Food Dye Safety | Birds Go Urban | Cougar's Long Trek

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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ AUGUST 27, 2011

New Twist on Radio

Probing the Brain's Last Gasp

Missing Particle Found

Rarer Earths

Fear of shortages drives efforts to find replacements for versatile metals

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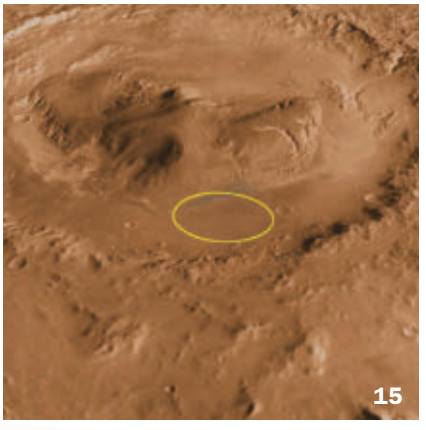

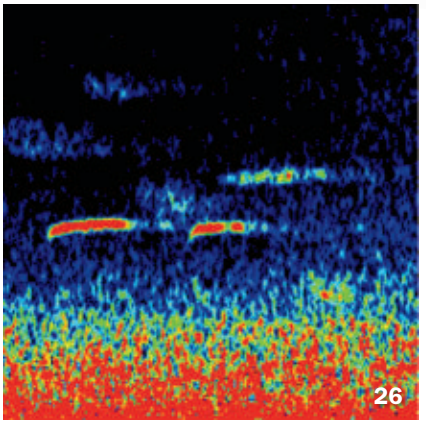

ScienceNews

In The News

Features

Departments

COVER Worries about the supply of rare earth elements such as those streaking this piece of bastnäsite have scientists searching for alternative materials.
Molycorp Minerals

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FROM THE EDITOR

Swedish names signify elements of rare value

Of all the elements in the periodic table, the rare earths have the oddest names.

Of course, you won't find some of those names so odd if you're from Sweden. Rare earth elements were first identified in a mineral unearthed from a quarry in Ytterby, a small town not far from Stockholm, in 1787. Yttrium, ytterbium, erbium and terbium are all named for Ytterby; many other rare earths have Scandinavian names, such as holmium, named for Stockholm, and scandium, named for Scandinavia.

But it's not the oddness of their names that makes the rare earths odd. It's the unusual arrangement of electrons in rare earth atoms that gives them their peculiar properties. And it's that electron arrangement that banishes most of the rare earths to a row sequestered beneath the main body of the periodic table. (Scandium and yttrium join the league of rare earths by virtue of occupying the two spaces above the single square reserved for the 15 other elements in the row below.)

Scientists have spent decades decoding the complicated interactions among rare earth electrons, attempting to explain and predict the curious properties that make the rare earths so valuable in gadgets and other technologies — most notably in products requiring powerful magnetic materials.

Limits on their availability have encouraged scientists to devise ways of reducing the need for rare earths, whether by using less of them or by finding novel magnet technologies that don't need them at all, as Devin Powell reports in this issue (Page 18). But in the meantime, the rare earths remain among the most versatile class of substances known in nature, useful for everything from providing superior sound in small speakers to giving colors to TV screens.

Perhaps of greater value, though, is the example of atomic complexity that the rare earths provide for probing the connections between macroscopic physical properties and subatomic machinations. Oddities in the rare earths' properties have induced scientists to pursue a detailed understanding of atoms with many electrons in atypical arrangements. Mysteries underlying the rare earths' unusual features have led to deeper knowledge about how electrons interact with their nuclei, with neighboring atoms and with each other. Some of that knowledge will no doubt be needed to make better use of rare earths in the future — or to figure out new ways to do what only the rare earths can do now.

— *Tom Siegfried, Editor in Chief*

JIM WEBB

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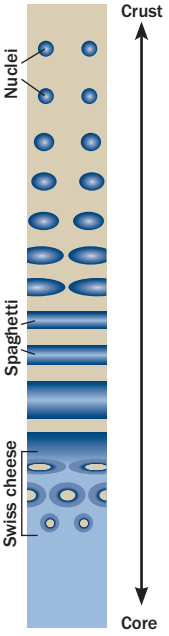
Say What?

nuclear pasta ***NOO-klee-uhr PAH-stah***\ ***n.*** Strange shapes of matter in the bottom layers of a neutron star's inner crust. A neutron star is an extremely dense dead star. In the inner crust, so many atomic nuclei — protons and neutrons — are shoved together that they can join up to form extended tubes ("spaghetti"), sheets ("lasagna") or even "Swiss cheese" (the pasta analogy has its limits). These pasta layers have both solid and liquid properties, kind of like rubber or liquid crystals. Astrophysicists at Texas A&M University–Commerce report online June 24 at arXiv.org that the types of pasta a neutron star has can affect the star's overall shape. Pasta may also affect the size of seismic waves that ripple through the crust when it ruptures during a magnetic flare. If so, astronomers may be better able to figure out what a neutron star's insides look like by studying its outsides. — *Camille M. Carlisle*



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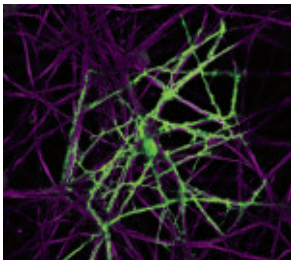
SCIENCE & THE PUBLIC BLOG

Smoke-exposed kids are more likely to have neurobehavioral disorders. See "Young minds at risk from secondhand smoke."

BODY & BRAIN

At-risk newborns may avoid death and disability by cooling off. See "News in Brief: Body & Brain."

Active neurons trigger changes that speed up signaling. Read "How exercise benefits nerve cells."



ATOM & COSMOS

The Milky Way may be in a midlife crisis. Read this story and others in "News in Brief: Atom & Cosmos."

Science Past | FROM THE ISSUE OF AUGUST 26, 1961

EARTH ONCE GLOWED — The earth's surface in its early years of life may have glowed like a beautiful rainbow, shimmering with the colorful array of light emitted by primitive organisms. Light emission may have occurred soon after life appeared on earth, when the atmosphere lacked oxygen.... As small amounts of oxygen appeared in the atmosphere, not all of the organisms could tolerate the presence of oxygen. However, those that could quickly and rapidly remove the oxygen by reduction with hydrogen or electrons from primitive foodstuffs survived. In removing the oxygen by the use of organic reducing substances, an excited state was produced resulting in the emission of light. The surviving organisms were therefore all potentially luminescent.

Science Future

September 6

In New York City, author Joshua Foer discusses the history and science of competitive memorization. See www.nyas.org

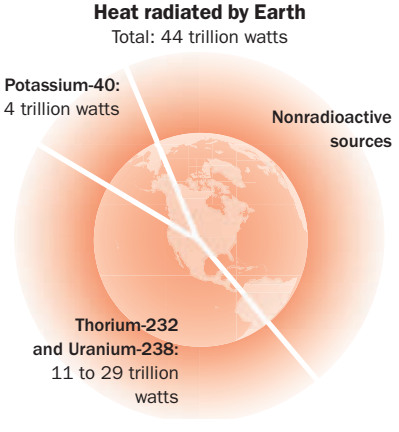
September 15

Deadline to submit photos illustrating "chemistry in our microbes" to the Colors of Chemistry calendar contest. For info go to colorsofchemistry.org

Science Stats

RADIOACTIVE EARTH

About half of the heat that Earth radiates into space comes from the decay of radioactive isotopes that occur naturally within the planet, scientists have found.

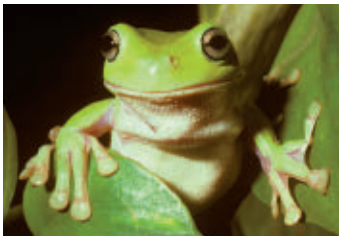


SOURCE: THE KAMLAND COLLABORATION/*NATURE GEOSCIENCE* 2011

How Bizarre

The same mucus that helps tree frogs' feet stick to leaves also makes them self-cleaning. The problem with sticky feet is that they tend to pick up a lot of dirt. To figure out how frogs keep their feet clean, researchers from the University of Glasgow in Scotland put White's tree frogs (*Litoria caerulea*) on a dusty platform. At first walking on dust made the frogs lose their grip, but their toes became sticky again after a few steps. The dust clumps together in the mucus and then comes off with each step in the frogs' footprints, says Niall Crawford, who presented the results July 3 at the Society for Experimental Biology meeting in Glasgow. Emulating frogs' feet could lead to self-cleaning, long-lasting adhesives.

— *Sandeep Ravindran*



CLOCKWISE FROM TOP LEFT: DANY P. PAGE, THE NEUTRON STAR PICTURE GALLERY, ADAPTED BY E. FELICIANO; COURTESY OF R. DOUGLAS FIELDS AND HIROAKI WAKE/NIH; © STEVEN DAVID MILLER/ANIMALS ANIMALS; T. DUBÉ

“Humans, unlike great apes, may have undergone a period of selection for individuals who divided spoils equally after a collaborative hunt.” —KATHARINA HAMANN, PAGE 10

In the News

STORY ONE

Genes, sightings retrace path of cougar’s journey

Biologists track cat from the Black Hills to Connecticut

By Nadia Drake

JHAVIV/ISTOCKPHOTO

If you want to see a cougar east of the Mississippi River, the best place to go is a zoo. Yet somehow a wild cat made its way to Connecticut this summer, ending a 2,000-mile journey that began in South Dakota’s Black Hills.

The tale starts with an unidentified body found on the roadside, hit by a car in the wee hours of the morning. Investigators puzzled over where it had come from and how it had reached its asphalt resting place.

But this wasn’t a human murder mystery: The victim was a young cougar, struck down on the Wilbur Cross Parkway in Milford, Conn., on June 11. The incident shocked a state where drivers are accustomed to seeing white-tailed deer dash in front of their windshields, not 140-pound predatory cats.

On July 26, after working for weeks to piece together the cougar’s story, scientists delivered a surprising saga of the cat’s 2,000-mile journey from the Black Hills of South Dakota to the green lawns of southern New England.

When the young male was killed, investigators initially thought he might have been a captive animal. But a necropsy suggested otherwise. “It was not declawed. It was not neutered. It wasn’t overweight,” says wildlife biologist Paul Rego of the Connecticut Department of Energy and Environmental Protection, who coordinated the state’s investigation. There was no microchip embedded under the animal’s skin — just porcupine quills.

Perplexed, scientists sent a chunk of muscle to the U.S. Forest Service’s Wildlife Genetics Laboratory in Missoula, Mont., hoping genetics could help determine the cat’s home range.

Over the last decade, the lab has built an extensive genetics database comprising 50 different wildlife species, says lab director Michael Schwartz. Scientists use the information mostly to study how land management affects population breeding patterns and the dispersal of animals within their current ranges, information crucial for preventing inbreeding and reproductive isolation.

“But we do a lot of this kind of work,” Schwartz says. “Every once in a while a cougar decides it’s going to show up in an area where there isn’t a wild population.”

Schwartz and his team compared DNA from the Connecticut cat with the roughly 800 cougar samples in the database. The wildlife biologists looked at 20 DNA microsatellites — areas with repeated genetic elements of varying length — as well as portions of maternally inherited DNA from mitochondria.

The mitochondrial DNA confirmed that the cat came from North America and was not a South American import, as captive animals sometimes are. The microsatellite data matched the genetic profile of the Black Hills cougar population, with 99.8 percent certainty.

Although the western United States is home to an estimated 30,000 cougars, the Black Hills cats number between just 200 and 250, says wildlife biologist Jonathan Jenks of South Dakota State University in Brookings, who has studied

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Incredible journey DNA evidence, reports of sightings and photographs by automated cameras helped biologists trace a Connecticut-bound cougar's path across the Upper Midwest. Because alternate routes are so densely populated, it probably continued on to Connecticut via Canada and upstate New York. SOURCE: WIS. DNR

this population since the cats began recolonizing the Black Hills in the late 1990s. Jenks and his team have put radio collars on an estimated 300 cougars and followed them as they traveled to places like Oklahoma and Saskatchewan. "About 90 percent of the sub-adult males leave the Black Hills," Jenks says. "And they travel extensively, that's for sure. Especially the males. But I'm surprised this one made it so far."

Schwartz says he was stunned to learn the animal's genetic profile was already in the lab's database. "We didn't believe it at first," he says. "We actually had our techs rerun the sample, just to be sure."

It turned out that the older samples — hair and fecal matter — had been collected more than a year earlier by biologists tracking the Connecticut-bound cougar across Wisconsin. First spotted in Champlin, Minn., in December 2009, the cougar zigzagged through Wisconsin, leaving behind a trail of paw prints, hair and poop.

Even in Wisconsin — with its bears and wolves — cougars are unexpected visitors, says mammalian ecologist Adrian Wydeven of the Wisconsin Department of Natural Resources in Park Falls.

There have been only five confirmed cougars in that state since 2008, so when the traveling cougar appeared, Wydeven and his team kept a watchful eye on the cougar's movements. From December 2009 through late spring 2010 they haunted the cat's trail, collecting samples and sending them to the lab. In December, a trail camera captured a cougar prowling through the evening snow near an area where hair had been collected, providing scientists with a glimpse of the elusive cat.

