RNAs' Secret Lives | Chaos on Europa | Greek Trade Revisited

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MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ DECEMBER 17, 2011

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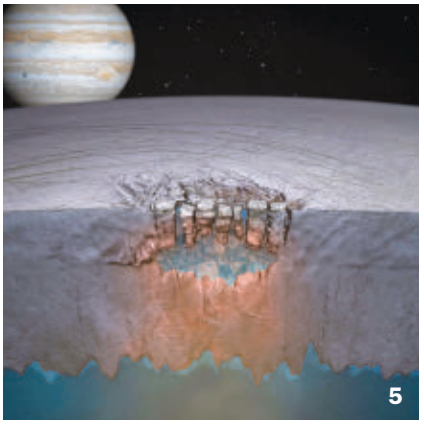
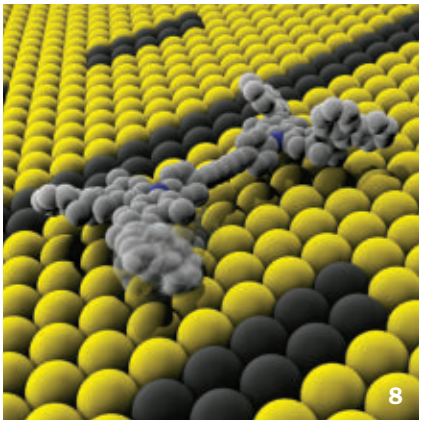
Snapshot of a Dreaming Brain

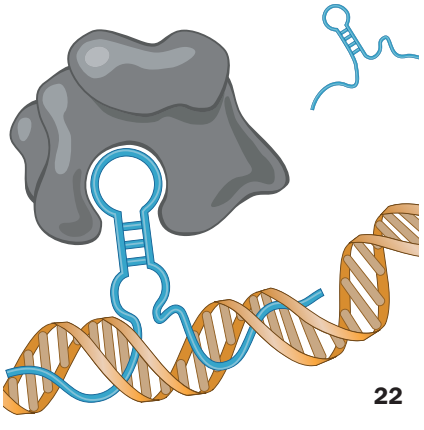
Dinosaur Migration

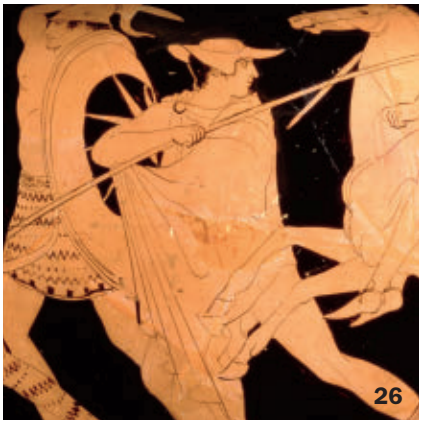
Nanoroadster Debuts

DECEMBER 17, 2011 • VOL. 180 • NO. 13









ScienceNews

In The News

Features

Departments

COVER Several new technologies in the works are attempting to wow viewers by making 3-D displays more realistic.
Cary Wolinsky

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Science News (ISSN 0036-8423) is published biweekly, for $54.50 for 1 year or $98 for 2 years (international rate $80.50 for 1 year or $161 for 2 years) by Society for Science & the Public, 1719 N Street NW Washington, D.C. 20036. Preferred periodicals postage paid at Washington, D.C., and an additional mailing office.
Subscription Department: PO Box 1205, Williamsport, PA 17703-1205. For new subscriptions and customer service, call 1-800-552-4412.
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FROM THE EDITOR

Turns out that 'junk DNA' wasn't just talking trash

Not that many years ago, scientists believed that most of the DNA in every human cell was junk.

Genes — the segments of DNA carrying the instructions for building proteins — constitute only about 2 percent of the chemical-unit letters in a human cell's complete set of chromosomes. All the rest was thought to be unreadable by the cell's machinery. It would be like a newspaper in which only the headlines made sense while the rest of the text was gibberish.

It turns out, though, that the cell can read nearly all the rest of the DNA — it was the biologists who didn't understand the DNA language. "Noncoding" regions of DNA, once dismissed as junk, do contain codes for making molecules; it's just that these molecules have jobs other than making proteins.

One important class of such molecules, called lincRNAs, play all sorts of important roles in the cell, as Tina Hesman Saey reports in this issue (Page 22). These RNAs have recently joined a growing roster of other RNA molecules as interlopers in the textbook story of how cells work. In the original fairy tale, DNA segments called genes served as blueprints for making "messenger" RNA molecules that carried instructions to the cell's protein-making factories. Some of the proteins, in turn, attached themselves to DNA at specific points to guide which of the genes in a given cell made proteins and which stayed dormant. Which genes were active drove the processes that gave each cell its identity, and hence its job in the body.

But now it's known that ragtag teams of RNA molecules — some short, some long — also regulate what happens in a cell, activating some genes and silencing others. DNA's relationship with its RNA cousin is multifaceted; the neat textbook charts listing genes, the proteins they encode and the jobs those proteins do reflect human-friendly labels for organizing knowledge, not the reality of cellular biochemistry. This new view suggests that people differ from other organisms, from worms to flies to mice, not because of protein-coding genes. It may be rather that species' defining features arise from diverse activities orchestrated by the multitude of RNA molecules produced from the cell's supposedly "junk" DNA, as Stuart Knowling and Kevin Morris of the Scripps Research Institute propose in a recent issue of the journal *Biochimie*.

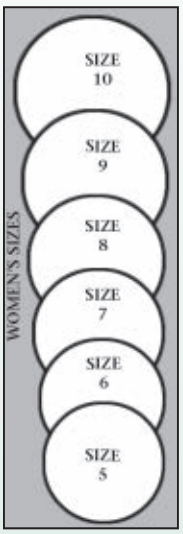
"It is becoming clear," Knowling and Morris write, "that what was once considered the trash of the cell is becoming treasure." —*Tom Siegfried, Editor in Chief*

JIM WEBB

The Sigh Heard 'Round the World

One soldier's incredible true story about the top secret operation that took his wife's breath away.

It was an American soldier in Iraq who showed me the true power of a piece of jewelry. He wrote to tell us that shortly after marrying his sweetheart he received orders to return to active duty as part of Operation Iraqi Freedom. Like a true romantic, he wasn't about to let 7000 miles (or a war) ruin their first Christmas as husband and wife. He found the perfect gift from Stauer and asked his new bride to call him when it arrived.



USING THE RING SIZE CHART
Place one of her rings on top of one of the circle diagrams. Her ring size is the circle that matches the inside diameter of the ring diagram. If her ring falls between sizes, order the next larger size.

"So far away, I would not be able to see her reaction, but I wanted to hear it," he wrote. On the day the package arrived, she called as promised. With her husband listening, halfway around the world on the end of the line, she opened the box and slowly lifted the lid.

"As soon as I heard her breath stop, I knew she'd seen it", the soldier wrote. Even though they were oceans and continents apart, in that instant the newlyweds were reunited. Romance wins again.

I love that story. I want to hear more of those stories, lots more. Those kind of unforgettable moments are the reason that the ***Emerald-Cut Diamond*Aura® *Gial Ring*** exists. In the fine tradition of jewelry designed to take her breath away, we created this stunning showcase for a magnificent 4 ¾-carat yellow, lab-created Diamond*Aura*. Layered in platinum over sterling silver, the luxurious golden yellow centerpiece is highlighted by dozens of sparkling white Diamond*Aura* rounds.

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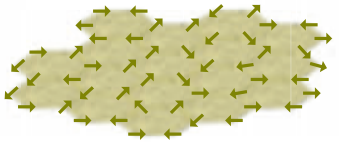
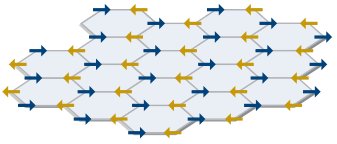

Spin liquid


Antiferromagnet

Say What?

Quantum spin liquid ***\KWAHN-tum spin LIH-kwid\ n.*** An exotic type of theoretical matter that, despite its name, isn't actually a liquid. In this material, quantum states called spins behave like molecules bobbing about in liquid. Instead of lining up neatly (as in magnets and in an antiferromagnet, left, seen in superconductors), the spins move around uncomfortably thanks to quantum fluctuations that keep them twitching even at absolute zero. Evidence for the existence of quantum spin liquids, first proposed in 1973, has remained controversial. But that hasn't stopped scientists from drawing new molecular blueprints that arrange atoms into geometries that keep the spins disordered, or in scientific lingo, "frustrated." Understanding spin liquids may help scientists design new kinds of electronics. *— Devin Powell*

Science Past | DECEMBER 16, 1961

HORMONES AFFECT NERVES — Add sex hormones to all the other things that can make you feel depressed on some days and elated on others. Evidence that sex hormones

can affect the body's central nervous system in roles unrelated to sexual functions has been reported by physiologists at the University of California, Berkeley. The findings show that a potent female hormone known as estradiol has a marked effect on brain excitability, a fact that may help explain the well-known monthly ups-and-downs of feminine temperament. Contrary effects produced on the brain by male and female hormones also point to a possible chemical basis for a woman's generally more excitable nature.

Science Future

January 1
Last day of the "Science of Gingerbread" exhibit at the Discovery Science Center in Santa Ana, Calif. See bit.ly/SNginger

January 22
Last day to visit an exhibit on race at the Museum of Life and Science in Durham, N.C. See bit.ly/SNrace

January 31
Deadline for entries in the 2012 Neuro Film Festival to promote brain research. Go to bit.ly/SNneurofilm

SN Online

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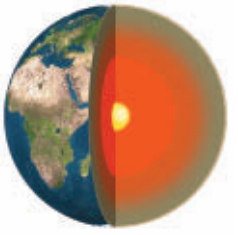
EARTH
Scientists get closer to knowing the exact makeup of Earth's innards. Read "Oxygen a bit player in Earth's outer core."



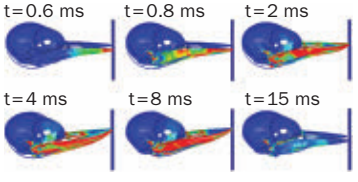
GENES & CELLS
A sense-mixing condition in which some people see smells or taste colors may have genetic roots. See "Unraveling synesthesia."

BODY & BRAIN
An illusion that tricks people into thinking a sore hand is healthy can reduce pain. Learn more in "Mirrors can alleviate arthritis."

An experimental therapy could improve heart attack treatment. See "Busting blood clots with a nanoparticle."

How Bizarre

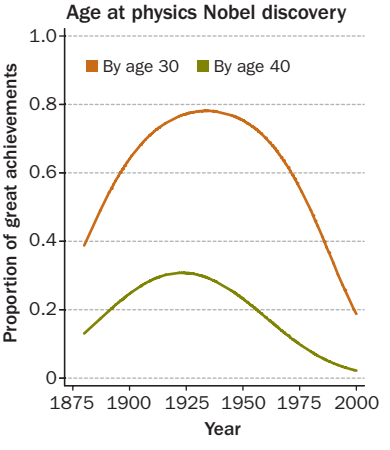
Scientists have figured out how woodpeckers can rat-a-tat-tat a tree 12,000 times a day at speeds up to 7 meters per second without a headache. A combination of traits distributes stress, protecting the birds' brains, researchers in Hong Kong and China report October 26 in *PLoS ONE*. Features include a spongy bone in the forehead, a thin Y-shaped bone that may act as a seat belt around the back of the head, and bones of unequal length in the upper and lower beak (one peck shown, with highest stress in red). The findings could aid in designing better helmets for people. *— Rachel Ehrenberg*



Science Stats | WHEN SCIENTISTS PEAK

A study of the ages of "peak creativity" of Nobel laureates finds that on average, prize-winning breakthroughs have come around age 40. The ages of high achievers have shifted over time, though, notably in physics during the 1920s and '30s (see chart, right), when young scientists pushed the field of quantum mechanics forward.

SOURCE: B.F. JONES AND B.A. WEINBERG/*PNAS* 2011



CLOCKWISE FROM TOP LEFT: E. EDWARDS; NASA; L. WANG *ET AL*/*PLOS ONE* 2011

“People have thought they created metallic hydrogen before, and they turned out to be wrong.” —WILLIAM NELLIS, PAGE 9

In the News

STORY ONE

Europa’s chaotic landscape hints at lakes beneath its icy surface

Pools might be good place to hunt for life on Jovian moon

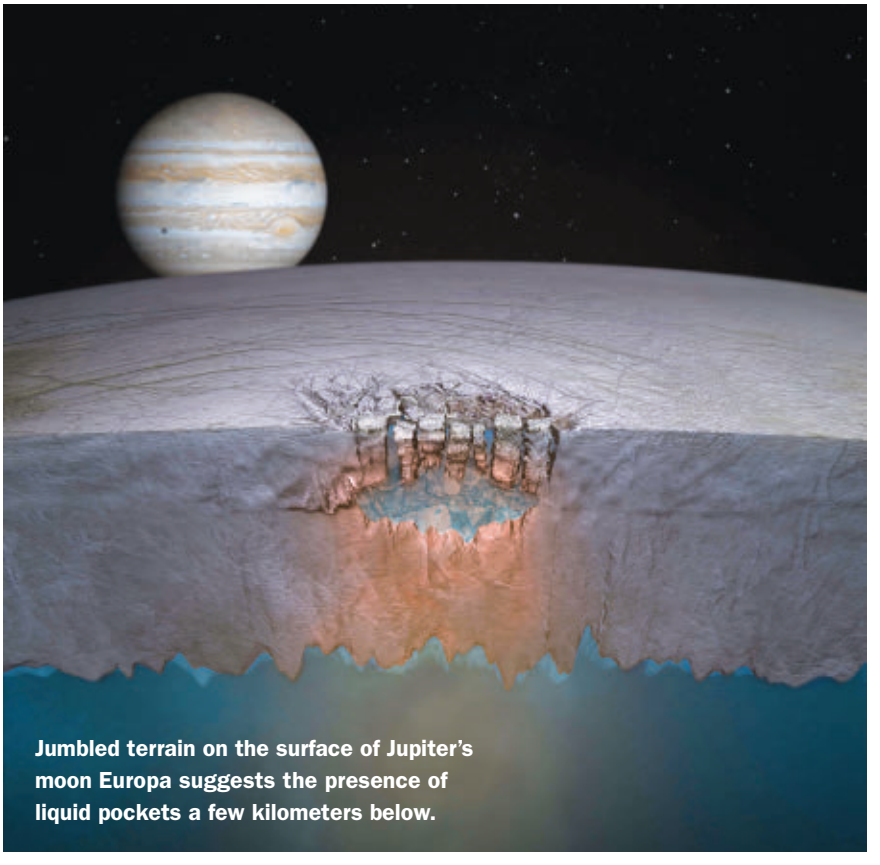
By Nadia Drake

Beneath its glossy veneer, Europa’s frozen crust might be carved into something resembling Swiss cheese, with enormous cavities of liquid water tucked into the rock-hard ice.

