemist and endocrinologist at Boston University who has spent a career researching the effects of vitamin D (which is actually not a vitamin but a hormone precursor). His new book is The Vitamin D Solution *(Hudson Street Press, 2010). Holick recently spoke with* Science News *biomedicine writer Nathan Seppa.*

How much vitamin D do we need?
Children should be taking at least 400 to 1,000 international units of vitamin D as a supplement every day, and adults should take 1,500 to 2,000 IU.

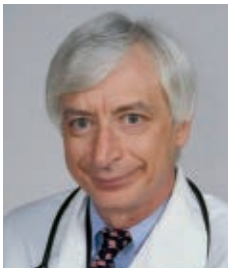
What about pregnant or breast-feeding women?
We tested pregnant women who were taking a prenatal vitamin containing 400 IU of vitamin D each day and drinking two glasses of fortified milk, and found that 76 percent of them — and 81 percent of their newborns — were still vitamin D deficient at the time of giving birth. We also estimate that most breast-feeding women are vitamin D deficient, and they pass along deficient milk to their infants.

Vitamin D deficiency has been linked to increased risks of infectious diseases, cancer, autoimmune diseases, heart disease, cognitive decline, Parkinson's disease, asthma, mood disorders and even diabetes. Is there biological evidence to show how vitamin D could influence so many conditions?
Sure. For example, we know that immune cells called macrophages activate vitamin D, which causes cells to make defensin proteins that specifically kill infective agents like tuberculosis bacteria. A Japanese study recently found that children receiving 1,200 IU of vitamin D each day reduced their risk of getting the flu by almost 50 percent. Every tissue and every cell in the body has a vitamin D receptor protein. It's estimated that upwards of 2,000 genes are directly or indirectly regulated by vitamin D.

Have there been clinical trials showing the utility of vitamin D?
Absolutely. For instance, a trial of postmenopausal women showed that taking vitamin D over four years reduced their risk of cancer by 60 percent.

Since we make vitamin D from sun exposure, don't our levels fluctuate with the seasons?
Only to a small degree, because most people avoid the sun. And sunblock reduces your ability to make vitamin D through your skin. The average levels we found ranged from 22 nanograms per milliliter of blood at the end of winter to about 28 ng/ml by the end of summer, unless you're a tennis player. Blacks start out at 13 to 15 ng/ml during the winter and go up to 22 ng/ml. Less than 30 ng/ml is insufficient vitamin D, and less than 20 ng/ml is considered a deficiency.

But don't dermatologists counsel people to limit their sun exposure?
Moderation in all things. Humans evolved in sunlight. Our hunter-gatherer forebears were making thousands of units of vitamin D every day, and our body has adapted to that need. That's why we think vitamin D research will have sustainability and won't go up in flames like vitamins C and E.



Every cell in the body has a vitamin D receptor protein. It's estimated that upwards of 2,000 genes are directly or indirectly regulated by vitamin D.

How do you see vitamin D use changing in the future?
It's likely that the [National Academies'] Institute of Medicine will come out with recommendations of at least 800 to 1,000 IU a day for adults and also substantially increase the tolerable upper limits. That's what influences what manufacturers can put in foods. Right now the upper limit is 2,000 IU a day. I would predict that within a couple of years many more foods [besides milk] such as pasta and bread will be fortified with vitamin D. I've estimated that across the board you could reduce health care costs by 25 percent by food fortification. Supplements are great, but nobody remembers to take them every day. As for sun exposure, a little bit is great for you, but you can only do it spring, summer and fall. So you really need vitamin D in a place where everyone would be able to get it, and that's the diet.

To what extent does the medical community agree with you on vitamin D?
I recently gave a talk in Toronto to internal medicine doctors and asked how many of them were "believers," like it was a religious revival. And 90 percent raised their hands. The test for vitamin D levels is now the most ordered assay by doctors in the United States. ■

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Could String Theory Be the Long-Sought "Theory of Everything"?

One of the most exciting scientific adventures of all time is the search for the ultimate nature of physical reality. The latest advance in this epic quest is string theory—known as superstring or M-theory in its most recent versions. Based on the concept that all matter is composed of inconceivably tiny filaments of vibrating energy, superstring theory has potentially staggering implications for our understanding of the universe.