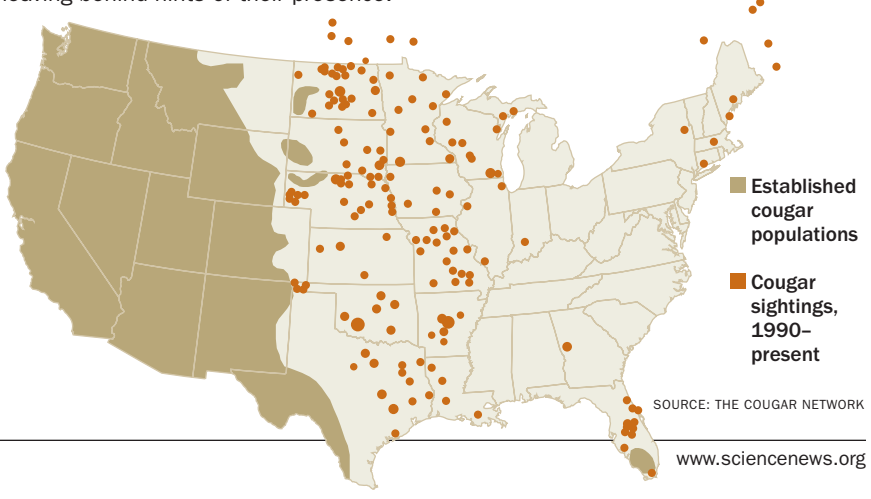
Then, after another trailside portrait in May 2010, the cat disappeared.

The next time he appeared was a year later and a half-continent away, just a few miles from the Connecticut shore. Scientists don't know much about the cat's journey between Wisconsin and Connecticut, but wildlife biologist Clayton Nielsen of Southern Illinois University in Carbondale speculates the cat probably crossed Michigan's Upper Peninsula into Canada, then wound down into New York. "There's no real way of knowing," he says. "But going south through Illinois, Indiana, Ohio — that's very poor habitat, with a high likelihood that people would see the animal."

Nielsen, who is studying cougars in the Midwest, says while roaming young males are increasing in the area, there are still no known breeding populations east of the Black Hills, except for an endangered group of less than 100 in and around the Florida Everglades. Scientists hypothesize that the Connecticut cat was wandering in search of food and a mate. But since he didn't find a mate, he kept on moving. Female cougars don't travel nearly as far as males, which limits the establishment of new breeding populations. But, Nielsen hypothesizes, if a few females made similar journeys, it's plausible that a cougar population could re-establish itself farther east. ■

Back Story | EASTWARD HO

Once found throughout the United States, breeding populations of cougars are now restricted to the American West and the swamps of southern Florida. Preferring to avoid humans, *Puma concolor* seeks large territories with an abundance of its favorite prey — which include white-tailed deer and porcupines. Young males seeking territories and mates are increasingly heading eastward into their ancestral range and leaving behind hints of their presence.



SOURCE: THE COUGAR NETWORK

FROM TOP: GEOATLAS/GRAPHI-OGRE, ADAPTED BY T. DUBÉ; GEOATLAS/GRAPHI-OGRE ADAPTED BY E. FELICIANO

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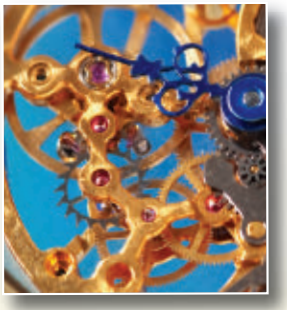

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Body & Brain

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‘Wave of death’ not a last gasp

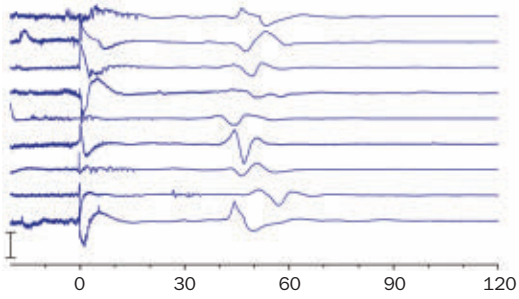
Rat brain activity seen nearly a minute after decapitation

By Laura Sanders

Almost a minute after a rat’s head is severed from its body, an eerie shudder of activity ripples through the animal’s brain. Some researchers think this post-decapitation wave marks the border between life and death. But the phenomenon can be explained by electrical changes that, in some cases, are reversible, researchers report online July 13 in *PLoS ONE*.

Whether a similar kind of brain wave happens in humans — and if so, whether it is inextricably tied to death — could have important implications. An unambiguous marker could help doctors better decide when to diagnose brain death, knowledge that could give clarity to loved ones and allow earlier organ donation.

In another *PLoS ONE* paper published in January, neuroscientist Anton Coenen and colleagues at the Radboud University Nijmegen in the Netherlands described this wave of electrical activity in the rat brain occurring 50 seconds after decapitation. The Nijmegen team, which was exploring whether decapitation is a humane way to sacrifice lab animals, wrote that this brain activity seemed to be the ultimate border between life and death. The team dubbed the phenomenon the “wave of death.”



Electrodes capture waves of activity in the brains of nine rats about 50 seconds after decapitation. The waves have been interpreted as a death marker.

But neurologist Michel van Putten of the University of Twente in Enschede, Netherlands, wasn’t convinced. “We have no doubt the observation is real,” he says. “But the interpretation is completely speculative.”

In the new study, van Putten and colleagues devised a mathematical model of how a nerve cell would behave if its oxygen and energy supplies were suddenly cut off. The model consists of just a single cell with three kinds of channels that allow charged particles to flow in and out. The spaces outside and inside nerve cells have unequal electrical charges, a difference that allows neurons to fire the impulses they use to communicate.

After an abrupt halt of energy and oxygen supply, the channels stop functioning normally, causing a buildup of positive charge outside the cell. This buildup prompts a big discharge of electrical activity about a minute after starting the simulation — the wave of death.

Study coauthor Bas-Jan Zandt of the University of Twente says that the simulation closely matches what is observed in the rat brain. This sort of cellular malfunction could be the start of a damaging process, he says, such as cell swelling, but there’s nothing about the actual wave that means the nerve cell is destined to die.

“It doesn’t cause damage to the cell,” Zandt says. “In principle, it is a reversible process.”

Other primates’ brains don’t shrink

Study suggests withering with age is a uniquely human trait

By Laura Sanders

Chimp brains don’t shrink as they age. That makes humans the only species whose brains wither with time, researchers report online July 25 in the *Proceedings of the National Academy of Sciences*.

“Chimp aging seems to be on a different trajectory than humans,” says aging and Alzheimer’s expert Caleb Finch of the University of Southern California in Los Angeles, who was not involved in the study.

The small number of great ape brains that have been studied show mild changes with age, Finch says, but nothing that approaches the damage seen in the brains of people with Alzheimer’s disease, for instance. Understanding differences in aging between humans and other primates may help scientists figure out why human brains are susceptible to age-related dementias.

In the new study, anthropologist Chet Sherwood of George Washington University in Washington, D.C., and colleagues scanned the brains of 99 chimpanzees with ages representing the entire adult life span, from 10 to 51 years. For comparison, the team imaged the brains of 87 healthy humans from 22 to 88 years old.

The human scans confirmed what other studies had found: All brain regions measured showed shrinkage with age. But chimp brains didn’t get smaller with age.

Sherwood points out that the results don’t answer a fundamental question for human evolution: “Why would we be built in such a faulty way that leads to this degeneration in our brains?” Perhaps a long life span is worth the drawback. Big brains and long life spans may free up older members of the population to look after the youngsters, he speculates.

C.M. VAN RIJN *ET AL./PLOS ONE* 2011

"Whatever biological function sleep serves takes time." —PAUL SHAW

Sleep interruptions erode memory

Storing information requires a continuous supply of Z's

By Tina Hesman Saey

Continuity of sleep, not just the total hours of nightly slumber, is crucial to forming and retaining memories, a new study in mice suggests.

Mice couldn't remember objects they'd seen before after a night of interrupted sleep, Asya Rolls of Stanford and her colleagues report online July 25 in the *Proceedings of the National Academy of Sciences*. Even though the mice got just as much sleep as normal and slept as intensely as usual, breaking that sleep into one-minute chunks was enough to erase the memory of toys the animal had seen in the past.

The results emphasize that sleep is a process, says Paul Shaw, a neuroscientist at Washington University in St. Louis who was not involved in the study. "Whatever biological function sleep serves takes time," he says. "So if you wake up, you disrupt that process and have to start from scratch again."

Scientists already had inklings that continuous bouts of sleep were important for learning and memory, Shaw says. But previous experiments had disrupted sleep in ways that made it hard to tell whether learning and memory problems stemmed from fragmented snoozing or from stress or other confounding conditions. In the new study, the Stanford researchers used a "really cool" genetic trick to interrupt the mice's sleep without all the problems associated with previous studies, Shaw says.

Rolls and her colleagues introduced a light-sensitive protein called channelrhodopsin-2 into certain brain cells. Shining a pulse of blue light on the cells through fiber-optic cables implanted in the brain activated the cells and briefly woke the animals. Outwardly, the mice didn't even appear to wake up. "They maybe just twitched a muscle," says Rolls. But the researchers could detect the brief arousals by monitoring the mice's brain waves.

Mice that got continuous sleep or that were woken up every two minutes over four hours remembered objects they'd seen before. The mice crawled on, sniffed, tasted and played with new objects far more than familiar objects. Mice that woke up every minute explored old objects just as much as new toys, indicating that the animals didn't remember which objects they had encountered before.

Humans and other animals may need much more than two minutes of uninterrupted sleep to keep memories intact, Shaw says. Mice typically sleep only a few minutes at a time. Fruit flies in Shaw's lab seem to need at least 30 minutes of continuous sleep to learn and remember things. People may need even longer snooze periods than that.

Treatment cuts organ rejection

Filtering kidney recipients' blood may boost transplants

By Nathan Seppa

Some people waiting for a kidney transplant might see their prospects brighten. By using a centrifuge to spin out troublesome antibodies from the blood of people needing a transplant, doctors have rendered many recipients able to tolerate a donated kidney their bodies might have otherwise rejected.

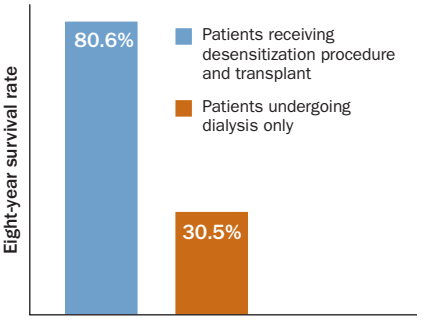
As many as 30 percent of people needing a kidney transplant harbor antibodies against proteins found in the donor organ. The antibodies can show up in anyone who has been exposed to foreign tissue via a blood transfusion, a previous transplant or even a pregnancy. These "sensitized" people require a near-perfect match from a living donor to get a kidney that won't be rejected — a medical long shot.

Robert Montgomery, a surgeon at Johns Hopkins University in Baltimore, and his colleagues treated 211 sensitized patients with a procedure in which blood is spun, filtered of the offending antibodies and replaced. After undergoing this procedure enough times to clear the rogue antibodies, the patients got a kidney transplant.

This group had an eight-year survival rate of 81 percent. The rate for 1,050 similar patients who stayed on dialysis over that period without getting a transplant was only 31 percent, Montgomery and colleagues report in the July 28 *New England Journal of Medicine*.

"This validates the approach," says Dixon Kaufman, a transplant surgeon at the University of Wisconsin–Madison who wasn't involved in the study. "This is very good evidence that it can provide a benefit." Publication of the new findings will allow more transplant centers to start adding the procedure to their programs, Kaufman says.

Survival rates among kidney failure patients



SOURCE: R.A. MONTGOMERY *ET AL*/*NEJM* 2011

Kidney patients who react strongly to foreign tissue often die waiting for a matching transplant. A desensitization treatment improves their survival rates.

Humans

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Kids share the loot, chimps hoard it

Group foraging legacy may prod humans to divvy up spoils

By Bruce Bower

Young kids have no problem saying mine and gimme. Yet even greedy rug rats go out of their way to share cool stuff equally if they've worked together to get it, a new study finds.

Adult chimpanzees, on the other hand, show no affinity for meting out fair shares after cooperative projects, say psychologist Katharina Hamann of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, and her colleagues.

A tendency to share and share alike evolved in ancient human foraging groups organized around collaborative food gathering, the researchers propose online July 20 in *Nature*.

"Humans, unlike great apes, may have undergone a period of selection for individuals who divided spoils equally after a collaborative hunt," Hamann says.

Hamann's team shows that pairs of 3-year-olds are most likely to share with each other after working together, but the jury is still out on chimps, remarks psychologist Frans de Waal of Emory University in Atlanta. In the new study, pairs of these apes — with each animal in a separate room — had to pull two ends of a rope simultaneously to move within reach a grape-bearing platform mounted between the rooms, a task that may have confused the apes, de Waal says. He and a colleague have found that pairs of capuchins share unequal amounts of food after jointly pulling a food tray close.

Kids as young as 3 years old frequently divvy up toys equally if they've worked together to get the goodies.

Hamann responds that chimps thoroughly grasped how to use the test device.

Finding that young kids who work together share together is "a very important result," says anthropologist Kim Hill of Arizona State University in Tempe. In modern-day human foraging groups, sharing often involves exchanging goods and services considered to be of equal value, such as one person gathering berries to share with another person who provides firewood, rather than people working on one task together.

The new investigation examined whether adults' keen interest in fair shares emerges early in life and occurs in humankind's closest evolutionary cousin, chimps. Pairs of 2- and 3-year-old German children jointly pulled a rope to move a board or a block that pushed four marbles within reach. One child ended up with three marbles and the other with one marble. On about three-quarters of these trials, lucky 3-year-olds gave a marble to their partners to even the take. One-quarter to one-half of lucky 2-year-olds gave a marble to a helper.

A minority of 3-year-olds shared an extra marble after manipulating a block on their own next to another child doing the same, or after being given more marbles than another child. Chimps rarely redistributed uneven amounts of food, whether or not pairs had worked together.

