Going Deep for Dark Matter | A Dry Moon | Cancer's Link to MicroRNAs

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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ AUGUST 28, 2010

Marsupial Origins: Not Where You Think

Playing Games with Proteins

Buyer Beware: BPA in Receipts

Sea Change

How hurricanes sculpt shorelines

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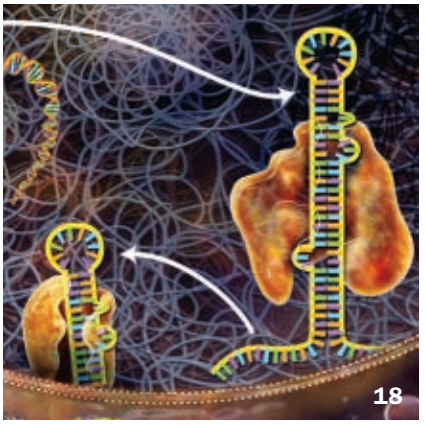
AUGUST 28, 2010 • VOL. 178 • NO. 5



ScienceNews

In The News

Features

Departments

COVER Breakwaters on Louisiana's Raccoon Island have failed to stop erosion of the island's shores, which are in the line of fire from seasonal storms. *Robert Caputo/Getty*

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FROM THE EDITOR

Scientists go to dark side, but it's for a noble cause

Science is like espionage. Agents from competing powers attempt to wrest secrets from nature's grasp. It may be for a noble cause, but just as with real-life spies, there's a dark side to the enterprise.

An apt example is provided by the current quest to find direct evidence of "dark matter," the mystery material that is roughly five times as abundant in the cosmos as ordinary matter.

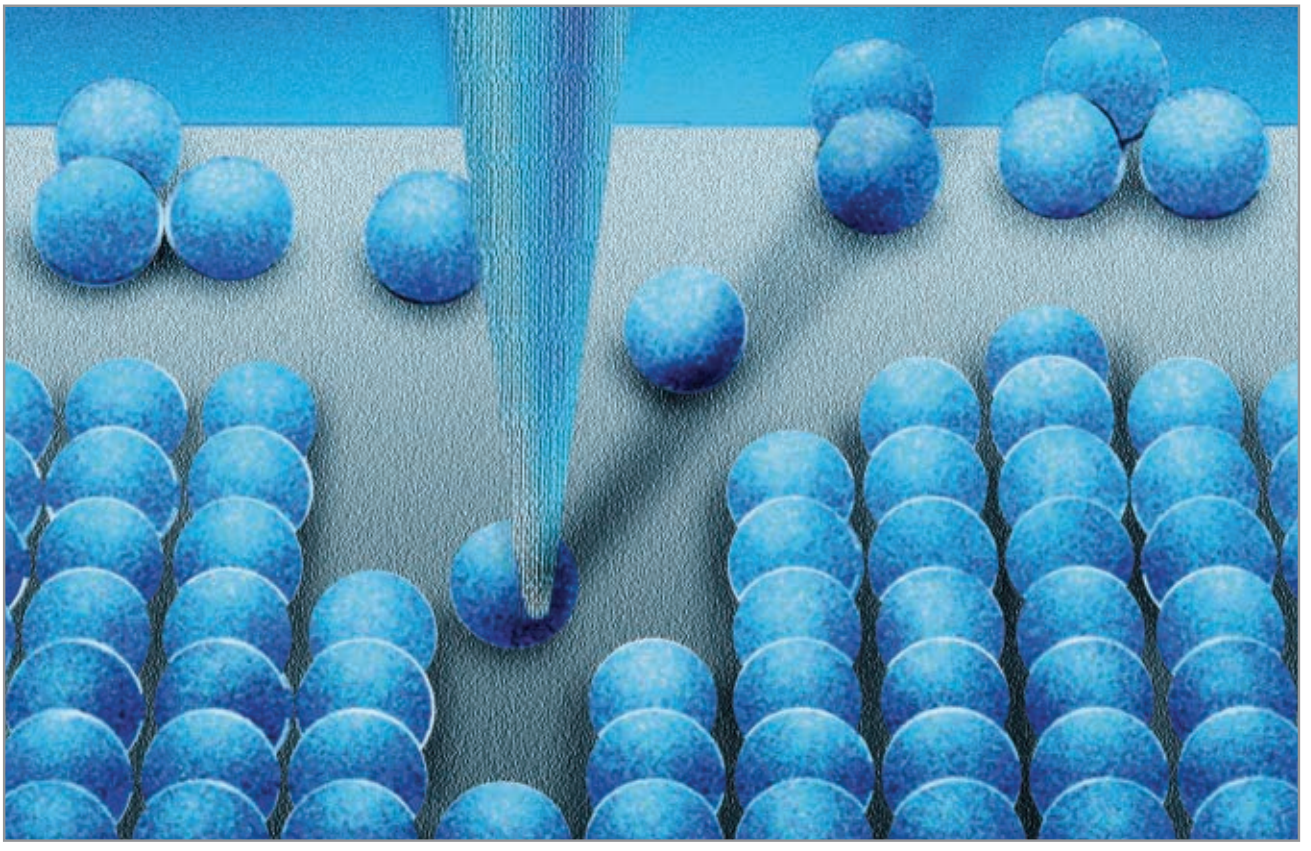
Dark matter's presence in space is inferred from the way galaxies spin and cluster. Details of those motions cannot be explained by the gravity exerted by visible matter. So some unseen mass must be at work, conventional wisdom declares, holding galactic clusters together and governing the rotation rate of matter at the outer edges of individual galaxies.

Pretty much everybody agrees that this nonluminous matter is probably composed of particles of a kind not encountered in everyday life — that is, it is made of something other than the ordinary constituents of atoms. In fact, solid observational evidence and theoretical requirements both suggest that dark matter particles are of a species never before detected.

For decades, physicists have attempted to record the presence of such a particle in fancy detecting devices, constructed underground to shield them from cosmic rays and other confounding influences. In this issue, *Science News* astronomy writer Ron Cowen reports (Page 22) on his visit to one of those underground laboratories, in northern Minnesota. He tells of the findings there and how they fit into the bigger picture of dark matter searches elsewhere around the world.

