Record Arctic Melt | Sleep and Learn | Genome, Part Two

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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ OCTOBER 6, 2012

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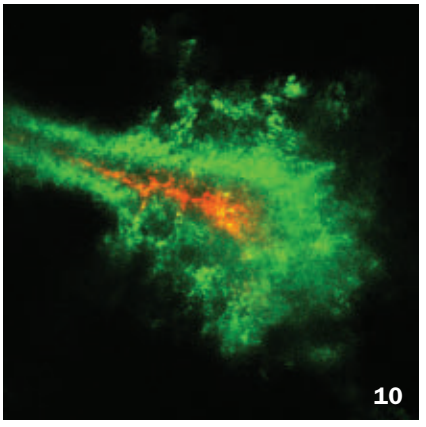

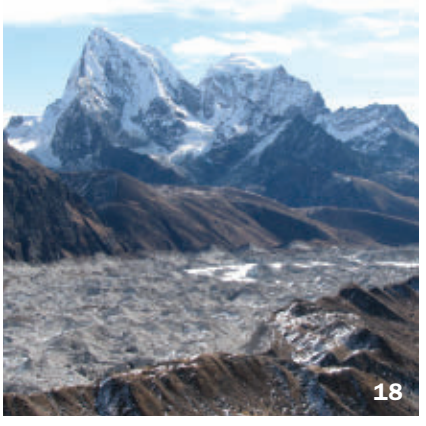

ScienceNews

In The News

Features

Departments

COVER Certain foods may contribute to obesity by interfering with the machinery the body uses to sense when it has had enough to eat.
Cary Wolinsky

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FROM THE EDITOR

Shrinking ice in the Arctic offers an uh-oh moment

In one of my first jobs, at the children's science television show *The Magic School Bus*, a prime goal was to get the show's characters (and, hopefully, the young audience) to an "aha!" moment, when they realized how something worked or how things were connected.

Scientists have had many climate-related aha! moments, from Joseph Fourier's discovery in the 1820s that the atmosphere helps warm the planet, later called the greenhouse effect, to more recent work on global warming and its effects (*SN: 6/30/12, p. 16*).

But now, it seems we're encountering something else entirely — what I would call an "uh-oh" moment. The Arctic Ocean's ice cover reached a record low this summer (at least for the satellite era, which began in 1979). A lid of thick ice has long sat atop this polar sea, even during the warmest months. But this summer the ice melted to an extent never seen before, as Alexandra Witze reports on Page 5.

Back in 2007, Witze covered what, until this summer, had been a record-breaking year in terms of shrinking sea ice. That year's sea ice loss took scientists by surprise. This year's even more dramatic drop shocked many more. It seems we are seeing the beginning of a fundamentally different era, Walt Meier of the National Snow and Ice Data Center in Boulder, Colo., told Witze. Granted, variability year to year is to be expected, influenced by storms and other factors. But the long-term trend means that the Arctic will soon be ice-free for the first time in millions of years.

Sea ice is integral to the Arctic ecosystem. That frosty shell has covered some of the Arctic Ocean for the last 13 million years, maybe longer, and has been widespread for at least 2 million years. Life in the Arctic — from ringed seals and polar bears to plants and microbes — has evolved to thrive in that icy world. Melting ice translates into changes, if not all-out threats, to organisms' livelihoods. It shifts patterns of oceanic and atmospheric circulation, of snowfall and permafrost.

And of course, loss of sea ice affects humans. Inuit and other native peoples rely heavily on sea ice for hunting. Already, seasonal changes in the breakup of ice have dramatically affected their societies. The massive melting at the top of the world alerts us that climate change is not just a specter emerging from theoretical projections. It's a shift of planetary proportions that's already here, altering people's lives. Uh-oh.

— *Eva Emerson, Acting Editor in Chief*

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Introducing | NEWFOUND CAVE ROBBERS

Newly named spiders with big, three-part claws and spikes on curved feet (below) are so unusual that they've earned a whole new family. Most spider families arise from reanalyzing known species, but Trogloraptoridae (named August 17 in *ZooKeys*) is the first newfound North American spider family since the 1890s. Volunteers surveying cave life in southwestern Oregon found the first specimens in 2010, and Charles E. Griswold of the California Academy of Sciences and his colleagues dubbed one of these specimens a new species, *Trogloraptor* ("cave robber") *marchingtoni* (above). Griswold suspects that this and a second species found in redwoods may be relicts of an ancient lineage that split from goblin spiders more than 135 million years ago. —*Susan Milius*

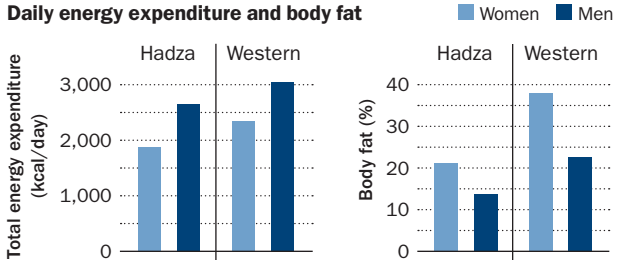
Science Past | FROM THE ISSUE OF OCTOBER 6, 1962

SOLID-STATE GYROSCOPE "DOES THE TWIST" — The "Twist" has reached outer space. A new solid-state gyroscope which "does the twist" has been developed by Westinghouse research scientists, the company announced. The vibragyro — as the dancing cylinder is called — develops a lengthwise twist for the same physical reason that body twist develops in a "twister" doing the popular dance. This is the first successful solid-state gyro and is particularly suited for use in space capsules and satellites, the scientists claim. The new gyro looks nothing like the conventional wheel-spinning gyroscope.... Like a rotating-wheel gyro, however, it has the same ability to act as a reference in space, detecting any motion that tries to swing it out of position.... With no rotating parts, this vibragyro is especially suitable for applications in weightless, ultra-high-vacuum conditions in outer space.

Science Stats | THE HUNTER-GATHERER DIET

Despite different lifestyles, U.S. and European people burn as many calories daily as the Hadza foragers of Tanzania. But the Hadza have much less body fat, suggesting calorie intake may be the bigger contributor to Western obesity. H. PONTZER *ET AL*/*PLOS ONE* 2012

Daily energy expenditure and body fat



Science Future

October 13–31
Aspiring scientists of all ages can light up a jack-o'-lantern with chemistry, make slime or dissect a cow eye at the Chicago Museum of Science and Industry. See the Spooky Science series at bit.ly/SFspooky

October 30
An astrophysicist discusses how scientists find and study planets orbiting other stars at the Hayden Planetarium in New York City. Learn more at bit.ly/SFexo

SN Online

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HUMANS
Some judges may be more lenient when criminals offer biological explanations for their behavior. See "Psychopaths get time off for bad brains."

ATOM & COSMOS
Astronomers see a black hole pick up its matter-sucking activity right on schedule. Read "Black hole's annual feast begins."

BODY & BRAIN
Changing gut microbes may set the stage for weight gain. Read more in "Antibiotics linked to fat buildup."

One olfactory brain region ramps up when scents go away. See "Smell deals with deprivation differently."

Say What?

Goldilocks variant *\GOHLD-ee-loks VAIR-ee-uhnt\ n.*
A form of a gene that is somewhat common in the population and makes a substantial contribution to disease. The name came about because scientists find this gene type "just right" for easy detection. Some genes have a big effect on health but are too rare to find easily: Unusual mutations in single genes, for example, cause cystic fibrosis. Others are common but their relationship to disease is too weak: Diabetes and heart disease may result from many gene variants, each contributing only a bit, if anything, to the disease. In a recent study of 14,002 people from various ethnic backgrounds, researchers found 105 goldilocks variants in Europeans, 132 in South Asians and 210 in African Americans. Those variants may be important for understanding disease risks and devising new drugs, an international team reports in the July 6 *Science*. —*Tina Hesman Saey*

INTRODUCING: COURTESY OF C.E. GRISWOLD; SN ONLINE: NASA, ESA, SEAN FARRELL/SYDNEY INSTITUTE FOR ASTRONOMY

“The questions we can now ask are more sophisticated and will yield better answers than the ones we were asking nine years ago.”

— ERIC GREEN, PAGE 11

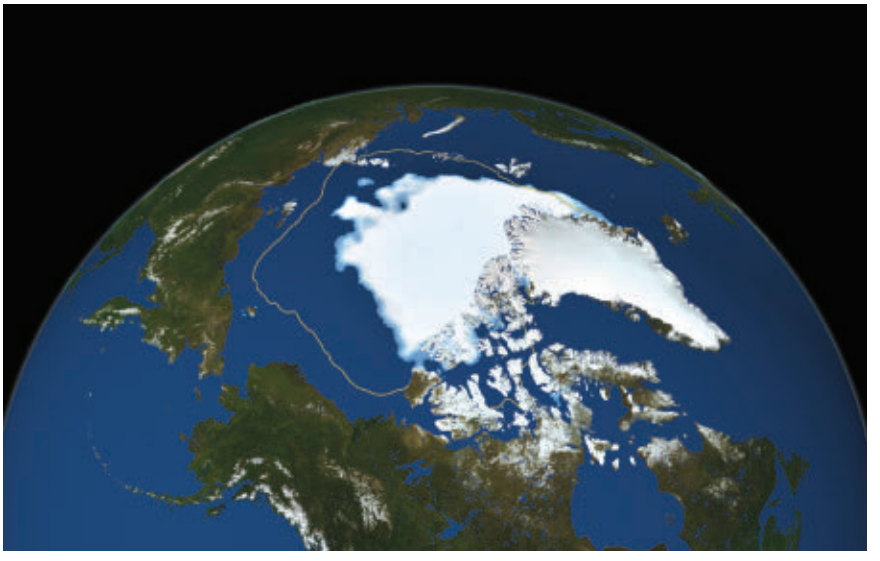
In the News

STORY ONE

Arctic Ocean ice melt smashes previous record

Frozen area falls well below 2007 minimum extent

By Alexandra Witze



As seen in this illustration based on satellite observations, the Arctic sea ice cover as of September 13 had receded far beyond the average minimum extent of frozen surface observed in the last three decades (yellow outline).

NASA

The future looks bleak for the floating skin of ice at the top of the world. Ice covered less of the Arctic Ocean this September than in any year since satellite records began in 1979.

At its low point on September 16, Arctic sea ice covered 3.41 million square kilometers, according to the National Snow and Ice Data Center in Boulder, Colo. That's 760,000 square kilometers below the previous modern record from 2007 and 3.29 million square kilometers less than the average annual minimum from 1979 to 2000 — an area nearly twice the size of Alaska.

In 2007, scientists described that year's record minimum as shocking and unprecedented. Now, they say, the 2012 melt shows that the Arctic sea ice cover has shifted to a profoundly different regime.

“The ice cover is now just so thin and weak in the springtime that large parts of it can't survive the melt season,” says NSIDC director Mark Serreze.

Arctic sea ice grows in winter and melts partly away each summer. Overall, more sea ice has been lost each year, a sign of changing Arctic climate. From 1979 to 2011, the amount of sea ice left in September at the end of each melt season dropped by an average of 12 percent per decade.

The ice isn't just shrinking; it's also thinning. The Arctic used to contain lots of thick ice — some 3 to 4 meters thick — that survived year after year. Now it's dominated by thinner ice only 1 to 2 meters thick and just one to two summers old. “It's almost like parts of the Arctic have become a giant Slushie at this time of year,” says Walt Meier, a sea ice expert at NSIDC.

Even so, the average Arctic sea ice thickness actually increased during August, according to computer modeling of sea ice volume. That's because so much thin ice melted away completely that the remaining ice got thicker on average, says Axel Schweiger, a polar scientist at the University of Washington in Seattle.

In 2007, winds, cloud cover and other weather conditions were just right for a lot of ice to melt. “There were a number of people saying [2007] was a one-off and you'll never see this perfect storm again,” says Serreze. “What Mother Nature is telling us is that you don't need a perfect storm anymore, just because the ice is so thin now.”

This year, ice cover stayed pretty much on track with 2007 levels through July, after which it rapidly nose-dived. One possible factor was a strong Arctic storm that spun up north of Alaska in early August, around the same time a lot of ice melted in the East Siberian Sea.

Serreze and others say it's too early to know how the storm might have been related to that sea ice loss — whether the storm broke ice apart and made it more susceptible to melting, or whether the two events just happened to coincide.

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

"My gut feeling is that it was probably not critical and we would have reached a new record regardless," says James Screen, a climate scientist at the University of Melbourne in Australia who has studied the role of Arctic storms in sea ice loss.

Nevertheless, says Meier, storms that thicker sea ice might once have weathered now rank a knockout punch for thin, unconsolidated ice. "The Arctic is becoming like a fighter with a glass jaw," he says.

During August, nearly 92,000 square kilometers of ice disappeared each day on average, the fastest rate ever observed for that month.

The six lowest sea-ice extents in the satellite record have now occurred in the last six years, according to the NSIDC. More melt means more open water exposed to sunlight; that water absorbs more heat and causes feedback loops that heat the Arctic even more.