NEWS BRIEFS

New World island roots

Prehistoric people who took sea voyages to an island 42 kilometers off the California coast laid down offshore roots by eating some. Between about 11,500 and 3,000 years ago, residents of San Miguel Island ate carbohydrate-rich corms — energy-storage bulbs attached to certain plant roots. Soil samples from a cave occupied by early islanders contain corm fragments, report ethnoarchaeologist Seetha Reddy of Statistical Research Inc. in Woodland, Calif., and archaeologist Jon Erlandson of the University of Oregon in Eugene in an upcoming *Journal of Archaeological Science*. The combination of corms and seafood provided a nutritious diet far from the mainland, the team proposes.
— Bruce Bower

Rock, paper, copycat

Rock smashes scissors, scissors cut paper and imitation trumps self-interest. People ape opponents' gestures in the rock-paper-scissors game more often than expected by chance, at least if the opponent moves first by a fraction of a second, say psychologist Richard Cook of University College London and his colleagues. Imitation is a lousy game strategy, since it always produces draws, but the brain has evolved to prompt involuntary mimicking of social partners' actions, the scientists propose online July 20 in the *Proceedings of the Royal Society B*. The imitation effect was strongest for the scissors gesture, which the researchers note is very different from the starting fist position.
— Bruce Bower

MAX PLANCK INSTITUTE FOR EVOLUTIONARY ANTHROPOLOGY

Genes & Cells

66,360 Estimated new cases of non-Hodgkin lymphoma in the U.S. in 2011

19,320 Estimated deaths from non-Hodgkin lymphoma in the U.S. in 2011

DNA switches tied to blood cancers

Histone-modifying genes altered in non-Hodgkin lymphoma

By Tina Hesman Saey

Mutations in genes that flick other genes on and off may be at the heart of two forms of the blood cancer non-Hodgkin lymphoma.

Two separate studies found that mutations in the *MLL2* gene lead to the cancer, researchers report online July 27 in *Nature* and July 31 in *Nature Genetics*. For certain subtypes of non-Hodgkin lymphoma, the mutations appear to account for most cases.

"*MLL2* gets put right at the top of the list," says Ryan Morin of the British Columbia Cancer Agency in Vancouver. Morin and his colleagues found that the gene is mutated in 89 percent of cases of follicular lymphoma, a slow-growing form of the disease.

"It's a [mutation] that defines the disease," says Riccardo Dalla-Favera, a molecular hematologist at Columbia University and coauthor of the paper in *Nature Genetics*.

Both studies also found that mutations in *MEF2B* are associated with a form of the cancer called germinal center lymphoma.

The mutations are among 100 found in people with lymphoma, the authors of the *Nature Genetics* paper estimate, which indicates the complex landscape of genetic changes in the disease. "The biology is yet to be explored," says Dalla-Favera.

But even with limited information about what the two newly discovered mutations do, their ubiquity in some forms of non-Hodgkin lymphoma could make them good targets for cancer-fighting drugs.

The two genes help turn other genes on and off through epigenetic changes — chemical tags on DNA or associated proteins that change the way genes operate without altering their information content. In this case, these tags influence how tightly DNA strands are wound around spool-like proteins called histones, which package the genetic material and keep it from getting tangled up.

The researchers think the mutations interfere with gene activation in general, but that changing the activity of a small number of genes is probably what triggers the cancer.

"I don't think epigenetics is going to have a role in every cancer, but it's really been underappreciated," Morin says. ■

Life

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Dolphin can sense electric fields

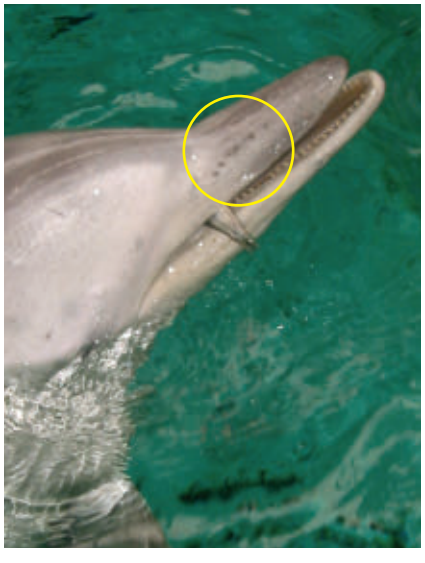
Ability may help species track prey in murky waters

By Nadia Drake

Fleeing fish beware: The Guiana dolphin has a super Spidey sense. But instead of danger, the dolphin detects faint electric fields generated by such things as contracting muscles, a beating heart and pumping gills — telltale signs of potential prey.

The dolphin is the first placental mammal known to have these super sensory powers, scientists report. It detects electric fields using organs on its snout that were once considered simple remnants of long-lost whiskers. Electroreception — the ability to sense these bioelectric fields — has already been described in sharks, amphibians, fish and some egg-laying mammals.

"We were really surprised to find this in the dolphin. Nobody had expected it," says sensory biologist Wolf Hanke of the University of Rostock in Germany.



Guiana dolphins can perceive electric fields using organs arrayed in pairs on their snouts. The dolphins are frequently referred to as "costeros," a name reflecting their preference for shallow, coastal waters.

Hanke and his team first suspected the Guiana dolphin (*Sotalia guianensis*) had electropowers based on the size of organs called vibrissal crypts on its snout. Earlier work suggested the crypts, shaped like pits, have a rich blood supply. "We thought they must have some function — they were pretty big — and otherwise would have disappeared during evolution," Hanke says of the crypts. When the team considered the dolphin's lifestyle, the idea became even more plausible. Scientists think the dolphins, which live off the eastern edge of Central and South America, are benthic feeders, gulping fish from the seafloor. The resulting plumes of sediment can limit visibility and echolocation, meaning a different way of detecting prey would be especially helpful.

> **"Everything that I'm doing when I'm talking, when my brain is working, is making an electrical field."**
>
> **PAUL NACHTIGALL**

The team reports the dolphin's sensory ability based on behavioral tests and an examination of the snout organs online July 27 in the *Proceedings of the Royal Society B*.

"This is a major breakthrough," says sensory physiologist Peter Madsen of Aarhus University in Denmark, who would now like to see additional dolphins tested. "I think they've demonstrated in a convincing way that this dolphin species can use electroreception, and in a way that's sensitive enough to potentially detect prey."

First, Hanke and his team examined a cross section of crypts taken from a dolphin that had died of natural causes. Under a microscope, the structures resembled electroreceptors in the egg-laying platypus and echidna, and looked somewhat like dolphin whisker follicles. The researchers counted 300 nerve fibers plugged into each one. "That's a lot," Hanke says. "It's not quite as much as pinnipeds [such as seals], but it's more than a rat's whisker."

The scientists then tested whether a Guiana dolphin could perceive electric fields. The researchers trained Paco, a 28-year-old male in captivity, to place his snout 10 centimeters from two electrodes set to emit either a current or no stimulus. When Paco detected a current, he would swim away. When he didn't, he stayed put. Paco's perceptive capabilities were then put to the test over hundreds of trials, using signals similar in strength to those generated by the dolphin's natural prey. Paco could perceive a current as weak as 4.6 microvolts per centimeter, much too faint for humans to perceive. "That's a factor of about 10,000 or so below what a human can feel when he touches a 12-volt battery with his tongue," Hanke says.

When researchers covered Paco's snout with a plastic shield, he didn't react to signals of any strength.

The scientists suggest that the crypts — originally responsive to mechanical, whisker-generated stimuli — evolved to respond to electrical stimuli instead. The necessary machinery is already there, Hanke says. "You just need to grow the nerve a little bit further and you have a basic electroreceptor."

Marine biologist Paul Nachtigall of the University of Hawaii at Manoa is curious whether related species have the same ability to detect natural electric fields, which animals generate in many ways. "Everything that I'm doing when I'm talking, when my brain is working, is making an electrical field. And water carries electricity," he says.

The finding, adds Madsen, is "a beautiful example of what's called convergent evolution, where animals find the same solution to the same problem, but from different starting points." ■

A. LIEBSCHNER

"We were really surprised to find this in the dolphin. Nobody had expected it." —WOLF HANKE

Wasps have a mind for mugs

Like humans, insect has a special gift for learning faces

By Susan Milius

A wasp may be the first invertebrate shown to have a special talent for learning faces of its own kind.

Like people, *Polistes fuscatus* wasps can tell individuals of their species apart. And like people, these northern paper wasps have a special talent for recognizing faces in particular, Michael Sheehan of the University of Michigan reported July 28 at the Behavior 2011 conference.

"To my knowledge, no other insect has yet been shown to have such specialized face learning for individual recognition," said Emilie Snell-Rood, an evolutionary biologist at the University of Minnesota. Studying how individuals of any species recognize each other enriches the understanding of a species' social scene.

Biologists have debated whether certain species — including people and some other primates, as well as sheep — have some specialized cognitive power for interpreting faces. Now, it seems, the discussion will spread to wasps.

The northern paper wasp turns out to be exceptionally good at learning the faces of others of its kind.

In *P. fuscatus* colonies, wasps sport irregular patterns of yellow, brown and black markings. Recognizing each other's quirky face markings seems to minimize aggression as queens clash for dominance when establishing joint nests.

Sheehan and colleagues experimented with the wasps' ability to learn by putting them into a T-shaped setup with an image at either end. Annoying electric tingles stopped when wasps moved toward the correct one of a pair of wasp faces, one of two abstract patterns or one of two caterpillar portraits. Researchers tested multiple pairs in each category.

The *P. fuscatus* wasps learned to select between images of all three types. Yet the insects did best when learning to pick out the correct wasp face, getting the right answer in about three-quarters of tests.

As further evidence that faces themselves are special to paper wasps, the insects did better at distinguishing images of real faces than learning images with face elements mashed together in unnatural clumps or of faces with the antennae blanked out.

Sheehan also tested a different species, *P. metricus*, and did not find signs of any special reaction to faces. But *P. metricus* lacks the varied face markings of *P. fuscatus*, and its colonies do not typically have more than one queen.

The contrast with *P. metricus* makes a particularly striking part of the case, said David Queller of Washington University in St. Louis.

P. metricus wasps did learn to distinguish between the variable faces of *P. fuscatus*. But their performance didn't differ from learning jumbled mashups of face parts or antenna-free faces. For them, Sheehan concludes, a face really is just another object. ■

MEETING NOTES

Good mother rattlesnake

Arizona black rattlesnakes may be more caring moms than researchers have given them credit for. Rattlesnakes give live birth to babies that are naïve but mobile and not in need of feeding. Females and babies linger near each other after birth, but how they interact has been a matter of discussion. Melissa Amarello of Arizona State University and two citizen scientists monitored new *Crotalus cerberus* moms and found a burst of defensiveness. Females that once tolerated people coming within a few yards began rattling at intruders from inside their dens, Amarello reported July 27. She even saw one female herding another mother's straying baby back to the den. —*Susan Milius*

Deviously helpful flowers

Nectar guides, the stripes and blobs on petals that tell pollinators where to sip, may help plants cheat insects. Anne Leonard and Daniel Papaj of the University of Arizona created a garden of fake flowers, some offering a sip of sugar solution and some not. Bumblebees lighting on a sugar-stocked flower found the reward faster if there were nectar guides. When researchers emptied the rewarding flowers and sugared up the former duds, bees returning to a previously lucky flower, now empty, were more likely to keep visiting if it had nectar guides. —*Susan Milius*

ISO well-spotted guy

Abdominal spots turn out to be the waspy version of a peacock's train. Marks on male *Polistes dominulus* paper wasps vary, and females prefer fellows with smaller, more elliptical ornaments, Amanda Izzo of the University of Michigan reported July 27. Such males are also more likely to win fights. Wasps raised on high-protein diets developed the more appealing look, the researchers found. —*Susan Milius*

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Atom & Cosmos

Collider finds heavy particle

Theory predicted existence of neutral Xi-sub-b baryon

By Devin Powell

Scientists have found a previously unseen particle using the Tevatron, the most powerful particle accelerator in the United States.

Predicted by the standard model of particle physics, the new particle fills a blank space in the family tree of baryons, making it a distant cousin of the neutron and the proton. Baryons are made of three quarks, fundamental building blocks of matter that come in different flavors. The newly discovered Xi-sub-b (Ξ_b^0) contains a strange quark, an up quark and a bottom quark.

"There are no big surprises, but we have an obligation to look everywhere we can to confirm whether the particles we predict are there or not," says Pat Lukens, a physicist with the Collider Detector at Fermilab, or CDF, team. Lukens presented the finding July 20 at the home of the Tevatron, Fermi National Accelerator Laboratory in Batavia, Ill.

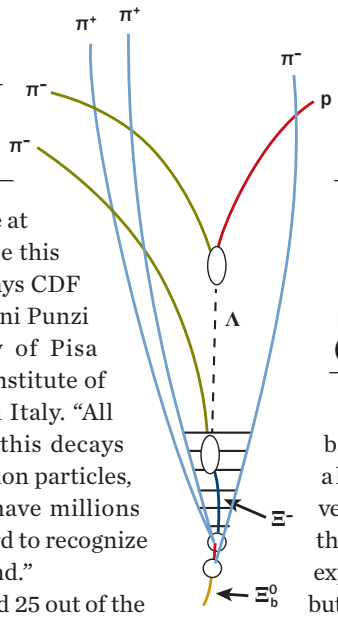
To find the rare particle, the CDF team sifted through data collected from 2001 to 2008. The circular collider creates new particles by smashing together protons and antiprotons traveling close to the speed of light; collisions reach energies of almost 2 trillion electron volts. That's about twice the energy of a flying mosquito concentrated into a spot the size of a subatomic particle.

The CDF detector did not directly observe the neutral Xi-sub-b, which breaks down almost immediately. Instead, the detector spotted debris left behind by this decay — a shower of lighter, longer-lived particles created during a complicated four-stage decay process.

"We weren't sure at all that we could see this particle's decay," says CDF spokesman Giovanni Punzi of the University of Pisa and the National Institute of Nuclear Physics in Italy. "All the particles that this decays into are very common particles, particles that we have millions of, that are very hard to recognize from the background."

Only an estimated 25 out of the almost 500 trillion collisions in the data matched this telltale decay signature.