That picture is not so pretty. Nobody has found definitive evidence of dark matter particles, although there have been some intriguing hints. Scientists on rival teams have vigorously dissed the other's results, showing about as much regard for each other as Cleveland basketball fans have for LeBron James. One long-running claim for dark matter detection is inconsistent with other findings, unless the dark matter particles are very light. But if they are, the theory that predicted their existence in the first place must be modified, abandoned or at least appended with a new force that doesn't fit in well with anything else.

In short, it's science at its most glorious, as intrepid competitors battle with nature and among themselves to secure another of nature's elusive secrets — and the nobility of the cause outshines the darkness. —*Tom Siegfried, Editor in Chief*



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Scientific Observations

"Proponents of data-driven science conjecture that hypotheses are obsolete: New knowledge will simply emerge from mechanical application of algorithms that mine data for plausible patterns. This approach is attractive, but there are potential pitfalls. The discovery of patterns from data alone is similar to the task faced by an explorer in an unfamiliar jungle, without a guide. With no sense of what is already known about the environment or its perils, she is likely to misclassify what she sees—fearing the intimidating but harmless snake; ignoring the tiny lethal frog.... [I]n the words of Mark Twain, 'you can't depend on your eyes when your imagination is out of focus.'" **—SOCIOLOGIST JAMES EVANS AND GENETICIST ANDREY RZHETSKY OF THE UNIVERSITY OF CHICAGO IN THE JULY 23 *SCIENCE*.**

Science Past | FROM THE ISSUE OF AUGUST 27, 1960

CAT PHOBIA TREATMENT — [A] patient was cured of cat phobia by forcing herself to handle velvet until she got used to it. The patient, a 37-year-old married woman ... had had a fear of cats as long as she could remember.... The therapist began ... [with] what she felt was the least objectionable idea associated with cats — their fur.... [First he used] velvet, which has some of the texture of cat fur. Gradually the patient progressed until she could be comfortable with a rabbit-fur glove .... The psychologist then picked out a live kitten with a mild disposition and gave it to the patient, who laughed and cried as she accepted it. She explained later that she wept because of the relief of having done something she thought impossible for her.

Science Future

September 11
Air and Space Museum's September Star Party near Paris, Va. See www.nasm.si.edu/events/skywatching/

September 15–17
Researchers and policy makers meet in Austin, Texas, to discuss aging in the Americas. Go to www.utexas.edu/lbj/caa/2010

October 4–8
World virologists meet in Italy about HIV/AIDS and cancer. See www.ihv.org

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DELETED SCENES BLOG
Even a perfect quantum memory can't pinpoint a particle, physicists say. See "Heisenberg's uncertainty principle still certain."

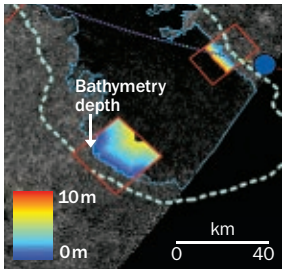
LIFE
For blue-footed boobies, chickhood trauma doesn't leave lasting scars. Read "Bullied booby chicks end up OK."

MATTER & ENERGY
Fifty years after the laser's creation, physicists have thought up a device that swallows light beams. Read "Behold, the antilaser."

HUMANS
Many things break down as people grow older, but emotional reactions don't seem to be one of them. See "Sadness response strengthens with age."

Firsts

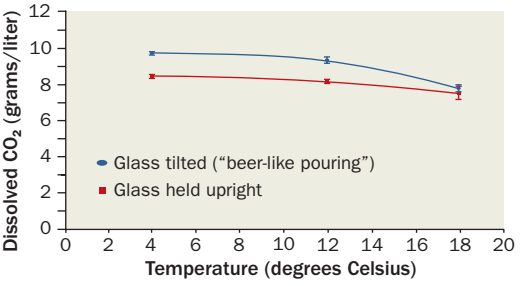
For the first time, astronomers have measured seasonal level changes for an alien lake: those of Ontario Lacus, a methane sea on Saturn's moon Titan. The lake's depth dropped by about 1 meter per year between the region's midsummer and fall (one year on Titan is 29.5 Earth years), evidence that Titan's seas condense and evaporate with the seasons. The Caltech-led team used Cassini spacecraft data to create the radar map (left), in which the dashed green line marks the 2005 shoreline and the solid blue line that of 2009. The team also calculated the slope of the lake bed's bottom, shown as rainbow swaths shaded by depth.



Science Stats | CHEERS

Champagne is fizzier when served cold and poured into a glass tilted to one side, a recent study found.

Dissolved CO_2 levels for temperature, pouring style



SOURCE: G. LIGER-BELAIR *ET AL/JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY* 2010

CLOCKWISE, TOP LEFT: DAVID BURKE; COURTESY OF ANDREY RZHETSKY; PUTNEYMARK/FLICKR; RADAR SCIENCE TEAM/NASA, JPL, CALTECH

“In the wake of an oil spill in U.S. waters that is likely the worst environmental disaster in history, I hope the public is more likely to pay attention to what happens in the oceans.” —DARIA SICILIANO, PAGE 10

In the News

STORY ONE

Receipts a large and little-known source of BPA

Studies raise alarm about exposure to hormone mimic

By Janet Raloff

Cash register and other receipts may expose people to substantial amounts of bisphenol A, a hormone-mimicking chemical that has been linked with a host of potential health risks, according to a trio of recent studies. Each offers preliminary evidence that a large number of retail outlets print sales receipts on certain types of heat-sensitive, or thermal, paper that use BPA as a color developer.

Two of the new studies also show that the BPA coating easily rubs off onto fingers. And one found evidence that BPA from receipts may penetrate skin.

The pollutant, which mimics the hormone estrogen and is used in the making of some plastics, has been tied to health risks from behavior problems in children to obesity and heart ailments. In animals, in utero exposures put moms and their offspring at risk for metabolic diseases.