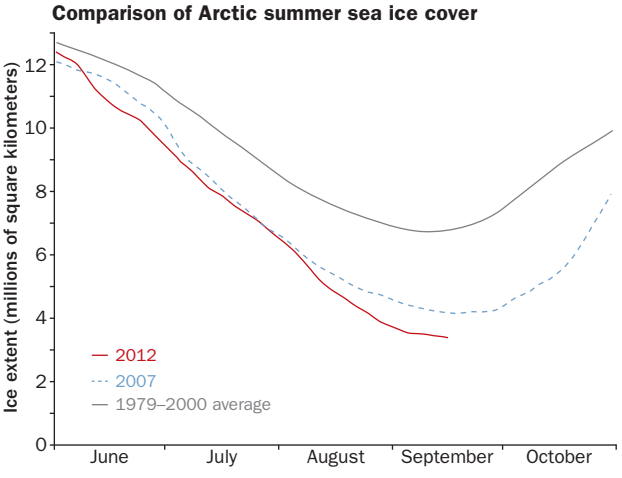
NSIDC counts an area as ice-covered if it has at least 15 percent sea ice, as seen by microwave instruments aboard satellites. This approach can over- or underestimate how much ice is really there, thanks to changes in factors such as clouds, fresh ice or the overall ice reflectivity.

To help improve the measurements, center scientist Julienne Stroeve traveled to the Arctic for the record ice melt. On September 11, she wrote online that ice concentrations at 83 degrees north were less than 40 percent — even though satellite data suggested that ice should cover nearly 100 percent at that spot.

Other research groups in Europe and Japan that monitor sea ice cover using different techniques confirm this year's record melt.

For now, the ice is beginning to refreeze. But the small amount lingering from the record summer melt probably means less ice next spring. "It sets us up for another world of hurt next year," says Serreze. ■

Low point Arctic sea ice usually reaches its minimum extent in September, when summer melting ceases and the ocean's surface starts refreezing. During the final two decades of the 20th century the area covered by ice bottomed out on average at around 7 million square kilometers; in 2007 the low was a record 4.17 million square kilometers. This year's melt undercut the 2007 minimum by more than 760,000 square kilometers.



Back Story | ICE-OUT

With Arctic ice melting more on average each summer since 1979, scientists are placing bets on when the top of the world might be completely ice-free for the first time in millennia. An "ice-free" Arctic might still contain some sea ice packed along the coasts of Alaska and Siberia. But the center would essentially be blue ocean.

Mark Serreze, director of the National Snow and Ice Data Center, is sticking by his longtime estimate of 2030 for an ice-free Arctic. Others think it could come sooner. At the rate ice cover and volume are dropping, the Arctic could be nearly ice-free in summer as early as 2016, according to a May paper in the *Annual Review of Earth and Planetary Sciences*.

Arctic nations — including Canada, Russia and the United States — are already jockeying to see what an ice-free Arctic might mean for expanding shipping or oil exploration. — *Alexandra Witze*

A drilling platform flares gas in Alaska's Beaufort Sea. Diminishing Arctic sea ice cover in coming decades will open new areas to oil production.

FROM TOP: NSIDC, ADAPTED BY E. FELICIANO; STOCKBYTE/GETTY IMAGES

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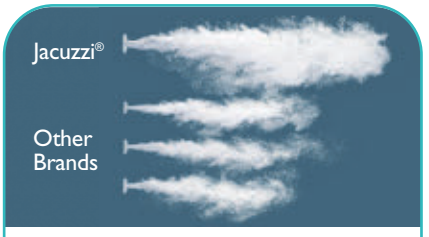

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Body & Brain

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Low-calorie diet doesn't extend monkeys' life

Study counters earlier work finding survival advantage

By Nathan Seppa

Rhesus monkeys on a calorie-restricted diet (such as the 27-year-old male at left) did not live longer than those consuming a more normal diet (like the male of the same age at right), researchers report in a study that began in the late 1980s.

NATIONAL INSTITUTE ON AGING/NIH

Decades of research have linked low-calorie diets with extended survival, but a new report finds that rhesus monkeys on strict diets don't live longer than their counterparts getting a standard diet.

The findings, reported September 13 in *Nature*, run counter to a 2009 study from the University of Wisconsin–Madison that showed a clear survival advantage in a calorie-restricted group of similar rhesus monkeys. Scientists suspect that differences in the two studies' designs might explain the discordant findings, leaving the question of longevity still dangling.

Both research groups will need to wait another decade or more before all the monkeys live out their lives. But the authors of the new study, conducted at a National Institute on Aging laboratory in Baltimore, say their data are unlikely to change.

"I don't think one study overturns 75 years of research," says Steven Austad, a biogerontologist at the University of Texas Health Science Center in San Antonio, who isn't part of either study team. But he notes that most previous calorie-restriction studies have been done in short-lived animals. "It's always been possible that whatever you used to increase their lives might not work the same in long-lived animals."

The median life span for a rhesus monkey in captivity is about 27 years, but some can reach age 40, says study coauthor Julie Mattison, a physiologist at the aging institute. The institute's study includes 121 monkeys, divided between calorie-restricted and standard-diet groups. Some monkeys were put on one diet or the other when they were already well into middle age. Others started on the regimen earlier in life.

Now, 23 years into the study, more than half of the monkeys have died and no survival advantage shows up from calorie restriction, the scientists report. The team considered only aging-related deaths attributable to causes such as heart disease, diabetes and cancer.

> **"I don't think one study overturns 75 years of research."**
> **STEVEN AUSTAD**

The calorie-restricted monkeys in the institute's study get about 25 to 30 percent fewer calories per day than normal, Mattison says. But she acknowledges that the control diet might also slightly underfeed the monkeys by perhaps 5 to 10 percent. "It may very well be that slight calorie restriction in the control animals, plus a nutritionally balanced diet," limits the survival difference between the groups, Mattison says.

The Wisconsin study control monkeys get more food than the institute's controls — a standard diet plus 20 extra grams of chow per day to eat as they wish. The institute's monkeys, on calorie restriction or not, get a variety of foods, whereas the Wisconsin monkeys all get standardized pellets. While both approaches provide essential nutrients and the same percentages of carbohydrates in the diet, the institute's monkeys get less sugar than the Wisconsin animals do.

"We don't know what that difference really means yet," says Ricki Colman, a biological anthropologist at the University of Wisconsin. Looking beyond longevity, the value of calorie restriction — in any species — might lie in overall health, not just racking up years, Colman says.

Mattison agrees, noting that while the new study didn't show a survival advantage from fewer calories, it did offer hints of a better life. None of the monkeys started on calorie restriction early on has developed cancer, she notes, compared with six monkeys in the standard-diet group.

But calorie restriction very early in life may come with risk. Some of these monkeys developed diabetes, even though they are far from obese, Mattison says, and some show signs that their immune systems might not be as good as those in the control animals.

"Science thrives when people get a result they don't expect," Austad says. "This study is going to provoke a lot of useful discussion." ■

"You can do quite a lot of things while you are asleep." — ANAT ARZI

Brain can learn while you snooze

Sleeping mind associates certain sounds with smells

By Laura Sanders

Even while in a deep slumber, people can still learn brand-new information. Sleepers soak in new associations between smells and sounds, knowledge that lingers into the next waking day, researchers report online August 26 in *Nature Neuroscience*.

The new study is the first to show that entirely new information can creep into the sleeping mind, says study coauthor Anat Arzi of the Weizmann Institute of Science in Israel. Sleep used to be considered a kind of reversible death, she says. "But the brain is not passive while you sleep. It's quite active. You can do quite a lot of things while you are asleep."

Instead of trying to teach people something complicated like a new language, Arzi and her colleagues relied on subjects' sense of smell. As anyone who has walked by a dumpster in July knows, smells can elicit a nose-jerk reaction. Catching a whiff of trash automatically makes people inhale less. But a scent of fresh bread spurs a long, deep inhale. Arzi and her team took advantage of this sniff reflex for their tests.

As people slept in the laboratory, the researchers delivered a pleasant scent, such as shampoo. While this nice smell crept into the sleepers' noses, the researchers played a particular tone. Later, a disgusting smell, such as rotten fish or carrion, was paired with a different tone. Neither the smell nor the sound woke people up.

After just four exposures to the smell-tone pair during a single night, the sleepers started to automatically respond to the tones without the accompanying smells, taking in bigger breaths when the shampoo-associated tone played and smaller breaths with the sound linked to the rotten-fish smell.

This new learned association lingered into the next waking day, too. As before, the shampoo sound elicited a long, deep inhale, while the rotten-fish tone caused more shallow breaths. "They learned what the tone signified," Arzi says.

One of the reasons these researchers found evidence for sleep learning when others had not is because they relied on people's sense of smell, says neuroscientist James Antony of Northwestern University. "It's a clever way of using this system that has a strong response."

Scientists don't yet know the limits of sleep learning, says Antony. Complex subjects like calculus, European history and Arabic might not work, but perhaps acquiring more subtle information — shifting preferences or habits, for example — might be possible, he says. ■

Military combat marks the brain

Regions involved in memory, attention changed in soldiers

By Laura Sanders

A single four-month deployment to Afghanistan is associated with brain changes and diminished attention, Dutch scientists report. Most changes went away by a year and a half after returning from combat, suggesting that the brain can largely heal itself — and that longer breaks between combat tours might be a good idea.

The study, which focused on healthy Dutch soldiers, reveals how the brain responds to stress outside of a laboratory, says clinical neuroscientist Rajita Sinha of the Yale University School of Medicine. "It's a nice way to start looking at natural high levels of stress we experience as humans," she says.

Researchers led by Guido van Wingen of the University of Amsterdam conducted brain scans while the soldiers performed a lab test that required them to hold several numbers in their memory simultaneously. Initially, the researchers found no brain differences between 33 soldiers who were about to be deployed for the first time and 26 who were still in training. Nor were there differences in a lab task that required intense concentration for several minutes.

But the story changed when soldiers were retested after experiencing combat, the team reports online September 4 in the *Proceedings of the National Academy of Sciences*. During the memory task, post-deployment brain scans showed lower activity in the midbrain, a region known to be involved in working memory, compared with the brains before deployment.

What's more, midbrain tissue showed signs of damage and weaker connections with another brain region, the prefrontal cortex. The midbrain and prefrontal cortex are involved in working memory and attention, among other things.

Performance of soldiers who had experienced combat worsened on the attention task, which required participants to quickly and accurately identify groups of dots. After combat, soldiers made more errors. And the number of errors corresponded to some of the changes picked up by the brain scans — the bigger the brain change, the worse the performance.

But most of these brain changes were not permanent, the team found. A year and a half later, all the measurements except for one had reverted to what they were before combat. "That was quite striking," says van Wingen. "The brain was able to recover from the adverse effects of stress."

Body & Brain

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Laser-sharp light zaps tumors

Infrared approach may offer radiation therapy alternative

By Janet Raloff

Claiming scalpel-like precision, Canadian scientists have delivered lightning-fast laser pulses of infrared light to obliterate tumors in animals. Whereas conventional radiation therapy delivers cell-killing radiation to all cells throughout a beam's path, the new approach causes no damage to tissue surrounding a targeted tumor, its creators say.

The spillover damage to healthy bystander cells triggers the nausea and other side effects associated with conventional radiation therapy, explains Nancy Ellerbroek, a clinical radiation oncologist in Manhattan Beach, Calif. So, if the new technology can treat tumors deep inside the body without exposing healthy tissue, "that would be really great," she says.

The just-patented system under development at the University of Sherbrooke in Canada delivers 1,000 pulses of infrared light per second, each lasting only about 100 quadrillionths of a second, says laser physicist and study coauthor Daniel Houde. In tiny regions of tissue — typically a volume about 100 micrometers in diameter and up to 10 centimeters long — this blast briefly creates a low-energy electron plasma called a filament, in which molecules are stripped of their outer electrons.

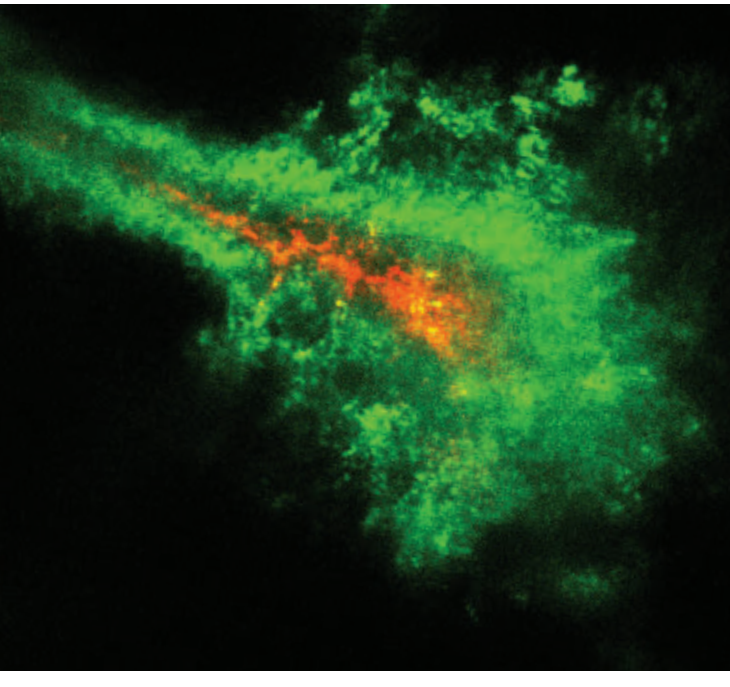
To illustrate the laser's accuracy, Houde's team irradiated a clear gel that turns cloudy when exposed to enough radiation to kill human cells. Using laser pulses, the Sherbrooke scientists wrote the S from their university's logo into the gel. No gel in front of the S turned cloudy, the researchers report online August 27 in the *Proceedings of the National Academy of Sciences*. When the researchers repeated the experiment with an X-ray beam, all gel in the path of the beam turned cloudy, up to and including the targeted region.