The Fermilab physicists calculate the mass of the particle to be about six times that of a neutron. That figure agrees with theoretical calculations reported in the *Annals of Physics* in 2009.



Physicists saw signs of Xi-sub-b in the shower of particles it left behind — a Xi particle (Ξ^-), a lambda particle (Λ), pions (π) and a proton (p).

Their estimate is "right on, bang on," says Jonathan Rosner, a high-energy physicist at the University of Chicago who coauthored the 2009 paper. "I wouldn't have expected anything other than this, but it's still reassuring."

Seven other baryons containing a single bottom quark have been confirmed so far, including a sibling of the new particle with a down quark instead of an up quark, found by Fermilab scientists in 2007. A ninth, also predicted by theory, remains at large.

No new physics for Tevatron ... yet

World's largest collider KO's unusual findings from rival

By Devin Powell

After the world's most powerful particle colliders went toe-to-toe July 22 at the Europhysics Conference on High-Energy Physics in Grenoble, France, the result was a technical knockout.

Data from CERN's Large Hadron Collider near Geneva delivered a serious blow to hints of unusual new physics coming from the Tevatron at the Fermi National Accelerator Laboratory in Batavia, Ill. With 70 trillion collisions under its belt, the LHC has stalwartly defended the standard model, the reigning theory of particle physics.

"We're learning that the standard model is very hard to kill," says Pierluigi Campana, spokesman for the LHCb detector team.

Researchers at the Collider Detector at Fermilab had reported the first signs of a rare decay in a paper posted online July 12 at arXiv.org. Particles called B_s mesons seemed to be disintegrating into a muon (a cousin of the electron) and an antimuon more frequently than expected. The standard model predicts that three out of every billion B_s mesons will meet this fate. Measurements suggested a higher rate of about 18 per billion.

But at the recent meeting physicists from two LHC detectors presented B_s meson decay sightings consistent with established particle theory.

Fans can look forward to a rematch, however. The Tevatron has found signs that the top quark (the heaviest fundamental particle) and its antimatter partner, the antitop quark, prefer to move in opposite directions. An initial search at the LHC found no evidence of this puzzling behavior, which would be at odds with the standard model.

But with the LHC dataset expected to at least double in size this year and the Tevatron collecting data until its shutdown in September, everyone is looking forward to a winter bout between these friendly rivals.

CDF COLLABORATION

3 meters	Length of Curiosity rover	200 meters	Daily range of Curiosity on Mars	110 watts	Power of Curiosity's radioisotope thermoelectric generator

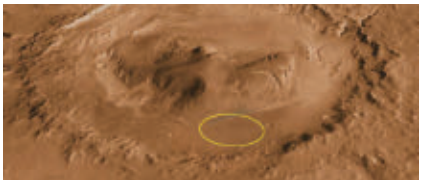
NASA sets sights on Martian crater

Rover Curiosity to begin exploring rocky basin in 2012

By Nadia Drake

NASA's six-wheeled Mars rover Curiosity now has a destination on the Red Planet: Gale Crater, an ancient, 150-kilometer-wide depression with a large mountain in the middle. The car-sized robot will spend at least two years wheeling around the rocky basin, collecting information about Martian history and looking for signs of habitable environments.

NASA announced the landing site for the $2.5 billion mission on July 22. Scheduled to launch later this year for an August 2012 landing, Curiosity and its payload of instruments will wheel around examining rocks, snapping photos and eating dust. There are 17 cameras on board; one on the rover's belly will capture the dramatic descent to the surface. A laser will help Curiosity identify intriguing rocks to study. When it finds one, the rover will approach the rock and drill into it, producing a powder that Curiosity will then ingest and analyze.



The rover Curiosity will touch down in Gale Crater, just south of the Martian equator, at the site outlined in yellow.

Gale Crater's central mound is a 5-kilometer-tall stack of sediments that scientists can read like chapters in a history book. The rocky pages will reveal Mars' geologic and environmental history, including how much water may have drenched the basin once upon a time. The crater also features canyons and fissures that may once have been habitable.

"Our primary goal is to explore habitable environments," says project scientist John Grotzinger of the Jet Propulsion Laboratory in Pasadena, Calif. "That means we have water present, that means we have a source of energy for microbes to undertake metabolism to live, and that we also have a source of carbon for life as we know it."

Curiosity will study clay deposits near the base of the mountain, then head toward an area rich in sulfur salts. Both form in the presence of water, says geologist Dawn Sumner of the University of California, Davis.

Gale Crater has been on the short list of Mars target sites for at least a decade.

NASA, JPL-CALTECH, ASU, UA

Matter & Energy

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Objects hidden in plain light

New invisibility cloaks work at visible wavelengths

By Devin Powell

The first invisibility cloaks that live up to their whimsical nickname have arrived.

Unlike previous cloaks, which manipulated specially polarized light or microwaves and infrared light already invisible to humans, two new approaches bend ordinarily visible light. Disguised by one of these materials, an object could vanish before your eyes.

"If invisibility is the goal," says applied physicist Majid Gharghi of the University of California, Berkeley, you need to build something that affects signals detectable by the human eye.

The cloak made by Gharghi's team is a sheet of silicon nitride draped over a bump. Light striking this bulge would normally scatter, revealing the anomaly. But thousands of tiny holes of different sizes etched into the silicon nitride guide the light, hiding the bump and anything beneath it. Light over a wide range of colors behaves as if striking a flat surface instead, the researchers report in the July 13 *Nano Letters*.

"The experimental demonstration at blue, green and red light looks impressive," says Steven Cummer, an electrical engineer at Duke University.

The holey pattern in the spongelike cloak curves light according to the same kind of mathematics that describes how a star's gravity curves a passing beam. Making such materials, called metamaterials, for visible light has been a long-standing challenge. The holes must be smaller than the wavelength of the light — mere tens of nanometers across for visible light, the shortest wavelengths cloaked to date.

The first prototype isn't ready to be wrapped up and sent to Hogwarts, though. It works only for light moving in a particular two-dimensional plane. Creating a 3-D silicon nitride bump capable of tricking light coming from any direction would be difficult with the techniques used in this experiment, says Gharghi.

"In this sense, their result is a major step backward," says Martin Wegener, an applied physicist at the Karlsruhe Institute of Technology in Germany.

Wegener and his colleagues recently developed a different carpet cloak that can hide a 3-D bump from red light passing through open air, using a plastic that is easier to work with than metamaterials.

The drawback is that holes can be made only so small in the polymer. This cloak can hide an object from red light, but fails at the shorter green and blue wavelengths, the researchers report in the June 1 *Optics Letters*.

C'mon radio, let's do the twist

Innovation might dramatically increase wireless bandwidth

By Devin Powell

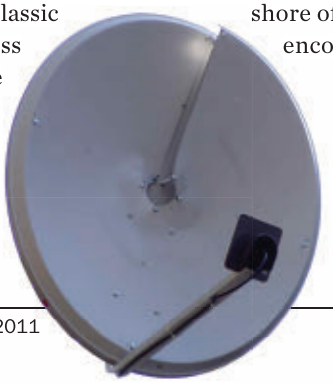
Broadcasting live from Italy: a new twist on radio that could pack more information into the airwaves.

Scientists have demonstrated a way to mold radio waves into spirals that could allow multiple radio stations to broadcast at the same frequency. Two waves with different shapes can carry different information without overlapping or interfering with each other.

That's good news not only for classic rock 'n' roll, but also for wireless networks and cell phones. These technologies communicate in the increasingly crowded radio frequencies, which lie between three hertz and 300 gigahertz.

"We think we can increase the bandwidth by an order of magnitude," says Fabrizio Tamburini, an astronomer at the University of Padua in Italy, whose team describes the recent experiment online July 12 at arXiv.org. This tenfold boost in capacity could help new wireless devices communicate without interfering with each other.

On the night of June 24, Tamburini and colleagues beamed two radio signals from a historic lighthouse on San Giorgio Maggiore, an island just offshore of Venice. The first encoded a pure tone in a traditional radio wave with peaks and troughs lined up neatly in a single, two-dimensional plane. The second signal bounced off a dish shaped like a flattened spiral staircase 80 centimeters across. This dish wrapped the electromagnetic radiation into a corkscrew without distorting the information it carried — a second tone with a higher pitch.



Twisted antenna dishes could pack multiple radio broadcasts into a single frequency.

F. TAMBURINI

The two signals, both broadcast at 2.4 gigahertz, traveled 442 meters through the air across open water and arrived onshore at the Doge's Palace, which once housed the rulers of Venice. A parabolic antenna picked up the radio waves, disentangling them like strands of woven rope. A crowd gathered below to hear the sounds, says Tamburini.

"Similar things have been done before using optical vortices and visible light, but not, to my knowledge, using radio waves," says Grover Swartzlander, a physicist at the Rochester Institute of Technology in New York.

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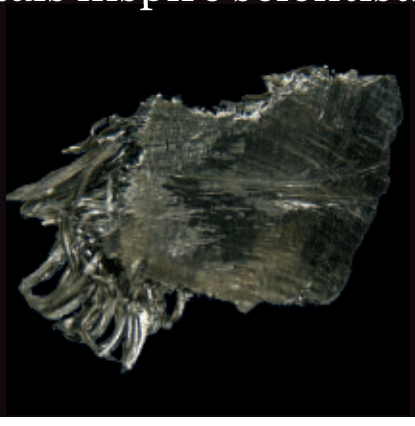
Sparing the

Potential shortages of useful metals inspire scientists to



The Toyota Prius isn't exactly a muscle car. But the magnets under the hood certainly pack a punch.

Pound for pound, these permanent magnets are some of the most powerful on the planet. They generate fields 10 times stronger than those of typical refrigerator magnets, helping the hybrid car's motor and generator to turn the wheels and charge the battery. The secret to the magnets' intense fields? About three pounds of alloy made with rare earth elements.

Rare earths, 17 chemical elements found mostly in an appendage to the periodic table, have long been the darlings of solid-state physics and the electronics industry. Without these materials, hard drives wouldn't be able to store so much information and smartphones wouldn't be so pocket-friendly.

"Take away the small rare earth magnets inside the earbuds for your iPod, and you're back to traditional-looking over-the-ear headphones," says Alex King, director of the U.S. Department of Energy's Ames Laboratory in Iowa.

But some people, particularly in the United States and Japan, have begun to worry about potential shortages in the supply of rare earths. Although the elements are not rare in themselves, they are concentrated in just a few locations. Last year, China produced about 97 percent of the rare earths mined on the planet. In recent years that country has been cutting back on the amount of rare earths it exports, reducing quotas by almost 40 percent in 2010.

Rising prices and a looming potential shortage have now ignited searches for alternatives to magnet technologies that chew up large amounts of rare earths.

For some applications, rare earth elements may be simply irreplaceable. The phosphors used in color televisions and other displays with cathode-ray tubes get their brilliant reds from europium compounds. This rare earth's electrons jump between energy levels and emit light in ways that can't be mimicked by any other element in the periodic table.

Magnets, which account for about one-fifth of global rare earth consumption, may be a different story. With DOE funding, materials scientists in the United States are reviving the study of magnets, a field that hasn't seen a major breakthrough in nearly three decades. Meanwhile, Japan — second only to China in global magnet production — has dedicated more than $150 million of its 2011 budget to research that would reduce its need for rare earths.

Some scientists plan to make the strongest rare earth magnets stronger with blends that use less of these materials. Others hope to ditch the elements in favor of common metals that might be good enough to get the job done.

"A lot of old problems in permanent magnetism are being revisited with new tools," says Oliver Gutfleisch, a materials scientist who studies magnets at the Leibniz Institute for Solid State and Materials Research in Dresden, Germany. "We have to produce a next-generation magnet."

Revisiting the iron age

The strength of a magnet — its ability to tug on iron — starts with its electrons. Every electron spins around its axis, like a planet or a figure skater. In most substances, electrons pair off, spinning in opposite directions. But some elements have unpaired electrons that spin in a way that makes their atoms into tiny bar magnets, with a north and a south pole. Expose a group of these atoms briefly to a magnetic field, and they line up with one another straight as soldiers, working together to make one big magnet.

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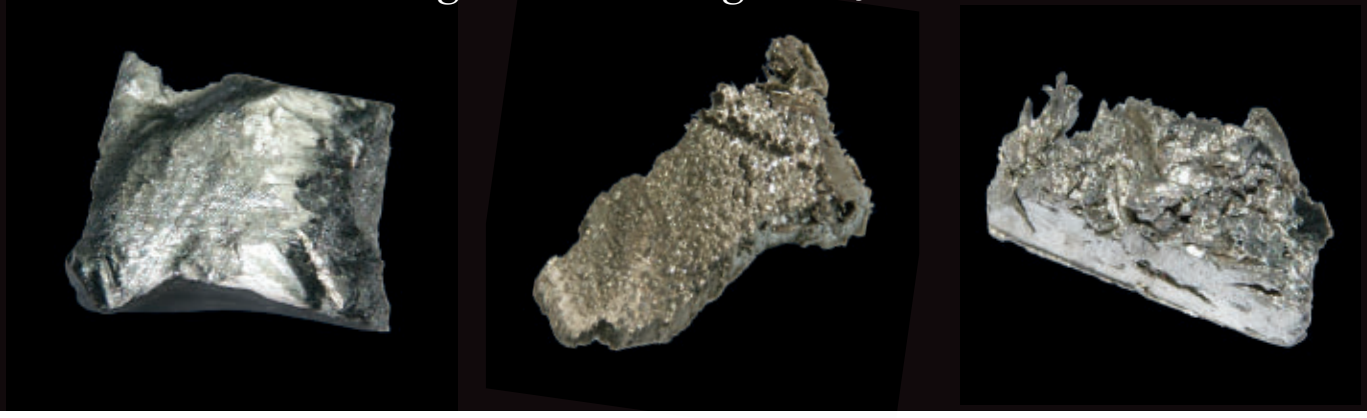
rare earths

seek alternatives for magnet technologies

By Devin Powell



A potential shortage of several rare earth metals (some shown) has spurred research into technologies that don't require them.