Based on growing concern about possible risks from BPA exposure, especially in children, the federal government recently warned parents about where their families were most likely to encounter the chemical. Store receipts did not make the list, although there have been hints for years that thermal receipt paper could be a rich source.

The BPA-receipts data offer “further evidence that bisphenol A, a dangerous chemical, has become all too prevalent in consumer products despite the fact that it is linked to harmful health effects in humans,” says U.S. Sen. Dianne Feinstein of California. She notes that “industry is fighting against legislation that would restrict the use of BPA,” including a bill that she coauthored.

Chemist John Warner learned about the chemistry of thermal- and pressure-sensitive papers while working for Polaroid years ago. Manufacturers lay a powdery coating containing BPA, a dye and a solvent onto one side of a piece of paper. When heat or pressure is applied, the coating’s constituents merge to release the ink’s color, he explains.

Warner largely forgot about the process until BPA hit the news, big time, about a decade ago. Wondering if thermal paper still used the chemical, he and his university students ran periodic assays — which invariably turned up receipts with substantial amounts.

On July 28, Warner and colleagues at the Warner Babcock Institute for Green Chemistry in Wilmington, Mass., formally published their data for the first time. Of 10 receipts recently collected in the Boston area, six contained 1.09 to 1.70 percent BPA by mass. Another two contained 0.30 to 0.83 percent BPA; the final pair had no measurable amounts. The findings appear online in *Green Chemistry Letters and Reviews*.

A Swiss study published online July 11 in *Analytical and Bioanalytical Chemistry* assayed 13 European sales receipts. Eleven contained BPA in quantities ranging from 0.8 to 1.7 percent of the paper’s mass.

And that BPA rubbed off easily, notes study coauthor Koni Grob, an analytical chemist with the Official Food Control Authority of the Canton of Zurich. Just holding the receipt paper deposited substantial BPA onto dry fingers.

“The shocking thing,” he says, “is what happened when I applied a bit of BPA onto my fingers with ethanol [alcohol]. After two hours it had disappeared. Totally.” He believes

Studies have found that handling thermal paper receipts can expose people to a hormone-mimicking chemical.

MIKE FLIPPO/SHUTTERSTOCK

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the BPA probably penetrated deeply into the skin, perhaps as far as the bloodstream.

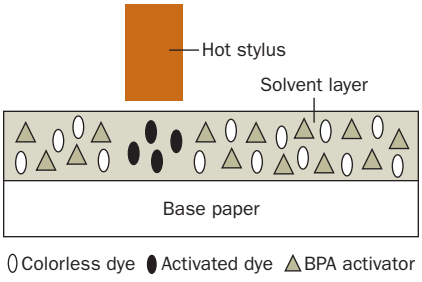
The Swiss team estimates that most people would not receive more than about 2.5 percent of the tolerable daily intake of BPA from handling a single receipt. But under a worst-case scenario — a pregnant cashier who wore hand cream that boosted BPA's permeability — someone might well sustain exposures that approached 50 micrograms per kilogram body weight, which is what European and U.S. regulatory agencies estimate as a tolerable intake.

"I think it's a scandal that you can have people touching thermal paper all day long," Grob says, since its surface coating could approach 10 percent BPA.

Frederick vom Saal of the University of Missouri in Columbia, who performed BPA assays for a recent study by the Washington, D.C.–based nonprofit Environmental Working Group, agrees.

"I won't touch receipts now," he says.

The EWG study found BPA in 32 of 39 receipts collected from retailers in Washington, D.C., seven states and a city in Japan. Sixteen of the U.S. receipts contained substantial quantities of BPA, on average 1.9 percent by weight, the group reported July 27.



Here's your receipt In thermal paper receipts, a colorless dye is embedded in a solvent layer along with an activator — often BPA — that causes the dye to darken. Heating the solvent layer allows the reaction to occur.

In follow-up studies, vom Saal has confirmed the same wet-versus-dry difference in transfer of BPA to fingers that was demonstrated by the Swiss group. Plus, vom Saal says, "we saw something they didn't report: that the longer you hold a thermal receipt, the greater BPA's transfer to your fingers."

Scientists at the National Institute of Environmental Health Sciences' National Toxicology Program have followed the emerging data on BPA in thermal paper. "We're exploring the feasibility of looking at how much [this paper] is contributing to exposures in people known to handle receipts frequently," says Kristina Thayer at NTP in Research Triangle Park, N.C. Such investigations might include testing to measure how well and how far BPA is absorbed through the skin and what conditions might influence that.

On July 15, the Environmental Protection Agency launched a BPA Alternatives in Thermal Paper Partnership. The program is recruiting paper companies, receipt-paper retailers, environmental groups, chemical companies and trade organizations to brainstorm ways to move "towards safer alternatives."

Appleton Papers of Appleton, Wis., switched to one of them — bisphenol sulfonate — in 2006, says company vice president Kent Willetts. EPA's new partnership program lists the sulfonate as a potentially acceptable substitute, he notes.

But, vom Saal observes, there's little way for a consumer to distinguish between receipts with and without BPA. They look identical.

"Frankly," Willetts says, "there hasn't been much awareness outside of the scientific and thermal-paper communities about this issue. So there was little outcry asking how to identify our paper."

The good news, Feinstein says, is that some paper companies have recognized the problem. "These companies should be commended, and it is my hope that consumers will demand that other companies voluntarily follow suit." ■

Back Story | WHERE TO FIND BPA

Aside from cash register receipts, bisphenol A is often found in products that contain polycarbonate plastics and epoxy resins. Common products that may contain BPA include:

Plastic baby and water bottles
Retailers and manufacturers have been switching to BPA-free plastics, but it can be difficult to tell if a bottle contains the compound unless it is specifically labeled as BPA-free.

Compact discs and DVDs
BPA-containing polycarbonate plastic is used in compact discs and DVDs for its sturdiness and flow properties when molten.

Food and beverage can liners
Cans are often lined with epoxy resins to keep the contents fresh. Until recently, virtually all can linings contained bisphenol A, but some companies have introduced BPA-free cans.

Plastic food storage containers
The U.S. Food and Drug Administration approved BPA for use in food containers in 1963, more than a decade before federal law required safety reviews for new chemicals.