Functionally, the laser's impact on affected tissue is exactly like X-rays, Houde says. Both types of radiation unleash electrons that deposit lethal amounts of energy. Both also induce the production of free radicals, molecular fragments that kill cells.

The laser therapy obliterated tumors induced experimentally in mice. However, those tumors were just under the skin of the animals' legs. Still unclear, Houde acknowledges, is how deeply filaments can be induced and still maintain their pinpoint accuracy. The goal, he says, "is to begin tests in humans within two years."

Radiation oncologist Theodore Phillips of the University of California, San Francisco suspects the laser technique may have limited applicability given the questions about how deeply inside the body it will work. "I suspect perhaps 1 or 2 centimeters at best," he says. So, for the more common, deeper tumors, he says, this technique would hold little appeal.

The researchers are already at work on a system to beam the laser's pulses through a fiber-optic cable. Then surgeons could, for example, use the laser like a scalpel during surgery with no need for lead shielding or other types of radiation protection, Houde says. ■



Nonstick trick in the brain

Getting drugs into the brain has proved to be a nanoscale puzzle: Anything bigger than 64 nanometers — about the size of a small virus — gets stuck in the space between brain cells once it gets through the blood-brain barrier. Justin Hanes of Johns Hopkins University School of Medicine and colleagues got around this rule by coating particles destined for brain cells in a dense layer of a polymer called polyethylene glycol. PEG acts like a Teflon coating for the particles, preventing them from sticking to structures within the brain and allowing them to move around more freely. When the researchers injected particles 100 nanometers across coated with either PEG (green) or negatively charged water-hating molecules (red) into the brain of a living mouse, the PEG particles easily penetrated the brain while the negatively charged particles got stuck. Larger nanoparticles would give doctors a more effective way to deliver drugs for brain cancers, strokes and other brain diseases, the team reports in the Aug. 29 *Science Translational Medicine*. — *Sarah Zielinski*

ELIZABETH NANCE, GRAEME WOODWORTH, KURT SAILOR

Genes & Cells

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Sequel to human genome released

ENCODE project catalogs regulatory machinery in DNA

By Tina Hesman Saey

The human genetic instruction book just got a lot more readable. Nearly a decade after the Human Genome Project assembled the genome's 3 billion chemical units, an international consortium has revealed new aspects of genetic grammar.

Already, the updated genome's tales are showing how genetic variants contribute to disease, giving researchers insights into human evolution and even changing how scientists define a gene.

"The questions we can now ask are more sophisticated and will yield better answers than the ones we were asking nine years ago," says Eric Green, director of the National Human Genome Research Institute, which coordinated and funded the mammoth Encyclopedia of DNA Elements, or ENCODE, project.

80 percent

Estimated portion of human genome that serves a purpose

Results from ENCODE, which involves more than 400 researchers around the globe, appear in the Sept. 6 *Nature*, with more than 30 companion papers published in *Nature*, *Science*, *Genome Research*, *Genome Biology*, *Cell* and *BMC Genetics*.

When scientists announced the completion of the Human Genome Project in April 2003, researchers could pick out genes that carry instructions for building proteins. But that information equals less than 2 percent of the genome. Some people passed the rest of the genome off as "junk DNA."

"Perhaps none of it is truly junk," says Ross Hardison, a biochemist and molecular biologist at Penn State University in University Park.

The ENCODE analysis reveals that at least 80 percent of the genome may serve some purpose. Within that 80 percent is a complex network of regulatory switches that control how cells interpret the genetic instructions contained in DNA.

The team carefully mapped out more than 4 million short stretches of DNA (usually about six to 10 DNA units, or bases, long) in the genome where proteins called transcription factors latch on, nudging genes' activity up or down. Changes in gene activity help determine how an organism grows and play a role in both health and disease. The scientists also noted places in the genome where DNA or its associated proteins are tagged with certain chemical marks that can change the way DNA is packaged, epigenetic changes that alter gene activity and influence how an organism develops and functions.

Most of the genome appears to be engaged in regulating gene activity, with multiple transcription factors and other regulatory proteins teaming up to control the action of each gene, says John Stamatoyannopolous, a genomics researcher at the University of Washington in Seattle. His team describes complex gene regulatory networks formed by 475 transcription factors in the Sept. 14 *Cell*.

Genetic variants linked to diseases tend to hit these regulatory buttons, Stamatoyannopolous and his colleagues discovered. For years, scientists have combed the genome looking for common genetic variants that contribute to disease. Many researchers were frustrated by such studies because most variants associated with disease don't lie within genes and therefore don't have an obvious effect on protein production.

Another study, published in the Sept. 7 *Science*, found that genetic variants that influence a person's risk for disease or that help determine physical characteristics such as height are located in regulatory switches. Those altered switches can affect activity of genes located far from the variant. And instead of just a few variants being involved in a disease or physical trait, the ENCODE project indicates that dozens to hundreds of variants, each with a subtle effect on gene activity, may play a role. That finding may help scientists account for a greater proportion of the genetic contribution to common diseases.

Many related diseases may share disturbances in certain regulatory networks, researchers discovered. For instance, about 24 percent of genetic variants involved in autoimmune disorders — such as Crohn's disease, lupus, rheumatoid arthritis and type 1 diabetes — affect switches flipped by transcription factors that interact with interferon regulatory factor 9, which stimulates production of an immune chemical that helps control inflammation.

Besides studying the complex plot of the genetics behind disease, researchers are using ENCODE as a resource for studying human evolution. Manolis Kellis and Lucas Ward of MIT used the data to unveil parts of the human genome that are changing more slowly than others. The researchers report online September 5 in *Science* that natural selection seems to weed out changes in about 4 percent of the genome, perhaps indicating that those parts of the genome are important for human evolution. Some of those important parts contain regulatory switches that affect development of eye cells needed for color vision or that help control growth of nerves.

Probably more of the genome has a function than not, but Ewan Birney, associate director of the European Molecular Biology Laboratory–European Bioinformatics Institute and one of the leaders of ENCODE, says there may be a tiny bit of junk in the genome. "I find it hard to believe that everything is really critical and important," he says. ■

Atom & Cosmos

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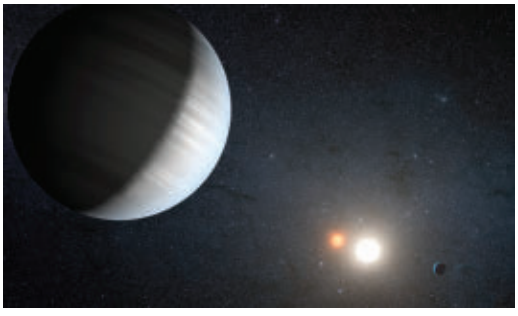
Exoplanet pair orbits twin suns

Outer orb sits in habitable zone of binary star system

By Nadia Drake

The Kepler spacecraft has spied the first pair of planets passing in front of the binary star system they orbit. The outer planet — a potential Neptune-like world — inhabits the life-friendly zone around the two stars, though it is probably too big to host life.



Kepler-47, illustrated here, is the first transiting multiplanet system found around two stars. The outer planet is in the system's life-friendly zone.

"It receives about 88 percent the amount of energy the Earth receives from the sun," said William Welsh of San Diego State University on August 29. "And it's a multiple planet system. It's hard enough to imagine how you get one planet in the binary; now we have two."

The system, called Kepler-47, could have even more planets: A tantalizing but unconfirmed hint of an additional world lurks in the blinking starlight produced when the planetary companions pass between the two stars and Earth. The additional blink has been seen clearly just once, so more observing time is needed to confirm a third planet.

Kepler-47, also described online August 28 in *Science*, further demonstrates the hardiness of planets. "Circumbinary multiple-planet systems were fully to be expected, given that single-planet versions have been found," said astronomer Greg Laughlin of the University of California, Santa Cruz. "But it's exciting nonetheless." Now there's more evidence that multiple planets can form and survive in the tumultuous environment around a binary star.

So far, scientists know that the outer planet, Kepler-47c, is roughly 4.6 times wider than Earth and that it goes around the stars every 303 days. The inner planet, Kepler-47b, is three times wider than Earth and whips around the stars every 49 days. One of the stars is similar to the sun, but the other is much smaller and dimmer. The two stars, a whirling duo some 5,000 light-years away in the constellation Cygnus, orbit one another in roughly 7.5 days.

Determining the boundaries of the habitable zone in binary systems isn't as simple as for single stars, because the moving stars create a shifting region in which liquid water could survive on an orbiting planet.

Well-placed orb could host life

Planet potentially the first in a newly recognized class

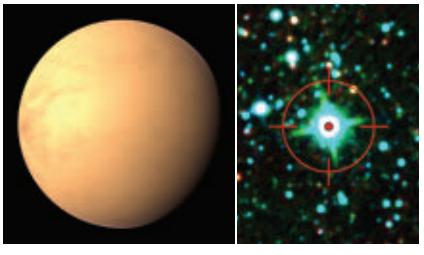
By Nadia Drake

A potentially habitable planet has been discovered orbiting the star Gliese 163, 50 light-years away. The planet is bigger than Earth — roughly seven times as massive — and resides near the inner edge of the star's habitable zone, Thierry Forveille of France's Observatoire de Grenoble reported on August 30. Depending on its composition and how insulating its atmosphere is, the planet could be capable of supporting life.

"I'd say that's a habitable planet," said Raymond Pierrehumbert of the University of Chicago. It's unlikely the planet would experience any sort of runaway greenhouse effect that would heat it beyond the point of livability, he says.

Forveille and his colleagues found the planet by searching for wobbles in the planet's host star with a telescope in Chile. Astronomers calculate that Gl 163c, as the planet is called, receives 30 to 40 percent more energy than Earth receives from the sun. Because the planet's radius is unknown, it's not yet clear what the planet is made of, but scientists speculate that it's a mix of rock and water.

Gliese 163 is an M dwarf star, smaller and dimmer than the sun, and hosts at least two planets. The innermost planet, Gl 163b, is 11 Earth masses and completes a revolution in just 8.6 days; next out is Gl 163c, with 7 Earth masses and an orbital period of 25.6 days. And there's a third potential planet, a 20-Earth-mass body much farther out, with an orbital period of 669 days.



Gliese 163c (illustration, left; false-color image, right) orbits within the habitable zone of a star 50 light-years away.

Searching for habitable planets around M dwarfs could be the fast track to finding a real Earth analog, astronomers say. "It's easier to find and follow up on an Earth-size planet in the habitable zone of an M dwarf," said Courtney Dressing of the Harvard-Smithsonian Center for Astrophysics.

FROM TOP: NASA, JPL-CALTECH, T. PYLE; PHL/UPR ARECIBO, IRSA/IPAC/NASA

2,321 Candidate planets identified by Kepler mission

77 Confirmed planet discoveries by Kepler mission

New direction in hunt for planets

Solar chemistry guides a search for rocky orbs

By Nadia Drake

Rocky planets zipping around distant stars might reveal themselves in what's chemically missing from their hosts.

Compared with stars like it, the sun contains fewer planet-building elements such as aluminum, calcium and silicon, Jorge Meléndez of the University of São Paulo in Brazil said on August 27. "For some reason, the sun is missing these more heavy elements." So stars like the sun might be a good place to hunt for rocky planets — and Meléndez and his colleagues are doing just that.

While astronomers already knew that stars accompanied by giant planets contain more heavy elements, this work suggests that chemistry could also flag the presence of smaller, terrestrial planets.

So far, one candidate shines brighter than the rest: a star called HIP 56948, 200 light-years from Earth, whose light suggests it has a composition like the sun's. While no planets have been found orbiting that star yet, Meléndez is still looking.

"In our opinion, it could be a very good target," Meléndez said.

To assess the elemental signatures written into the solar twins, Meléndez and his colleagues spied on 11 stars using the Magellan telescope in Chile. The scientists found that the sun is different from most of those stars, and suggest that building rocky planets depletes the amount of planet ingredients available to the forming star.

While the idea is compelling, it needs to be verified, said Nader Haghighipour of the University of Hawaii at Manoa. "It's an approach that, considering our solar system, seems to be viable," he said. "Until they find one or two systems with planets, it's hard to say anything."