One of the buried lakes on Jupiter’s watery moon, lurking a few kilometers below a region called Thera Macula, contains at least as much water as the U.S. Great Lakes, scientists report online November 16 in *Nature*.

These hidden Europan reservoirs would explain jumbled, chaotic surface features that have puzzled scientists for more than a decade. The existence of such cavities implies vigorous mixing of materials between Europa’s frigid surface and the sloshing ocean hiding beneath — a tantalizing prospect for scientists considering whether life could evolve on the Jovian moon.

“It would be great if these lakes harbored life. But even if they didn’t, they say that Europa is doing something interesting and active right now,” says planetary scientist and study coauthor Britney Schmidt of the University of Texas at Austin.



Jumbled terrain on the surface of Jupiter’s moon Europa suggests the presence of liquid pockets a few kilometers below.

B. SCHMIDT, DEAD PIXEL FX, UNIV. OF TEXAS AT AUSTIN

Schmidt and her colleagues uncovered the lakes while considering how chaotic regions on Europa, such as Conamara Chaos, might form. The team compared archival images of these tangled terrains with similar landforms on Earth: fractured, collapsing Antarctic ice shelves and icy caps perched atop subglacial Icelandic volcanoes. Interacting water and ice craft these terrestrial jumbles, and similar processes might explain observations on Europa.

The team “took an array of related processes and shuffled them in new, extraterrestrial ways,” says glaciologist Ted Scambos of the National Snow and Ice Data Center in Boulder, Colo., who likens Europan chaos-crafting to an “upside-down cake” version of earthly events.

On Europa, warm, pure ice rises through the crust, eventually reaching a contaminated layer within a few kilometers of the surface. That dirty layer then thaws, forming a lens-shaped lake and cracking the weakened ice above it. Then, water pushes up through the cracks, fracturing and rearranging the surface ice. “Fracturing catastrophically disrupts the ice in the same way that it causes ice shelves to collapse on Earth,” Schmidt says.

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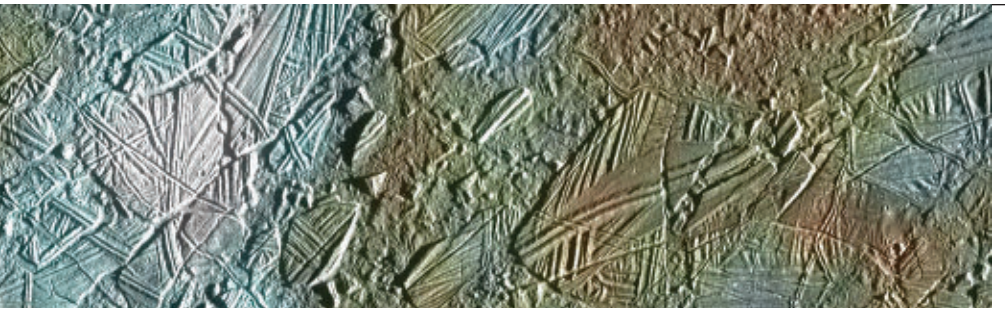


Jumbled icy patches, such as the Conamara Chaos region pictured here, may indicate the presence of Great Lakes–sized liquid reservoirs a few kilometers beneath Europa's surface. The picture shows an area roughly 70 by 20 kilometers.

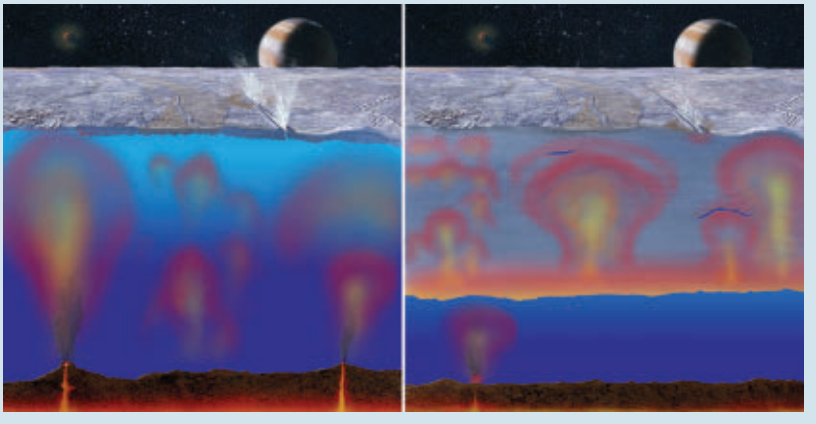
Eventually, the pocket refreezes, raising the mussed terrain above surrounding areas.

Busted-up regions like Conamara and Thera Macula cover roughly 50 percent of Europa, meaning that the moon's crust might host many enormous lakes within a few kilometers of the surface. Preliminary estimates suggest that the pocket beneath Thera Macula could remain liquid for as long as 300,000 years. And if the earthly comparison holds, these chaotic regions could be forming quite quickly. "On Earth, when an ice shelf collapses, it takes hours to days to weeks for the main event," Schmidt says. "But the ice shelf continues to evolve for months, even years afterwards."

The team's hypothesis merges two conflicting explanations for these puzzling terrains, says Robert Pappalardo, a planetary scientist at the Jet Propulsion Laboratory in Pasadena, Calif. "It's a very exciting model that seems to explain most of the observations as we understand them," he says. The watery cavities could be potential targets for a future life-seeking lander, but Pappalardo says scientists need to pinpoint exactly where the buried lakes are. "We want to go to some place that's been in recent contact with water below, so we can test whether there's life there today," he says.

The National Academy of Sciences' Planetary Science Decadal Survey committee recently ranked a mission to Europa among the highest priorities in planetary science — if costs total significantly less than the $4.7 billion originally proposed. Pappalardo is part of the team designing lower-cost missions to Europa, and says two types of visits are currently under review: one involving an orbiting spacecraft, and a second using a probe that would fly by the moon more than 30 times. The two missions would return different types of information about Europa's icy crust and the ocean lying beneath, and potentially answer lingering questions about the crust's thickness and potential subsurface lakes. Each mission is targeted for about $1.5 billion, and both could fly if a planned Mars sample return mission is shelved. But, "we are being realists," Pappalardo says. "We expect just one mission option would go forward if Europa were to get the nod."

The lakes might boost Europa back into the extraterrestrial spotlight, since they imply that the moon is actively sending materials from the surface — such as oxygen — into its ocean, potentially seeding the depths with compounds needed for life. "You're taking the surface of Europa, which is plated with whatever the Jupiter system can throw at it, and mixing it catastrophically," says Don Blankenship, study coauthor and geophysicist at UT Austin. "Then putting it down a few kilometers. It's like a washing machine." ■



Back Story | EXTRATERRESTRIAL OCEANOGRAPHY

Scientists have concluded, based on images of shifting surface features and data from a magnetometer aboard the Galileo spacecraft, that Europa hides a liquid ocean beneath its icy crust. But just how thick the outer ice layer is remains a mystery. Some researchers think it could be just a few kilometers deep (left) — thin enough for the ocean, which may be kept liquid by tidal heating, to reach the surface through fissures in the frozen material. Other scientists favor a thicker rind as much as 30 kilometers deep (right), which would transfer heat to the surface in plumes of flowing ice. Scientists also hypothesize that hydrothermal vents might heat the oceans from below and provide a suitable environment for life.

FROM TOP: NASA, JPL, UNIV. OF ARIZONA; NASA, JPL

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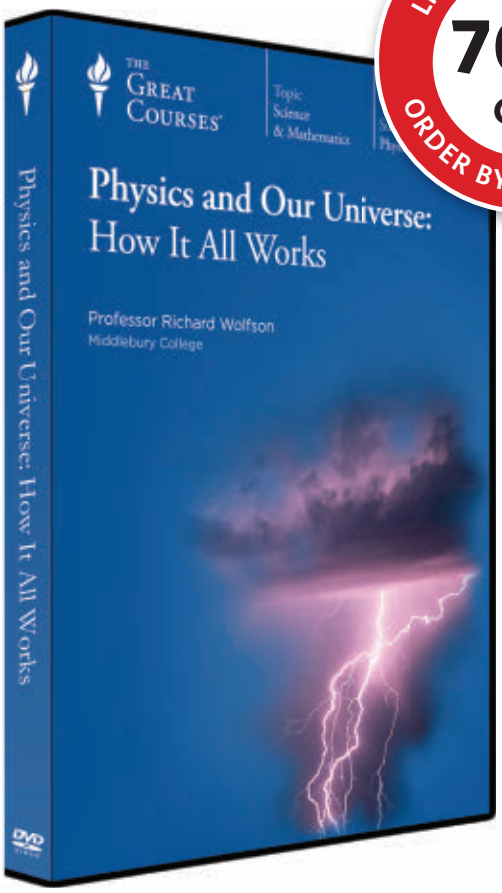

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Molecules

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Sturdy plastic easily repaired

New material has durability combined with remoldability

By Rachel Ehrenberg

A tough new plastic that's easily healed if damaged could find use in products prone to getting beat up, such as paints or parts for cars and sailboats. What's more, it can be recycled into completely new products like plastic molding for electronic devices or optical lenses.

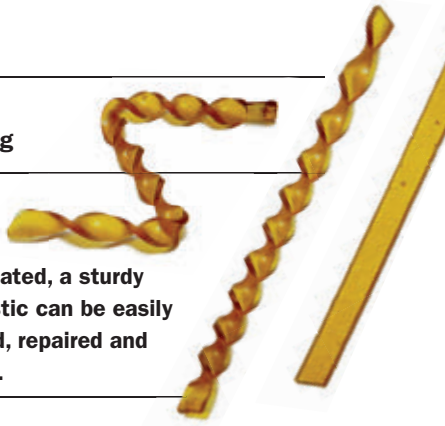
Chemical bonds in the new material continually break and re-form. At really high temperatures, the bonding switcheroo makes the material malleable, but the reactions are so sluggish at ordinary temperatures that the material's shape is essentially fixed, the researchers report in the Nov. 18 *Science*.

"They developed a unique and very powerful approach that will have a great deal of applications," says polymer chemist Christopher Bowman of the University of Colorado Boulder.

Superdurable plastics such as those used for kitchenware and some car parts are molded into shape and then "cured," turning them into one giant cross-linked molecule. The molecules of softer plastics like those in soda bottles typically aren't held together with these strong bonds and can be melted and reshaped.

To get an in-between material, scientists led by Ludwik Leibler of France's National Center for Scientific Research in Paris mixed a regular epoxy resin with acids and then added a zinc-based compound to help the other ingredients react.

The resulting material consists of a network of molecules, each holding hands with four others. These molecules are constantly switching who they hold hands with, but the number of bonded hands in the material always stays the same. When heated, this molecular hand swap speeds up. The molecular flexibility means that at high temperatures the material can easily be remolded.



When heated, a sturdy new plastic can be easily remolded, repaired and recycled.

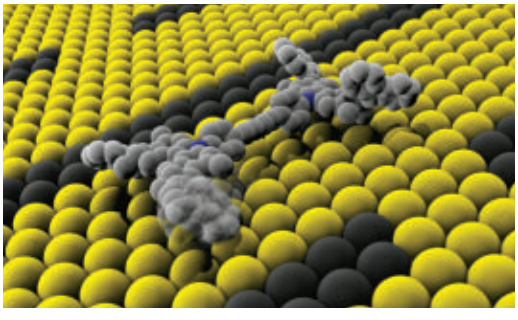
"You can do anything you want," Leibler says. "You can work it like wood, you can make big parts if you want, and the beauty of it is all of the ingredients are things that are already used in composites."

Tiniest car goes for a test-drive

Nanosized carbon vehicle lurches along with zap of electricity

By Rachel Ehrenberg

Scientists have created the tiniest electric car ever — although it won't be coming to your local dealership anytime soon. With four molecular wheels and a carbon-based frame, the nanoroadster is a step toward devices that mimic the machinery of molecular life.



A miniature four-wheel vehicle (light gray) rolls across a surface when zapped with electricity that contorts the wheels' axles.

The researchers started with little motorized "wheels," molecules inspired by the motors that some bacteria use to propel themselves, and attached them to a frame. Carbon double bonds serve as axles between two wheels; when the entire unit is zapped with electricity, the double bonds become single. This contorts the axles, rotating the wheels and propelling the car forward, researchers report in the Nov. 10 *Nature*. In test-drives on a copper surface, the car went as far as 20 nanometers — about 10 car lengths, says organic chemist Ben Feringa of the University of Groningen in the Netherlands.

"The interactions with the surface are very important," Feringa says. "The key is to not make it stick to the surface, because it will never move, but also it cannot fly away."

Another difficulty of working at the nanoscale is that when molecules are close together they interact, and not necessarily in the way that you want, says Paul Weiss, director of the California NanoSystems Institute at UCLA.

"The biggest thing here is these four motors operating together," says Weiss. "It's really terrific work."

Nature is adept at making such minimachines. Proteins transport cargo inside cells and help muscles move, for instance. Building similar molecules that cooperate and carry out tasks could lead to all sorts of machines and uses, Weiss says.

There are still kinks to iron out before these little cars can be mass-produced efficiently. The molecular machines are made in a solution that's then poured on the copper surface, and only cars that land right-side-up are drivable. But such production issues should be relatively easy to overcome, says Weiss.

"We're really learning the forces and the lay of the land at the nanoscale," he says.

FROM TOP: © CNRS, ESPCI, CYRIL FRESILLON; RANDY WIND, MARTIN ROELFS

Matter & Energy

30 kelvins | Lowest temperature at which hydrogen conducted electricity

295 kelvins | Highest temperature at which hydrogen conducted electricity

Metallic hydrogen seen in the lab

Team in Germany claims to have made long-sought material

By Devin Powell

Hydrogen gas squeezed at tremendous pressures in the laboratory has transformed into a metal, say a pair of scientists in Germany. But their bold claim is being met with skepticism.

Many scientists have tried to make metallic hydrogen since its existence was first predicted in 1935. The exotic substance is thought to form at high pressures, such as those in Jupiter's core. It may be a superconductor at room temperature, useful for making wires that carry electricity with little loss of current. And NASA hopes to one day put it to work as a rocket fuel that would be more powerful than anything around today.

> "Making metallic hydrogen is often considered the Holy Grail for high-pressure physics."
>
> MIKHAIL EREMETS

"Making metallic hydrogen is often considered the Holy Grail for high-pressure physics," says Mikhail Eremets, a physicist at the Max Planck Institute for Chemistry in Mainz, Germany, who with Ivan Troyan reported the results online November 13 in *Nature Materials*.