Dental sealants
Several studies have found traces of BPA in saliva immediately after the application of dental sealants.

Impact-resistant plastics
Polycarbonate plastics are used in safety helmets, bulletproof glass, traffic signals, computer cases and a wide variety of other applications where BPA exposure is unlikely and of little or no public health concern.

TOP: T. MENDUM *ET AL./GREEN CHEMISTRY LETTERS AND REVIEWS* 2010, ADAPTED BY T. DUBÉ; BACK STORY, CLOCKWISE FROM TOP LEFT: ONEBLUELIGHT/ISTOCKPHOTO; MARKGODDARD/ISTOCKPHOTO; FOTOGRAFIABASICA/ISTOCKPHOTO

Molecules

"There are about 18,000 homicides annually in the United States … so stuff like this is needed." —ARPAD VASS

In world of proteincraft, humans win

People solve molecular puzzles in online computer game

By Rachel Ehrenberg

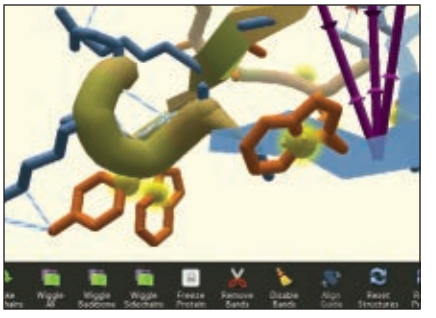
Compared with slaying dragons or building civilizations, figuring out the shape of a protein doesn't sound particularly thrilling. But turn the task into an online game, replete with the competition and camaraderie of *World of Warcraft*, and the masses will come.

More than 57,000 people, many nonscientists, got involved in *Foldit*, a game geared to solving the puzzle of protein structure, scientists report in the Aug. 5 *Nature*. And several top-ranked players outdid state-of-the-art computer algorithms that tackle the same tasks. The project suggests that online games tapping into the wisdom of crowds may be a fruitful approach to scientific challenges.

"Humans have all sorts of creativity, problem-solving skills and insights," says study coauthor Seth Cooper of the University of Washington in Seattle. "Hopefully other problems can be cast in this way so people without formal training can still get involved and help out."

Making games of mundane tasks, such as cleaning, is a trick familiar to babysitters. "Dress a tedious task in the guise of a game, and there are players who will spend hours and hours on end doing a task they wouldn't otherwise do," says Stanford University's Nick Yee, who studies the sociology of online games.

Foldit tackles the protein-folding problem. In cells, each protein starts as a string of amino acids and must fold into a particular 3-D structure before it can do its job. A protein's final shape is determined by the sequence of its amino acids, but predicting that final structure from amino acid sequence alone is extremely difficult.



A computer game allows people to compete at solving protein-folding puzzles.

In *Foldit*, players tweak, tug and twist partially folded proteins, with the aim of reaching 3-D structures that are energetically stable. Top players outperformed Rosetta, a computer algorithm designed to figure out protein structure.

Foldit was such a success that the University of Washington is starting a new center for game science, Cooper says.

Device detects whiffs of stiffs

Sniffer tube offers new way to find where bodies are buried

By Laura Sanders

Researchers have unearthed a new way to find a buried body. The method can detect trace compounds emanating from decomposing rats months after death.

If the technique also works for human remains, it may help police find hidden graves of victims months after a murder, researchers say. Because the method relies on a superthin, flexible tube to catch faint chemical signatures in air pockets near a corpse, it could be used to detect bodies buried in hard-to-reach areas, such as under concrete slabs.

"There are about 18,000 homicides annually in the United States and 100,000 missing persons, so stuff like this is needed," says forensic scientist Arpad Vass of Oak Ridge National Laboratory in Tennessee.

Currently, corpse-sniffing dogs, ground-penetrating radar and chemical analyses of air and soil can pinpoint buried bodies. But none of these methods work in every situation, says Thomas Bruno of the National Institute of Standards and Technology in Boulder, Colo., coauthor of the study, to appear in *Forensic Science International*. The new method promises to be specific, sensitive and flexible, Bruno says.

The tube could be inserted in a small hole drilled into a concrete slab or rubble to sniff out bodies buried underneath. "For a body buried under a concrete slab, there is nothing else that would work," Bruno says. "Ground-penetrating radar has problems, and you don't have access to the soil to do analyses."

As a corpse decomposes, tissues break down, releasing bits of nitrogen-containing compounds into the surrounding soil and air pockets. These compounds react with a chemical called ninhydrin, causing it to change color. A bluish-purple flush signals a decomposing body. (Ninhydrin is also used at crime scenes to detect sloughed-off skin tissue in fingerprints.)

This method may be more precise than a cadaver-sniffing dog, Bruno says. "When you get a positive result with a ninhydrin reaction … you can be pretty confident about the compound that produced it. But if you get a positive response from a dog, there could very well be a cadaver present, but it could also be something else."

To test their method, Bruno and NIST colleague Tara Lovestead built a "little pet cemetery" of rat grave sites. The rats were placed in wooden boxes containing soil and either left on top of the dirt or buried 8 centimeters deep. Researchers collected air by threading a thin tube through holes in the boxes. After five weeks, the probe detected strong signals from all boxes containing dead rats. Rat-free boxes showed very low levels of these compounds.

FOLDIT TEAM/UNIVERSITY OF WASHINGTON

Genes & Cells

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

Sponge genome reveals diversity

Ancient creatures sit squarely at base of animal evolution

By Tina Hesman Saey

The common ancestor of all animals may have resembled a certain absorbent, yellow, porous someone who lives in a pineapple under the sea. The evidence lies in the genes, not the pants.

A complete genetic catalog of the sponge *Amphimedon queenslandica* suggests that the first animals already had a complex kit of genetic tools at their disposal. Sponges harbor between 18,000 and 30,000 genes — roughly the same number as humans, fruit flies, roundworms and other animals, an international team of researchers reports in the Aug. 5 *Nature*.

Scientists have deciphered the genetic catalog of a sponge (shown in a coral).