MEETING NOTES

More Milky Ways

The Milky Way and its satellite galaxies, the Magellanic Clouds, are not one-of-a-kind: There are at least two distant galaxies that very closely resemble the local assemblage, Aaron Robotham of Australia's International Centre for Radio Astronomy Research and the University of St. Andrews in Scotland reported on August 23. Like our own spiral galaxy, these two galaxies also have relatively large and nearby companions. Astronomers spotted the Milky Way's twins in data returned by the Galaxy and Mass Assembly survey. The survey, which is tasked with mapping the local universe, studies the nearest 340,000 galaxies. So far only 14 of those resemble the Milky Way and Magellanic Clouds — and only two are very close matches. Robotham and colleagues suggest that just 0.4 percent of Milky Way-mass galaxies host observable Magellanic Cloud-type satellites, meaning that while our Milky Way isn't one of a kind, it also isn't a dime a dozen. — *Nadia Drake*

Hot planet keeps its water

A small planet whizzing around its star in 17 hours, 41 minutes must surely be a lava world, a scorched pile of rock with nary a water molecule in sight, right? Wrong. New observations of the planet called 55 Cancri e, which is just two times larger than Earth, suggest that although the world is super-heated, the planet is most likely made of a rocky core and shrouded in an atmosphere containing as much as 20 percent water, said Diana Dragomir of the University of British Columbia on August 27. "This planet is so close to its star we don't expect it to have an atmosphere, but there it is," she said. Dragomir observed the planet as it passed between its star and Earth, which — when combined with previous data — allowed her to determine what the planet is probably made of. The results suggest that while the surface temperature is smoldering at thousands of degrees, 55 Cancri e has somehow managed to hold on to an atmosphere. — *Nadia Drake*

Seven Sisters distance

Though the Pleiades star cluster sparkles clearly in the night sky, astronomers still don't really know how far away it is. Determining the distance to the young, bright cluster is important because astronomers base several principles on it, such as how young stars behave and how far away nearby galaxies are. Early estimates placed the cluster at an average of about 434 light-years away; then along came the European Space Agency's Hipparcos satellite, which found a distance of roughly 398 light-years by taking high-precision measurements of stellar motion and position. "If Hipparcos is correct, then we have an incomplete understanding of young stars," said Carl Melis of the University of California, San Diego. Melis is attempting to determine the distance to the stars using a supersensitive array of radio telescopes, an ongoing project he described on August 27. So far, Melis has one measurement: 473 light-years. Another method, described by Siegfried Röser of Germany's University of Heidelberg, determined a distance of 410 light-years. Some of the discrepancy, Röser suggests, could be a consequence of measuring stars at different edges in the cluster, which is spherical and expanding. — *Nadia Drake*

Life

"Dinosaurs have come and gone, but mites have hardly changed." —DAVID GRIMALDI

Amber-tombed mites look familiar

Oldest arthropods sealed in resin similar to modern forms

By Meghan Rosen

Two tiny mites trapped in fossilized tree resin have smashed the record for ancient amber-preserved arthropods, a group of critters that includes beetles, butterflies, spiders and shrimp. At 230 million years old, the mite fossils are about 100 million years older than previous finds and indicate that mites' basic body blueprint was built to last.

"Dinosaurs have come and gone, but mites have hardly changed," says David Grimaldi of the American Museum of Natural History in New York City. "Their body form is quite similar to what we see in gall mites today."

That similarity is somewhat surprising considering that Earth was profoundly different 230 million years ago, when most plants were ferns, the Atlantic Ocean didn't exist and pterosaurs cruised the skies. The Triassic-period mites, however, look just like their present-day relatives: They have segmented bodies, piercing mouthparts and legs bristling with "featherclaws," Grimaldi and his colleagues report September 11 in the *Proceedings of the National Academy of Sciences*.

Mites do seem to have made major adaptations to their diet. Unlike modern gall mites, which feast mostly on flowering plants, the Triassic ones chowed on conifers.

Grimaldi's team discovered the two species of mites, *Triasacarus fedelei* and *Ampezzoa triassica*, smothered in droplets of amber from a now-extinct species of cone-bearing tree.

Each golden globule is about the size of a grain of rice. The creatures, visible only through a microscope, appear as tiny flecks that mar the fossilized resin's clarity. "You can see these little critters in all their lifelike glory," says paleoentomologist Michael Engel of the University of Kansas in Lawrence.

At 230 million years old, the mite species *Triasacarus fedelei* (top) and *Ampezzoa triassica* (bottom) are 100 million years more ancient than any other arthropods to be found in amber.

The team picked through ancient sediments in the Dolomite Alps of Italy in search of resin dollops, and then took two years to examine 70,000 amber droplets, shards and fragments. Only three housed arthropods. "With this discovery, we're obviously all hot and ready to go back and screen through lots more," Grimaldi says.

Average bears are pretty smart

Tests reveal solitary species' ability to learn concepts

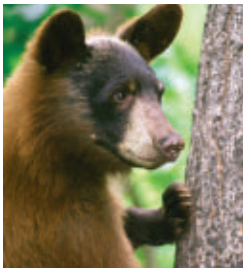
By Susan Milius

American black bears that take computerized tests by pawing, nose-bumping or licking a touch screen may rival great apes when it comes to learning concepts.

Using three zoo bear siblings as classroom subjects, comparative cognitive psychologist Jennifer Vonk of Oakland University in Rochester, Mich., and her colleagues presented pairs of pictures to the bears on a rugged computer screen and gave them food treats for touching the image from a certain category. To demonstrate learning a concept, bears had to figure out what kind of picture would earn a treat and then pick that kind of image from a new set.

One challenge, picking a black bear's picture instead of a person's, could be mastered by relying on a mix of visual clues such as furriness or snout shape. But picking out all the animals from non-animals — cars or landscapes, for example — required finding more abstract connections among pictures that didn't look much alike.

At least one of the bears showed some capacity for each of the five concept tests, Vonk and colleagues report in an upcoming *Animal Behaviour*.



American black bears, which live relatively solitary lives as adults, show an ability to learn concepts such as image recognition.

Bear intelligence has been "very underappreciated," says Gordon Burghardt of the University of Tennessee in Knoxville. "They're very smart and they have large brains." They also live relatively solitary lives, an important contrast with the mostly social animals tested for complex mental capacities to date.

The new study's tests, similar to ones that gorillas and orangutans took, were aimed at homing in on the mental capacities of these not-particularly-social bears. The bears differed considerably in how well they met the challenges, possibly because of the order in which researchers presented the tests. One animal learned to tell animals from non-animals but didn't quite get the "bears versus humans" challenge.

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Loyal proteins take on big jobs

Cells off-load noncritical work on multitasking enzymes

By Rachel Ehrenberg

Monogamy is not for the faint of heart, at least if you're a protein.

Scientists examining the convoluted network of a cell's metabolic reactions find that loyal proteins — those that stick to one main task — have important, high-stress jobs. Their promiscuous counterparts, which dabble in various chemical reactions, do tasks less crucial to life.

The new work, published in the Aug. 31 *Science*, examined the activity of enzymes — the proteins that make chemical reactions happen — in the bacterium *E. coli*. Researchers at the University of California, San Diego and Harvard Medical School used a computer model to analyze the various reactions that allow the bacterium to go about its business.

Of the 1,081 enzymes studied, 404 were generalists, carrying out multiple chemical reactions. The 677 specialist enzymes, it turned out, were essential for the bacterium's survival, tasked for example with turning genetic instructions into proteins.

Revealing where the generalists and specialists do their stuff in a metabolic network could help scientists identify starter enzymes for designing new drugs, fuels and other chemical products. It also may help biologists create organisms from scratch, says Pablo Carbonell, a synthetic biologist at the University of Évry-Val-d'Essonne in France.

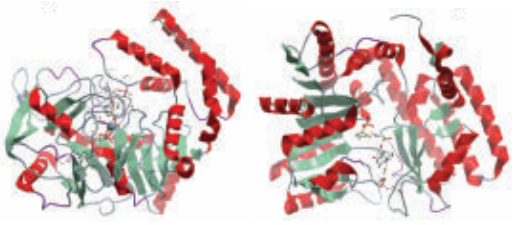
The work clears up a long-standing question about promiscuity and monogamy among enzymes. Enzymes act on what scientists call substrates; for example amylase, an enzyme in saliva, breaks down the substrate starch. For more than 100 years enzymes have been presented as exceedingly loyal to their substrates. But a number of promiscuous enzymes that interact with multiple substrates in multiple reactions suggest that not all enzymes are the dedicated, loyal players they've been made out to be.

In the 1970s, microbiologist Roy Jensen put forward the idea that early in the history of life almost all enzymes carried out several tasks, albeit not as efficiently as today's specialists. This multitasking would have allowed a primitive cell with a small repertoire of proteins to get things done. But why these promiscuous enzymes persist today remains a puzzle.

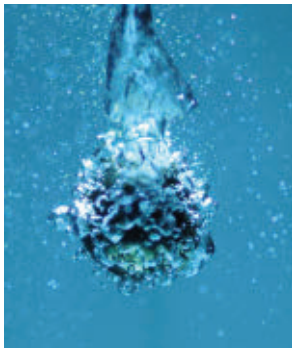
The network approach allowed the researchers to examine where monogamy and promiscuity matter. "In a way it's like looking at a traffic pattern in a city," says team member Bernhard Palsson of UCSD. Palsson and his colleagues looked for points in *E. coli*'s metabolic network that have to work for the whole system to function. "We know in a city that there are critical streets, intersections or bridges where if stuff goes wrong, things come grinding to a halt," Palsson says.

In addition to catalyzing reactions essential for life, the monogamous enzymes work at major thoroughfares in the network. So enzymes that deal with glycolysis, the almost constant process of turning food into energy, are specialized, loyal and dedicated. But an enzyme that deals with making vitamin B12, which cells don't need much of, can be a promiscuous jack-of-all-trades type.

Promiscuous does not equal unimportant, though. Enzymes tasked with recognizing and breaking down toxic substances serve the cell better if they can recognize and deal with more than one kind of danger. ■



A loyal protein (left) that makes one kind of chemical reaction occur usually has a very important, active job in the cell. Promiscuous proteins (right) do work that's less essential.



Bubble-free boiling

Dip your finger in water and then quickly dip it in molten lead — you won't get burned, thanks to an insulating layer of steam that forms around the finger. Chemists have now exploited this phenomenon, known as the Leidenfrost effect, to boil water without making bubbles (as seen at left, top). Researchers covered a steel ball with water-hating materials and chemicals. This turned the sphere's exterior into a nanoscale mountain range peppered with deep valleys. Heating the sphere to 400° Celsius and dropping it in room-temperature water spurred boiling, but no furious bubbles, the team reports in the Sept. 13 *Nature*. Treating the surface of another sphere to make it water-loving instead locked the water in a violent bubbling phase (like that seen at left, bottom). Manipulating this phase-chemistry could lead to tricks for reducing drag on ships or preventing forceful bubbling explosions in labs or kitchens.
—Rachel Ehrenberg

FROM TOP: SYSTEMS BIOLOGY RESEARCH GROUP/JACOBS SCHOOL OF ENGINEERING/UCSD; IVAN VAKARELSKI

Filter unmixes oil and water

Combination of chemistry and gravity could help clean spills

By Rachel Ehrenberg

Oil's disdain for water is legendary, but once forced to commingle they're nearly impossible to separate. Now scientists have developed a specialized filter that cleanly separates the two, allowing water to pass through and leaving oil behind.

Such filters could prove useful for cleaning up oil spills or cleaning water at treatment plants.

A simple setup using the new filter successfully removed more than 99.9 percent of oil from an oil-water mix, researchers report online August 28 in *Nature Communications*.

Oil and water both stick to their own, staying on opposite sides of the room at a molecular cocktail party. But add a surfactant — a molecule that is partly attracted to water and partly attracted to oil — and you've got a social lubricant that forces water and oil to mingle. Once this socializing happens, it's difficult to undo.

One way to get them apart is with a filtering membrane coated with water-hating molecules; such membranes allow oil through, but not water.

Think of a nonstick Teflon pan, says materials scientist Anish Tuteja, who led the new work. Oil moves smoothly across such surfaces while water beads up. The new membrane is the opposite of Teflon, allowing water to pass through but not oil. And it works with gravity alone.

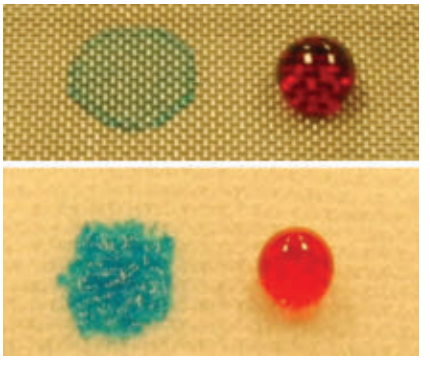
Tuteja and his colleagues start with a filter scaffolding — this can be wire screen, filter paper or a piece of polyester fabric. Then they dip the screen in a blend containing two compounds: POSS (fluorodecyl polyhedral oligomeric silsesquioxane) and PEGDA (polyethylene glycol diacrylate). A few minutes under ultraviolet light cures the membrane, and it's hardened and ready to use.

When a water-oil mix is poured onto the filter, the PEGDA is attracted to the water and tries to bond with it, which contorts the surface of the filter on a molecular level, pulling the water through. The oil, which is less dense than water, stays on top.

"It's a very counterintuitive filter," says Tuteja, of the University of Michigan.

Tuteja and his colleagues put the new filter into a simple device to separate oil and water. When a mixture is poured into the container, water flows through the POSS-PEGDA filter into the bottom of the container. A second, traditional filter allows oil sitting atop the water to be diverted off to the side into a different container. The setup worked quite nicely, separating rapeseed oil and water, for example, and the diesellike hexadecane and water. Instead of requiring vacuums or elaborate setups that use pressure and power to force a mixture through a filter, the new arrangement uses only gravity.

"The research is excellent; the membrane is a feat in itself," says marine engineer Jerome Milgram of MIT. He adds that it remains to be seen whether such a setup would work well in the field. An oil spill in the ocean, for example, might require thousands of hours and thousands of gallons of filtering.