Iron is one of the most magnetizable materials on Earth, but there's a good reason why magnets aren't usually made of pure iron. At the slightest provocation, such as a tiny electric field or change in temperature, iron's atoms break rank and swing out of alignment, ruining the magnet. Iron is thus considered magnetically soft.

Metallurgist Iver Anderson, who spent years purifying rare earth metals in the crucibles of the Ames Laboratory, now hopes to harden soft iron alloys to create a magnet free of rare earths. The goal isn't to make something that can rival today's best magnets, just something with a better bottom line.

"For many applications, we don't have to reach the same magnetic strength levels as rare earth magnets," he says. "For hybrid cars, we need something maybe 50 percent or so as strong."

Anderson and his colleagues plan to harden a blend of iron and cobalt by changing the shape of its crystal structure. The cube-shaped atomic lattices that make up iron cobalt give atoms too much freedom to wiggle around. Other crystal structures, such as hexagons and tetrahedrons, are better at keeping atoms in line, so "we're trying to figure out a way to distort the cubic structure and make it tetrahedral," says Anderson. Computer simulations he presented at an Energy Department meeting in May suggest that this goal could be achieved by peppering the usual iron cobalt recipe with other atoms: tungsten, maybe, or nitrogen.

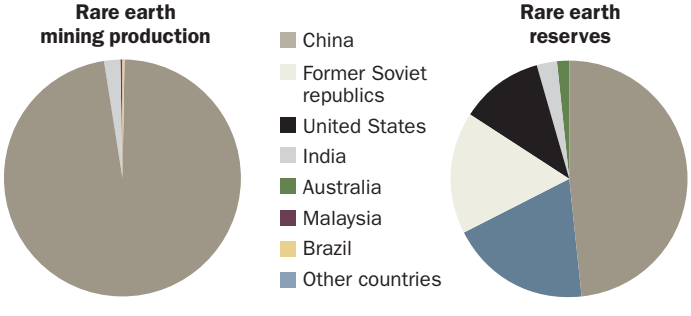
The Ames team is also dusting off "alnico" magnets, commercialized in the 1940s. Made mostly of aluminum, nickel, cobalt and iron, these magnets are reasonably hard but only about one-fifth as strong as the best rare earth magnets. Tweaking the structure of these magnets to line up the iron cobalt grains might up the oomph.

"We're at least a year away from knowing whether this will work," Anderson says. "Whether it makes sense from an economic standpoint is another step beyond that."

Another scientist who wants to work with magnets from the iron age is Migaku Takahashi of Tohoku University in Japan. He is experimenting with combinations of iron and nitrogen because thin films made out of these elements are the most magnetizable material known. In March, Takahashi's collaboration announced a method to create powders that retain this property, though they still lack the hardness needed to be useful for rare earth–free magnets. Like Anderson, Takahashi is taking the

Rare indeed

China contains about half the world's reserves of rare earth elements, and it far outstrips other countries in producing them from mining operations.



SOURCE: USGS

long view; he doesn't expect to be able to make a commercial magnet out of this material until at least 2023.

Rare attraction

Uncertain that these well-explored traditional materials will yield new surprises anytime soon, Ames scientists and other groups are trying to reinvent rare earth magnets from the bottom up.

The best rare earth magnets used today date to 1983, when scientists at General Motors and the Sumitomo Special Metals Co. in Japan independently created the first alloy of iron, boron and the rare earth metal neodymium. This breakthrough was driven by economics; the best magnets at the time were made of cobalt and the rare earth samarium, and the price of cobalt was rising rapidly.

Adding neodymium atoms smothers some of the iron's magnetic strength but greatly improves its ability to resist demagnetization. Neodymium magnets can achieve about 56 megagauss-oersteds, or MGOe, a unit of magnetic field strength. That compares with more than 10 MGOe for the best non–rare earth magnets, and less than 5 MGOe for the stuff used in refrigerator magnets.

"It's hard to imagine making a more perfect magnetic material than neodymium-boron-iron," says George Hadjipanayis, a materials scientist at the University of Delaware in Newark, whose research was crucial to the invention of the first neodymium magnets.

Confident that no single material could do a better job, Hadjipanayis and his colleagues have turned to composite neodymium magnets. The researchers are grinding magnetically hard and soft materials into pellets and trying to bind them like candies stuck in a ball. The soft stuff, perhaps iron cobalt, should boost the magnet's pull. The hard stuff, rare earth compounds, should preserve the strength.

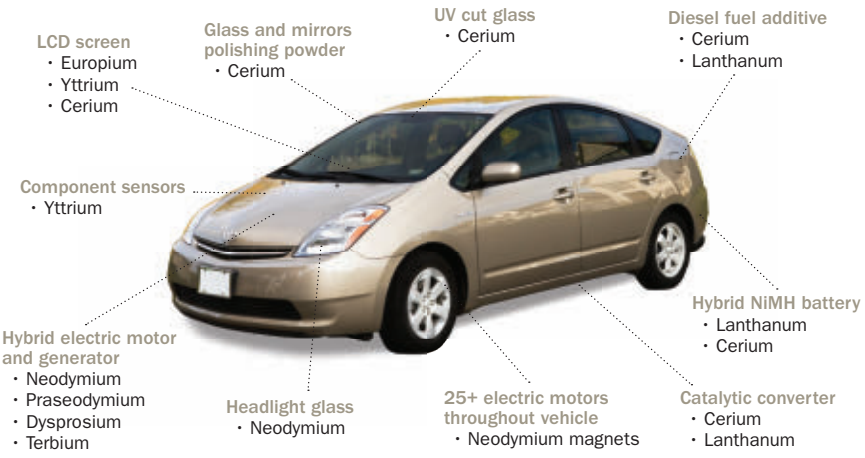
For the materials to play well together, though, these pellets must be extremely small, small enough to qualify as a "nanocomposite" material. When hard chunks and soft chunks are arranged in a kind of patchwork quilt, the hard bits stay connected over distance by the equivalent of magnetic springs. If stretched too far over the soft bits, the springs snap, and the nanocomposite stops behaving as a single material.

A magnet structured as a nanocomposite could achieve some 120 MGOe — more than twice as strong as anything on the market today, according to calculations published in 1993 by Ralph Skomski and Michael Coey of Trinity College Dublin. It would also use significantly less rare earth material.

"Nanocomposite magnets are the holy grail for rare earth magnets," says John Burba, executive vice president and chief technology officer at Molycorp Minerals in Greenwood Village, Colo.

New teamwork

Thanks to advances in nanotechnology in the years since nanocomposites were first proposed, Hadjipanayis' team can now create suitably tiny and uniform bits of hard and soft magnetic materials — while also preventing oxygen from



Hybrid vigor A vehicle such as the Toyota Prius contains rare earth elements throughout its various advanced technologies, including more than 20 pounds of lanthanum in the battery pack.

What rare earth elements are good for

Element	Sample use
Scandium (Sc)	Alloyed with aluminum in baseball bats
Yttrium (Y)	Alloyed with other metals to make aircraft engines
Lanthanum (La)	Improves refractive index of camera lenses
Cerium (Ce)	Found in catalysts in self-cleaning ovens
Praseodymium (Pr)	Tints welding goggles
Neodymium (Nd)	Mixed with iron and boron to make the world's strongest permanent magnets
Promethium (Pm)	Emits radiation used in long-lived nuclear batteries
Samarium (Sm)	Mixed with cobalt to make strong permanent magnets
Europium (Eu)	Gives light to red phosphors in televisions
Gadolinium (Gd)	As an MRI contrast agent, improves clarity of images
Terbium (Tb)	Gives light to green phosphors in televisions
Dysprosium (Dy)	Hardens magnets against high temperatures
Holmium (Ho)	Absorbs neutrons in nuclear reactor control rods
Erbium (Er)	Turns ceramic glazes pink
Thulium (Tm)	Emits radiation in portable X-ray machines
Ytterbium (Yb)	Added to semiconductors in solid-state lasers
Lutetium (Lu)	Detects radiation in PET scanners

damaging their surfaces, a key problem in making nanocomposite magnets. So can a team at General Electric's Global Research Center in Niskayuna, N.Y.

GE is pursuing nanocomposite magnets because it's the largest manufacturer of wind turbines in the United States. New turbine designs incorporate huge magnets that can better handle fluctuations in wind speed and provide more torque than older designs. But a turbine capable of powering about 2,400 homes uses as much as a ton and a half of rare earth permanent magnets.

Last year, in response to a steep increase in the price of the metal rhenium (which is not a rare earth), GE scientists made a very strong replacement "superalloy" out of very small grains of nickel. Using techniques similar to those developed for that and other work, the researchers now aim to improve the strength of rare earth magnets by about 40 percent while decreasing the amount of rare earths in the magnets by 80 percent. What these magnets will be made of, though, is still anyone's guess.

"We're exploring several different hard and soft materials but haven't selected a specific chemistry yet," says materials scientist Frank Johnson of GE.

Choosing the right stuff for a nanocomposite isn't easy. In 2002, physicist Ping Liu, now at the University of Texas at Arlington, and colleagues published a paper in *Nature* describing experiments that mixed magnetically hard and soft particles made of iron and platinum. His team fused the particles, and the resulting magnetic fields were more than 50 percent stronger than the hard material on its own.

But Liu hasn't figured out how to get all of the grains lined up before fusing, which would allow the nanocomposite to reach its full potential. And the platinum may make this approach too expensive to be viable for everyday magnets.

Dyspros and cons

If they ever live up to their promise, nanocomposite magnets should reduce the demand for both neodymium and for another rare earth element called dysprosium.

Dysprosium hardens magnets against heat by reshaping their magnetic fields. Every neodymium magnet intended for a hybrid car, a wind turbine or another application in which temperatures soar to hundreds of degrees must be spiked with a bit of the pricey dysprosium. It costs more than seven times as much as neodymium and is currently mined in only one place in the world: clays in southern China. So some researchers are exploring pragmatic ways to cut down on its use.

Changing the microstructures of magnets could help, as neodymium magnets made of smaller grains are naturally more resistant to demagnetization. Working with the magnet company Intermetallics, materials scientist Satoshi Sugimoto of Tohoku University and colleagues recently developed fine-grained magnets that require 40 percent less dysprosium.

The best fine-grained magnets completely free of dysprosium may belong to Kazuhiro Hono, a researcher at the National Institute for Materials Science in Tsukuba, Japan, and colleagues. These magnets, to be described in September in *Scripta Materialia*, are 60 percent more resistant to demagnetization than commercial neodymium magnets that lack dysprosium. But Hono's magnets are still not quite good enough for cars and wind turbines.

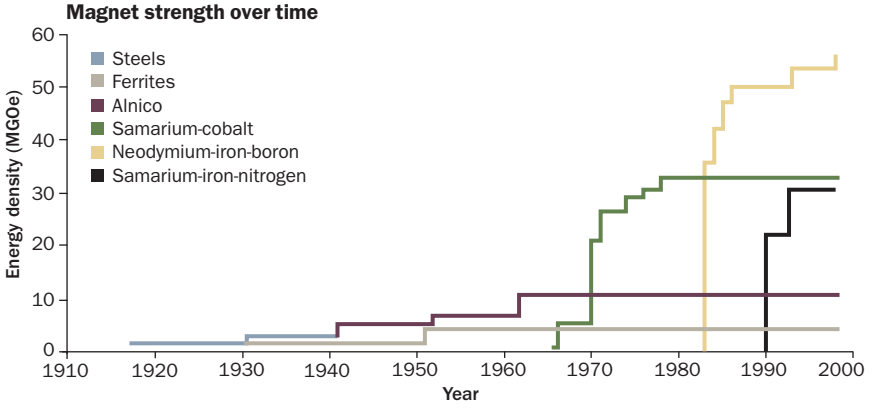
Despite recent advances, neither Japan nor the United States appears to be counting on magnet breakthroughs anytime soon. Geologists from the University of Tokyo and their colleagues recently proposed dredging the Pacific Ocean for rare earths (*SN: 8/13/11, p. 14*). Several Japanese companies have also started "urban mining" programs meant to reclaim the rare earths buried in cell phones and other devices. Hitachi is working to reclaim 80 percent of the rare earths from the magnets of discarded hard drives and air conditioners.

In the United States, Molycorp Minerals has reopened a mine on the edge of California's Mojave Desert that was once a profitable source of europium and cerium. Last year, the company began processing previously mined ore for rare earths, including neodymium.

But these efforts to dig out of a difficult situation may not prove economical, and the combined creativity of scientists on both sides of the Pacific may fall short. So Toyota has launched a program to rid its cars altogether of permanent magnets — rare earth or not — by developing a new motor that would run on electromagnets, which generate fields by passing current through coils of wires and have traditionally been considered too bulky for hybrid and electric cars.

If Toyota engineers succeed, these new motors could push forward the next generation of hybrid vehicles without the need for any rare earths. ■

Power up Magnets containing rare earth elements, such as neodymium and samarium, achieve far higher measures of magnetic field strength than older magnets based on iron alloys.



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Explore more

- Ames Lab site on rare earths: www.ameslab.gov/rare-earth-metals

the color of controversy

Link between food dyes, childhood hyperactivity gets renewed attention

By Laura Beil

When it comes to the safety of dyeing food, the one true shade is gray.

Artificial colorings have been around for decades, and for just about as long, people have questioned whether tinted food is a good idea. In the 1800s, when merchants colored their products with outright poisons, critics had a pretty good case. Today's safety questions, though, aren't nearly so black and white — and neither are the answers.