To see if hydrogen could be made to conduct electricity, Eremets and Troyan squeezed a room temperature sample of the gas between two diamonds. At record-breaking pressures more than 2.3 million times that of Earth's atmosphere, the hydrogen became opaque and reflective. Its resistance to the flow of current dropped to one ten-thousandth that of hydrogen at lower pressures.

That's evidence that the gas changed into something else, say the researchers. To show that this new substance was a metal, they cooled it from room temperature to 30 kelvins. The resistance rose slightly, but the material remained conductive.

"[The finding] has stimulated a lot of activity and is going to have a big impact on attempts to produce metallic hydrogen," says Isaac Silvera, a physicist at Harvard University who has tried to make metallic hydrogen.

But while Silvera agrees that the gas changed under pressure, he and other physicists aren't convinced that the hydrogen changed into the long-sought metal.

"People have thought they created metallic hydrogen before, and they turned out to be wrong," says William Nellis, a physicist now at Harvard. In 1996 he and colleagues at Lawrence Livermore National Laboratory in California used shock waves to make hydrogen that conducted electricity but survived only for a fraction of a second, not long enough to definitively prove that it was a metal.

Nellis worries that interactions between hydrogen and the equipment used in the new experiment may have muddied the German group's measurements. Hydrogen is extremely reactive at high pressures.

Arthur Ruoff, a physicist at Cornell University, says the increase in resistance when the hydrogen was cooled doesn't make sense. In a typical metal, resistance would decrease. For exotic types of conductors, it can increase — but that increase should have been more dramatic than the 20 percent rise measured by Eremets and Troyan, says Ruoff.

To satisfy his critics, Eremets plans to refine this tricky experiment. But he's not surprised that the result has proven controversial.

"Hydrogen attracts so much attention in our field," says Eremets. "Of course there will be a lot of emotion, of course there will be a lot of demands." ■

NEWS BRIEFS

Crystal springs

An unusual crystal that shrinks when heated reveals a new way for solids to vibrate. Typically, blocks of atoms inside a crystal rock back and forth as if connected by springs. But in scandium trifluoride, the "springs" — the vibrations themselves — get stiffer as they stretch. The resulting wiggles give scientists something new to look for when trying to identify materials that respond to heat in unusual ways, says Brent Fultz of Caltech, who led the team reporting the finding in the Nov. 4 *Physical Review Letters*. — *Devin Powell*

A slice of superconductor

Current has been spotted flowing without resistance through a material only one atom thick — the world's thinnest superconductor. Made of silicon and indium atoms, the film can carry a current just as dense as that in a bulkier material, researchers at Japan's International Center for Materials Nanoarchitectonics in Tsukuba report in the Nov. 11 *Physical Review Letters*. This slimmed-down superconductor could be useful for making small devices. — *Devin Powell*

A swill laser trick

A new plastic chip developed in Scotland can identify the brand and age of whiskey — a useful trick for telling a true Scotch whisky from a fake. The device requires only a single drop of the spirit. Laser light sent through a fiber-optic cable scatters off the liquid as it flows through a small channel on the chip, revealing characteristics of the fluid, researchers report in the Nov. 7 *Optics Express*. — *Devin Powell*

Body & Brain

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

First brain image of a dream made

Feat opens a door to probing the stuff of nocturnal dramas

By Laura Sanders

The contents of a person's dream have been revealed by brain scan for the first time, scientists report in the Nov. 8 *Current Biology*. By monitoring the brain of a man who has unusual control over his dreaming, the accomplishment brings researchers closer to understanding how the brain spins its nightly yarns.

"It's really exciting that people have done this," says sleep researcher Edward Pace-Schott at Massachusetts General Hospital in Charlestown and the University of Massachusetts Amherst. "And it also brings back lucid dreaming as a very powerful scientific tool."

Lucid dreaming is the rare ability to direct behaviors while in a deep sleep. By all objective measures, the person is dead to the world: Most muscles are paralyzed and the eyes are doing the quick jitters that characterize REM, a vivid dreaming phase of sleep. But at the same time, the lucid dreamer knows that he is dreaming and can control the scenes, says study coauthor Michael Czisch of the Max Planck Institute of Psychiatry in Munich.

Czisch and his team set out to catch a lucid dreamer's brain activity with a machine called a functional MRI. Instead of creating complex fantasias of flying over the Alps or slaying dragons, six experienced lucid dreamers were asked to squeeze their left hands and then their right hands repeatedly in a dream. "It's a rather easy thing to do," Czisch says.

The dreamers and scientists worked out a "ready" signal. After the participants entered a dream while sleeping in the fMRI machine (a challenge because the machine is very noisy), they would look back and forth quickly with their eyes, which are still able to move during REM sleep. When the scientists saw these particular bursts of eye muscle activity, they knew a dreamer was about to attempt the squeezes.

Of the six dreamers, only one was able to pull the whole thing off. The fMRI revealed increased activity in a brain region important for movement called the sensorimotor cortex as the participant squeezed his hands in the dream. When the dreamer squeezed his right hand, the left side of his brain's sensorimotor cortex showed increased activity. When the dreamer squeezed his left hand, the right side of his sensorimotor cortex saw a boost.

Czisch and his team repeated the experiment while this participant was fully awake, and also while the man imagined squeezing his hands. Similar brain regions showed boosts in activity whether the hand-squeezing was performed, imagined or dreamed.

The work is preliminary, Czisch says. Because the results come from a single participant doing a simple, predetermined task, it's not clear how other people would perform on self-generated dreams. "To get real insight into a complete dream plot is a bit science fiction," he says. But improving methods might lead to a deeper understanding of how the brain weaves emotions, memories and thoughts into dreams.

Eye movements indicate hypnosis

Involuntary alterations suggest a true trance can't be faked

By Laura Sanders

Though less obvious than giant red swirls in the eyes, a glassy gaze that jumps around in bizarre patterns may mark a fake-proof hypnotic trance, researchers report.

Though this ocular giveaway was observed in just one woman, the results suggest that that hypnosis truly is an altered state of consciousness, says study coauthor Sakari Kallio of the University of Skövde in Sweden and the University of Turku in Finland.

Kallio and his colleagues studied a middle-aged, healthy and highly hypnotizable woman. Normally outgoing and chatty, when the woman heard the word "hypno," she withdrew and fell quiet.

Because one of the most striking changes was the appearance of a diffuse, unblinking stare, the scientists measured a series of involuntary eye features, such as pupil reflexes and quick movements.

Under hypnosis, the woman's pupils were smaller than in normal conditions. What's more, she had an abnormal pattern of small eye movements, called saccades, toward a target. The woman's saccades were shorter and scarcer under hypnosis, the team reports online October 24 in *PLoS ONE*.

A woman's hypnotically induced stare indicates an altered state of consciousness, researchers propose.

S. KALLIO *ET AL*/*PLOS ONE* 2011

A group of 14 people watched videos of the hypnotized woman and tried to copy her strange eye behavior. But they couldn't, suggesting that these eye movements can't be faked.

Because the results are from a single person, larger studies are needed to know what these strange eye movements represent, says Irving Kirsch, a psychologist at Harvard Medical School's Beth Israel Deaconess Medical Center in Boston and the University of Plymouth in England. "It's an interesting study," he says, "but we'll have to see if it's generalizable."

Sex abuse linked to heart disease

Women victimized as youths have higher cardiac risk

By Nathan Seppa

Women who report having been forced into sex at a young age have an elevated risk of heart disease as adults. Some of the higher cardiac risk is traceable to behavioral and lifestyle factors, but much of it goes unexplained, researchers reported November 14.

"This tells us that the immediacy of the tragedy is being followed by risk that may have implications in later life," said Clyde Yancy, a cardiologist at Northwestern University School of Medicine in Chicago who was not involved in the study. "That's very disconcerting."

The researchers analyzed data from more than 67,000 women who were age 25 to 42 in 1989, when they volunteered to participate in a large health care study. Questionnaire responses revealed that 11 percent said that they had had "forced sexual activity" during childhood or adolescence, the years through age 17.

After following the women in adulthood for 18 years and tabulating any heart problems they encountered in that time, the scientists were able to discern that women who had had at least one episode of forced sexual contact when young faced roughly a 56 percent greater risk of cardiovascular disease than did women with no history of childhood sex abuse.

"It's clear that this association is strong," said epidemiologist Donna Arnett of the University of Alabama at Birmingham, president-elect of the American Heart Association.

The single biggest factor contributing to the heart disease risk was a tendency to become overweight, said study coauthor Janet Rich-Edwards, an epidemiologist at the Harvard School of Public Health and Brigham and Women's Hospital in Boston. The abused women also had higher rates of smoking, drinking, high blood pressure and diabetes than women not abused in youth.

But taken together, these well-known risk factors for heart disease still accounted for less than half of the risk increase, Rich-Edwards reported.

Some heart attacks have always been a mystery, with the patients showing no warning signs beforehand. Cardiologist Nieca Goldberg of New York University's Langone Medical Center said that, in women, one source of that added risk might arise from the stresses of pregnancy, especially if a woman encounters high blood pressure, preeclampsia or gestational diabetes.

> "I think we need to look toward screening young women for cardiovascular risks."
> NIECA GOLDBERG

"In women, we need to look outside the traditional cardiovascular risk factors," Goldberg said. Some biological changes occur in some women due to stress, such as chronically elevated levels of hormones such as cortisol, norepinephrine or epinephrine. The new study suggests risk factors that "go beyond behavioral changes," she said. "I think we need to look toward screening young women for cardiovascular risks."

MEETING NOTES

Vitamin D for the heart

Giving vitamin D to patients after they have survived a heart attack or another serious cardiac event lowers their levels of two compounds implicated in heart disease. Yoav Arnson of Meir Medical Center in Kfar Saba, Israel, and colleagues identified 50 patients who had had a heart attack or an episode of unstable angina — a cardiac red alert. All the patients were immediately started on standard drugs and half were randomly selected to also get 4,000 international units of vitamin D daily. After five days, the vitamin D group showed a decrease in the inflammation-causing compounds called vascular cell adhesion molecule-1 and interleukin-6. VCAM-1 is central to atherosclerotic plaque formation and IL-6 is broadly associated with coronary risk. Patients not getting vitamin D showed clear increases in both compounds during the five days. This could explain some of the vitamin's heart-protective properties, Arnson reported November 16.

— *Nathan Seppa*

Clean teeth provide more than just a winning smile

People who get the plaque scraped off their teeth may be less likely to have a heart attack, Emily Chen of Taipei Veterans General Hospital in Taiwan reported November 15. Chen and colleagues tracked the health of more than 100,000 people, roughly half of whom reported getting their teeth cleaned by a dentist or a dental hygienist at some point. The heart attack rate in these people over seven years of follow-up was one-fourth lower than in those who didn't report any dental cleanings. Poor oral health leading to gum disease has been tied to chronic infection and heart disease, but few studies have explored the prospective benefits of preventing cardiac problems. Teeth cleaning provided only minimal protection against stroke. — *Nathan Seppa*

Life

Giant dinos may have migrated

Seasonal roaming perhaps helped sauropods get big

By Nick Bascom

Recalling the trek made by the cartoon *Apatosaurus* Littlefoot in *The Land Before Time*, real sauropod dinosaurs in prehistoric western North America may have fled the summer drought conditions of lowland river floodplains for the lush vegetation of upland settings. Such migrations, if they occurred, might explain how long-necked sauropods reached their immense size, researchers suggest online October 26 in *Nature*.

With fearsome Jurassic predators about, the bigger sauropods grew, the safer they were. "Once sauropods reached their full size, they were effectively immune to predation," says study leader and geochemist Henry Fricke of Colorado College. An allosaur attack would have been as harmless as "a bunch of hyenas trying to attack an elephant."

Some paleontologists believe that sauropods grew so large because they had difficulty chewing and so needed huge stomachs to digest food. As the animals' stomachs evolved to bigger sizes, so did the rest of them, the theory goes. While Fricke doesn't discount this theory, he believes that seasonal sojourns to areas rich in vegetation also played a part in the evolution of gigantism in sauropods.

Fricke and his colleagues pursued his seasonal migration theory by studying chemical variations in the teeth of the sauropod *Camarasaurus*. "When animals drink water, the oxygen in that water gets incorporated into the bloodstream and eventually into tooth enamel," Fricke explains. That water takes on distinct chemical signatures based on where in the environment the dinosaur lapped it up. For example, water from a mountain tarn and water from a lowland swamp will have different amounts of a particular form, or isotope, of oxygen that has two extra neutrons in its nucleus.

Fricke and his colleagues measured oxygen isotopes extracted from the enamel of several dozen 150-million-year-old *Camarasaurus* teeth from the western United States, and then compared the enamel isotope levels with those of minerals found in nearby sediments. Because the levels differed between the enamel and sediments, Fricke believes that sauropods must have been leaving the basin itself and going to the adjacent highlands to eat and drink.

Chemical differences between sauropod teeth and nearby sediment suggest the dinosaurs migrated seasonally.

"Food may not have been the sole reason the sauropods moved," says George Engelmann of the University of Nebraska at Omaha, who was not involved in the study. "But the isotopic variation suggests, at least, that they were moving around."

Fricke plans to test the tooth enamel of other nonsauropod dinosaur species, such as *Stegosaurus*, so that he can provide a more complete picture of sauropod feeding behavior. If the oxygen isotope levels of smaller herbivores indicate that they remained in the lowlands year-round to feed, then Fricke will have more evidence that a higher nutrient demand was the central factor driving the sauropods to migrate. ■

Toothy ancestors found

Tiny but seemingly fierce, these members of a now-extinct group of mammals called dryolestoids scrabbled for existence nearly 100 million years ago in the shadows of dinosaurs. Paleontologists recently unearthed rare skulls and other bones of a previously unknown species in Argentina; in the Nov. 3 *Nature*, Guillermo Rougier of the University of Louisville in Kentucky and colleagues name the species *Cronopio dentiacutus*, its name in part a nod to its acutely sharp teeth. Few mammal fossils have been found in South America from this time period, before the age of dinosaurs gave way to the age of mammals. Scientists hope the discovery will reveal more about whether early mammals evolved differently in North and South America. Dryolestoids are most closely related to a modern group of mammals called therians, which includes marsupials such as opossums and placental mammals such as people. —*Alexandra Witze*

Environment

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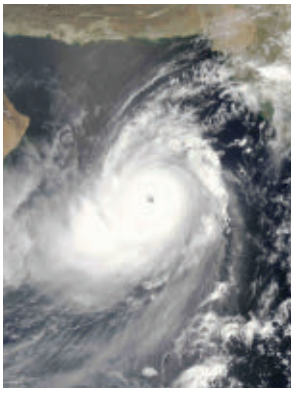
Pollution bringing stronger cyclones

Soot weakens winds that break up storms in Arabian Sea

By Janet Raloff

A large and growing brown cloud of persistent air pollution hovering over northern India and surrounding regions has doubled — and occasionally tripled — the intensity of late spring cyclones in the Arabian Sea during the last three decades.