A. KOTA ET AL./NATURE COMMUNICATIONS 2012

A blend of chemical compounds coating stainless steel mesh (top) or polyester fabric (bottom) allows water (blue) to pass through while oil (red) is repelled and beads up.

Environment

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Nanopollutants pose crop risk

Tiny particles can boost toxic absorption by plants

By Janet Raloff

Nanoscale pollutants entering crop roots trigger a host of changes that can stunt growth, boost the plants' absorption of pollutants and increase the need for crop fertilizers.

Crops are exposed to manufactured nanomaterials in the exhaust from diesel-fueled tractors and in fabrics, sunscreens and other products that collect in the solids separated out of sewage and wastewater. These solids are routinely spread on U.S. fields to improve soils. Two new studies offer a glimpse at the toxic effects such nanoparticles may pose to future crops as exposures rise.

To study the impact on crops, a team led by Patricia Holden of the University of California, Santa Barbara exposed soy plants from germination through bean production to soil treated with either of two widely marketed metal-oxide nanomaterials: the cerium oxide used as a catalyst in diesel fuel and other products, or the zinc oxide particles used in sunscreens and as antibacterial agents.

This is the first investigation of the effects of nanomaterials on plants exposed via soil. "That's cool and obviously relevant to how plants would be affected in their native environment," notes analytical chemist Mark Schoenfisch of the University of North Carolina at Chapel Hill.

Compared with untreated plants, those grown in soil spiked with the highest dose of zinc oxide nanoparticles developed fewer leaves, Holden's team reported in the Sept. 11 *Proceedings of the National Academy of Sciences*.

By contrast, cerium oxide stunted plant growth at all concentrations, "but most dramatically at the lowest level used," Holden says.

Zinc accumulated in soy leaves and beans grown in treated soil. Cerium oxide's entry into the plants, however, didn't go farther than the roots' nodules. In plants receiving the highest cerium oxide doses, those nodules didn't contain the bacteria that normally take the nitrogen from the air and convert it into a chemical form (ammonia) that soy and other crops use as a fertilizer.

The ability of soy and other legumes to fix nitrogen "is one of the most important microbial processes in agriculture," says Jason White, an environmental toxicologist at the Connecticut Agricultural Experiment Station in New Haven. So the ability of cerium oxide to shut this process down "was the most significant new finding" — and the most troubling.

In a second study published September 4 in *Environmental Science & Technology*, White's team exposed the roots of tomato, zucchini and soy plants to fullerenes, widely used nanomaterials manufactured from pure carbon. Because trace residues of toxic pesticides such as DDT lace soils long after their last application, White's group looked to see if nontoxic quantities of fullerenes in the root zone affect how plants respond to any breakdown residues of DDT (banned in the United States since 1972).

When fullerenes were present, all three types of plants removed more of the pesticide from the material in which they had been grown — in this case, vermiculite. Since plants were not grown to the fruiting stage, White says, there's no way to know if the pollutant would also accumulate in the crop — "but it was certainly in the shoot system."

KIMBERLY CASEY/GSFC/NASA

Asian ice loss rethought

Rising temperatures in the Himalayas may bring more moderate melting of the region's glaciers than some previous studies have concluded. By combining six years of topographic measurements gathered by NASA's Ice, Cloud and Land Elevation Satellite with radar data collected by the space shuttle *Endeavour* in 2000, an international team mapped glaciers throughout the range. The researchers estimate that the mountains as a whole lost nearly 13 billion metric tons of ice per year from 2003 to 2008. That figure is more than twice the melting tonnage reported earlier this year by another team using data from the GRACE satellites (*SN: 8/25/12, p. 18*), but much less than ground-based observations have indicated. The study also challenges the long-accepted idea that a coat of rocky debris slows ice loss: Dirty glaciers like Nepal's Ngozumpa (shown) shrank at about the same rate on average as their cleaner neighbors, the researchers note August 23 in *Nature*. —*Allison Bohac*

NEWS BRIEFS

Black carbon not so black

Black carbon, aka soot, may not have as big an effect on global warming as scientists had thought. Climate models generally assume that soot mixes with other particles in the atmosphere in a way that enhances overall warming. Now, measurements near Los Angeles, San Francisco and Sacramento suggest that instead of doubling this particular effect, black carbon increases it by an average of 6 percent. Many simulations may thus overestimate warming attributable to black carbon—although soot contributes to atmospheric heating in other ways. The work, led by Christopher Cappa of the University of California, Davis and Timothy Onasch of Boston College and Aerodyne Research in Billerica, Mass., appears in the Aug. 31 *Science*. —*Alexandra Witze*

Archaea may be behind ocean's methane exhalations

A ubiquitous one-celled microbe may be behind the copious amounts of methane at the ocean's surface. Methane, a greenhouse gas, is produced by anaerobic microbes, those not dependent on oxygen, so scientists have puzzled over how the ocean surface could be saturated with the gas. In the Aug. 31 *Science*, William Metcalf of the University of Illinois at Urbana-Champaign and his colleagues show that a type of archaea—common microbes unrelated to bacteria—produces a phosphorus-rich food that aerobic bacteria crave. When they eat it, the bacteria jettison methane as a by-product. The scientists also identified an aerobic microbe with a gene to make that methane feedstock: *Pelagibacter*, one of the sea's most abundant organisms. —*Janet Raloff*

Antibacterial agent weakens muscle strength in mice

A germ-fighting chemical added to many soaps, toothpastes and fabrics can interfere with how muscles contract, new research shows. The doses of the chemical, triclosan, found to diminish muscle strength and blood flow in mice roughly matched those already found in people in some parts of the United States, Isaac Pessah at the University of California, Davis and his colleagues report in the Aug. 28 *Proceedings of the National Academy of Sciences*. The report suggests that triclosan interferes with the movement of calcium into and out of cells. Although the agent was tested in mice and fish, the mechanism by which it impaired muscle activity could occur in people. U.S. surveys have found triclosan in fluid samples from about three-quarters of people tested. —*Janet Raloff*

Face smarts

Humans aren't the only animals who possess special skills with mugs

By Susan Milius

Queens of the paper wasp *Polistes fuscatus* recognize wasp peers by face.

M. SHEEHAN

Let's take a minute to turn faces upside down.

Pick any face. Ignore beards, glasses, hairdos or lack of any hair to do, and upend the facial features of Charles Darwin, Ray Charles or anyone named Charlotte who reads *Science News*.

People who normally remember or match a face perfectly well have trouble when it is standing on its head. But before there's a chorus of "well, obviously," let's try turning dogs upside down, too.

Most people who don't breed dogs or judge shows don't recognize an individual dog nearly as well as a person's face to begin with. And when pictures of poodles and Irish setters flip upside down in quizzes of learning and memory, people struggle a bit more than they do with the natural versions. But scores drop only modestly with these flipped-dog pics, compared with the dramatic drop for facial flips.

The disproportionate decline in remembering inverted faces has shown up in a variety of recall tests, with comparison groups from dogs to bridges, airplanes, stick figures, even clothing from 17th and 18th century paintings. Upside-down faces are where quiz scores really slump, and researchers view that slump as one of the signs that test-takers are actually experts at face perception.

A dog is a dog in any orientation. Same for other organisms and objects. But right-side-up faces apparently are so compelling that people have become especially masterful at recognizing the human visage. Know-it-at-a-glance holistic techniques behind this mastery fail when the world turns upside down.

The world of face-perception science didn't exactly turn upside down last winter. But it developed a novel slant when two evolutionary biologists from the University of Michigan argued that a type of paper wasp, like people, shows signs of using specialized approaches to recognize faces of its own kind.

Paper wasps aren't mammals, or even vertebrates. Before this study, the notion that a creature so distant from humankind in the tree of life could possess face expertise was weirder than an upside-down Darwin. Now the wasp development has added some sizzle to the endeavor of establishing what face-perception abilities other creatures may actually have. Emerging patterns in the animal world may reveal what drives the evolution of remarkable face prowess.

"The search is on," says neuroscientist Winrich Freiwald of Rockefeller University in New York City.

While some researchers continue to invent tests (and debate how to interpret test results) for probing facial aptitudes among humankind's primate cousins, other efforts have pushed beyond primates. Sheep, as well as those paper wasps, appear to have some special face skills. And faces may be important among rodents in ways that demand a more ticklish view of what face perception means. When it comes to face smarts, researchers are finding that the size of an animal's brain may not matter as much as the company it keeps.

You're good, really

Extreme skill at learning faces comes so naturally to many people that it can be hard to recognize as anything special.

But consider how many faces of family, friends, coworkers, classmates, teachers, neighbors, store clerks, actors and even

long-dead historical figures on money, stamps and book frontispieces you can easily recognize. Learning to identify all those people by their hands would be a daunting challenge.

One argument that faces are something special for human perception points to newborns' phase of facial fascination. In a classic test, babies averaging just 9 minutes old turned their blurry gazes farther to follow a schematic eyes-nose-mouth setup than to follow a disk with higgledy-piggledy features.

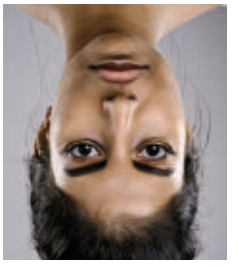
When babies grow up into children, at least three parts of the brain, and perhaps more, respond more strongly to human faces than to other objects, Freiwald says. Just how such skills develop as an infant ages, and how nurture might enhance nature, is still a matter of furious discussion.

Another nod to specialization comes from studies of people who suffer brain injuries that damage their powers of perception. Some people end up essentially blind to faces, a condition called prosopagnosia. "Not surprisingly, many prosopagnosics have impairments with both faces and objects," says Bradley Duchaine of Dartmouth College.

But extensive testing has found people who struggle with just faces. A woman known in scientific papers as PS survived a blow to the back of her head after being hit by a bus. She recovered well enough to sail through tests of naming objects, but had to depend on haircuts, voices and other nonfacial cues to name children in the kindergarten class she taught, or even members of her own family.

Her difficulties and the accompanying stress emphasize just how important face perception is in society. A face serves as a badge of identity, a meter of welfare, a novella of reactions and intents: all important aids in negotiating the alliances and enmities of social living. So it's easy to imagine how evolution may have favored skill for remembering faces.

Then there are the neuroscience tricks, such as the upside-down face test, that highlight a specialized system for face recognition by causing that system to fail. Take the bit of inverted spookiness called the Thatcher effect, honoring the former British prime minister whose portrait stars in a storied demonstration of the phenomenon. (Look to the image at right to see the effect on a more generic face before reading the spoiler ahead.)



At first glance, this upside-down face appears normal. But flip it right side up, and you'll see that your face-adept brain has duped you.

At first glance, a test's upside-down portrait comes across as no more than a flipped version of an ordinary person. Rotating the image right-side-up, however, creates a growing queasiness that turns B movie–gruesome as the brain can finally perceive the details properly. The eyes and mouth sit upside down relative to the rest of the face. Even partly right-side-up, a face that hadn't been disturbing now looks nightmarish.

Messing with orientation isn't the only way to tease the face-perception system. A person trying to identify the upper part of a composite face as, say, George Clooney's works fast and accurately when the Clooney half appears misaligned from another celeb's mouth and jaw. When the halves line up to form the familiar facial oval, perception falters; the face-specialized system apparently tries to identify the half-and-half face as if it were indeed one whole.

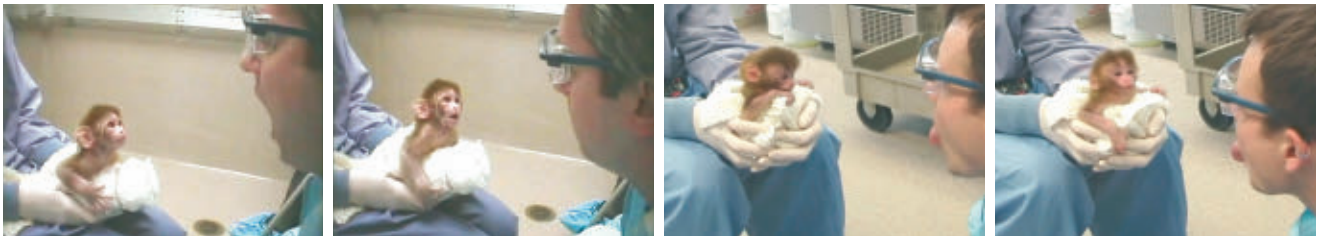
Relative faces

Many of humankind's primate relatives live a complex social life too, and some of them also show interest and skill when it comes to faces.

Very early in life, chimps and at least one kind of monkey react to faces, although the babies are flexible about whom they gawk at. Rhesus macaques just 3 days old lip smack and stick out their tongues if a human adult does so in front of them, Pier Francesco Ferrari of the University of Parma in Italy and colleagues have found. In 2009 in *Current Biology*, Ferrari and colleagues also reported baby macaques gazing into their mothers' faces and lip smacking when mom did. Yet the babies don't make faces at a gesturing human hand or a spinning disk.

Macaques as old as 2 years still show some kind of interest in faces after a face-free start in life. Yoichi Sugita of the National Institute of Advanced Industrial Science and Technology in Tsukuba, Japan, worked with Japanese macaques raised for six months to two years without seeing faces. (Their human caregivers wore hoods.) When researchers finally presented pictures of faces, the macaques looked longer at the visages of other macaques, and of humans too, than at pictures of cars, alarm clocks and other unfamiliar objects.