Comparison with other animals supports the idea that sponges form the base of the animal branch of life's evolutionary tree, says April Hill, a developmental biologist at the University of Richmond in Virginia.

Some scientists have suggested that comb jellies, not sponges, were the first multicellular animals (*SN: 4/5/08, p. 214*).

Sponges don't make some body parts, such as muscles, nerves and epithelial tissues like skin or gut linings, that are found in more complex animals. Yet proteins that nerve cells use to communicate and connect are encoded in sponges' genes. So are proteins needed for epithelial tissues. Sponges also have genes that are important in other animals for helping the immune system tell an animal's own cells apart from foreign cells.

One striking result, says study coauthor Mansi Srivastava of the Whitehead Institute in Cambridge, Mass., was that genes shared by humans, sponges and other animals are some of the very genes involved in cancer. "So cancer is really a disease of multicellularity," she says.

Cellular assassin's surprise benefit

Disabling killer protein might encourage repeated cancers

By Tina Hesman Saey

Killing off damaged cells should help prevent them from turning cancerous, but two new studies show that a massive die-off can lead to the disease instead. The findings, published in the Aug. 1 *Genes & Development*, may have implications for some cancer therapies.

When a cell is under extreme stress, such as that caused by DNA damage, a protein called p53 steps in as a cellular security system and dispatches other proteins to deal with the problem. When all else fails, p53 unleashes Puma, a protein that sets in motion a cell-suicide program called apoptosis.

Apoptosis has long been thought to be an important defense against cancer, perhaps the most important. So researchers fully expected that mice lacking the Puma protein, and thus the ability to kill damaged cells, would be highly susceptible to cancer after radiation treatment.

Two research groups independently tested the ability of genetically engineered mice lacking the Puma protein to withstand repeated rounds of cancer-inducing radiation exposure.

Both groups found that instead of being riddled with cancer, mice lacking Puma "got no tumors at all" after radiation exposure, says Andreas Strasser of the Walter and Eliza Hall Institute of Medical Research near Melbourne, Australia, who led one of the teams.

"The fact that this was found by both groups separately gives added credibility" to the result, says Robert Weinberg, a molecular cancer researcher at MIT's Whitehead Institute for Biomedical Research in Cambridge, Mass.

But mice with intact Puma — mice that should have been protected against cancer — developed lymphoma after a couple of rounds of radiation. Both teams traced the source of the lymphoma to overworked stem cells in the bone marrow.

Under normal conditions, radiation causes so much DNA damage that blood cells can't cope, so they turn on Puma's cell-suicide program. In that way, about 80 percent of mature blood cells die after a massive dose of radiation.

Surviving stem cells have to "first deal with the DNA damage from radiation, and then they have to expand [their numbers] and regenerate like crazy making new blood cells to save the animal from anemia," says Andreas Villunger of Innsbruck Medical University in Austria, who led the second team. The pressure to reproduce blood cells quickly puts stress on stem cells and may result in mutations that lead to cancer the next time stem cells have to work that hard.

The results may help explain why children cured of leukemia often develop other types of cancer 20 or 30 years later, Villunger says. About 15 percent of new cancer cases are in cancer survivors, he says. That suggests some new tumors could be related to aggressive treatment of the first cancer, and doctors should reevaluate how hard they hit tumors with chemotherapy drugs or radiation.

MAELY GAUTHIER

Body & Brain

14.2 grams Average daily fiber consumption by 2- to 6-year-olds, Burkina Faso

8.4 grams Average daily fiber consumption by 2- to 6-year-olds, Italy

Young man's dreams, old man's fate

Disorder can presage neurodegenerative disease by decades

By Laura Sanders

Vivid, violent dreams can foreshadow brain disorders half a century later, a new study finds. The finding, reported in the Aug. 10 *Neurology*, highlights how some neurological diseases may take hold decades before diagnosis and suggests that spotting warning signs may allow doctors to monitor and treat patients long before the brain deteriorates.

People with a mysterious condition called REM sleep behavior disorder, or RBD, have violent dreams that frequently involve fighting off an attacker. The normal muscle paralysis that accompanies dreams is gone, leaving the dreamer, who is most often male, to act out the dream's punches, twists and yells.

Doctors used to think of RBD as an isolated disorder. But follow-up studies revealed that a striking number of these patients later develop neurodegenerative diseases, including Parkinson's disease and Lewy body dementia. Estimates vary, but research suggests that anywhere from 80 to 100 percent eventually get a neurodegenerative disorder.

"The consensus among all RBD researchers is that it's not a matter of if, but when," says Carlos Schenck of the Minnesota Regional Sleep Disorders Center in Minneapolis, who was one of the first researchers to describe RBD. "Basically, the longer you follow these men, the more they will convert to a neurodegenerative disorder."

Vivid, violent dreams can portend brain disorders half a century later, a new study finds.

In the new study, neurologist Bradley Boeve of the Mayo Clinic in Rochester, Minn., and his colleagues wanted to know just how long the interval between RBD and a neurodegenerative disorder can be. Boeve and his team examined the medical records of patients from the Mayo Clinic to identify people diagnosed first with RBD and then with a neurodegenerative disorder at least 15 years later.

Of the 27 patients who fit the criteria (of which only three were women, reflecting the curious male predominance of RBD), the median interval between onset of the sleep disorder and of the neurological disorder was 25 years, the team found. For six of these patients, Boeve says, the sleep disorder was first noticed by their spouses on their honeymoon or shortly afterward. In one case, RBD preceded Parkinson's disease by 50 years.

Such a long interval brings the hope that if a "mysterious and magical neuroprotective agent is identified," Schenck says, it could be used before brain damage is severe. Some researchers think that by the time dementia symptoms appear, it is already too late to undo the damage.

Gut flora reflects children's diets

Africans have more versatile and robust intestinal bacteria

By Gwyneth Dickey

A termite a day may keep the doctor away.

African children who eat a high-fiber diet (and the occasional wood-digesting insect) have gut bacteria that help protect them from diarrhea and inflammatory disease, a new study finds. The research may lead to new probiotics that improve the digestive health of Westerners, who were found to have a less versatile assemblage of intestinal microbes.