Within the last decade, several early-season tropical cyclones have ripped through the region. Gonu, the strongest, smashed through the Middle East in 2007, killing dozens and causing more than $4 billion worth of damage.



Cyclone Gonu, seen here in June 2007, produced Category 5 winds before hitting Oman and Iran.

MODIS RAPID RESPONSE TEAM/NASA

These big storms, which invariably make landfall, represent a new environmental impact that can wreak havoc on people from northern India through the Middle East, climate scientist Amato Evan of the University of Virginia in Charlottesville and his colleagues propose in the Nov. 3 *Nature*.

Warming sea-surface temperatures can boost the intensity of hurricanes, known in the Indian Ocean as cyclones. And for many decades, Evan says, water in the Arabian Sea has been "really toasty." But winds in the upper and lower atmosphere there tend to blow briskly in opposing directions, in a phenomenon known as vertical wind shear. "This is the most hostile environment one could imagine for a hurricane," Evan explains. "It literally tears a storm apart." That appears to explain why major cyclones here were rare — until recently.

Evan and his team analyzed every regional tropical cyclone going back 30 years. None had occurred during the monsoon season, and before 1998, cyclones in the months before and after that rainy season seldom reached wind speeds exceeding about 80 kilometers per hour. But since then, five monster storms reached wind speeds double the norm.

After poring over weather data for the period, the researchers found that in premonsoon months there had been a slow relaxation in the average vertical wind shear, from 11 meters per second to 8 meters per second. That lower speed appears to represent some type of threshold, Evan says: Once vertical wind shears reach it, there's an explosion in storm intensities, he says.

The researchers ultimately linked the steady fall in vertical wind shear in cyclone seasons with a 3-kilometer-thick brown cloud of soot and other pollutant particles, known as aerosols, in the region's lower atmosphere. This pollution has increased sixfold in 80 years, the scientists report, and now prevents roughly 10 percent of sunlight from reaching the sea surface.

Computer analyses indicate that the pollution cloud's cooling effect on the ocean below has slowed wind speeds in the atmosphere — and allowed storm intensities to mushroom. "This link to the brown cloud is quite robust," Evan says.

Evan and his team don't have many storms on which to base this claim of a regional shift in climate signals, says Ryan Sriver of Pennsylvania State University in University Park. "But then, I'm skeptical of everything," he says. "They do appear to have pretty strong evidence." ■

NEWS BRIEFS

Brush with tsunami protection

Coastal vegetation, often touted as a buffer against extreme waves, really can save lives during a tsunami, a new paper suggests. Scientists from the University of Hohenheim in Germany and the World Agroforestry Centre in Bogor, Indonesia, analyzed 180 cross sections of the coastal landscape in Aceh, Indonesia — a region devastated by the 2004 Indian Ocean tsunami. Other factors being equal, having trees or shrubs between a village and the coast can reduce casualties by an average of 5 percent, the team reports online November 7 in the *Proceedings of the National Academy of Sciences*.
—Alexandra Witze

Microbes' hotter job market

Microbes are important in releasing stored nutrients from frozen soils into the warming atmosphere. As frozen soil thaws, so too do the microbes within — genes and all. A team led by Janet Jansson of the Joint Genome Institute in Walnut Creek, Calif., and the Lawrence Berkeley National Laboratory has warmed up samples of Alaskan permafrost and watched how the genetic activity of the critters living within changed. When warmer, microbes altered the way they cycled key elements such as carbon and nitrogen, the researchers report online November 6 in *Nature*. As part of the work, the team pieced together the genome of a methane-munching bug never before seen, the first time such a complex soil organism has been assembled in such a way.
—Alexandra Witze

Science & Society

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Brains may be war's battlegrounds

Neuroscience discoveries could lead to defense applications

By Laura Sanders

Instead of the indiscriminately destructive napalm or atom bomb, the signature weapon of future wars may be precise control over the human brain. As global conflicts become murkier, technologies based on infiltrating brains may soon enter national arsenals, neuroethicists assert in a paper published online October 31 in *Synesis*. Such "neuroweapons" have the capacity to profoundly change the way war is fought.

Advances in understanding the brain's inner workings could lead to a pill that makes prisoners talk, deadly toxins that can shut down brain function in minutes, or supersoldiers who rely on brain chips to quickly lock in on an enemy's location.

The breadth of brain-based technologies is wide, and includes the traditional psychological tactics used in earlier wars. But the capacity of emerging technologies is vastly wider — and may make it possible to manipulate minds with exquisite precision.

In the paper, neuroscientists James Giordano of the Potomac Institute for Policy Studies in Arlington, Va., and Rachel Wurzman of Georgetown University Medical Center in Washington, D.C., describe emerging brain technologies and argue that the United States must be proactive in neuroscience-based research that could be used for national intelligence and security.

"A number of these different approaches are heating up in the crucible of possibility, so that's really increased some of the momentum and the potential of what this stuff can do," Giordano says.

In the not-too-distant future, technologies called brain-machine interfaces could allow the combination of human brains with sophisticated computer programs. Analysts with a brain chip could quickly sift through huge amounts of intelligence data, and fighter pilots merged with computer search algorithms could rapidly lock onto an enemy target, for instance.

Neuroscience could also find its way into interrogation rooms: As scientists learn more about how the brain generates trust, drugs could be developed that inspire that emotion in detainees. Oxytocin, a hormone produced by mothers after childbirth, is one such candidate. Perhaps a whiff of oxytocin could alter a person's executive functions, turning an uncooperative prisoner into a chatty friend.

> "Eventually, some of this stuff is going to be out there."
> JONATHAN MORENO

Other sorts of psychopharmacological manipulation could boost soldiers' performance, allowing them to remain vigilant without sleep, heighten their perceptual powers and erase memories of their actions on the battlefield. Because neuroscientists are beginning to understand how the brain forms memories, it's not inconceivable that a drug could be designed to prevent PTSD. Such technology could enable more sinister applications, though, such as creating soldiers who wouldn't remember atrocities they committed or detainees who couldn't recall their own torture.

Some of these abilities are more probable than others, says bioethicist Jonathan Moreno of the University of Pennsylvania in Philadelphia. Drugs exist that increase alertness, but so far no drug has clearly boosted brain function. "Honestly, there isn't much, compared to caffeine or nicotine," he says.

Giordano and Wurzman also describe drugs, microbial agents and toxins derived from nature that could harm enemy brains in a more traditional way. The list includes a neurotoxin from a shellfish that is water soluble, can be aerosolized, and causes death within minutes; a bacterium that can induce hallucinations, itchiness and strange tastes; and an amoebic microbe that crawls up the olfactory nerve to invade the brain, where it kills brain tissue.

"The article contains an arsenal of neuroweapons, and these raise lots of ethical and legal issues," says bioethicist Jonathan Marks of Pennsylvania State University in University Park.

Some scientists have already committed to resisting the application of their research to what they consider illegal or immoral military purposes. "It's not enough just to study the issue of ethics," says Curtis Bell of Oregon Health & Science University in Portland. "The potential for misuse of this knowledge is so strong that the responsibility of neuroscience goes further than just studying."

Bell is circulating a petition for neuroscientists to pledge not to participate in developing technology that will be knowingly used for immoral or illegal purposes. About 200 neuroscientists from 18 countries have signed, he says.

Ideally science would have no place in combat, Giordano acknowledges, but that view ignores reality. "On one hand, what you'd like to say is science and technology should never be used to do bad things," says Giordano. "History teaches us otherwise, so we have to be realistic about this."

The U.S. military is investing in brain-related research, though it's difficult to estimate how much such research is happening, Moreno says. The Defense Advanced Research Projects Agency lists several neuroscience-related projects on its website, including "Accelerated Learning," "Neurotechnology for Intelligence Analysts" and "Cognitive Technology Threat Warning System."

"The fact of the matter is that we do live in a world in which there are people who would like to do bad things to us or our friends," Moreno says. "Eventually, some of this stuff is going to be out there." ■

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Genes & Cells

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Gene may speed up aging in brain

Study in pilots finds decreased performance in flight tests

By Tina Hesman Saey

A genetic variant that makes a small tweak in an important brain protein may cause aging to hit some people's brains harder than others.

Pilots' performance on a flight simulator test generally declines slightly with age. But a new study shows that pilots with a particular version of a gene called *BDNF* have a faster drop than others. Researchers also observed a decline in the size of an important learning and memory center in the brains of those with the variant, Ahmad Salehi of the Department of Veterans Affairs Palo Alto Health Care System and Stanford University and colleagues report online October 25 in *Translational Psychiatry*.

About 38 percent of pilots in the study carried the variant in either one or both of their copies of *BDNF*. Over the course of two years, the flight simulator scores of all the pilots in the study declined a little with age. But scores of pilots carrying the variant dropped about three times as much as scores of pilots who have the normal version of the gene.

The drop in scores was not so dramatic that pilots should be removed from the cockpit, says Salehi. "It certainly did not disable them at all," he says. But the score drop did reflect a slightly faster decline in factors like reaction time, navigation skills, plane positioning and performance in emergency situations.

In some of the pilots, the researchers measured the size of the hippocampus, a structure in the brain that is important for learning and memory. After age 65, men who had the alternate version of the gene lost more hippocampus volume than men with the normal version of the gene, the researchers found. The size of the hippocampus was not associated with scores on flight simulator tests.

It's not just pilots that need to worry about aging brains. "Anybody who works with complex machinery could be in the same situation," Salehi says.

The genetic variant is a single-unit DNA change in the *BDNF* gene. Such a small change can have big consequences; for example, the *BDNF* protein is usually released from brain cells only when it is needed, but the substitution causes the protein to be pumped out of cells continuously.

Exactly how much of aging's impact on the brain is caused by genetic differences in *BDNF* is not clear, says William Mobley, a neurologist and neuroscientist at the University of California, San Diego. "It could be one of a thousand factors that play a role," he says. But the new work highlights the importance of *BDNF* and suggests more research is needed to figure out how to counteract the negative effects of the version associated with accelerated mental decline.

Flight simulator test scores of pilots who have a variant of the *BDNF* gene declined more rapidly with age than did those of pilots with the normal version.

Ancient horses spotted

Prehistoric painters weren't taking artistic license when they painted polka-dotted horses on the walls of a French cave 25,000 years ago. DNA analysis of ancient horse remains from Europe and Siberia suggests that the animals came in bay, black and leopard-spotted at least 16,000 years ago.

Previous genetic studies suggested that horses were either bay or black before domestication, and more elaborate patterns emerged as a result of human breeding. That left many people wondering why dappled horses adorn cave walls in Pech-Merle, France (shown).

In a new study published online November 7 in the *Proceedings of the National Academy of Sciences*, Arne Ludwig of the Leibniz Institute for Zoo and Wildlife Research in Berlin and colleagues report that of 31 horses studied, 18 were bay, seven were black and six carried genetic variants that produce a leopard-spotted pattern. —*Tina Hesman Saey*

FROM TOP: A. SALEHI; THE GRANGER COLLECTION, NYC

Atom & Cosmos

.001 millitesla — Minimum magnetic field strength in moon rocks

5 millitesla — Magnetic field strength of a refrigerator magnet

How the moon kept its magnetism

Outside forces may have maintained the ancient lunar field

By Nadia Drake

External forces beating up the ancient moon may explain how it once maintained a magnetic field for more than 400 million years — longer than scientists had thought such a small object could be magnetized.

Either wobbly rotation produced by Earth's gravitational tug or asteroids smacking into the lunar surface may have triggered enough turbulence in the moon's molten core to generate a long-lasting magnetic field, report two teams of scientists in the Nov. 10 *Nature*.

"This has been a very fundamental question for 40 years," says study coauthor Christina Dwyer, a graduate student at the University of California, Santa Cruz. Though absent today, this ancient field is recorded in rocks retrieved from the moon's surface and in magnetized patches of crust spied by orbiting spacecraft. "The moon was magnetized," Dwyer says. "We don't know how."

Normally, heat escaping from a planet's interior causes fluid in the core to slosh around, creating a magnetic field. But the moon would have cooled off too quickly for the sloshing to be maintained. Instead, each research team points to a different spoon that would have mechanically stirred the early moon's innards to create magnetism.

Dwyer's team suggests that a slight, Earth-driven wobble in the moon's axis of rotation mixed the liquid core. "The Earth is tugging on the moon and that tug — even though it's quite small — keeps the moon wobbling," says planetary scientist Francis Nimmo of UC Santa Cruz. The wobble is greater when the moon is closer to Earth. As the moon moves farther away — as it has over the last 4 billion years — the wobble decreases. The magnetic field decreases, too, disappearing completely about 2.7 billion years ago. If this model is right, says Nimmo, "younger [lunar] rocks ought to be magnetized, but they ought to be magnetized less strongly than older rocks."

The second team proposes that large asteroids smacking into the moon messed up its rotation rate and perturbed the liquid core. Six large, ancient lunar impact basins with magnetized rocks at their centers support this idea, says study coauthor and fluid dynamicist Michael Le Bars of the French national research agency and the University of Aix-Marseille. "A reasonably large impact can generate a magnetic field for about 10,000 years," he says. If so, then lunar rocks might show spike after spike of magnetism as impacts pummeled the early moon.

Though different, the two theories are not mutually exclusive; together they add up to "a major, major advance in our understanding," says planetary scientist Benjamin Weiss of MIT. Studying the magnetic record preserved in lunar rocks would be a good way to test the theories, he notes, since tracing magnetic intensities over time should produce a pattern that might match one or both predictions.

Some lunar rocks already on Earth have revealed magnetic fields, though the measurements are decades old. "It would be nice if somebody goes back and redoes those measurements with the modern techniques," Nimmo says.

Ian Garrick-Bethell, a planetary scientist at UC Santa Cruz, says both papers are "clever and elegant," but that more mathematical simulations need to be done.

Earth's gravitational tug or asteroid impacts may have helped the young moon sustain its magnetic field for more than 400 million years.