Some other nonhuman primates show signs of face expertise during picture



TOP: WARREN GOLDSWAIN/SHUTTERSTOCK; ADAPTED BY E. FELICIANO; BOTTOM: P.F. FERRARI *ET AL*/*PLOS BIOLOGY* 2006

Monkey see, then do Infant rhesus macaques mimic a person's facial expressions, opening their mouths (left two video stills) and sticking out their tongues (right two stills) when a person does the same. Such facial imitation may help infant monkeys prepare for a social world.

tests. Chimps appear to perceive faces better in a right-side-up orientation than in an upside-down portrait. Most studies testing for this inversion effect found it, Lisa Parr of the Yerkes National Primate Research Center in Atlanta reported in a 2011 review in *Philosophical Transactions of the Royal Society B*. In their version of the test, Parr and colleagues judged that chimps' upside-down difficulties were greater with chimp faces than with pictures of species they had never encountered (capuchin monkeys) or objects with which they had little to no experience (cars, for example).

Parr and her colleagues also worked out a way to test chimps on half-and-half faces, in an echo of the human tests. When the upper part of a portrait of one chimp's face sat weirdly fused atop the mouth and jaw of a different individual, about two-thirds of test chimps matched the mash-up to a picture of the top chimp instead of the bottom one. (Attending to eyes may be particularly important.) When Parr skewed the halves and broke the illusion of a new whole face, test chimps dropped closer to evenly dividing their matches between the whole faces contributing to the composite.

Not just primates

Sheep likewise react to faces in sophisticated ways. Yes, sheep. In the *Oxford Handbook of Face Perception*, published in 2011, neuroscientist Keith Kendrick and a colleague hailed sheep as dispelling a long-held notion linking specialized face perception only with primates.

Sheep may not have the brainy luster of the primate lineage, but they do lead social lives and they do attend to faces. During his years at the Babraham Institute in Cambridge, England, Kendrick and his colleagues trained sheep in such protocols as using pictures as clues to which arm of a Y-shaped enclosure holds a reward at its end. With such procedures, the researchers established that sheep can remember the faces of 50 other sheep for at least two years and can distinguish subtleties between an actual face and a computer-morphed image that is only slightly different. And that's just a crumb of the case that Kendrick, now at the University of Electronic Science and Technology of China in Chengdu, has made for sheep as face experts.

In the classic test of distinguishing between upside-down pictures of faces of their own breed, sheep showed the diagnostic dip in performance that people and chimps do. Yet for pictures of buckets or portraits of an unfamiliar sheep breed, right-side-up versus upside-down didn't make much of a difference.

Sheep even showed signs of distinguishing between facial expressions. When presented with a picture of a sheep face captured after a stressful bout of isolation or a picture taken during apparent calm, sheep tended to favor the contented sheep.

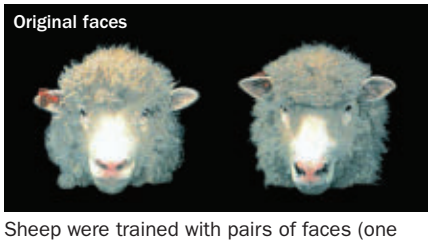
Paper wasps don't have any facial expression — the hard outer skeleton of an insect's body can't move — but they do have faces. And the common paper wasp, like distant primates, appears to have specialized facial skills, Elizabeth Tibbetts of the University of Michigan and Michael Sheehan, now of the University of Arizona in Tucson, reported in *Science* last year.

Taking a close-up look (with respectful distance) at the faces of *Polistes fuscatus* reveals a riot of stripes, almost-eyebrows, quasi-mustaches, forehead swatches and cheeky splashes of yellow and brown. These colorful countenances reportedly stare back at the huge face of a human drawing near. Part of why Tibbetts loves working with the paper wasps, she says, is that they track her as she walks toward them in the lab and "they look at you in ways that other insects don't."

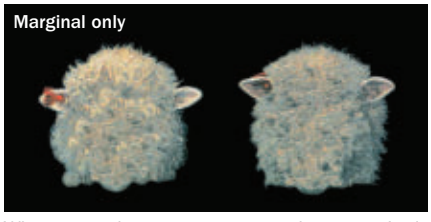
These paper wasps are also the only insects known so far to recognize familiar individuals of their own species by their faces, she says.

To explore the limits of a queen wasp's face skills, Tibbetts and Sheehan pasted a picture at each crossbar end of a T-shaped wasp passage. Pictures showed wasp faces, geometric patterns or some nonfacial object that a wasp might hunt, such as caterpillars. One picture in each pair designated a refuge from an electric zap that researchers shot through the floor. (Unfortunately, Tibbetts says, the team couldn't figure out how to train wasp queens by offering food rewards,

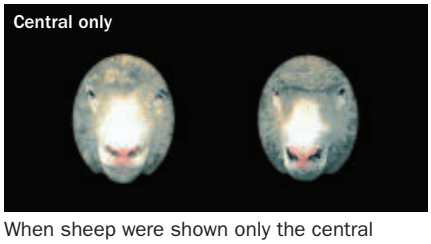
Woolly skills To test the nature of sheep's facial abilities, researchers first trained sheep to walk toward one of a pair of faces presented at either end of a Y-shaped passage. Then the researchers changed the faces in various ways (outlined below) and tested how those changes affected recognition. The results suggest that sheep definitely rely on marginal features, but when it comes to familiar faces, they can use expert shortcuts based on central characteristics.



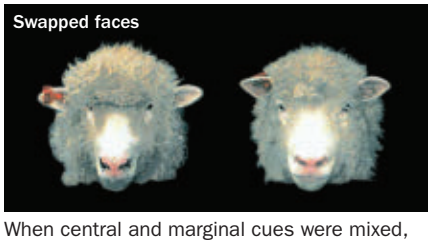
Sheep were trained with pairs of faces (one pair shown). All the faces belonged to sheep of the same breed, but only some were familiar.



When central cues were removed, so marginal cues had to be used, sheep could still identify both familiar and unfamiliar faces.



When sheep were shown only the central features of the faces, discrimination became more difficult for unfamiliar faces. But sheep still performed pretty well on familiar faces.



When central and marginal cues were mixed, sheep most often identified a target sheep via the marginal cues. However this trend was less strong for familiar faces.

J. PEIRCE *ET AL./NEUROPSYCHOLOGIA* 2000

as has been done with the sheep. Food is not particularly motivational since queens can go without it for a month.)

In the study, the paper wasps learned to distinguish between two faces faster than they learned about geometric patterns or other pictures. Jumbling the features slowed down the learning and destroyed any particular advantage wasps normally showed in face learning. Thus, wasps too must have their own version of a specialized face-recognition system, conclude Tibbetts and Sheehan.

Studies in a related wasp added a social dimension to the story. *P. metricus* queens flunked a test for recognizing individual faces of their own kind.

It makes sense that faces wouldn't matter much in this species compared with *P. fuscatus*, Tibbetts says. Queens of the face-indifferent species usually found colonies on their own, so there's not much pressure to recognize potentially mutinous royal housemates. In contrast, face-smart queens of the common paper wasp regularly cluster with other young queens to build a joint nest and lay eggs there. These clustering queens fight and establish a dominance hierarchy from one top queen on down. So face expertise should help individuals keep track of whom to fight and whom to cower from among scrappy, ambitious royalty.

Tibbetts is now working on understanding how face skills develop throughout life and how experience nurtures inborn capacities. Testing her ideas would be a problem in people; raising babies away from faces or with loving but masked mothers — don't even think about it. Paper wasps and other facially deft but not so emotionally charged animals may offer insights.

Face feeling

Much of the study of faces relies on what they look like, which is not so strange a research bias for visually oriented humans. But that preoccupation may mean that science is missing whole other worlds of face perception, such as that of nocturnal, burrow-dwelling rodents, says Michael Brecht of Humboldt University in Berlin.

Rats live in a smelly, touchy world, and Brecht and his colleagues have been studying what he calls their "amazing" whisker-sensing abilities. Rats meeting whiskers-to-whiskers may perform an unappreciated exchange of facial expressions, he and his colleagues proposed late last year in *Behavioral Neuroscience*.

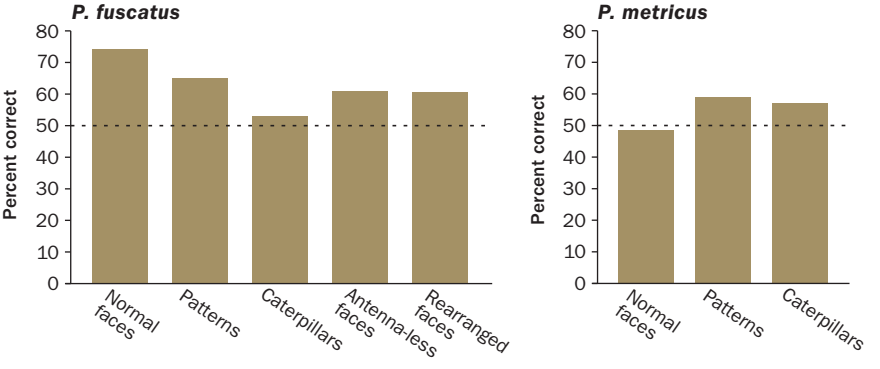
When rats meet, they sniff both ends (no suggestion yet of a specialized rear end perception system). But front-end encounters prevail after initial investigation. Rats align nose to nose, though trimming the whiskers can throw off the alignment. Then the rats sweep their whiskers forward and back. Among aggressive rats, the whiskers angle more forward and sweep faster than in apparently more serene rodents. Thus the whisker touch, which gives rats so much information about their world, may be detecting a whisker-position equivalent to sneers and stick-out-your-tongue taunts. Instead of just studying how animals look at each other's faces, Brecht suggests a fuller picture of specialized facial skills would include facial touching, too.

Even focusing on just ho-hum sight, more animal groups remain to be tested. Patterns may point to the evolutionary history of facial expertise, says neuroscientist David Leopold of the National Institute of Mental Health in Bethesda, Md. People, chimps, sheep and paper wasps almost certainly did not inherit their powers full-blown from a mutual common ancestor, he notes. Yet ancestors of some or all might have passed down building blocks of those skills.

After reviewing what's known so far about face perception in nonhuman animals, Leopold has sketched out some speculations that he hopes biologists will someday be able to test. Perhaps far back in time, he says, ancestors developed capacities for watching faces of possible predators. Though the ability to track the direction of another creature's gaze doesn't seem widespread, maybe ancient ancients started with some kind of interest in eyes. And then certain conditions may have nudged branches of descendants toward more elaborate attentions, not so much to predators but to the faces of their own kind.

At this stage it's just the start of a story, but Leopold predicts that tales of animals that evolved in social groups among plenty of faces will make a good long chapter. ■

Buggy mugs For those willing to look closely, the faces of *Polistes fuscatus* wasps (right) differ in markings and shades. Queens who build joint nests pick up on those differences, too. In tests asking the wasps to choose a target image from two possible offerings, *P. fuscatus* queens recognized full faces better than other images. Singleton queens, of the species *P. metricus*, didn't show the same aptitude.



SOURCE: M. SHEEHAN AND E. TIBBETTS/*SCIENCE* 2011

Explore more

- A. Calder *et al* (editors). *Oxford Handbook of Face Perception*. Oxford University Press, 2011.

M. SHEEHAN


E
F

TRICKS FOODS PLAY

What you eat may fool your brain into packing on the pounds

By Janet Raloff

Photography by Cary Wolinsky

Most people would never equate downing a well-dressed salad or a fried chicken thigh with toking a joint of marijuana. But to Joseph Hibbeln of the National Institutes of Health, the comparison isn't a big stretch.

New animal experiments by Hibbeln and his colleagues have recently shown that the body uses a major constituent in most vegetable oils to make its own versions of the psychoactive ingredient in marijuana. Called endocannabinoids, these natural compounds play a role in heightening appetite. So overproducing them unnecessarily boosts hunger, similarly to how pot triggers the munchies (*SN: 6/19/10, p. 16*).

If what happens in people mirrors what happens in animals, then the prevalence of soybean oil, corn oil and other polyunsaturated vegetable oils in today's Western diet means your body is "dumping out a lot of these marijuana-like molecules into your brain," explains Hibbeln, a nutritional neuroscientist. "You're chronically a little bit stoned."

Vegetable oil's link to endocannabinoids is just one example of newfound and surprising ways that foods can confuse calorie-sensing networks and foster obesity — in some cases by damaging the brain. Especially troubling: Excess body weight itself can exaggerate the risk of the brain telling a well-fueled body that it is running on empty.

By understanding what messes with the body's satiety meters and why, scientists hope to identify tactics for reducing a diner's likelihood of becoming another statistic in the obesity epidemic.

Energy in the balance

Responsibility for monitoring calorie input and energy output falls to the brain. And the job is not easy, says endocrinologist Michael Schwartz, director of the University of Washington's

PHOTO ILLUSTRATION: RICK KYLE

Diabetes and Obesity Center of Excellence in Seattle.