Duccio Cavalieri, a microbiologist at the University of Florence in Italy, and his team compared the DNA in gut microbes of 29 healthy children ages 1 to 6 from Burkina Faso and Italy. The African children ate a diet high in fiber, cereals, nonanimal protein and plants, while the European children ate a typical Western diet high in animal protein, sugar and fat, and low in fiber.

Breast-fed children from the two groups had similar gut bacteria, likely because the children eat the same food. But in older children the gut microflora of the two groups started to look different. The results were published online August 2 in the *Proceedings of the National Academy of Sciences*.

Children from Burkina Faso had high numbers of bacteria that digest plant fibers. Also found in the guts of termites, these bacteria break down fibers that humans typically can't. The bacteria make short-chain fatty acids previously shown to provide energy and protection from inflammatory gut diseases such as Crohn's disease.

Burkina Faso's children also had decreased numbers of diarrhea-causing bacteria compared with children from Italy. That finding surprised the team, because African children's water supply is often polluted with such bacteria.

African children also had a helpful diversity of gut bacteria, the authors report. These children not only had more of the good bacteria, but also had bacterial strains that weren't found in European children.

"The notion that gut flora plays a role in human health has been marginally ignored," says evolutionary nutritionist Loren Cordain of Colorado State University in Fort Collins. "What we've found over the past five or 10 years is that it plays a huge role in our health and well-being."

Life

230 thousand Approximate number of described marine species

1–1.4 million Estimated total number of marine species

Marine census count continues

Most species diversity seen in waters by Japan, Australia

By Susan Milius

A 10-year, 2,700-scientist effort to find and record marine life estimates that roughly 80 percent of sea species remain undiscovered.

The international Census of Marine Life has so far described 1,200 new species, with more on the way. Census scientists have also tallied an average of 10,000 known marine species in each of 25 important ocean regions.

Based on the ease with which scientists are still finding new species, researchers suggest that much of the oceans' diversity remains unknown.

"There is a lot more to do, but most of the big stuff is known," says Ron O'Dor of Dalhousie University in Halifax, Canada, the senior scientist for the census.

Big stuff, however, such as species of whales or turtles or sea lions, barely amounts to a drop in the oceanic bucket. Census data indicate that crustaceans are the largest chunk of known marine creatures, including crabs, shrimp and the unsung but ecologically crucial krill.

Formal census efforts will come to an end in October 2010 when researchers unveil their final results. But a first set of papers on regional efforts was published in *PLoS ONE* on August 2.

A marine-life census has discovered more than 1,200 species, including this crustacean found near Antarctica.

Australian and Japanese ocean waters, each with about 33,000 known species, top the list for highest diversity among the 25 regions surveyed. The Gulf of Mexico, examined before the 2010 oil spill, ranked in the top five with 15,374 species. (The other two high-scoring zones: China with 22,365 and the Mediterranean with 16,848.)

Other areas with lower totals, such as the waters off South Korea, were rich in species for their seabed area.

Census scientists also ranked the biggest threats to sea life. Overharvesting tops the list, O'Dor says, with fisheries such as cod collapsing dramatically in recent decades. Next come habitat destruction from coastal development, pollution and other human activities. Climate change presents a major challenge too, with associated perils of altered seawater chemistry.

The census is a historic effort that gives "the first integrated look at the diversity and distribution of life in the oceans," says marine ecologist Daria Siciliano of SeaWeb in San Francisco. "In the wake of an oil spill in U.S. waters that is likely the worst environmental disaster in history, I hope the public is more likely to pay attention to what happens to the oceans." ■

Marsupial family tree gets new root

New genetic analysis traces group's origins to South America

By Gwyneth Dickey

The kangaroo's twisted marsupial family tree is now in order, thanks to jumping genes. Genetic evidence shows that a South American ancestor gave rise to all Australian marsupials, and that the South American opossums were the earliest group to branch off from the other six marsupial clans.

Distinctive for raising their live-born young in protective pouches, marsupials all trace back to a common ancestor that split from other mammals about 130 million years ago. But fossil and genetic evidence conflict about which subsequent marsupial species evolved first, and where.

Jumping genes provide new clues for solving the puzzle. These strands of DNA make copies of themselves to reinsert randomly in the genome — the entire set of genes in a cell's nucleus. Gene-jumping is rare, and each jump is unlikely to happen again. So if two species share a jumping gene, they probably inherited it from a common ancestor.

Maria Nilsson and colleagues at Westfälische Wilhelms Universität Münster in Germany compared jumping genes in the seven main branches of marsupials. In the July *PLoS Biology*, the team presents a new marsupial family tree with slightly different familial relationships than other research had predicted.

"It's a different type of data and it's much cleaner" than fossil and other genetic data, says evolutionary biologist David Pollock of the University of Colorado School of Medicine in Denver, who was not involved with the research.

All Australian marsupials arose from a single South American ancestor species, the new tree shows. And the South American opossums sit on the earliest branch of the marsupial tree.

There's always potential for error in molecular studies, says mammalogist Ines Horovitz of the University of California, Los Angeles. But the study "contributes new data, and that's always important," she says.

Next, Nilsson says she wants to use jumping genes to probe the relationships among the Australian marsupials to see exactly how they're related. ■

C. D'UDEKEM D'ACOZ/RBINS

"… maybe you don't want to be on contraceptives when you're picking your mate."—SUSAN JENKS

Lemurs on the pill make less scents

Birth control disrupts female odors that serve as social cues

By Susan Milius

Putting a female lemur on birth control turns her normally informative scents to nonsense.

Doses of Depo-Provera, a human contraceptive also used in zoos and animal research, shift the odor secretions of female lemurs so dramatically that their scents no longer give clear cues to kinship, identity and genetic quality, says study coauthor Christine Drea of Duke University in Durham, N.C. A female lemur whose hormones are disrupted by contraceptives may have real trouble attracting a compatible mate, Drea reported July 26.

Ring-tailed lemurs (shown at the Duke University Lemur Center) communicate using scent.