NASA

NEWS BRIEFS

Duck and cover

It's likely that Russia's Phobos-Grunt spacecraft, launched November 8 from the Baikonur Cosmodrome in Kazakhstan and aiming for the Mars moon Phobos, will fall back to Earth — but where and when are still unknown. After launch, the unmanned craft's engines failed to fire, leaving it stuck in low-Earth orbit. Efforts to rescue the mission have been unsuccessful, and a dwindling power supply leaves the Russian space agency a limited amount of time to save the probe. This mission is Russia's first to Mars since 1996, when the Mars-96 spacecraft failed. The Phobos-Grunt craft had been intended to rendezvous with Phobos, scoop up some samples and return them to Earth. — *Nadia Drake*

Faster-than-light neutrinos, the sequel

Neutrinos have been spotted traveling faster than light — again. This time, physicists on the OPERA collaboration used shorter 3.5-nanosecond pulses of particles that allowed individual particles to be tagged instead of the spread-out bunches in the original experiment, which had raised concerns that some particles started their journey early. Again, neutrinos made the 730-kilometer trip from the European laboratory CERN near Geneva to Italy's Gran Sasso National Laboratory 60 nanoseconds faster than light would have. This additional evidence, which rules out one possible source of error in the experiment, was reported online November 17 at arXiv.org. — *Devin Powell*

Out of the Box

3-D entertainment steps beyond the glasses and headaches

By Devin Powell

Science fiction fans know what a 3-D display ought to look like. The film *Forbidden Planet* showed them more than half a century ago. On a distant world once inhabited by an advanced alien civilization, human scientist Dr. Morbius discovers a table that can create holographic videos. He calls up a ghostly projection of his daughter that's smaller than but otherwise identical to the girl herself.

"Aladdin's lamp in a physics laboratory," says an awed spacefarer peering over Morbius' shoulder.

Compared with this Krell technology, the magic of today's 3-D televisions and movie screens are a bit lacking. Just ask moviegoers whose eyes felt strained as they watched *Avatar* from behind a pair of goofy glasses. Or move your head side to side while playing Nintendo's latest portable gaming device, the 3DS: You will see that Mario's world just doesn't rotate like the real world would.

But a handful of research teams are hoping to create a 3-D experience that's glasses-free, comfortable and as in-your-face as watching the Super Bowl from the front row at the stadium. By combining existing techniques with a few new

CARY WOLINSKY AND RICK KYLE

tricks, the researchers are finding better ways to fool the brain into thinking the action is right there in the room.

A screen currently under development reveals an object's sides when you peek around it. And an in-the-works teleconferencing system made of a spinning mirror can conjure up floating faces worthy of the Wizard of Oz. Other approaches bypass the trickery completely and go straight for the tried-and-true 3-D experience of holography: A postcard-sized Princess Leia made her debut earlier this year (*SN Online: 1/26/11*), and the military recently acquired a prototype table akin to Dr. Morbius'.

"The technology is getting closer to creating something that looks like a sculpture made out of light," says Gregg Favalora, a veteran 3-D display designer who works for the consulting company Optics for Hire in Arlington, Mass.

Scaling up some of these technologies to make affordable flat screen televisions will take years, if it ever happens. But in the meantime, these new approaches may find their way into niche markets that can benefit from the richer experience 3-D promises.

From both sides now

The human brain has a built-in talent for working out depth from flat images. Even an old-fashioned movie looks somewhat three-dimensional on a normal TV set. Shadows on a bone tossed into the sky in *2001: A Space Odyssey*, for example, reveal it to be an honest-to-goodness bone, not a cardboard cutout. And when chariots racing around a hippodrome in *Ben-Hur* partially block each other from view, the audience knows who's in the lead.

Today's commercial 3-D movie screens and televisions make objects leap out at the audience by displaying two overlapping images. Each image captures a different perspective, offset by the space between the eyes. Special glasses filter the pictures — which often have slightly different colors or light that bends in a different way — so the left eye sees one image and the right sees another. The brain puts these two scenes together to infer depth. It's an old trick that dates to the first half of the 19th century, when English scientist Sir Charles Wheatstone used mirrors to redirect side-by-side images, one into each pupil.

Portable gaming devices, cell phones and cameras of today can achieve the same effect without glasses. These technologies slice the two images into ribbons that get stitched together like zebra stripes. Each eye sees a different set of stripes thanks to a barrier with vertical slots. Because the trick requires the eyes to be in just the right spot, it works particularly well for small screens held at a fixed distance.

But, glasses or not, no consumer technology provides a 3-D view that turns like the real world does when you move your head to the side. Moviegoers all share the same point of view, regardless

Adding up By layering individual images, researchers can create a composite 3-D image that looks different depending on the viewing angle. Images of dice mid-tumble (bottom three) are used to create a composite that looks different when viewed from the left than from the right (top two).

of where they're sitting — meaning an important clue normally used to compare object distances is missing.

Douglas Lanman of MIT's Media Lab and his colleagues are attempting to solve the problem with objects that rotate as a person walks by. Sitting in the lab is a glowing white screen that would look at home illuminating an X-ray of a lung in a doctor's office. The screen's light shines through a transparency showing a shimmering butterfly, a jade Chinese dragon, a handful of dice in mid-tumble.

Even at first glance, the colorful 3-D images are captivating. But move your head, and they seem to know that you're there. Each image turns gracefully because it is made from up to five different images printed on different layers stacked on top of each other. These images add up to reveal a slightly different scene when looked at from different angles, thanks to a mathematical method adapted from CT scanners. While the scanners construct 3-D views by adding together flat X-ray images, Lanman's display works backward, decomposing 3-D views into flat ones.

"With some clever computation and clever optics, we can display objects that you can actually see around," he says.

Four LCD screens stacked on top of one another show videos from up to seven viewpoints via the same trick. The display will be presented this month in Hong Kong at a meeting of the Association for Computing Machinery's Special Interest Group on Computer Graphics and Interactive Techniques.

A second approach out of Lanman's lab mashes together many pairs of perspectives into a single image on an LCD screen. A pattern on a second overlying screen flickers faster than the eye can see, filtering the image for different viewing angles. A prototype display built out of 22-inch computer monitors calculates the pattern needed for every frame of a video of a car, but the computing power required limits screen size.

"We're trying to find ways to take these ideas and make them more practical," says Lanman.

Easier on the eyes

But Lanman's screens face a problem that's universal among 3-D displays already on the market. Their beauty stirs conflict in the eyes of the beholder.

When you look at something close to you, your eyes naturally swivel inward. At the same time, the thickness of the eyes' lenses changes to focus light bouncing off the object. These two mechanical tweaks (called vergence and accommodation) are coordinated by the brain to provide a proper sensation of depth.

When you watch a 3-D movie on a flat screen, though, this synchronization goes haywire. The eyes aim where the image appears to be, but the lenses adjust to the distance of the screen. Cross your eyes and you'll feel the disconcerting effects of this conflict: a blurry image, eyestrain and sometimes headaches.

"No one knows exactly how many people experience this discomfort," says Martin Banks, a vision scientist at the University of California, Berkeley. "All we can say is that it's enough that we're paying attention to it."

The farther an object appears to pop out in front of or behind the screen, the more likely that the image will stress out the eyes. Every screen has a "zone of comfort" that depends on its size and distance from the audience, Banks' team reported in January in Burlingame, Calif., at the Stereoscopic Displays and Applications meeting.

One way to ease this stress is to show multiple viewpoints of a scene to each eye simultaneously. Seeing two different views can create the illusion that the light comes from a spot in front of the screen, tricking the lenses into making adjustments that match the swivel of the eyes.

At the University of Southern California in Los Angeles, Paul Debevec has figured out a way to pack hundreds of different viewing angles together to eliminate eyestrain. He's ditching flat screens in favor of a rapidly flickering projector. It bounces images off a pair of aluminum plates jointed together like an A-frame tent, a double-sided mirror of sorts that spins 900 times per minute.

At one instant, the mirror shoots one image at an observer's right eye. A split second later, the mirror has spun a bit and can target the left eye with a different image, creating the illusion of 3-D. The mirror and projector are synchronized so every viewer sees different pairs of images depending on that person's point of view.

During a demo of the device, Debevec films someone and sends the video data to a faraway projector. The person's face

UBC, IMAGER LABORATORY, MIT MEDIA LAB, CAMERA CULTURE GROUP

materializes within the whirl of the mirror. The depth of the display, limited to a few inches by the size of the aluminum plate, makes the face look like a mask rather than a full bust.

"It's not really in full 3-D," Debevec says. "It's more like high relief."

Debevec hopes to develop the device into a teleconferencing system that is comfortable on the eye and accommodates a moving viewer.

Holovision

For full 3-D that really gets inside your head — images that rotate every which way, leap out of the screen as far as you'd like and take it easy on the eyes — there's nothing that beats the realism that a hologram can provide.

"The holographic display is the closest to how human beings see around themselves," says Nasser Peyghambarian, a physicist at the University of Arizona in Tucson. "It's the Holy Grail of all displays."

From comic books to credit cards, people have been playing around with still holograms for decades. These images are the children of lasers, born when two beams interfere with each other while striking a light-sensitive material. This coupling imprints a fringe pattern that, when illuminated, bends light to create an object in exquisite detail.

Peyghambarian, like many before him, hopes to give life to these still images. He's creating a new kind of holographic plastic that can be rapidly imprinted, erased and imprinted again.

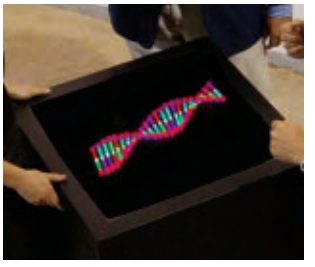
His first prototype, a transparent plastic screen slightly larger than a playing card, updated only once every two seconds, a far cry from movies' 24 to 30 frames per second. Since reporting on the device last year in *Nature* (*SN: 12/4/10, p. 8*), he has increased the size to a foot on each side, but still hasn't achieved the 10 frames per second he is shooting for.

At MIT, engineer Michael Bove has used mostly inexpensive, off-the-shelf parts to make small holographic videos that update 15 times per second. He is in talks with the electronics industry about developing a television that might cost no more than a few hundred dollars to build. Currently, though, the display is fuzzy and in just one color.

For any holographic display, the bottleneck is the sheer amount of data going into each image. Increase the size of the image, the number of colors, how often it refreshes or how steep an angle it can be seen from, and the required processing power explodes, quickly reaching unmanageable proportions.

The largest holographic video display to date, measuring 6 feet diagonally, belongs to the military. For five years, the Defense Advanced Research Projects Agency, or DARPA, funded the development of a tabletop display that projects videos up to a foot high, visible from angles greater than 45 degrees above the table.

"People looking at these images do what we call the 'holodance,'" says Mark Lucente, a consultant based in Austin, Texas, and former researcher at Zebra Imaging, the company that built the device. "They start to move their heads to the side, up and down, the same as if someone's showing you a sculpture."



Holographic tables promise to one day provide a realistic 3-D experience.

Achieving the effect requires the equivalent of 27 high-end computer work stations crunching 10 gigabytes of holographic data per second. Instead of lasers writing on plastic, the hologram pattern is generated by modulators that turn the data into light and an array of tiny devices that shape the direction and intensity of the light as it emerges from the table.

In August, the first prototype was installed at the Air Force Research Laboratory at Wright-Patterson Air Force Base in Ohio. Darrel Hopper, a researcher at the lab, will test whether the display helps people make sense of complicated scenes — from skies filled with planes to aerial views of tanks on the ground.

"The volume of inherently 3-D data sets we use has grown exponentially and will continue to do so," Hopper says. "We need people to be able to interact with this data as if it were a true 3-D object."

Seeing clearly

Whether any of these new 3-D displays will make the transition into the home remains to be seen. Other technologies developed over the years have come and gone, such as a colorful device developed by the now-defunct Actuality Systems that looked like a glowing crystal ball.

"The market for these technologies wasn't big enough," says Nick Holliman, who studies 3-D displays at Durham University in England.

He thinks that new glasses-free approaches will be adopted first by specialized groups. Beyond the military, car designers and oil companies are interested in 3-D displays. Hospitals may also be a natural fit.

Several electronics companies are backing the development of glasses-free television sets. Philips has created a display that exploits lenses to scatter different views of a scene around a room. And Toshiba has unrolled a prototype of a 55-inch device that will cost $10,000 or more. But the screens, marketed to businesses and advertisers, offer viewers only nine different perspectives.

Ultimately, the introduction of new 3-D technologies into the home may be stymied by a problem that even the cleverest engineer can't solve: "There hasn't been a huge wave of 3-D content yet into the marketplace," says Stephen Baker, vice president of industry analysis for NPD Group, a market research company headquartered in Port Washington, N.Y.

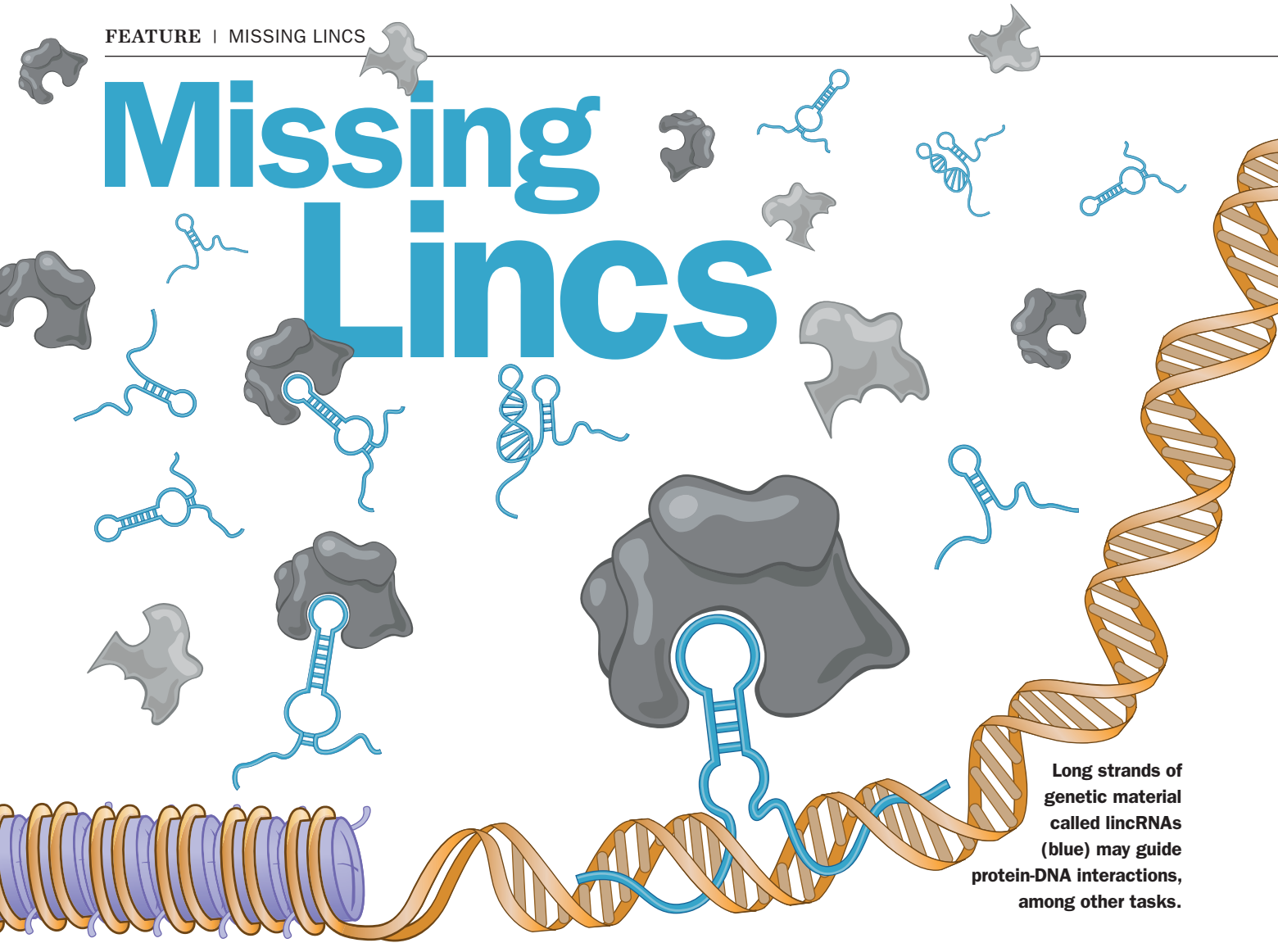
Realistic 3-D television displays won't be worth much if there's nothing to watch. In the end, moviemakers must choose to film in three dimensions and network sports producers need to decide that basketball games really do look better with a little depth. ■

Explore more

- For a history of holograms written by Mark Lucente: http://bit.ly/lucente

ZEBRA IMAGING

Missing Lincs



Long strands of genetic material called lincRNAs (blue) may guide protein-DNA interactions, among other tasks.