Take the conclusions reached by a recent government inquiry: Depending on your point of view, an official food advisory panel either affirmed that food dyes were safe, questioned whether they were safe enough or offered a conclusion that somehow merged the two. It was a glass of cherry Kool-Aid half full or half empty.

About the only thing all sides agree on is that there would be no discussion if shoppers didn't feast with their eyes. Left alone, margarine would be colorless, cola wouldn't be dark, peas and pickles might not be so vibrantly green, and kids cereals would rarely end up with the neon hues of candy. But as the 1990s flop of Crystal Pepsi showed, consumers expect their food to look a certain way.

Some of the earliest attempts to dye food used substances such as chalk or copper — or lead, once a favorite for candy — that turned out to be clearly harmful. Most of the added colors in use today were originally extracted from coal tar but now are mostly derived from petroleum.

Overseeing the safety of artificial food color was one of the reasons the U.S. Food and Drug Administration was founded (with its current name, in 1930). And the issue of food dye safety has continued to attract government notice, sometimes in dramatic ways, such as the time investigators demanded to know why trick-or-treaters became ill in 1950 after eating Halloween candy dyed with orange No. 1.

The most recent government attention came in March, when an FDA advisory panel made up of scientists, consumers and industry representatives held a two-day hearing to try to

SUZANNE TUCKER/SHUTTERSTOCK

determine whether food dyes cause hyperactivity in children. It is a debate that has gone on, in some incarnation, more than 30 years. Though scientific attention has grown, the disagreement lingers, partly because the issue is complicated to study and partly because dyes, if harmful, probably affect only a subset of children who have some yet-undiscovered genetic sensitivity. Over the years, skeptics of any connection have seized on uncertainties and other logistical flaws in the research that could lead to misleading results.

Still, many scientists say studies are strong enough to warrant some kind of government action. And some of them are now criticizing the FDA, saying that, in retrospect, questions about the hyperactivity-dye link were presented to the advisory panel in a way that meant inaction was almost a foregone conclusion.

"To me, the whole process was defective," says Bernard Weiss, a psychologist in the Department of Environmental Medicine at the University of Rochester School of Medicine and Dentistry in New York who was invited to speak before the panel. The main question that committee members were assigned was whether "a causal relationship between consumption of certified color additives in food and hyperactivity in children in the general population has not been established" (a conclusion ultimately supported by 11 of 14 voting panel members).

Weiss calls that "a ridiculous question," not only because of its tortured, negative wording, but also because even those concerned about food dyes acknowledge that the science has not shown a link to hyperactivity in *all* kids.

Untrue colors

Nine different artificial dyes are currently approved for use in the United States; many of these chemicals have been staples of the food industry for generations. While the FDA does not have data on consumption, it does keep track of how much dye of each type gets the OK for use in products; the amount per capita has increased fivefold since the 1950s. Dyes have never been without criticism — a "pure food" movement was well under way even by the late 1800s. But specific concern about hyperactivity and other neurological effects first arose in 1975, when Ben Feingold, former chief allergist at Kaiser Permanente Medical Center in San Francisco, hypothesized that food additives were contributing to hyperactivity. His book *Why Your Child is Hyperactive* drew largely on his own clinical observations.

In 1976 in the journal *Pediatrics*, researchers published a study that compared a regular diet with a diet that eliminated artificial flavors and colors in 15 hyperactive children. After eating what has since become known as the "Kaiser Permanente elimination diet" or the "Feingold diet," children showed an improvement in symptoms such as difficulty paying attention.

Three decades of studies since then have accumulated evidence linking food dyes to an exacerbation of hyperactivity. But the controversy remains unsettled. Skeptics have a lot of ammunition, pointing out that findings often have been inconsistent and confusing. To set up a study of food dyes, researchers have to juggle a lot of variables at once — including how big a dose of dyes to give, which ones to give and the fine art of having parents and teachers document symptoms that aren't easy to measure.

Other factors also complicate the research. Studies have used mixtures of dyes, making it difficult to tease out the possible effects of any individual color. Also, it may be that only an unknown subset of children are affected: In a scientific analysis, the children not affected might outnumber those who are, blunting the overall findings when data are lumped together.

Finally, evidence suggests that dyes may not be the lone culprit. Children who appear to be sensitive to dyes may also have neurological reactions to other ingredients, even naturally occurring components such as wheat and chocolate. In some studies, children were given the dyes in cookies; if the children react to wheat or milk as well, the "placebo" might not have been the placebo scientists thought.

In the end, the disagreement comes down to this: How much evidence is necessary to add product warnings about (or ban, as some consumer groups want) chemicals that offer no nutritional benefit and are consumed each day by millions of healthy children?

Europe gets the blues

Food safety advocates believe the substantial suggestion of harm, even without proof, is enough to take action. So does the European Parliament, which in 2008 dictated that foods with certain dyes had to contain warnings that the

Added color The U.S. Food and Drug Administration currently certifies nine synthetically produced food dyes (three popular colorings are described below). Such dyes can transform colorless products, giving faded veggies a more vibrant hue and making children's candies more fun.

Brilliant blue
Designated as blue No. 1 by the FDA, this dye is found in ice creams, ice pops, baked goods and a host of blue raspberry–flavored beverages. It shows up in ranch-flavored chips, prepared guacamole and mixed-berry applesauce. The dye was approved by the FDA in 1969.

Allura red
Red No. 40 is found in strawberry-flavored drinks, ice creams and cream cheeses; some Nutri-Grain bars; licorice; and most other red sweets. It was approved by the FDA in 1971 and, in terms of consumption, is currently the most-used food dye.

Tartrazine
Yellow No. 5 is in products such as Mountain Dew, Peeps, Doritos and Cheez Doodles. It's commonly found in relish, pickles, lemon-flavored seasonings and boxed macaroni and cheese. The dye was approved by the FDA in 1969.

FROM TOP: SONDRAP/ISTOCKPHOTO; NITO/SHUTTERSTOCK; GREENPIMP/ISTOCKPHOTO

chemicals "may have an adverse effect on activity and attention in children." Neither the FDA nor American lawmakers have gone that far, saying that the levels of dye currently in foods are safe.

Most dyes have no set cap on the amount that can be used, just stipulations requiring manufacturers to use only enough to reach their desired color, and no more. "When the FDA established legal limits on dyes, they did not consider children," says Laura Anderko, a researcher in public health at Georgetown University Medical Center in Washington, D.C. And it is not known, she says, what the lasting effects from constant exposure might be. "Kids, they have a long shelf life. If they are exposed at an early age — depending on those kinds of petrochemicals that are consumed — it could mean lifelong impacts," she says.

The color industry says any link between food coloring and hyperactivity remains unproven. "We don't see any strong compelling data at this point that there is a neurological effect," says Sean Taylor, a chemist at Verto Solutions in Washington, D.C., and a representative of the International Association of Color Manufacturers. He notes that the dyes on the market today have been consumed in populations worldwide, without any apparent harm, for decades. In animal toxicity tests, Taylor says, most of the dyes in food are excreted, and the small amounts absorbed are broken down by the liver.

More than a dozen clinical studies have tried to investigate the relationship between food dyes and hyperactivity. In 2004, psychiatrists David Schwab from Columbia University and Nhi-Ha Trinh of Harvard University published a meta-analysis of all 15 known double-blind placebo-controlled trials — meaning those in which neither the researchers nor the participants knew who was getting the dyes. That study, in the *Journal of Developmental & Behavioral Pediatrics*, reported that the results "strongly suggest an association" between food dyes and hyperactivity, though the researchers included a long list of caveats.

Following the 2004 meta-analysis, the British Food Standards Agency (the equivalent of the U.S. FDA) commissioned large studies to further examine whether food dyes, along with a common food preservative, affected children's behavior. Unlike most previous investigations, these new experiments included children from the general population who had no history of hyperactivity.

In those studies, researchers from the University of Southampton gave two groups of children (one toddler group, and one school age) beverages with one of two mixes of food dyes and the preservative sodium benzoate or a placebo, and asked parents and educators to note any behavior changes. The older children also took a computerized test designed to measure attention.

The results, published in 2007 in the *Lancet*, "lend strong support for the case that food additives exacerbate hyperactive behaviors," the researchers write. "Our results are consistent with those from previous studies and extend the findings to show significant effects in the general population." The scientists recognized the potential political impact of their findings: "The implications of these results for the regulation of food additive use could be substantial."

And in Europe, they were. While the European Food Safety Authority did not think the evidence was strong enough to prompt action, the European Parliament was convinced. Dyes are not banned outright, but warning labels alone have been enough to change the way many products are made. A strawberry sundae at McDonald's in the

In the limelight

Though concern over a link to hyperactivity has prompted the latest attacks on food dyes, artificial colorings have caught the public's attention for other economic and health reasons for more than a century.

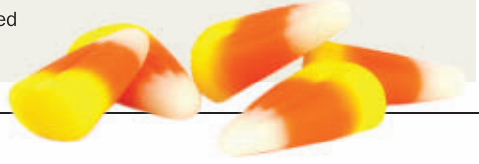
1850s A Victorian-era domestic standby *Enquire Within Upon Everything* described how bread could be tested at home for the presence of alum, a metallic salt used to create a more preferable, whiter color in the dietary staple. As early as the Middle Ages, some bread manufacturers were rumored to make very white bread on the cheap by adding chalk.

1890s One effort used by the dairy industry to prevent newly invented and relatively cheap margarine from undercutting the popularity of butter was the push for regulations that would tax or ban margarine with the yellow tint of butter. (Naturally, margarine is colorless.) Anticoloring laws were adopted in 30 states, and some legislatures went so far as to demand that margarine be dyed pink. Because of the restrictions, some margarine manufacturers sold yellow dye packets with their products, so consumers could color their own margarine at home.

1950s In 1950, children became ill after eating Halloween candy containing orange No. 1, which had been approved for use in food by the U.S. Food and Drug Administration. The reports led to a public outcry, and along with other concerns, led the FDA to re-evaluate the safety of food colorings. Several dyes were delisted, and the Color Additive Amendments of 1960 established the current regulatory protocol.

1970s In the 1970s, it was red No. 2's turn to cause a stir. Russian studies had suggested that the dye caused rats to develop intestinal tumors and was toxic to the gonads and embryos. Though the tests were largely debunked, when combined with earlier studies showing breast tumors in female rats fed the dye, the findings were enough to lead to a public health scare. The FDA banned red No. 2, and many manufacturers removed red products regardless of whether they contained the dye. Mars didn't bring back red M&Ms until the late '80s.

1990s Natural food dyes have caused controversy too. The reddish cochineal extract and carmine came to the attention of the Center for Science in the Public Interest in 1998. The dyes, made from a type of female beetle, had been used for hundreds of years, exempt from certification because they are natural. Recorded allergic reactions as well as anecdotal reports of outrage among vegetarians and kosher-keeping Jewish people who were unknowingly consuming insect products prompted demands for labeling. The FDA agreed to require manufacturers to list the dyes as ingredients on the product label, but consumers have to figure out for themselves that the products come from animals.



KARENMOWER/ISTOCKPHOTO

United States gets a boost of crimson from red No. 40. In Great Britain, a McDonald's strawberry sundae gets its red only from strawberries.

In 2008, the year warning labels took effect in Europe, the D.C.-based Center for Science in the Public Interest (the same food watchdogs known to denounce the nutritional wasteland of convenience foods and movie popcorn) petitioned the FDA to ban the dyes. A long list of scientists and researchers signed on to the center's appeal. "Food manufacturers voluntarily could substitute safe natural colors or other ingredients (such as fruit or fruit juices) for dyes, but that's unlikely to happen throughout the food supply without the level playing field provided by government regulation," the document stated. "Accordingly, the Food and Drug Administration ... should ban the use of dyes in all foods; until such action takes effect, the FDA should require a prominent warning notice on product labels."

While no large trials have been published since 2007, the government took the Center for Science in the Public Interest petition seriously enough to hold the hearings in March, asking members of its Food Advisory Committee to decide whether the evidence establishes a link between food dyes and hyperactivity in children in the general population.

Even Michael Jacobson, executive director of the Center for Science in the Public Interest, says he would answer "no." To him and others, it was not the valid question to address. Better, he said, would have been to assess whether food dyes pose a danger to certain children, in the same way that allergens affect only susceptible people. Few products, no matter how dangerous, affect everyone in the population. "Even smoking does not affect everybody," he says.

Metabolic black box

No one knows which children may be at risk, because the biology behind any potential neurological effect associated with hyperactivity isn't clear. Taylor, the color industry biochemist, says that animal studies find that the molecules do not easily get through intestinal cell walls, and most of the dye passes through the body without leaving the digestive system.

Laura Stevens, a nutrition researcher at Purdue University in Indiana, acknowledges that this is the case. "In animals, very little of it is absorbed," she says. "It is excreted in the feces." But that doesn't necessarily negate the idea of any effects on the body, she says; effects could come through metabolites, or through indirect mechanisms.

As examples, she cites two studies by British researchers. In one, published in the *Journal of Nutritional Medicine* in 1990, the scientists investigated how the yellow dye tartrazine affected the zinc levels of 10 hyperactive boys, compared with 10 nonhyperactive peers. (Zinc is a mineral important for proper brain function.) The team found that zinc levels dropped in the blood and increased in the urine among the hyperactive kids after tartrazine consumption. Another study, published in the *Journal of Nutritional and Environmental Medicine* in 1997, found a similar drop in zinc levels, and an increase in hyperactivity, in some children consuming tartrazine.

Newer research suggests that dyes trigger the release of histamines, which are part of the body's immune system. An experiment reported last year in the *American Journal of Psychiatry* suggested that differences in genes that control histamines might explain why some children are affected and others are not.

But studies are few. In truth, Stevens says, aside from extrapolations from animal studies, the metabolic fate of dyes in humans is a black box. She and her colleagues at Purdue are among those trying to look at food dye metabolism in humans. "If there's any chance at all there's a problem, this should be addressed," she says.