Drea and her colleagues have identified more than 300 compounds in the scent secretions of female lemurs. Glands on the forelimbs, tail and other parts of the body secrete chemical cues that the lemurs rub onto branches or other community bulletin boards where neighbors sniff out the news.

Working with 12 adult female ring-tailed lemurs at the Duke Lemur Center, Drea and colleagues studied female genital odors by analyzing secretions chemically and observing animals' sniffing behaviors. The researchers collected scents before and after giving the lemurs a form of the hormone progestin called medroxyprogesterone acetate, or MPA, sold as Depo-Provera. Details of the study were published online July 28 in the *Proceedings of the Royal Society B*.

Female lemurs injected with MPA released a blend of scent components different from their normal odor, Drea reported. Some of the usual components disappeared. Others, such as alcohols and fatty acids, shrank in proportion.

If women react to the hormones the way lemurs do, "maybe you don't want to be on contraceptives when you're picking your mate," said behavioral biologist Susan Jenks of the Sage Colleges in Troy, N.Y.

Exactly what parts of an odor tell a lemur's nose who's who remain to be discovered. But researchers could no longer use scent to "fingerprint" an individual on birth control. "They smell like any other female lemur on contraceptives," Drea said.

Natural male enhancement

Ducks' penises grow longer with increased competition

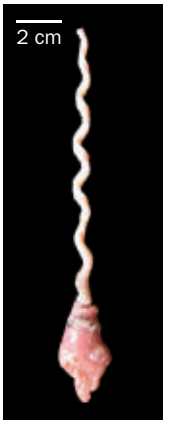
By Susan Milius

New measurements find that the length of a duck's penis depends on the company he keeps. And in this case, it's his fellow males who make the difference.

A drake's penis substantially wastes away at the end of one breeding season and then regrows as the next season begins. Among lesser scaup and ruddy ducks, the regrowth varies in length or timing depending on whether males have to compete with a bunch of other guys, said Patricia Brennan of Yale University.

Her new measurements offer the first evidence in vertebrates that social circumstances influence penis growth, she reported July 29.

In many birds, males don't grow specialized organs to deliver sperm. But ducks' penises can reach considerable length (25 centimeters for a ruddy duck). To see if competition among males influences penis growth, Brennan housed some of her drakes in groups of seven to eight males with just five or six females. Other males lived with just a female.



The corkscrew-shaped penis of a ruddy duck.

Among the scaup, males competing in groups grew penises 15 percent longer, and sometimes up to 25 percent longer, than drakes with no mating rivals, Brennan reported.

Among ruddies, penis length did not differ overall between males in competitive crowds and those in lucky privacy. What did differ was timing.

In the competitive groups, a few big males grew prodigious organs. Other males grew more moderate penises, which started wasting away weeks earlier than those of dominant males or males with no competition.

In a crowd, a ho-hum male apparently doesn't bother sustaining a big investment in tissue that's not going to pay off.

"Elegant," said evolutionary ecologist Maydianne Andrade of the University of Toronto Scarborough. The new experimental results show that ducks "are essentially engineering their own phallus in response to social challenges."

FROM TOP: DUKE UNIV. LEMUR CENTER; P. BRENNAN

Atom & Cosmos

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Lunar interior has very little water

Tests on rocks returned by Apollo missions come up dry

By Alexandra Witze

The moon's insides might not be all wet after all. A new study suggests that, contrary to other recent work, the lunar interior is as bone-dry as scientists thought when NASA astronauts first lugged home moon rocks 40 years ago.

New analyses of chlorine in those rocks, published online August 5 in *Science*, indicate that the moon contains just one-10,000th to one-100,000th the water that the Earth's interior does.

Researchers have long argued over whether the moon has water on its surface, delivered there over eons by comet impacts. But the new studies tackle a more fundamental question: How much water did the moon contain when it formed, 4.5 billion years ago?

Most scientists think the moon coalesced out of the debris produced when a Mars-sized object smashed into the embryonic Earth. As the moon cooled, an ocean of magma covering its surface began to crystallize. Zachary Sharp of the University of New Mexico in Albuquerque and his colleagues studied what would have happened to two isotopes of the element chlorine during that process.

Apollo 16 astronaut Charles Duke collecting moon rocks in 1972.

Chlorine-35, which is lighter than chlorine-37, would have vaporized more easily from the magma ocean. But if the magma also contained a lot of hydrogen — perhaps in the form of water, H_2O — more chlorine-37 would escape the magma along with chlorine-35.

That's not what Sharp's team saw when analyzing 11 samples of Apollo moon rocks and soil. The best explanation, Sharp says, is that there was hardly any hydrogen — and no water — in the moon's magma ocean.

Apollo scientists reached the same conclusion 40 years ago. But in 2008, an analysis of a handful of lunar volcanic glass beads suggested they might have formed in a wet environment. Since then, researchers have also looked at lunar samples of the mineral apatite, which can hold water in its chemical structure. Some of these researchers have concluded that the moon could have contained quite a bit of water, perhaps almost as much as Earth did.

Such estimates are hard to reconcile with the new chlorine work. One possible explanation: Some parts of the moon may have been wetter than others. It's also possible that one person's "bone-dry" could be another person's "relatively damp," says Francis McCubbin of the University of New Mexico.

Nearby galaxy is a very dark place

Holds record for concentration of mysterious missing mass

By Ron Cowen

Devotees of the dark side have reason to rejoice. Observations confirm that a faint group of stars in the Milky Way's backyard has the highest density of dark matter — the invisible material thought to account for 83 percent of the mass of the universe (see Page 22) — of any galaxy known.

The findings, reported online July 28 at arXiv.org by Joshua Simon of the Carnegie Observatories in Pasadena, Calif., along with Marla Geha of Yale University and their colleagues, provide a bonanza for astronomers trying to unveil the nature of dark matter.

When astronomers discovered the galaxy Segue 1 in 2007, they weren't sure if it was anything more than a cluster of stars, perhaps stripped from the nearby Sagittarius dwarf galaxy. But observations with the Keck II telescope atop Hawaii's Mauna Kea now confirm the status of Segue 1 as a galaxy by showing that its stars have a diverse chemical makeup, Simon says.