SIGRID KNEMEYER

Lesser-known genetic material helps explain why humans are human

By Tina Hesman Saey

Nearly everybody knows that Frank Lloyd Wright designed Fallingwater, the house in Pennsylvania that sits above and appears to cascade into a waterfall. I.M. Pei's glass pyramid at the Louvre in Paris is similarly famous. And Frank Gehry is widely known for the curvilinear shining steel Walt Disney Concert Hall in Los Angeles.

But most people couldn't name the contractors and subcontractors responsible for translating those great architects' blueprints into solid structures.

Geneticists have the same problem. Details for erecting an organism's structure are encoded within DNA, written in chemical subunits designated by the letters A, T, C and G. But it has been hard to say exactly who takes those details and oversees the construction of the organism from proteins and other molecular materials.

Only now have scientists begun identifying the previously invisible contractors who make sure that materials get where they are supposed to be and in the right order to build a human being or any other creature. Some of these little-known workers belong to a class of molecules called long intergenic noncoding RNAs.

Scientists used to think that these "lincRNAs" were worthless. As their name suggests, these molecules — at least 200 chemical letters long — do not encode information that the body's manufacturing machinery can use to cobble together proteins. And the lincRNAs originate in what scientists used to view as barren wastelands between protein-coding genes. But new research is showing that these formerly underappreciated workers have important roles in projects both large and microscopic.

"They regulate every process under the sun," says John Rinn, an RNA researcher at Harvard Medical School.

In the last few years, scientists have

learned that lincRNAs, as well as other RNAs that are long and noncoding but not intergenic, perform a variety of jobs. Some serve as guides showing proteins where to go, while others tether proteins to different types of RNA, or to DNA. Some work as decoys, distracting regulatory molecules from their usual assignments. Some may even have multiple roles, all the while chattering away to other RNA within cells. (It is not idle gossip; RNA communication within cells may ward off diseases such as cancer.) And as the ultimate multitaskers, lincRNAs keep proper cellular development ticking along and help define what makes mice mice and people people.

New 'genes'

LincRNAs are just one type of multitalented RNA that has until recently been undervalued. While DNA has been revered as a precious archive housing genetic secrets, RNA — a chemical cousin copied from DNA — has long been viewed as little more than an errand boy. The name of one important type of RNA that goes on to make proteins, messenger RNA, reflects that bias. Two other types of RNA, transfer RNA and ribosomal RNA, help read messenger RNA during protein creation, leaving many scientists to assume RNA's only job was as a low-level employee on the protein production line.

That notion began to change when researchers with the Human Genome Project finished compiling the human genetic archive a decade ago. That archive contains about 3 billion genetic letters, far more than the genomes of less complex organisms such as roundworms and fruit flies. But the project revealed that people's roughly 22,000 protein-specifying genes don't greatly outnumber those found in simpler organisms.

The finding was one of the biggest surprises in biology. An average *C. elegans* roundworm contains just 959 cells; the human brain has an estimated 100 billion neurons — more than the total number of cells in 100 million roundworms. How could it be that the same set of building materials used to construct simple lowly worms could also produce vastly more complex humans? It turns out that, in the same way a bucket of LEGOs or an Erector Set can yield an array of toy structures depending on how the pieces are put together, the answer lies in assembly.

One of the first clues to the importance of assembly came from the FANTOM project (for "functional annotation of the mammalian genome"), an ongoing international effort to identify every piece of RNA made in a mammalian cell. In 2005, the research revealed that even though genes that code for proteins make up only 1.5 percent of the mouse genome, more than 63 percent of the genome's DNA is copied into RNA. In humans the number is even higher, with up to 93 percent of the genome made into RNA, even though protein-coding genes make up less than 2 percent of the genome.

At first, many scientists didn't know what to make of the excess RNA. Some thought it was overexuberance on the part of the DNA-copying machinery. But gradually researchers began to realize that many of those extra RNAs had important jobs to do.

If RNAs can do important work without making proteins, the definition of a gene needs to be expanded, says Leonard Lipovich, a geneticist at Wayne State University in Detroit. "You realize there are not 20,000 genes; there are 40,000."

Last year, Lipovich and colleagues reported in the journal *RNA* that they had found evidence of 6,736 long noncoding RNAs encoded in the human genome. Some estimates suggest that the human genome may encode more than 10,000.

Further work, reported by John Mattick of the University of Queensland in the June issue of *FEBS Letters*, suggests that the number of noncoding RNAs of all types is greater in humans than in other primates and greater in those primates than in mice. The same logic follows on down to puffer fish, fruit flies and beyond.

With so many long noncoding RNAs floating around in cells, the next question to answer is what do they do. "For the vast majority, we have absolutely no idea," says Ahmad Khalil of Case Western Reserve University in Cleveland.

Some, though, appear to act like general contractors — not hammering in the nails and pouring the foundations of cells themselves, but dictating how the job should be done.

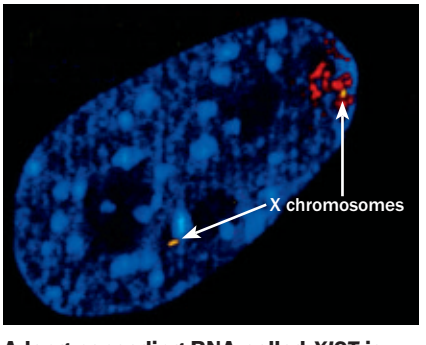
'LincRNA' lingo

Long RNAs come in all different lengths, as measured by the number of chemical subunits in the strand. "Long" versions, sometimes called "large," are at least 200 chemical units long, while RNAs of the "micro" variety typically have around 22 units.

Intergenic "Intergenic" refers to RNAs that are copied from portions of the DNA that sit in regions between protein-coding genes. But the designation is becoming less meaningful as scientists discover that these regions yield RNAs with important tasks.

Noncoding Messenger RNAs are decoded in a cell's ribosome to make proteins; "noncoding" refers to RNAs that do not end up as codes for proteins.

RNA RNA, for "ribonucleic acid," is a chemical cousin to DNA, created from the DNA template in a process known as transcription. DNA is made up of the chemical subunits adenine (A), thymine (T), cytosine (C) and guanine (G). RNA substitutes uracil (U) for the T.



GENECLEANER/WIKIMEDIA

A long noncoding RNA called *XIST* is responsible for coating one chromosome (red) in female mammals (mouse cell shown), turning off that chromosome.

Long lineup

One of the most famous long noncoding RNAs, known as *XIST*, is also one of the most hands-on. *XIST* is in charge of shutting down one of the X chromosomes in every single cell of women and girls. Women and other female mammals have two copies of the X chromosome, while males have one X and one Y chromosome. Having a double dose of X chromosome genes could be harmful, even lethal, so women turn one off. *XIST* — a "lncRNA" because it is 19,000 letters long, noncoding but not intergenic — directs the decommissioning.

XIST doesn't have a long commute to work; it coats whichever X chromosome makes it, preventing other genes on the chromosome from being activated. *XIST* isn't made in males; a partner long noncoding RNA called *TSIX* (*XIST* spelled backward) helps keep the other X chromosome in women in working order.

One of the most well-studied lincRNAs, named *HOTAIR*, wasn't lucky enough to get a job close to home. It is copied from DNA on chromosome 12 but has to travel to chromosome 2 to shut down several genes in a group known as the HOXD cluster, genes important for proper development of an organism, Rinn and colleagues reported in *Cell* in 2007. A study reported last year in *Nature*, from Stanford University genomicist Howard Chang and his colleagues, showed that *HOTAIR* works at 854 different job sites.

Not only does *HOTAIR* help direct development, but it is also important throughout life to help cells pinpoint their location in the body.

Breast cancer cells are full of *HOTAIR*, especially those that migrate throughout the body, Chang's team reported in the same paper in *Nature*. Cells in about a third of breast tumors studied made more than 125 times as much *HOTAIR* as normal breast cells do. And when copies of *HOTAIR* pile up in cancer cells, the cells start to drift away from the tumor. Having too much of the lincRNA appears to reprogram a cell's internal compass, says Chang, who is also a Howard Hughes Medical Institute scientist. "It's kind of like a car driven by a faulty GPS device."

Whether promoting health or misdirecting cells, lincRNAs don't necessarily act alone. *HOTAIR* and some other lincRNAs direct crews of proteins known as histone modifiers. Histones are spoollike proteins that wrap up DNA so it can fit inside the cell nucleus. Where the histones sit along the DNA and how tightly the DNA is wrapped around them affects whether genes are turned on or off. *HOTAIR* works a bit like a surveyor putting chemical tags on histones associated with genes that need to be put under tight wraps. The lincRNA does this by bringing two different groups of proteins to selected genes. One of the protein groups plasters a closed sign on a histone protein, signaling that the gene is not open for business, while the other group rips down billboards advertising for the gene, Chang's group reported last year in *Science*.

At least 26 different lincRNAs need to be on to keep an embryonic stem cell a stem cell.

A lincRNA known as *HOTTIP* also works with a crew of histone modifiers, but instead of shuttering genes, *HOTTIP*'s crews hang grand-opening signs to attract gene-activating machinery. Working in concert with proteins, these and other lincRNAs can precisely control which genes are turned on and when — a precision necessary to coordinate the untold steps that go into cooking up a human.

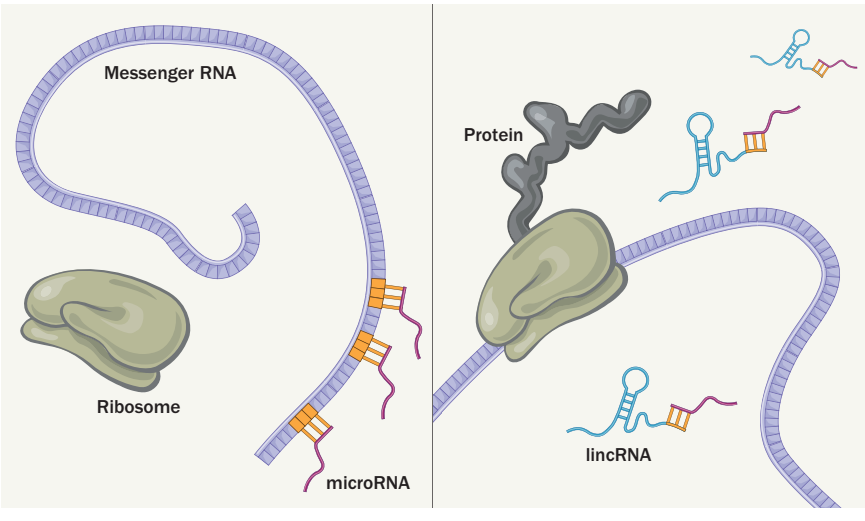
Contractor communication

In the recipe for humans, lincRNAs are in the thick of things from the very beginning. At least 26 different lincRNAs need to be on to keep an embryonic stem cell a stem cell, Rinn and his colleagues reported in the Aug. 28 *Nature*. As stem cells transform into various types of cells, they turn off some specific lincRNAs and turn on others, creating a mix of activity that can define the cell.

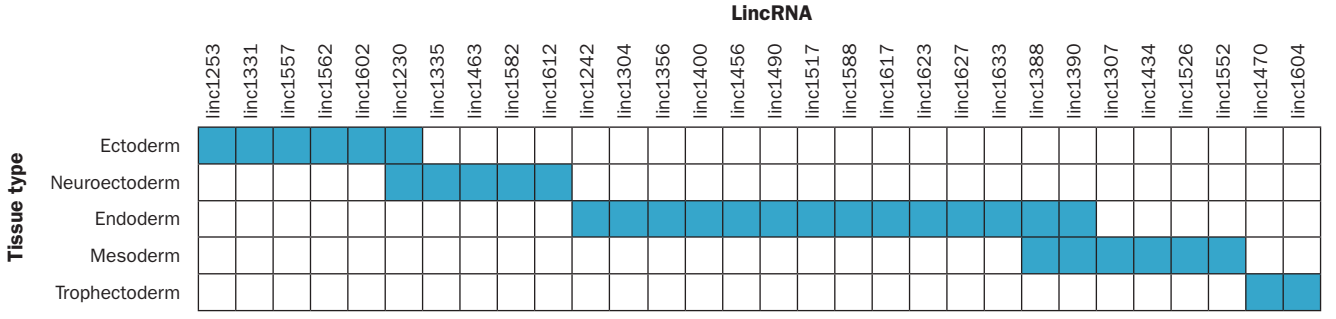
"They describe a cell's identity better than protein-coding genes do," says Rinn, who is also affiliated with Beth Israel Deaconess Medical Center and the Broad Institute of MIT and Harvard. He and his colleagues have developed computer software that attempts to pinpoint a cell's type by looking at which lincRNAs it makes.

In a molecular name-that-cell contest, lincRNAs beat out proteins. Each type of cell has such a special mix of lincRNAs that the computer program can correctly identify a cell from only two lincRNAs, while four or five proteins are required for a positive ID.

RNA distractors MicroRNAs can glom on to the backs of messenger RNA and block protein production (left). But lincRNAs with the right binding sites (orange) can act as decoys, distracting microRNAs and allowing protein production at the ribosome to proceed (right).



SIGRID KNEMEYER



Seeing patterns Researchers recently identified 30 lincRNAs that appear to act as barriers preventing an embryonic stem cell from turning into various tissue types. Blue boxes indicate where the knockdown of a lincRNA led to genetic activity patterns characteristic of differentiation.