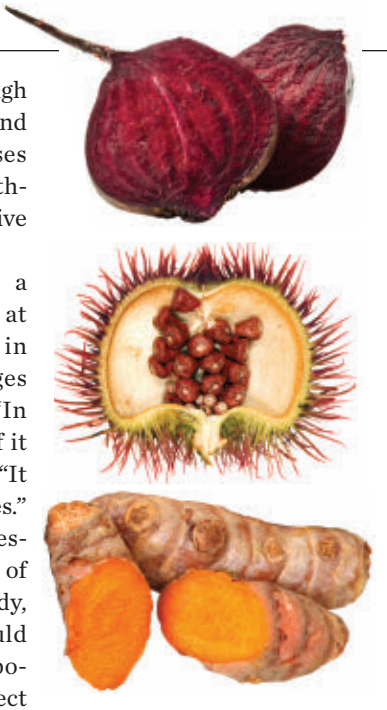
Ultimately, the future of food dyes may not rest with scientists or government regulators, but with consumers, says Ron Wrolstad, an agricultural chemist at Oregon State University in Corvallis.

"A lot of times now, particularly with natural colorants, it will be a marketing decision rather than a regulatory ruling," he says. The snack food giant Frito-Lay, for instance, has announced, and heavily publicized, a commitment to use fewer artificial dyes in its products. A company spokeswoman said in December that the move was in response to consumers wanting more snacks "made with real food ingredients."

"My personal opinion is that the synthetics don't cause you any harm, but I don't think they do you any good," Wrolstad says. While other researchers are looking for harmful effects of synthetic dyes, Wrolstad is looking for beneficial effects of natural, plant-derived colors. "A lot of these compounds have antioxidant properties," he says.

Though just as the idea of harm by synthetic colors isn't universally accepted, neither is the suggestion of benefit from dyes extracted from plants. "I would feel a lot more comfortable if we had some data on those, too," Weiss says.

In the meantime, dyes of all kinds will continue to dominate the grocery aisle unless shoppers demand otherwise. In the food business, the most influential color is green. ■



Going natural Natural food dyes include betanin (derived from beetroot), compounds from the seeds of the achiote tree and curcumin (from turmeric).

Explore more

- For a transcript of the food dye hearing, visit http://1.usa.gov/qJJKkM

FROM TOP: OKSANA2010/SHUTTERSTOCK; DR. MORLEY READ/SHUTTERSTOCK; LE DO/SHUTTERSTOCK

WHEN BIRDS GO TO TOWN

Urban settings offer enterprising critters new opportunities — if they can cope with the challenges

By Susan Milius

Anne Clark and Kevin McGowan are discussing, perfectly seriously, how a crow might be able to recognize a car. Not tell a car from, say, a cat, but pick out the red Subaru from other cars in the parking lot.

Clark, an animal behaviorist at Binghamton University in New York, is sitting in her own red Subaru with McGowan, of Cornell's Laboratory of Ornithology in Ithaca. Neither bothers to mention — it's apparently so routine — that when Clark pulled into the lot, two crows flapped over to nearby trees. Country crows often back away from human doings, but these birds lingered as if people-watching.

Clark and McGowan are running a long-term study of what urban life is like for a group of Ithaca's crows, tagging and following them as they grow up, take over or lose territories, and succeed or not in raising the next generation of research subjects. Even in a university town, the birds probably aren't lured to the Subaru by the thrill of scientific discovery, but rather by the scientists' occasional ploy of flinging peanuts and dog food out the window to engineer some bird activity.

"They know us," McGowan says. There isn't another Subaru in the lot to test the birds' discriminatory abilities, but McGowan has inadvertently conducted his own experiment. He sold his car and bought a new one. McGowan was temporarily invisible automotively, but the birds caught on eventually. And the old car's new owner reported that a crow appeared to be following him to work. It was OK; the driver just provisioned the

Paris crows feast on some human leftovers. They're not the only birds that have learned to like garbage.

WITT/SIPA/ASSOCIATED PRESS

car with peanuts for an occasional fling.

New food sources are just one of the opportunities that organisms of all kinds — including ants, birds and cockroaches on down to zoysia grass — encounter when they take up life around people. As human populations boom, more and more plants and animals are becoming city dwellers, a shift that intrigues biologists fretting over the practical problems of nuisance critters as well as theoreticians musing over how organisms adapt to new environments. For even a green town presents plenty of novelty unknown in any species' evolutionary history.

The considerable number of birds that now share cities and suburbs offer as good a focus as any for scientists trying to understand what happens when animals go to town. Though some birds are seizing new opportunities, the lifestyle often comes with costs. Biologists are now beginning to see how birds respond to some of the major facts of city life, from discarded french fries to relentless low-pitched noise.

And other studies are showing how, by encouraging species that can cope and filtering out those that can't, urban areas are creating mix-and-match combos of inhabitants that have never had to deal with each other in quite the same way before. Odd juxtapositions of predators, competitors, prey and, oh my, people become a challenge in themselves.

Feed me

Clark and McGowan didn't intentionally train Ithaca's crow population to car watch, and the researchers throw food only when other attempts to coax a bird to cooperate have failed. Still, Team Crow's adventures in the parking lot turn out to be a classic example of the new crow-human dealings that emerge where people abound. One of the big attractions of these urban environments is all the leftover and left-outside human food just waiting for the enterprising forager.

Clark, McGowan and Binghamton graduate student Jennifer Campbell-Smith are searching for this year's nests so McGowan or another tree climber can band nestlings. The nestlings will be included in a database of crow families going back more than two decades. Crow family territories in Ithaca are smaller and nestle together much more densely than they do in rural New York, and the family sagas are complex. A day riding around on a spring nest survey is like dropping in from Mars and having to pick up the plotlines of *The Sopranos*, *Lost* and a lot of Shakespeare, all with feathers.

All morning Clark has proved almost clairvoyant at driving in traffic along Ithaca roads and suddenly veering onto the shoulder after glimpsing the dark form of a nest among the many dark forms in conifers half a block away. The woods by the parking lot are tough even for the clairvoyant, though. A crow pair nested here last year, but the team never determined which tree held the young.

Crows are nesting in the same clump of trees this year, and the dilemma calls for flinging food in hopes that the birds it draws will take some back to the nest. They readily flap down to the asphalt to pick up the goodies and fly off with bulging beakfuls. A few loads get ferried into the dense tangle of branches in an uphill corner of the pines, but again, spotting which tree has the nest proves tricky.

There's another handful of peanuts. And another. After more than an hour of observation from the parking lot, the woods and two vantage points in a cemetery across the street, there's still no obvious tree. The crows have gotten a fine lunch but have managed to keep their nesting address private. One might ask who trained whom.

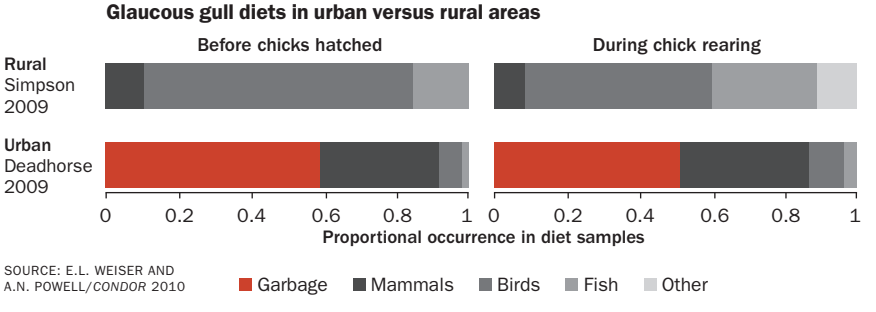
For birds such as these Ithaca crows, which can balance a natural wariness with some strategic boldness, the world is their garbage dump. A 2010 study of glaucous gulls found that birds in northern Alaska towns rely heavily on human garbage, with up to 85 percent of regurgitated pellets and breeding-season bird remains including human leftovers. In Seattle it's "roadkills, Cheetos and french fries, and Kentucky Fried Chicken — all the favorites," says John Marzluff of the University of Washington.

In an upcoming article in *Studies in Avian Biology*, Marzluff discusses classic studies of three bird populations that picked up the knack of opening, and drinking from, milk bottles delivered to people's doorsteps in the morning. He says Seattle's crows even know what time the keepers at the zoo throw fish to the penguins, and the birds show up to vie for the handouts.

On the other side of the Pacific, birds known as jungle crows have visited a shrine in Kyoto and helped themselves to some of the thousands of fat-rich, potentially crow-edible candles set out along the paths. Video recordings revealed that the crows don't shrink from flames, says Hiroyoshi Higuchi of the University of Tokyo. Crows carried still-smoldering candles away, suggesting an explanation for puzzling fires in fields nearby.

Human food, even when it's not aflame, may not be so good for birds, though. In a 2009 study comparing the effects of available food on chick rearing in suburban and rural places, Clark, McGowan and Rebecca Heiss, a graduate student

Dropping dietary clues Glaucous gulls living around the town of Deadhorse, Alaska, get much of their food in the form of human garbage, researchers recently found. This part of the diet proved particularly important to the gulls during chick rearing. Rural birds studied in Simpson, Alaska, appeared to get their dinner elsewhere.



SOURCE: E.L. WEISER AND A.N. POWELL/*CONDOR* 2010

at Binghamton at the time, reported evidence that nutrient deficits in suburbia may be limiting the growth of young crows there. Suburban crows lag behind country cousins in size, and offering suburbanites high-protein, high-calcium supplements boosted nestling growth. What startled the researchers, though, was what happened when they set out supplemental nestling food in the countryside. Crows that took home the best nutritional formula used by specialists in nursing orphan chicks ended up with noticeably punier youngsters than neighbors relying entirely on wild food. Even the best food that humans could concoct fell short of a natural diet.

What human nutrition does for birds seems to depend on the species, meaning some dive and others thrive. Abundant human garbage, for example, is proposed as one of the drivers behind population booms in urban gulls worldwide over the last 50 years. The garbage in the diets of those glaucous gulls in northern Alaska turned out to be important in successfully raising chicks, according to an analysis in the fall 2010 issue of the *Condor*.

Yet the glaucous gulls also hunt other birds. Work done at the University of Alaska Fairbanks by Emily Weiser and Abby Powell has confirmed that remains of more than a dozen at-risk bird species turned up along with the garbage in gull nest debris. While garbage may be a boon for the gulls, their rising numbers may lead to more predation on rare birds — changing the circumstances for these already stressed populations.

Even the abundant food that human enthusiasts set out on their feeders comes with complications, writes Darryl Jones of Griffith University in Nathan, Australia, in the spring 2011 issue of *Emu*. Evidence so far suggests that feeding birds during the winter increases their chance of survival and advances the timing of nesting and egg laying come spring, meaning more time for raising young. Yet feeding can also push birds out of sync with natural food supplies and may encourage migratory species to stick around all year, possibly competing with winter residents.

Urban birds deal with new surroundings in innovative ways. This hummingbird nest is in a power plant's boiler feed return pipe.

"There is absolutely no doubt that this amount of human provisioning is having massive and widespread influences on bird populations," Jones says, "and we really need to know what is happening."

Sounds of the city

Fine urban dining options often come with unnatural noise. But oddly enough, studies in the 1990s didn't find that rumbling traffic affected the way city birds sing, says Hans Slabbekoorn of Leiden University in the Netherlands.

Unaware of those negative results at the time, Slabbekoorn went about carefully checking noise in male great tit territories. The more traffic noise competing with a male's arias, the higher their minimum frequency, Slabbekoorn's team reported in 2003. Much of the cacophony of urban environments, the cars and air conditioners and leaf blowers and such, growl and grind in the lower frequencies. Studies now suggest that birds can show some musical accommodation.

The frequency change that human hubbub prompts in great tits doesn't come from singing the same songs at a different pitch, Slabbekoorn and graduate student Wouter Halfwerk announced in 2009. In a study designed to get at the mechanism of the song accommodation, the team experimented with individual birds, analyzing their normal songs and then playing some recorded urban rumble-grumble. Great tits have individual repertoires of up to nine songs. "Peta peta peta," Slabbekoorn sings, a song heard from the same bird that also does "petati petati." Lower pitches, prone to get drowned out, dominate some of these songs but not others. During the sessions of recorded urban noise, males sang fewer of the songs with substantial lower notes, showing off more of the high end of the repertoire.

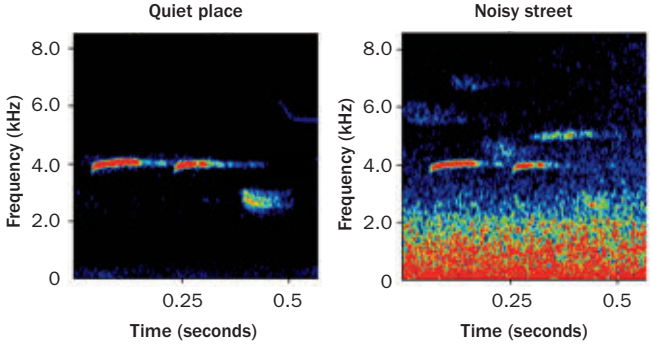
As an additional test, the researchers played what they call reverse urban noise, an artificially created opposite to traffic sounds that puts most of the sound energy at the higher frequencies instead of the lower ones. Confronted with this vexation, the males abandoned the higher-pitched tunes in their repertoire and returned to the lower ones.

Song switching may be the great tit way, but researchers are finding it's not the only way birds get around extra sound. Nightingales tend to sing louder in loud places, and European robins grow more likely to sing at the formerly unrobinlike hours of the relatively quiet urban night.

While birdsong may be music to human ears, to the birds themselves it's, "Get your foul feathered rump out of my territory right now," "Choose me, baby" or some other vital communication. Disrupting such important messages or sabotaging some other aspect of sound could be exacting costs even for birds that readily live in the din. It's a tricky

Over the grumble

The sounds of the city can drown out the lower ranges of a bird's songs (figures show a great tit song in a quiet forest and the same song masked by urban rumblings). Recent studies suggest birds try to accommodate in various ways.