To maintain a constant weight, a 160-pound man would need to consume "about 1 million calories over the course of a year," Schwartz explains — "and expend almost exactly that same million calories." Only by integrating hosts of chemical signals day and night can the brain manage this energy-budgeting feat, which it has done quite well for most people throughout most of history.

Though scientists once thought the body controlled appetite through a process of error correction, they now know that the brain doesn't wait for mistakes to occur before sending signals that alter everything from blood pressure and breathing rates to food intake. It instead predicts upcoming needs by analyzing outputs from sensors assessing internal and external conditions. This anticipatory process is known as allostasis.

People tend to become consciously aware of this complex balancing act only when the brain triggers the release of hormones that elicit sensations of hunger, thirst or some overwhelming sense of fullness. But allostasis may occasionally stumble in the context of the current food environment.

Throughout much of human history, hunger would have dominated; chronic famine was the rule. So evolution has programmed the brain to prompt the body to pig out on energy-dense foods, especially fats, whenever they become available, says Daniele Piomelli of the University of California, Irvine. By gorging on fat during brief dietary bonanzas, people could store enough energy to get through the next caloric dry spell.

Today, with 24/7 access to food, a biological drive to eat high-calorie fare is rapidly evolving into a health liability. Globally, more than one in five adults are overweight, with more than a third of them obese. And in some countries, including the United States, one in six children over age 2 are also obese.

The brain's faulty anticipation of energy needs, as well as other forms of neural confusion, may be fostering an unconscious urge to overeat.

Chewing the fat

Piomelli can attest to that. Last year, his team showed that diets high in vegetable oils messed with allostasis. These oils triggered overeating in animals by turning on production of hunger-promoting endocannabinoids (*SN Online: 7/8/11*). In an upcoming issue of *Obesity*, Hibbeln's team now blames this trickery on the linoleic acid found in that oil.

The central role of endocannabinoids in the nervous system's regulation of food intake has been known for at least a decade, Hibbeln says. When endocannabinoids bind to cellular structures known as receptors, brain tissues release dopamine, a messenger molecule that elicits a pleasant feeling. Until this reward system turns off, an urge to eat persists (*SN: 6/19/10, p. 16*).

When a person downs too much linoleic acid, it is as if the reward-seeking switch in the brain gets stuck in the "on" position. The impact — at least in Hibbeln's mouse study — is visible to the naked eye.

Some of the animals in the study chowed down on a diet that derived 1 percent of its calories from linoleic acid, a proportion consistent with what Americans typically ate around 1900. Animals in a second group ate food in which linoleic acid supplied 8 percent of all calories, an amount in line with what's found in a more modern U.S. diet. Even though both groups received the same proportion of their calories from fat and carbs, mice getting more linoleic acid gained substantially more weight.

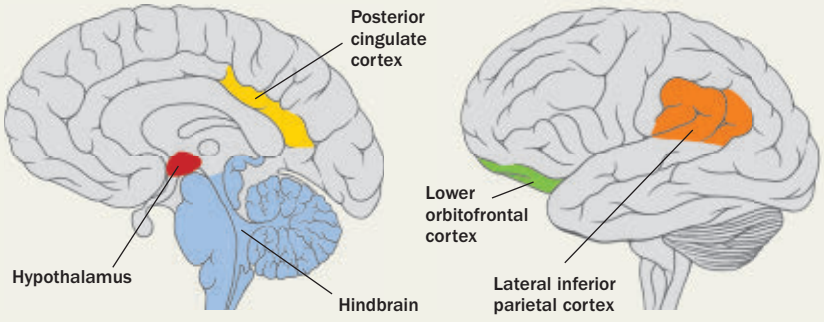
Those mice not only ate more, but they also gained more fat for every calorie eaten, Hibbeln explains. "You and I would rather eat more and gain less weight — and that would be what we saw with rats getting 1 percent linoleic acid."

Brain games

By promoting overeating, linoleic acid may trigger other changes that further derail the brain's ability to manage calories. Any energy the body consumes but doesn't use gets stored as fat. Hardly deadweight, fat can recruit immune cells that can spew inflammatory molecules and foster disease (*SN: 2/28/04, p. 139*).

Early research had suggested that the heart and the rest of the circulatory system were the main victims of these

Wiring gone awry By balancing caloric intake and output, the brain helps maintain a healthy body weight. But new research suggests that a modern Western diet, and the fat that often comes with it, can cause damage and confusion in crucial brain systems.



Rats on a fatty diet showed signs of cellular damage in a hypothalamic aggregation of neurons known as the arcuate nucleus. The damage was linked to overeating.

The default network, which includes these cortical regions and generally turns off when a person focuses on a task, never shut down in people who were overweight.

Areas of the hindbrain respond to endocannabinoids, appetite stimulants made by the body. Oils high in linoleic acid can lead to an overproduction of these compounds.

Obesity in teens has been linked to a reduction in the size of this brain area, which is involved in inhibiting behaviors and reducing impulsivity.

BOTH: PATRICK J. LYNCH/WIKIMEDIA COMMONS, ADAPTED BY T. DUBÉ

molecules. But emerging data indicate that fat-triggered inflammation also harms the brain.

For instance, Schwartz's group fed some normal-weight rodents standard chow for eight weeks to eight months and gave others meals with much more fat. Within a day, animals getting the fattier diet, but not the others, showed signs of inflammation in a part of the brain's hypothalamus known as the arcuate nucleus. When nerve cells here are activated, they drive hunger. As activity dials back, animals eat less, sometimes even losing weight.

Within a week of beginning the fatty diet, rats showed biochemical evidence of ongoing cellular destruction in this brain area. Shortly afterward, the cell damage appeared to subside. Two weeks later the damage returned.

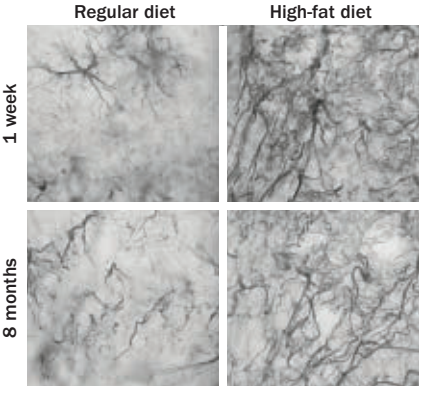
Nerve cells in the arcuate nucleus aren't the only players in eating and satiety, Schwartz notes, "but they seem especially important in terms of processing inputs from signals in the blood that are informing the brain about how much body fat mass there is." And not surprisingly, as brain damage progressed, the rats ate more than they needed to maintain their body weight. They ended up gaining weight, Schwartz's team reported in the January 3 *Journal of Clinical Investigation*. The team saw the same effect in mice.

As the brain damage became chronic, the arcuate nucleus appeared to lose its sensitivity to hormonal cues about how much body fat exists, Schwartz says. The brain interprets a reduced signal to mean that there is not enough body fat, and thus delays any command to stop eating. "Because you get less bang for the buck when you eat, in terms of satiety," he says, "you eat bigger meals."

Scans of similar brain regions in people who were lean, overweight or seriously obese showed signs that this kind of brain damage may not be limited to rodents. More or less, Schwartz says, the heavier a person, the bigger the signs of cellular destruction.

Other studies have found additional signs of damage in the brains of obese people, though this work hasn't pegged inflammation as the instigator.

Fat's scars Rodents fed a high-fat diet show changes in the brain at one week and eight months compared with rodents eating a regular diet. Damage is marked by a proliferation of cells called astrocytes, which can lead to scarring.



In one such study, endocrinologist Marc-Andre Cornier of the University of Colorado Denver and his colleagues identified a body fat–related deactivation of the shutoff switch for a neural processing center known as the default network. Spanning several brain regions, this network normally engages only when people are not consciously thinking or focused.

Once people start to focus on a task, the network should turn off, says Cornier. But, reporting late last year in *Obesity*, his team found that among formerly heavy people who had dieted and were now still somewhat overweight, the default network never shut off. This was true even when the study participants hadn't overeaten.

This network's activity could prove a distraction, Cornier says, preventing the brain from effectively monitoring satiety cues: "We know, for instance, that the more obese you are, the more you underestimate the number of calories that you eat and the less likely you are to feel hunger and satiety."

Related work linked obesity in teens with a reduction in the size of an area of the brain known as the orbitofrontal cortex, which plays an important role in inhibiting all types of behavior. Compared with lean teens, heavyweights showed impaired decision making, attention and monitoring of behaviors, and exhibited increased impulsivity, Antonio Convit of the Nathan S. Kline Institute for Psychiatric Research in Orangeburg, N.Y., and colleagues reported last year in *Obesity*.

Excess body fat may be only a proxy for what is really behind the brain problems: inflammation, high blood pressure or prediabetic changes like poor blood sugar control. "We think that maybe the obesity and these other factors cause the damage that lowers the brakes on certain behaviors, which in turn allows kids to eat more than they should," Convit says. "It sets up a vicious cycle."

A not-so-sweet trend

Low-calorie foods may also reeducate the brain's calorie-sensing machinery with lessons that might be best never learned.

Some 187 million Americans consume sugar-free foods and beverages, mostly in the form of soft drinks. Although a majority choose artificially sweetened soft drinks to keep from gaining extra pounds, such drinks may actually contribute to weight gain.

It's something Sharon Fowler of the University of Texas Health Science Center at San Antonio and her colleagues documented in a 2008 study. They analyzed data on almost 3,700 participants of a long-running heart study. Among recruits who started with a normal weight, frequent diet-soda drinkers went on to become overweight or obese during the next seven to eight years at roughly twice the rate seen among participants who avoided diet drinks. Fowler's group concluded that artificial sweeteners might be fueling the obesity epidemic that they had been designed to fight.

The problem may trace to the fact that diet drinks cause the brain to receive unreliable cues to a meal's calorie count, suggest animal experiments by behavioral neuroscientist Susan Swithers of Purdue University in West Lafayette, Ind. In what amounts to real-world Pavlovian training, the brain learns to link sweet-tasting foods passing through the mouth with the subsequent release of calories in the gut. But when that dietary signal becomes untrustworthy, with sweetness sometimes indicative of incoming energy,

other times not, the brain abandons sweetness as a gauge of expected calories.

By the time the brain figures out how much energy it has gotten in any given meal, animals who had downed sugary foods will have overeaten.

Mixed caloric messages from sweeteners can also mess with the hormonal milieu that normally signals when it is time to push back from the dinner table. For instance, a key satiety hormone known as GLP-1 was inappropriately low after sugary meals in rodents that had, over the course of several weeks, received erratic clues to the energy associated with sweetness.

Low GLP-1 led to elevated blood sugar, even though the animals' production of insulin — secreted to manage blood sugar — remained normal, Swithers' team reported July 15 in *Behavioral Brain Research*. If the same thing happens in people, then artificial sweeteners could prove a double whammy for overweight diabetics who often turn to the sweeteners to help control their waistlines and blood sugar.

The brain's energy-tallying network is also vulnerable to confusion when oral fat sensors relay inconsistent signals, the Purdue group finds. A study published by the team last year in *Behavioral Neuroscience* linked substantial weight gain in animals to the occasional replacement of fat with olestra, a no-calorie substitute.

Fighting the fat

Together, these findings suggest that the brain, a longtime master at tracking caloric intake, can be fooled. And when that happens, Swithers observes, weight management suddenly becomes challenging. "Now we have to start counting calories, reading food labels and tracking how many steps we took today," she says.

But for people who are overweight, a sustained, long-term exercise regime may offer unconscious benefits. Cornier and his colleagues showed that halfway into a yearlong program of supervised treadmill exercise, most of a dozen adult recruits were losing fat and weight. Although participants reported no drop in appetite, brain scans revealed that regions helping to regulate food intake were less responsive to visual images of food than before the trial began — a potential boost for dietary willpower. It's still preliminary, Cornier says, but this exercise regime appears to help repair the default network's faulty switch.

Benefits may also come from tweaking the endocannabinoid system. But first researchers need a better understanding of how it works.

Piomelli's team recently reported signs that the brain's response to fat begins in the mouth, where taste sensors shoot an immediate message to the brain that calories are coming. The brain then warns the gut. When the fat actually arrives there, confirmation returns in the form of reinforcing endocannabinoids.

That the brain receives signals both before and after fat arrives in the gut "was completely unexpected," Piomelli says, "and makes no sense, unless this endocannabinoid system in the intestine is doing more than one thing." He now suspects this signaling system is "not just there to make us eat more fat, but also to facilitate fat's absorption."

If true, he says, then this may offer new ways to intervene therapeutically, for instance with drugs that alter signals associated with fats.

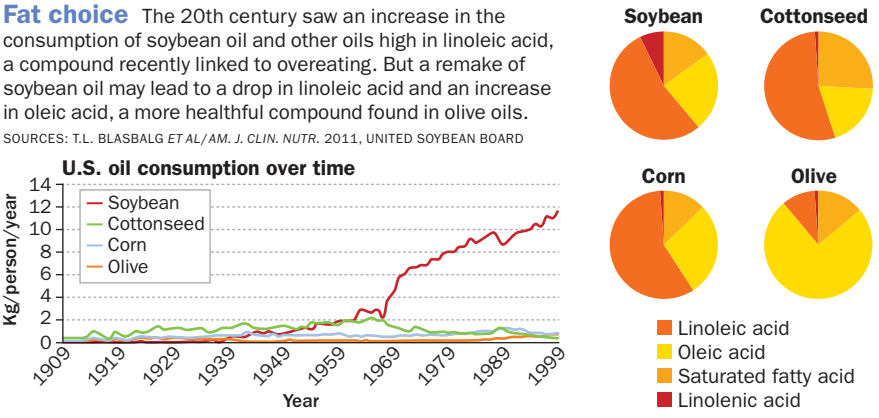
Hibbeln has an even simpler and more immediate solution: Diminish the endocannabinoid signal by reducing the intake of linoleic acid or blunting its impact.