Just how lincRNAs choose which genes to turn on and off isn't yet known. But Pier Paolo Pandolfi, a geneticist at Beth Israel Deaconess and Harvard Medical School, suspects that the lincRNAs are whispering to each other and to other RNAs, keeping tabs on all a cell's goings-on. Pandolfi laid out his hypothesis for how this chatter might help control protein production and other processes in the Aug. 5 *Cell*.

Protein-coding messenger RNAs are often prevented from making their instructions into proteins by tiny snippets of RNA called microRNAs. The microRNAs glom on to certain messenger RNAs like paparazzi crowding a celebrity.

If lincRNAs and messenger RNAs share a string of chemical letters that interest the microRNAs, the lincRNAs can serve as a decoy, distracting microRNAs so messenger RNAs can get their jobs done. As long as two molecules both have the signatures that the microRNAs seek, the little RNAs will clamor around both messages with equal fervor.

Last year, Pandolfi's group found that the RNA copied from a pseudogene (a defunct copy of a gene that no longer makes proteins) can attract microRNAs away from the messenger RNA copied from a real gene called *PTEN*, which is important in protecting against cancer (*SN: 7/17/10, p. 14*). That finding led to the suggestion that, by acting as decoys, RNAs could regulate protein production or other processes within a cell. Pandolfi calls this idea the ceRNA hypothesis (for "competing endogenous RNA").

A growing body of evidence suggests that Pandolfi's hypothesis is more than just a clever idea. Researchers at Columbia University performed a computerized search of the human genome and found 7,000 genes whose messenger RNA copies could act as microRNA decoys in 248,000 interactions, a result reported in the Oct. 14 *Cell*.

The Columbia team and Pandolfi's team independently found that tweaking levels of a few messenger RNAs that distract microRNAs from *PTEN* messenger RNA can lead to prostate cancer or a type of brain tumor called glioblastoma. Just messing with levels of a messenger RNA from another gene known as *ZEB2* throws off *PTEN* protein levels and can lead to melanoma in mice, Pandolfi's group reported in another paper in the Oct. 14 *Cell*.

Some lincRNAs also appear to contain microRNA magnets. Researchers from Italy report in the same issue of *Cell* that they have found an RNA called *linc-MD1* that is important in muscle development. The lincRNA sponges two microRNAs away from the messenger RNA of two genes, allowing more muscle-building proteins to be made from those genes. Cells taken from people with Duchenne muscular dystrophy have lower levels of *linc-MD1* than normal muscle cells do. Without *linc-MD1* to draw them away, the microRNAs pile on to the messenger RNAs and prevent the muscle proteins from being made.

With so many interconnected parts in the system, researchers need to think carefully about the consequences of tweaking levels of any RNA within a cell, Pandolfi says.

If any decoy isn't made, potentially hundreds of conversation partners could be affected, with amounts of proteins they each produce being altered by 10 to 30 percent.

"People say, 'that's ridiculous. That's nothing,'" Pandolfi says. But if 200 or more conversation partners are each perturbed by 10 percent, "that's devastating."

Losing one noncoding RNA may be disastrous for a cell, but for want of noncoding RNAs whole species may never have evolved, argues Queensland's Mattick. He and others say the real function of lincRNAs is to give evolution a sort of molecular clay from which to mold new designs.

New proteins rarely appear, leaving evolution a limited set of building materials to work with, Mattick says. But new lincRNAs pop up all the time; some of them appear in only one species. Given the molecules' jobs as directors and overseers, evolution may use them to make design variations on the fly.

Humans have several lincRNAs that are found in no other species. Many of those RNAs are made in the brain, leading scientists to speculate that the molecules may be at least partially responsible for that important organ's evolution.

If Mattick is right, making a human from the same building materials used to create roundworms and fruit flies doesn't pose such a puzzle. It does, however, mean finding the right contractors. ■

Explore more

■ Read more about lincRNAs at John Rinn's lab website: www.rinnlab.com

M. GUTTMAN *ET AL*/*NATURE* 2011

Jars of plenty

Ancient Greek trading vessels carried much more than wine

By Susan Gaidos

Wine flowed freely from ancient Greece during its golden age, but new work suggests nuts and various herbs were also in demand.

With the help of DNA analysis, scientists are getting a present-day look at centuries-old trade in the Mediterranean. Such studies may help debunk some long-held assumptions, namely that the bulk of Greek commerce revolved around wine.

During the fifth through third centuries B.C., the Mediterranean and Black seas were major thoroughfares for ships loaded with thousands of curvaceous jars known as amphorae, thought from their shape to contain a drink made from fermented grape juice.

But only recently have researchers peered through the lens of 21st century genetics to identify the actual remnants of the jars' long-disappeared cargo. Analyses of DNA fragments from the interior of nine jars from Mediterranean shipwrecks now reveal various combinations of olive, ginger, walnut and herbs in the rosemary family, along with the expected grapes.

The findings, reported in an upcoming *Journal of Archaeological Science*, suggest that the ancient Greeks produced and traded a wide range of foods. The economy of the time was much more sophisticated than previously thought, says Brendan Foley, an archaeologist at Woods Hole Oceanographic Institution, who coauthored the work with biologist Maria Hansson of Lund University in Sweden and colleagues at the Hellenic Ministry of Culture and Tourism.

Some of the jars selected for the study had been stored on shelves for nearly two decades, suggesting that DNA buried within the amphora walls remains viable long after the jars are brought up from underwater.

"That opens the possibility that many of the artifacts that are in museum storehouses or other collections may still contain information about their original contents," Foley says.

With such information, scientists could reconstruct a more accurate picture of the crops being grown and the products changing hands when the world's first complex economies were getting under way, possibly gaining clues to the agriculture, technologies, art and geopolitics that played into daily life.

Curvy jars called amphorae (a version from fifth century Greece shown) were often used as storage and trading vessels, as well as for decoration.

ASHMOLEAN MUSEUM, UNIV. OF OXFORD, THE BRIDGEMAN ART LIBRARY INTERNATIONAL

Crimes and clues

A period of rapid expansion and population growth throughout the Mediterranean began around the fifth century B.C. Classical Greece was transformed from a simple peasant society to a sophisticated civilization, and Greek merchants began using currency. Instead of swapping for goods in kind, merchants were paid for their products and services with small coins of silver, gold or an alloy of the two, electrum.

To determine what was being traded for those coins, scientists look to artifacts, including amphorae still neatly packed aboard sunken merchant ships or strewn across the Mediterranean seabed.

Foley, who has recovered dozens of such containers in his deep-sea explorations, says that different civilizations from different locations and times established their own style of making amphorae. The Greek versions, with their long narrow necks and handles on either side, were assumed to be ideal cargo containers for wine and olive oil.

When Foley surveyed the scientific literature, he found 27 articles in peer-reviewed journals that directly spoke of amphora contents from Greece's golden age. In the articles, 95 percent of the 5,860 Greek amphorae were described as wine vessels.

The finding raised a red flag, he says. "To me, it didn't seem reasonable to assume that 95 percent of all trade goods in these jars were one commodity."

To find out what was carried inside

the jars, he turned to Hansson, who suggested searching for DNA evidence. Though some archaeologists had flirted with the idea of collecting DNA samples from the jars in the early 1990s, those researchers had little success.

Hansson says that the tools of the trade have improved dramatically since then, making today's DNA analysis much cheaper and friendlier to use. Researchers also have access to databases of DNA information on many of the world's plant species, making it possible to identify a specific food item or crop.

By drawing on these databases, Hansson identified short segments of DNA that show up in plants and might have been used as food, flavorings or preservatives in ancient Greece. She then synthesized small molecules, called primers, to bind to any such fragments remaining in the jar. A second round of primers targeted specific types of plants.

DNA samples were first collected by scraping the ceramic inside the jar with a steel tool. The scientists used this method to look inside two empty amphorae that Foley had recovered from a 2,400-year-old shipwreck off the coast of the Greek island Chios. The findings, reported in 2008 in the *Journal of Archaeological Science*, showed that one of the amphorae held an olive product, probably olive oil, flavored with oregano. The other jar probably carried wine because it appeared to contain fragments of DNA from terebinth, a plant used to preserve wine.

Looking for ways to extract genetic material without causing damage to the artifacts, Foley and Hansson continued to perfect their method. They considered pouring a buffer solution into a jar and sloshing it around to draw out the DNA fragments. After realizing that the dry jar would absorb all the buffer material, the team turned to the Massachusetts State Police crime lab.

A forensics expert there suggested a solution: taking swabs specifically designed to pick up trace samples of DNA and saturating the swabs with the buffer solution before rubbing them along the inside of the jar.

The approach worked better than the original scraping method, allowing the scientists to get more detailed information on the contents the jars carried over their lifetimes. Five of the nine jars contained grape DNA, and all of the jars contained DNA from at least one other plant species, the researchers report in their upcoming paper.

A fuller picture

But the method is not perfect. One problem is that the fragments that remain in the jars are short and not well preserved, says Hansson. Many samples contain strings of only 70 to 100 base pairs, the chemical units that make up DNA. That's enough genetic information to tell whether a specific container carried olives or grapes, for example, but not enough to identify among herbs of the same family.

The process also may not work on items that have been exposed to sunlight or have undergone extensive cleaning, Foley says. Conservators often bathe artifacts found on land in acid, which would destroy genetic information carried within the ceramic.

Artifacts coming out of shipwrecks may also be subjected to a long rinsing process to flush out salt, believed to break up a jar and cause it to crumble to dust. To see if such rinses also wash away DNA, Foley and Hansson are preparing another round of studies. By swabbing the vessels throughout the rinsing process to extract any DNA inside, the team hopes to record if and when the genetic information degrades.

Still, the noninvasive technique provides a way to look at large numbers of archeological artifacts in ways that were previously not possible, Foley says.

"It means that we can take the most sensitive and valuable archaeological artifacts and apply this technique to extract information from these things," he says.

Mark Lawall, a specialist in ancient Mediterranean trade at the University of Manitoba in Winnipeg, Canada, says with only a limited number of jars analyzed so far, it has yet to be seen how much the DNA will add to what is already known about ancient trade.

"Historians were absolutely right to assume that most amphoras contained wine or oil," he says. "Nothing in the article disproves that."

To get a fuller picture of what was being traded, DNA data would have to be combined with other information about a ship and its contents, Lawall says. Analyzing a much larger number of jars from a single documented wreck, for example, might reveal what percentage of the cargo was wine.

Foley and his colleagues plan to take on such studies. As word of the DNA findings has spread throughout the archaeological community, other scientists are inquiring about the technique to see what their vessels were carrying. Already, nearly 100 swabs from various teams line Hansson's freezer awaiting their chance at analysis.

"Eventually when we find the right artifacts, we can find out what the ancients were using for preservatives, cosmetics and medicines," Foley says. "We're going to get the first real look at all of these aspects of this critically important period when the modern world was launched." ■

GRAPE
5 out of 9

OLIVE
6 out of 9

JUNIPER
8 out of 9

Ancient cargo

Of the nine amphorae analyzed in a recent study, five showed remnants of grapes. More carried other goods such as olive products and juniper.

SOURCE: B.P. FOLEY *ET AL/JOUR. OF ARCHAEOLOGICAL SCI.* 2011

Explore more

- Explore ancient Greece via the Hellenic Ministry of Culture and Tourism's ODYSSEUS portal: odysseus.culture.gr/index_en.html

FROM TOP: JANNOON028/SHUTTERSTOCK; LUIS CARLOS JIMENEZ DEL RIO/SHUTTERSTOCK; RICHARD PETERSON/SHUTTERSTOCK

Hedy's Folly: The Life and Breakthrough Inventions of Hedy Lamarr, the Most Beautiful Woman in the World

Richard Rhodes

In Rhodes' newest book, the prolific Pulitzer Prize–winning author (*The Making of the Atomic Bomb*) once again interweaves moving biographical portraits with dramatic depictions of scientific discovery.

The bulk of *Hedy's Folly* centers on an unlikely invention team — Hedy Lamarr, a golden age Hollywood starlet, and George Antheil, a firebrand American composer. As the plot unfolds, the pair invents a frequency-hopping radio device to help American torpedoes evade enemy guidance-jamming systems in World War II.

Rhodes proves adept at elucidating the science behind this invention and the subsequent development of spread-spectrum systems (which today enable the use of cell phones and Wi-Fi), but his particular genius lies in placing the invention within a tumultuous historical moment. Antheil brushes shoulders with artistic luminaries such as Igor Stravinsky and James Joyce, while Hedy and her first husband, an oppressive munitions maker who basically imprisons her in their mansion, entertain Benito Mussolini and German weapons engineers at the dinner table.

With crisp, unadorned prose and plentiful quotes from primary sources,

Rhodes paints a compelling history. Lamarr escapes her husband and flees to Hollywood, where she finds enormous success while inventing in her spare time (a habit she picked up from her father). Antheil's musical innovations with player pianos, while unconventional, give him the technical skill to implement Lamarr's plan for wirelessly synchronizing torpedoes with ships.

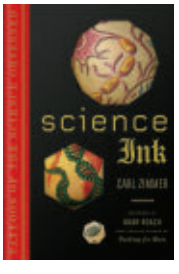
In the end, Rhodes' latest book proves a riveting narrative, propelled by the ambition and idiosyncrasies of the inventors at its core. — *Nick Bascom*
Doubleday, 2011, 272 p., $26.95

Science Ink

Carl Zimmer

Strip away the lab coat, and you'd be surprised what you might find on a scientist's backside. You might uncover not only a butterfly on a lepidopterist, but an extinct lobe-finned fish or the name of a lover spelled in DNA letters.

Zimmer, a science writer and the author of 10 books, pulls together some of the most fascinating tattoos worn

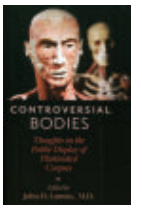


by scientists and science fans. Several years ago, Zimmer noticed a scientist friend's DNA tattoo at a pool party and wondered what else scientists were hiding. He posed that question on his blog, and soon he couldn't keep up with the flood of responses. "Without intending it," Zimmer writes, "I became a curator of tattoos, a scholar of science ink."

In the book's tattoo collection, an astronomer carries a whole galaxy on his foot, and Schrödinger's cat is frozen, forever dead and alive, on a forearm. Photographs of tattoos are organized by scientific topic, and each is accompanied by a short essay telling the story of the tattoo and the science behind it. The essays are fresh and clever, adding scientific substance and making the volume more than a coffee-table book.

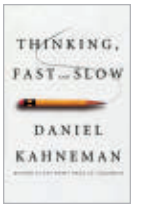
As Zimmer points out, science is a natural subject for tattoos; of course people obsessed with the particulars of a species or a class of molecules would etch the object of their fascination in their skin, so as to always carry it close.