In **Superstring Theory: The DNA of Reality**, you explore this intriguing idea at a level deeper than that available in popular articles. Your guide is Dr. S. James Gates Jr., the John S. Toll Professor of Physics and Director of the Center for String and Particle Theory at the University of Maryland at College Park. Throughout these 24 lectures, he explains the concepts of superstring theory and mathematical ideas like hidden dimensions, dark matter, and black holes—all at the level of the nonscientist. He also draws on the illustrative power of graphics and animations to enhance your understanding and take you to the heart of these cutting-edge ideas.

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Superstring Theory: The DNA of Reality

Professor S. James Gates, Jr.
University of Maryland at College Park

Winner, the Klopsteg Award of the American Association of Physics Teachers
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4. Honey, I Shrunk to the Quantum World—Part I
5. Honey, I Shrunk to the Quantum World—Part II
6. Dr. Hawking's Dilemma
7. I'd Like to See a Cosmos Sing in Perfect Harmony
8. Einstein's Hypotenuse and Strings—Part I
9. Einstein's Hypotenuse and Strings—Part II
10. Tying Up the Tachyon Monster with Spinning Strings
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12. It's a Bird—A Plane—No, It's Superstring!
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17. The Fundamental Forces Strung Out
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19. Do-See-Do and Swing Your Superpartner—Part II
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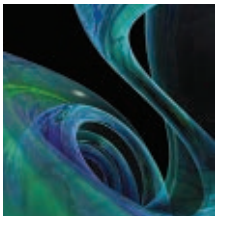

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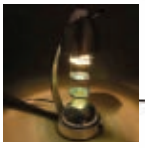

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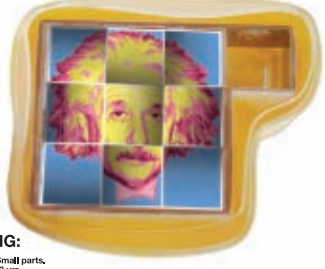

Do you picture yourself a mastermind or whizkid? Now you can prove it. Tackle this mind-bending puzzle and find yourself pictured right next to Einstein when you reach the right solution.

#X31520-10 . . . . . $14.95

⚠WARNING:
CHOKING HAZARD – Small parts.
Not for children under 3 yrs.

Mindflex

Are Your Thoughts as Powerful as You Think They Are?

Advanced technology of this mental acuity game lets you compete in a mental marathon. Obstacles are put in place for your mind to conquer, and you can even reposition them into different set ups. The outcome depends on your concentration. Simply put on the lightweight headset and focus. Sensors inside the headset measure your brainwave activity, allowing you to raise a small foam ball in a gentle stream of air when you focus on this task. Once you lose concentration or just relax, the ball will drop. Applying your physical and mental coordination, your task is to guide this ball through each obstacle. Requires four C batteries and two AAA batteries. Recommended for ages 8 and up.

#X32003-49 . . . . . $99.95

The Heroes of Scientific Discovery

Lil' Giants of Science Collection

Carry the most notable scientific minds in your pocket. These miniature scientist action figures are colorful caricatures, and the perfect gift for any scientific fan. Fun for play and display, the set includes Darwin, Einstein, Newton, and Tesla. Size of each: 3" tall.

#X31520-78 . . . . . $17.95

The Amazing Drinking Birds

Great Conversation Piece for the Office or Home

⚠WARNING:
CHOKING HAZARD – Small parts.
Not for children under 3 yrs.

These famous entertaining birds never stop drinking! Simply get a glass of water ready, dunk the bird's head towards the glass and release it—the drinking bird will bob back and forth while periodically taking a drink. It will amuse you for hours as you watch it bob and learn the science behind it. Birds may also be used as relative humidity indicators. Their bodies consist of a glass vial filled with red or blue dye (will stain if broken). Includes two birds. Weight: 0.42 oz Size: 4-⅛" x 7" x 2-⅛"

3053617J $8.95

Please note this product is not a toy and is not intended for use by children under age 8. Contains methylene chloride and may stain clothing and other surfaces. Do not swallow liquid or allow to come in contact with eyes or skin. Non-flammable. Keep away from flame or other heat sources. If shipping to AK or HI, additional hazard fees may apply.