The United Soybean Board, an industry group, reports that for reasons unrelated to the recent linoleic acid findings, it is developing new soy crops that will yield an oil high in oleic acid (the prominent fatty acid in canola and olive oils) and low in saturates. One by-product of this tinkering will be a dramatic drop in the linoleic acid fraction in soybean oil from more than 50 percent to less than 5 percent.

Until the new oil arrives in stores, diners might want to switch to olive or high-oleic canola and sunflower oils, and increase their consumption of fishy omega-3 fatty acids, Hibbeln says. In his experiments, mice getting a diet high in linoleic acid proved fairly resistant to fattening up if they also had fish oil.

Unfortunately, strategies for keeping the brain's signaling system on point offer the most promise for people who have not yet begun fattening. "The biggest problem with obesity is not that you can't lose weight, it's that you can't keep lost weight from coming back," Schwartz says. New findings suggest that once the body gains weight, the brain tends to begin vigorously defending that new weight with signaling that occurs at an unconscious level.

It's no secret that protecting the brain from diet-induced trickery or outright damage will be challenging, Schwartz says. But identifying the culprits, whether faulty messages or damaged brain cells, may make way for solutions. "I am very optimistic that interventions to effectively prevent and treat obesity are in our future." ■



Fat choice The 20th century saw an increase in the consumption of soybean oil and other oils high in linoleic acid, a compound recently linked to overeating. But a remake of soybean oil may lead to a drop in linoleic acid and an increase in oleic acid, a more healthful compound found in olive oils.

SOURCES: T.L. BLASBALG *ET AL/AM. J. CLIN. NUTR.* 2011, UNITED SOYBEAN BOARD

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- Rachel Ehrenberg. "Stomach's sweet tooth." *Science News*. March 27, 2010.

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Soundings: The Story of the Remarkable Woman Who Mapped the Ocean Floor

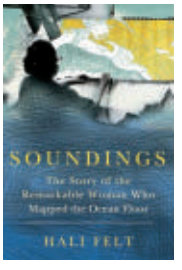
Hali Felt

In today's Google Earth world, it's hard to remember that until recently much of the planet remained a literal blank on the map. Ocean floors, in particular, were a greater mystery than the surface of the moon.

Not until the 1950s did the face of the deep begin to reveal itself, thanks to painstaking cartography by Marie Tharp and Bruce Heezen of the Lamont Geological Observatory. Line by line, Tharp transformed sound waves bounced off the ocean bottom into 3-D maps. With them, and with Tharp's discovery of a rift running down the Atlantic's middle, scientists finally visualized plate tectonics and developed their modern understanding of the Earth.

Heezen and Tharp were offbeat characters, so it's fitting that Felt relates their tale in a slightly offbeat fashion. She melds straightforward chronicles of geophysics with quasi-fictionalized scenes where "Marie and Bruce" work, talk and argue intimately together. After Heezen's death, Tharp spent three more decades cataloging and defending the work she had done with him; following Tharp's 2006 death, Felt similarly curates the story of this underappreciated pair.

Gory scientific detail is left out in favor of narrative sketches, yet the approach works for such a quirky character as Tharp. This is a woman who stubbornly refused to work on Lamont's campus, dressed herself in Heezen's old clothes after he died and filled her three-story house with an ever-shifting entourage of slightly peculiar assistants.

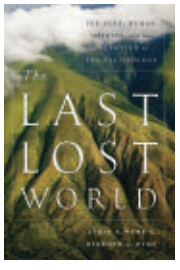


But this is also the woman who mapped the ocean floor, forever changing scientific understanding of the planet. Ignored and marginalized for much of her career, Tharp has at last come into her own. —*Alexandra Witze*
Henry Holt, 2012, 340 p., $30

The Last Lost World: Ice Ages, Human Origins, and the Invention of the Pleistocene

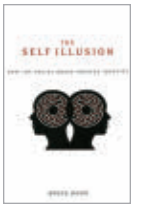
Lydia V. Pyne and Stephen J. Pyne

The Pleistocene epoch — lasting from 2.6 million to about 10,000 to 12,000 years ago — was an exciting time: Continent-sized ice sheets advanced and retreated multiple times, and several varieties of humans inhabited Earth. During warm interglacial episodes, hyenas and hippos lived as far north as England; in colder periods, exotic species rendered Europe, in the words of this father-daughter writing team, "a woolly Serengeti on steroids."



The Last Lost World, however, is not so much about the facts of the Pleistocene as it is about the idea of the Pleistocene — how scientists realized that ice ages occurred, that *Homo sapiens* shared the Earth with close kin and that the previously unknown phenomena of evolution and extinction shaped the biological landscape. Indeed, the Pynes note, the Pleistocene was "invented" during an intellectual upheaval that changed the scientific landscape as much as the Pleistocene had sculpted the physical world.

In the early 19th century, nascent sciences such as geology severed ties with the humanities, provided a true sense of Earth's age and guided researchers to find ever more clues to an ancient world hidden in soils, sediments and caves. A great story is buried in this book, but readers must dig through layers of metaphor to unearth it. Nevertheless, an ardent prospector can find enough nuggets to make the excavation worthwhile. —*Sid Perkins*
Viking, 2012, 320 p., $26.95

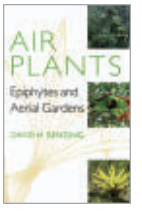


The Self Illusion
Bruce Hood
Explore the latest neuroscience and psychological research showing how the brain generates a sense of self. *Oxford Univ., 2012, 368 p., $29.95*

Earth
Frank H.T. Rhodes
A geologist provides a "tenant's manual" to the planet, encouraging humankind to keep up with home maintenance. *Cornell Univ., 2012, 400 p., $29.95*

Why Cats Land on Their Feet
Mark Levi
This and 76 other physics questions are answered using an intuitive approach to math that aims to make critical thinking seem as easy as child's play. *Princeton Univ., 2012, 216 p., $19.95*

Curious Behavior
Robert R. Provine
Delve into the evolutionary origins of yawning, hiccupping, tickling, laughing and other innate acts that help reveal how the brain works. *Belknap, 2012, 271 p., $24.95*



Air Plants
David H. Benzing
A biologist offers a tour of 28,000 plants that grow without soil and explains how these oddballs have adapted to life in the air. *Cornell Univ., 2012, 256 p., $39.95*

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Higgs love

Tom Siegfried's essay "Behind the Higgs" (*SN: 7/28/12, p. 26*) may be the best piece of science journalism I've seen. He explained enough about the Higgs boson's importance in the scheme of things for me to read about different aspects of the work and see how they fit into the whole picture, but even more, to get how impressive the symmetry of the picture is (pun intended) and how validating of the scientific method itself the work has been.
Ed Sylvester, Tempe, Ariz.

I love aha moments, and though there has been tons of press on the Higgs boson, it wasn't until I read Tom Siegfried's editorial ("Nature's Secrets Foretold," *SN: 7/28/12, p. 28*) that I finally had one for Higgs! I looked at a couple supposedly explanatory pieces on the Huffington Post, and even watched the YouTube videos, saving this piece for last. This fine piece described the origination of Higgs after sufficient cooling and a split between electromagnetic and weak forces. I was merrily taking notes until....

You should have given a spoiler alert! I have saved the last Harry Potter book for a marathon reading session and had been very careful never to have found out the ending. Boo on you! But thanks again for the article.
Linda Mendoza, Chico, Calif.

You had no choice under the circumstances but to try to explain the nature of the Higgs boson and how it relates to everyday experiences — a tall order. But you did a great job. I hadn't thought of considering the emergence of the Higgs field as a phase change or condensation. I appreciate the work you and the staff do tackling the breadth and depth of all the material you cover. Great work!
John Bodine, Naperville, Ill.

Amidst the articles on the discovery of the Higgs boson, it seemed that the Higgs was highly unstable and its existence was deduced only from the decay of daughter particles. So how does the Higgs particle exist in a stable form in order to create the Higgs field?
Karl Veit, Arlington, Va.

The Higgs boson doesn't create the Higgs field; it is a mathematically required consequence of the fact that the Higgs field exists. The boson's existence merely signals that the field is there.
—Alexandra Witze

Correction

The article "Male contraceptive shows promise" (*SN: 7/28/12, p. 11*) incorrectly stated sperm counts as "per cubic milliliter"; it should have said "per milliliter."

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

The Science Life

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In a novel take on Portuguese fish soup, this bed of fettuccine is made from gelatin and topped with balls containing the soup.

Vegetable juice "spaghetti"

Mango juice "yolk"

Exploring the science of cooking

When a group of women in Lisbon, Portugal, entered a cooking contest in 2006, they decided to put their own spin on a Portuguese fish soup. The team created green fettuccine from gelatin flavored with coriander and garlic, meant to mimic an algae bed. Egg yolk–sized spheres, made of algae extract and filled with fish soup, nestled on top.

The contestants had been asked to apply ideas from molecular gastronomy, a field exploring the science of cooking. In 2007, the Lisbon team founded a molecular gastronomy company called Cooking.Lab. The group educates chefs and the public about the field, creates unusual dishes or drinks for special events and performs research to develop food products with new textures and flavors.

The company began as an informal gathering of five women interested in science and cooking who teamed up to offer molecular gastronomy workshops. After a while, "we felt that we needed to grow a little bit," says cofounder Catarina Prista, a yeast physiologist and molecular biologist at the Technical University of Lisbon's Superior Institute of Agronomy. "We were just a bunch of ladies giving workshops."

Cooking.Lab's members aren't your average home cooks, though: They're trained in biochemistry, microbiology, cooking and food engineering and design. They often employ lab methods plucked from a broad range of scientific fields. For a 2007 contest, for example, the team borrowed a DNA separation technique using a sugar gradient solution and centrifuge to make a multilayered "molecular cocktail" with mint, raspberry, lemonade and edible gold.

But molecular gastronomy is not just a set of cooking techniques, says cofounder Joana Moura (shown). The field can include any experiment to investigate why specific ingredients, conditions and methods produce certain cooking results. "You can apply molecular gastronomy even if you're doing a fish at home or cooking some vegetables," she says. The company published a molecular gastronomy book in Portuguese called *Cozinha com Ciência e Arte* (Cooking with Science and Art) last year and plans to develop a smartphone app. *—Roberta Kwok*

Experiment with your food

If you want to try creating new foods in your home lab (aka kitchen), or just sample some molecular gastronomy creations, here are some resources to get you started.

Books

- *On Food and Cooking*, by Harold McGee
- *Molecular Gastronomy* and *Kitchen Mysteries*, by Hervé This
- *Culinary Reactions: The Everyday Chemistry of Cooking*, by Simon Quellen Field
- *Cooking for Geeks*, by Jeff Potter
- *Taste What You're Missing*, by Barb Stuckey
- *Modernist Cuisine*, by Nathan Myhrvold, Chris Young and Maxime Bilet

Restaurants

- Colborne Lane, Toronto
- wd~50, New York City
- Minibar, Washington, D.C.
- Alinea, Chicago

Websites

- experimentalcuisine.com
- www.curiouscook.com
- blog.khymos.org

Journals

- *Flavour*
- *International Journal of Gastronomy and Food Science*

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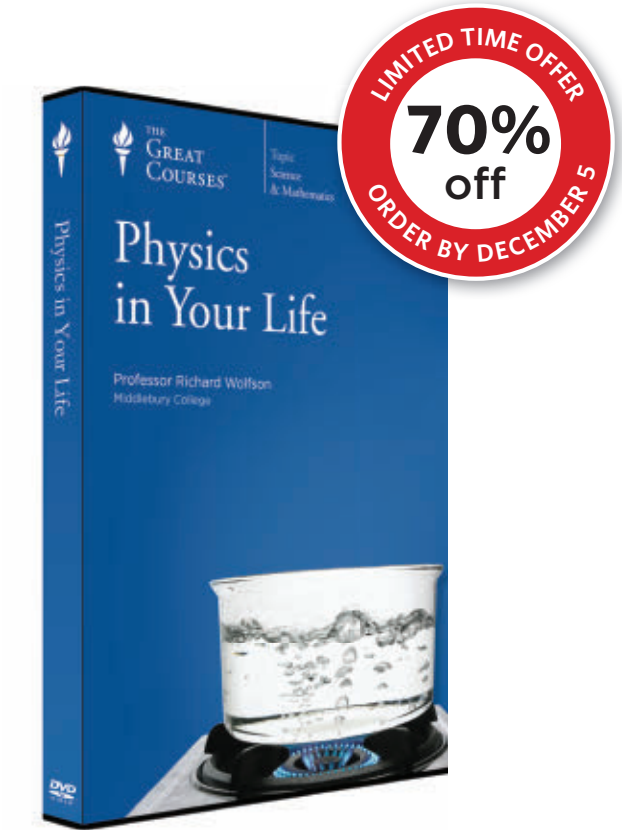

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