So watch out: This is the kind of book that might give readers some wild ideas. It's also the kind of subject that makes other science writers wish they had thought of it first. — *Erika Engelhaupt*
Sterling, 2011, 271 p., $24.95



Controversial Bodies
John D. Lantos, ed.
A dozen authors discuss issues surrounding the display of human bodies whose flesh has been preserved by plastic. *Johns Hopkins Univ. Press, 2011, 145 p., $35*

What Makes Your Brain Happy and Why You Should Do the Opposite
David DiSalvo
By weaving together the latest studies, a science writer examines why people's desires often thwart their goals. *Prometheus Books, 2011, 288 p., $19*



Thinking, Fast and Slow
Daniel Kahneman
A psychologist argues that separate mental systems organize decision making and inspire a litany of thinking errors. *Farrar, Straus and Giroux, 2011, 352 p., $27*

How We See the Sky
Thomas Hockey
Learn to see more when you look up with this naked-eye guide to the day and night skies. *Univ. of Chicago Press, 2011, 239 p., $20*

Powering the Future
Robert B. Laughlin
A Nobel laureate in physics breaks down alternatives for the world's energy supply. *Basic Books, 2011, 224 p., $24.99*

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Technology Update

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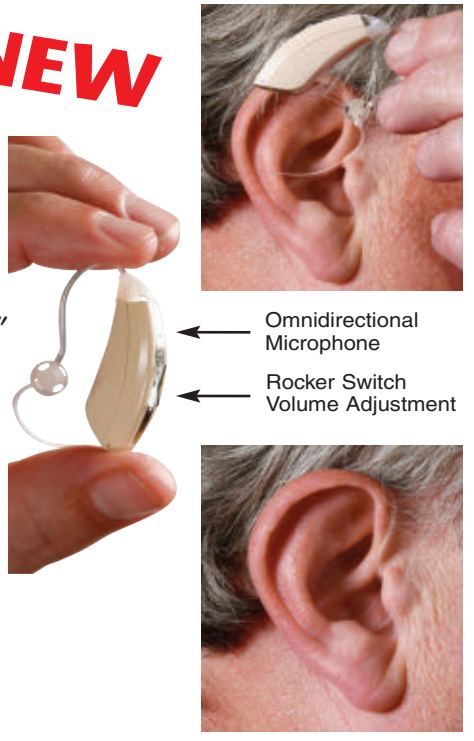

Are you tired of missing out on conversations and constantly having to say "Can you repeat that?" You're not alone. At times, almost everyone would like to be able to amplify conversations, TV dialogue, church sermons and even birds chirping. But do you really want to fork out thousands of dollars for a hearing aid? Now, there is an attractive alternative. It's called Perfect Choice HD™, the perfect choice for high definition sound amplification.

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Predators inspire poetry and fear

Regarding "Lopped off" (*SN: 11/5/11, p. 26*): One of the Tao Te Ching's chapters (excerpt below) is very prescient on the unintended consequences of human behavior. It was written around 500 B.C., long before our innovative abilities threatened the entire planet. It is ironic that science both leads to innovations that cause the destruction, and now allows us to realize the full range of consequences.

Woe to him who willfully innovates
While ignorant of the constant,
But should one act from knowledge of the constant
One's action will lead to impartiality,
Impartiality to kingliness,
Kingliness to heaven,
Heaven to the way,
The way to perpetuity,
And to the end of one's days one will meet with no danger.

Carl Abbott, Santa Cruz, Calif.

Your article failed to quote or cite any of the fine poetry about vultures. The works of Atwood, Belloc, Kennedy and others touch on the scientific points you were making.

Vultures eat dead, bloated cows
So they won't go to waste.
Thus making up in usefulness
What they lack in taste.

Dave Jordan, Brevard, N.C.

The author quotes Peter Kareiva of the Nature Conservancy: "If you could restore the balance of ecosystems — look at how many deer there are in the Northeast, and what a big problem they create for homeowners and everybody — would it be so bad if cougars came back?"

As a lifelong resident of the Northeast familiar with the deer issue — let me just say a resounding YES! It would be bad if we got major predators like cougars or wolves here. Children would not be safe playing in their own backyard. Small household pets are at risk now because coyotes have moved into the Northeast. And the issue with deer eating cottonwood trees that is a problem out west does not exist here in the Northeast. All we need to do is harvest more of the deer every year. *We* are the top predators here.

Kenneth V. Hoffman, Peace Dale, R.I.

How heads get holes

In the article "Incas not always hostile" (*SN: 11/19/11, p. 16*), it would be interesting to know how many of the skulls examined were trephinated. Since trephination was practiced for a number of reasons (including allowing egress of bad spirits in cases of illness and head injury), it is conceivable that the trephination was made directly over a depressed skull fracture. Since the trephinated bone would have been removed, evidence of the injury would have been lacking. It is conceivable that the 7.8 percent cited as the rate of war injuries is artificially low and that the Incas may have been more bellicose than this article would have one believe.

Stephanie Rifkinson, New York City

In the researchers' analysis, skull surgery, or trephination, occurred on seven of 23 Inca individuals who suffered major cranial trauma, most likely due to warfare, and on 21 of 77 individuals who had minor, healed cranial injuries. Surgical openings were located adjacent to head wounds, sometimes partly overlapping with them, and were probably made after war wounds had been inflicted, the scientists say. — Bruce Bower

Charged up by lightning

If the lower part of a cloud is negative and the upper part positive, why does the "Lightning in 3-D" graphic in the story "Like a bolt from above" (*SN: 11/5/11, p. 16*) show the positive charge below the negative charge?

Bobby Baum, Bethesda, Md.

There is a great deal of variety in how a cloud can become electrified, and the graphic shows an instance in which electrical breakdown traveled from a region of negative charge toward and through a lower region of positive charge. We chose it because it represented real data for a flash that the New Mexico Tech scientists found intriguing. — Alexandra Witze

Thanks for science memories

I now am 85 years old and have — it seems like forever — been receiving *Science News Letter* and *Science News* since the 1940s. While I was an undergraduate zoology major at Houghton College in New York, each week I would post on the department bulletin board pertinent articles I had clipped from your magazine. Now I want to thank you for the high-quality articles you have continued to print for more than six decades.

Wayne Frair, New York City

Iceman's demise

The article "For his last meal, Iceman ate goat" (*SN: 9/24/11, p. 8*) makes the assertion that he was murdered. Science should not be about guessing. But, if I were to guess as to the way the Iceman came to his end, I would say he fell into a crevasse and impaled himself on his own arrow. As a hunter, he may have carried a single arrow in one hand and his bow in the other. Falling into a crevasse, he would have put his hand down to break his fall, putting the arrow below him. If he tried to pull the arrow out of his back, the arrowhead would have separated from the arrow and caused even more bleeding. Sometimes the truth is less dramatic than our imagination.

Will Willette, Lisbon Falls, Maine

Correction

"Sparing the rare earths" (*SN: 8/27/11, p. 18*) incorrectly referred to the gauss-oersted as a "unit of magnetic field strength." This unit (used in the magnet industry) compares the magnetic strengths of materials by measuring the energy densities of their magnetic fields. The article should have said that the gauss-oersted is a unit used to compare the strengths of magnets.

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

From the Archive

To read the full 1939 article, visit
www.sciencenews.org/archive_coelacanth

Find "extinct" fish alive in South African waters

Hint of a "Lost World" beneath the sea, a survivor of long-gone geologic ages, has been hauled up in a trawler's net off the east coast of South Africa: a fish of a kind supposed to have disappeared utterly from the earth 50 million years ago.

Word received in Washington, D.C., was heard with amazement by scientists of the Smithsonian Institution, as if someone had announced the discovery of a living dinosaur. But the strange find is attested by the word of colleagues "down under" known to be competent and hard to fool. It seems impossible; yet apparently it's real.

The fish is a rather big one, about five feet long, dark blue in color with a metallic luster, with big goggle eyes. It has two back fins, the forward one in two sections or lobes. The paired fins under its body are almost leg-like, paddle-shaped in outline. The two lobes of its tail-fin are uneven.

Closer inspection shows a pair of openings, known as spiracles, behind the eyes, sharp conical teeth like a cat's, heavy bony plates under the wide jaw. The skeleton is made not of bone but of cartilage.

All this, to scientists, is a picture of an exceedingly primitive type fish. Some of the skeletal characters, and especially the bony jaw plates, mark the specimen as a surviving member of one of the most ancient groups of fishes, known as the Crossopterygians. There is no common name, for the whole family is supposed to have become extinct at least 50 million years ago, in Mesozoic time, the age of the dinosaurs.

Coelacanth fossils were studied long before scientists got to know the living creatures.

UPDATE

Survivors lurk in Indian, Pacific

When Marjorie Courtenay-Latimer first got a look at the strange sea creature that a trawling fleet had pulled from the waters off of South Africa's coast in 1938, she immediately realized that it was something significant. Courtenay-Latimer, a curator at a natural history museum in East London, South Africa, sent a sketch to an amateur ichthyologist who later confirmed that the fish was indeed special — a coelacanth, a member of a group known only from fossil evidence and thought to be extinct for millions of years.

The name of the new species, *Latimeria chalumnae*, paid homage to its discoverer. But it was the amateur ichthyologist J.L.B. Smith who set out to find another coelacanth after the first had become putrefied and unsuitable for study. "He distributed illustrated leaflets up and down the east coast of Africa, printed in English, French and Portuguese. He cajoled trawler skippers to watch for the precious fish. He offered a handsome reward for its capture," according to reports in *Science News Letter*. The efforts paid off, eventually: An intact, wholly preserved coelacanth was recovered from a native of the Comoro Islands, near Madagascar, in 1952.

Since this "living fossil" first appeared, around 300 specimens have been caught. In the late 1990s, coelacanths captured near Indonesia became a new species, named *Latimeria menadoensis*. And a report in November in the *Proceedings of the National Academy of Sciences* raises the possibility of a third family member, suggesting that a population of coelacanths living off of the northern portion of Tanzania's coast may be distinct from their Comoro Islands relatives, having diverged 200,000 years ago. — *Elizabeth Quill*

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As the mist clears, you press on toward the mouth of the jungle. A vine–twisted darkness lies ahead. But like the intrepid explorers of old, who came to South America in search of fortune and glory in the form of precious green stones, you can't help yourself. You've heard tales of *a scintillating 50 carat emerald...*

Entering the green depths of the forest, you ask yourself, "Is it worth it?" But soon enough you realize it is. After following your guide past snakes and snares, you catch a glimpse of the glorious green treasure... and then you wake up. It was all a dream. Except the emerald. That part was real. The gigantic stone can be yours in our ***Oval Emerald Pendant*** **for only $129!**

The largest emerald we've ever offered. Although emeralds of this size often land in museums, we think something so spectacular belongs around a neck--not under glass. The impressive 50-carat faceted stone is a natural emerald carefully enhanced by our jewelers to bring out its finest color. And its exquisite, sterling silver frame is ringed with meticulous filigree and beadwork which has been hand worked in Bali, demonstrating only the most refined craftsmanship.

The Rich Verdant Color of Spring

Emeralds are one of the most rare and valuable of gemstones. The emerald is well deserving of its placement among the "big four" which includes diamond, sapphire and ruby.

Mineral Class	Beryl		
Color	Deep Green		
Hardness	7.5 on the MOHs Scale		
Cut	Faceted	Birthstone	May
Refractive Index	1.577-1.583		

The stuff of legends. Here at Stauer, we want legendary emeralds like this to be available and affordable. But we also want our legend to live on. So, we're going to give you 300 reasons to come back to Stauer. Receive **$300 in Stauer Gift Coupons for FREE** per order—$25 to use every month for 12 months, with **NO MINIMUM PURCHASE REQUIRED... ever**. Basically, we're paying you to shop Stauer.

We're so sure you'll consider our ***Oval Emerald Pendant*** a masterpiece, we offer a 30-day money back guarantee. If you're not mesmerized by it's beauty, return it for a full refund of the purchase price. Sometimes even our best customers are surprised by our prices, but with our client-friendly approach **we've earned a rare A+ Rating from the Better Business Bureau**, so you can wear this genuine 50-carat emerald with confidence. It's time to turn those green dreams into reality!

JEWELRY SPECS:
- 50 carat genuine emerald pendant
- .925 sterling silver setting - Chain sold separately

Oval Emerald Pendant
(50 carats)—~~$249~~ **$129**

Oval Emerald Ring
(10 carats)—~~$195~~ **$129**

Oval Emerald Earrings
(15 ctw)—~~$195~~ **$129**

Oval Emerald Set
(Includes ring and earrings)
(25 ctw)—~~$390~~ **$199** *Save $191*

Bali Tulang Naga Chain—$99

Get $300 in Free Stauer Gift Coupons! *See details left.*

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"Well, I finally did it. I finally decided to enter the digital age and get a cell phone. My kids have been bugging me, my book group made fun of me, and the last straw was when my car broke down, and I was stuck by the highway for an hour before someone stopped to help. But when I went to the cell phone store, I almost changed my mind. The phones are so small I can't see the numbers, much less push the right one. They all have cameras, computers and a "global-positioning" something or other that's supposed to spot me from space. Goodness, all I want to do is to be able to talk to my grandkids! The people at the store weren't much help. They couldn't understand why someone wouldn't want a phone the size of a postage stamp. And the rate plans! They were complicated, confusing, and expensive… and the contract lasted for two years! I'd almost given up when a friend told me about her new Jitterbug phone. Now, I have the convenience and safety of being able to stay in touch… with a phone I can actually use."

The cell phone that's right for me. Sometimes I think the people who designed this phone and the rate plans had me in mind. The phone fits easily into my pocket, and flips open to reach from my mouth to my ear. The display is large and backlit, so I can actually see who is calling. With a push of a button I can amplify the volume, and if I don't know a number, I can simply push "0" for a friendly, helpful operator that will look it up and even dial it for me. The Jitterbug also reduces background noise, making the sound loud and clear. There's even a dial tone, so I know the phone is ready to use.

Affordable plans that I can understand – and no contract to sign! Unlike other cell phones, Jitterbug has plans that make sense. Why should I pay for minutes I'm never going to use? And if I do talk more than I plan, I won't find myself with no minutes like my friend who has a prepaid phone. Best of all, there is no contract to sign – so I'm not locked in for years at a time or subject to termination fees. The U.S.–based customer service is second to none, and the phone gets service virtually anywhere in the country.

Monthly Minutes	50	100
Monthly Rate	$14.99	$19.99
Operator Assistance	24/7	24/7
911 Access	FREE	FREE
Long Distance Calls	No add'l charge	No add'l charge
Voice Dial	FREE	FREE
Nationwide Coverage	Yes	Yes
Friendly Return Policy[1]	30 days	30 days

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