FROM TOP: JON RIDLER, CORNELL LAB OF ORNITHOLOGY; WWW.CELEBRATEURBANBIRDS.ORG; H. SLABBEKOORN

matter to test, but Slabbekoorn's group has some evidence. Great tits nesting at various distances from a Dutch motorway fledged fewer offspring in noisier territories, his team reported in the February *Journal of Applied Ecology*. Though tits persist, they're paying a price for their urban homes.

And, like any other bit of city living, noise can affect different dwellers differently. Investigating that variability has been challenging because shrubbery, food, pollution, people and plenty of other factors vary along with city noise. For a cleaner test, one team turned to another kind of noisy environment: land around natural gas wells. In piñon-juniper forests of the southwestern United States, some wells run thundering compressors around the clock while others in the same kind of woodlands don't. Loud compressor zones had about the same number of bird nests as quiet sites, but only 21 nesting species instead of 32, says Clinton Francis of the National Evolutionary Synthesis Center in Durham, N.C.

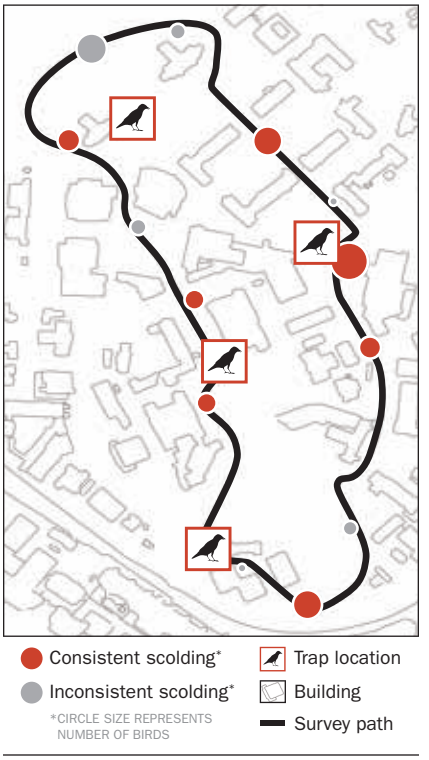
One of the species conspicuously rare around compressors was the Western scrub jay, which raids nests of a variety of species and eats the eggs. Low risk of jays may have had something to do with why several species such as black-chinned hummingbirds appeared to favor noisy sites. And low numbers of jays likewise might explain why the bird community that tolerates relentless compressor roars overall reproduces more successfully than the quiet community. Ability to cope or not has rejiggered the dynamics of the bird mix.

The living city

The inevitable species in all of these mixes is *Homo sapiens*. Humans, for all their generosity with garbage, have a dark side as far as a bird is concerned. They're not just predators, they're opinionated predators with technology.

Crow shooting, for example, used to be much more common around Ithaca. McGowan hypothesizes that crows living in the city now descend from those that were willing to take a chance and move closer to people as shooting waned.

Beware the caveman Birds seem to be capable of recognizing threatening people, and can pass that concern on to others. The map below shows sites in Seattle where researchers in caveman masks captured crows and locations where the same masks elicited scolding from birds more than two years later.



Several decades ago, old-timers told him that crows hardly ever appeared in town. These days, he and Clark have banded more than 2,000.

Crows may have gotten cozier with people, but the birds don't forget insults. Crows even appear to recognize and remember the faces of upsetting humans, Marzluff and his colleagues reported in *Animal Behaviour* in 2010. Marzluff and other experimenters trapped wild Seattle crows just once while wearing rubber masks sold on the Internet as caveman faces. More than two years after the incident, people of various genders and ages and with different body sizes and walking gaits attracted shrieking, dive-bombing crows when wearing the masks. Yet the same people could walk unmasked with hardly any attention from crows.

Crows can even learn grudges from other crows, the Marzluff team reported in June online in the *Proceedings of the Royal Society B*. Five years after the original trapping episode, crows that weren't among the offended birds — and crows that weren't even hatched at the time of trapping — now scold people wearing the masks. The tendency to mob someone wearing the dangerous face has become twice as common at some Seattle sites and spread at least a kilometer from the original study area, apparently via crow information networks.

Crows are celebrated as clever birds, but some capacity for distinguishing among individual people has even turned up among birds of more humble reputation: free-ranging pigeons. When two similar-looking people wearing coats of different colors routinely set out food in a park in Paris, the pigeons could still tell the friendly one from the one that chased them even when the people switched coats, Ahmed Belguermi of Université Paris Ouest and colleagues reported online in *Animal Cognition* in June. Birds hopping around sidewalks and city parks know about more than human clothing. When Clark is viewing an especially edgy bird, she sometimes puts it at ease by facing off at an angle and pulling out her cell phone for a mimed conversation. Crows seem to assume that people on cell phones ignore their surroundings.

Such studies of urban birds are telling a nuanced tale of animal reactions to previously unencountered environs. A casual observer might assume that animals thriving in the city are just the oblivious, bold species that don't happen to notice or care if people tramp among them. But that doesn't appear to be the case.

Instead, Clark says, "living in a city is probably very cognitively complicated." A bird in the country seems to flourish with just a few simple rules about humans. "People — bad! Fly away!" as she puts it. To survive among the urban wonders and terrors, though, metropolitan animals are using their native cognitive abilities to distinguish the opportunities from the perils. In the city, it's caveman — bad, Subaru driver — good. ■

Explore more

- Cornell celebrates urban birds: www.birds.cornell.edu/celebration

H.N. CORNELL *ET AL./PROCEEDINGS OF THE ROYAL SOCIETY B* 2011, ADAPTED BY T. DUBÉ

The Man of Numbers: Fibonacci's Arithmetic Revolution

Keith Devlin

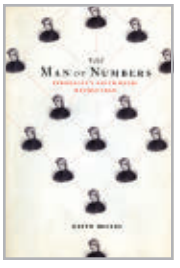
Leonardo of Pisa, also known as Fibonacci, is best remembered today for introducing a sequence of numbers: 0, 1, 1, 2, 3, 5 and so on, each number after 0 and 1 equaling the sum of the two before it. The Fibonacci sequence is closely connected to the "golden ratio" used in art and architecture and turns up frequently in mathematics and nature.

For Devlin, NPR's "Math Guy," Leonardo of Pisa is much more: he's the man who brought arithmetic to the West — a celebrity of 13th century Italy.

"The likes of Apple Computer's Steve Jobs and Microsoft's Bill Gates will always be linked to the rise of the personal computer, and in this way Leonardo should be linked to the rise of modern arithmetic," Devlin writes.

The book, which draws heavily on academic sources, pieces together the little that is known about Leonardo's life. As a young man, he traveled to North Africa and learned Hindu-Arabic numerals and *al-jabr*, the basis of modern algebra. At the time, merchants and traders in Italy still used Roman numerals, which were impractical for multiplication or division.

Leonardo's *Liber Abbaci* was the first comprehensive arithmetic textbook in Europe. It helped change the way business was done, with hundreds of math problems based on everyday commerce such as converting currency or calculating profits.



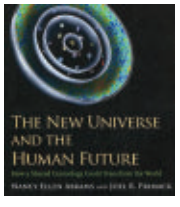
A mathematician himself, Devlin demonstrates Leonardo's original methods by walking the reader through copious calculations that read like cooking recipes. Readers with the patience to tackle the math, though, will discover a legacy that extends across eight centuries to the textbooks of schoolchildren today and the numbers that run the modern world. — *Devin Powell*

Walker & Co., 2011, 183 p., $25

The New Universe and the Human Future

Nancy Ellen Abrams and Joel R. Primack

Living only for the present, using up natural resources, polluting the environment without considering future generations — can humans ever change? Lawyer and popular-culture lecturer Abrams and her husband Primack, an astrophysicist noted for his work on dark matter, argue that people might, if only they learned a little cosmology.



Echoing the words of Joseph Campbell, who studied the myths of ancient and modern peoples, the authors argue that the world needs a modern understanding of human beginnings — a common story. The origin of the universe — with concepts such as the Big Bang, cosmic inflation, dark matter and dark energy — could become this overarching story for all humankind.

Abrams and Primack are careful to explain that they're not discounting religion as a way for people to connect with each other and understand the meaning of the universe. But the authors believe that by understanding concepts of cosmology, a more global understanding of the human role in the cosmos will emerge.

"We need to *feel in our bones* that something much bigger is going on than our petty quarrels and our obsession with getting and spending, and that the role we each play in this very big something is what really defines the meaning and purpose of our lives," they write.

The authors tell the cosmology story well and illustrate it with stunning images, in the book and online at www.new-universe.org. But it's unclear whether a universal understanding of cosmic origins can ever take hold, since those who disagree may never pick up the book in the first place. — *Ron Cowen*

Yale Univ. Press, 2011, 256 p., $28

The Bleeding Disease

Stephen Pemberton

A historian shows how advances in treatment made hemophilia manageable — yet led to many deaths from HIV-tainted plasma. *Johns Hopkins Univ. Press, 2011, 377 p., $50*

Vulture

Thom van Dooren

The much-maligned birds get their due attention in this thoughtful look at vultures' natural and cultural history. *Reaktion Books, 2011, 192 p., $19.95*

The Sorcerers and Their Apprentices

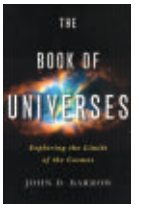
Frank Moss

Preview some of the new technologies that the digital wizards at the MIT Media Lab are cooking up, from a foldable car to robotic feet. *Crown Business, 2011, 272 p., $27.50*

Lip Service

Marianne LaFrance

A psychologist examines the science of smiles and their many social uses, from a baby's enticing grin to a bully's malicious smirk. *W.W. Norton, 2011, 321 p., $26.95*



The Book of Universes

John D. Barrow

Explore this universe and the many others that may be possible in this tour of the science and scientists behind theories of the multiverse. *W.W. Norton, 2011, 354 p., $26.95*

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From the Archive

To read the full 1930 article, visit **www.sciencenews.org/archive_dirac**

Material Objects Seen as Holes in Space by British Scientist

A new idea of the constitution of space was presented when Dr. P.A.M. Dirac, twenty-five year old Cambridge physicist already famous in mathematical circles, announced to the British Association for the Advancement of Science at its recent meeting in Bristol his new theory that there is everywhere an infinite density of negative energy electrons.

Gone is the idea that there is absolutely nothing in a perfect vacuum, for Dr. Dirac said: "A perfect vacuum is now to be considered as a region of space in which all the states of negative energy and none of those of positive energy are occupied."

Everything that is material to us, all the material things of the universe, are made up of "holes" in this vast space sea of negative energy, according to Dr. Dirac's theory. In other words, things that actually exist and can be experimented with have positive energy and can be considered to be vacant places in the space of minus or negative energy.

Dr. Dirac told the physicists what they have long wished to know, just what is the nucleus of the hydrogen atom, better known as the proton. He said: "It will be a sort of hole in the distribution of negative energy electrons. To make the hole disappear which we can do by filling it up with an electron of negative energy, we must put into it a negative amount of energy. This means that the hole itself will have a positive energy. It now appears reasonable to interpret this hole as a proton."

The Alpha Magnetic Spectrometer, delivered to the International Space Station in May, may offer clues to the nature of antimatter.

PHOTO: NASA; PAPER: PAPHIA/ISTOCKPHOTO

UPDATE

Antimatter pops from Dirac math

Math can reveal the secrets of the physical universe, assuming theorists know how to interpret the equations. Physicist Paul Dirac's prediscovery of antimatter offers perhaps the best example. In the late 1920s, Dirac realized that quantum mechanics was telling him something that other scientists had failed to see: Electrons could have negative energies.

If negative energies are possible, Dirac speculated in 1930, electrons would want to fill up those negative-energy states. A vacuum would thus actually be a sea of negative-energy electrons. If one such electron popped out of the sea, people would see the hole left behind as a positively charged particle of ordinary matter. Because electrons and protons were the only particles then known, Dirac concluded that the holes would be protons.

But a proton's mass is nearly 2,000 times greater than an electron's. So Dirac revised his idea, correctly concluding in 1931 that the holes were a new type of particle with the same mass as an electron but a positive charge. Dirac had predicted antimatter.

In 1932, physicist Carl Anderson saw Dirac's positively charged electron in cloud chamber tracks, dubbing it "positron." Today physicists know that every particle has an antiparticle, but they don't yet know for sure why matter instead of antimatter dominates the universe.

—Elizabeth Quill

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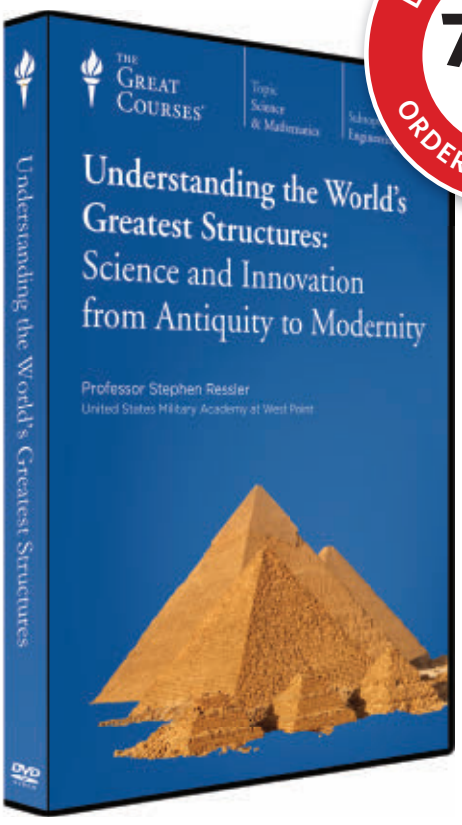

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