After examining the stars' compositions, Simon's team calculated the total amount of mass in Segue 1 — both the unseen dark matter and the small number of faint, visible stars — by measuring how fast the stars move. The faster the stars orbit about the center of Segue 1, the heavier the galaxy must be.

The team found that although the stars in Segue 1 have a combined mass of no more than about 1,000 suns, the mass of the whole galaxy is more than 500 times larger. "That tells us that Segue 1 is made almost entirely of dark matter," Simon says.

Segue 1 is both dark matter–dominated and compact, yielding a dark matter density higher than any other known galaxy. The galaxy's high density and proximity to Earth — about 80,000 light-years distant — make it an ideal place to look for proposed signatures of dark matter.

"It's extremely important to figure out the dark matter properties of galaxies," says Rosemary Wyse of Johns Hopkins University in Baltimore. Galaxies such as Segue 1, which have such a tiny amount of visible material to gravitationally disturb the dark matter, are the best places to reveal the true distribution and nature of the unseen material.

NASA

Earth

28,000 square km — Estimated deforestation in Brazil, 2004

7,500 square km — Estimated deforestation in Brazil, 2009

Potential predictor of solar storms

Microwave bursts may warn of impending eruption from sun

By Sid Perkins

Fluctuating bursts of microwave energy from the sun could give advance warning of the huge solar flares known as coronal mass ejections, new research hints.

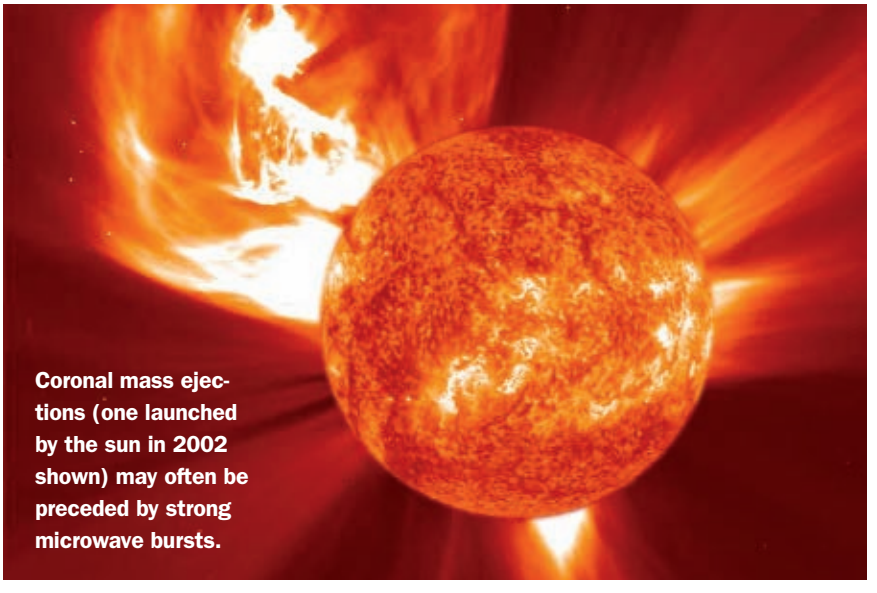
During these events, immense clouds of radiation and charged particles erupt from the sun's surface. When these coronal mass ejections, or CMEs, strike and envelop Earth, they can disrupt radio communications, overload power grids and zap Earth-orbiting satellites, said Pierre Kaufmann, a solar physicist at Mackenzie Presbyterian University in São Paulo, Brazil.

While studying the solar emissions associated with 10 CMEs that occurred during a period of intense solar activity in October and November 2003, he and colleague Rodney V. Souza noticed that the sun emitted bursts of microwave energy during or before each one. For three of the CMEs, the burst coincided with the flares' eruptions from the sun's surface, Kaufmann reported August 9. But for the other seven, the microwave bursts — which fluctuated every few seconds — preceded the eruption of the CME by between five and 15 minutes.

Kaufmann's team is now expanding the study to determine how often microwave bursts occur without a subsequent CME. If bursts that aren't ultimately linked to CMEs turn out to be rare, the emissions could serve as a warning that a CME will soon follow.

The largest fraction of charged particles from a CME reaches Earth between several hours and a couple of days after leaving the sun. But some of the most energetic — and therefore the most potentially damaging — particles travel at half the speed of light and reach Earth in just minutes, said Dalmiro J. Maia, a solar physicist at the University of Porto in Portugal.

Even a warning that comes minutes before a CME's eruption could help engineers prevent damage to satellites or other equipment, Maia said. Early warnings would be especially useful for protecting probes orbiting Mercury or Venus, which would be struck by clouds of charged particles more quickly than Earth would.



Coronal mass ejections (one launched by the sun in 2002 shown) may often be preceded by strong microwave bursts.

SOHO/ESA & NASA

MEETING NOTES

Forest loss slowing in Brazil

Deforestation has dropped dramatically in Brazil thanks to a variety of incentives that may provide a model for other regions as well, Columbia University geographer Ruth S. DeFries said August 9. Besides stepping up enforcement of strict laws regarding deforestation, Brazil has reduced bank loans to large agricultural producers, boosted incentives to increase agricultural production on lands already cleared and increased public awareness of deforestation. The result: Forest losses dropped from 28,000 square kilometers in 2004 to about 7,500 square kilometers in 2009. Policies such as those implemented in Brazil in recent years can help preserve large areas of virgin forest in nations such as Peru, Suriname and the Democratic Republic of the Congo, DeFries suggested.
—Sid Perkins

Chinchilla poop rain gauge

The size of fecal pellets in ancient rodent middens can provide clues about rainfall in times past, paleoecologist Claudio Latorre Hidalgo of Pontifical Catholic University of Chile in Santiago reported August 9. He and colleagues scrutinized middens left by chinchillas at nine sites in South America's Atacama Desert. The size of the largest fecal pellets in a midden correlated with rainfall for that site at the time the midden formed. The new proxy for rainfall may prove useful when other sources of climate clues, such as sediment cores drilled from lake beds, aren't readily available, he noted.
—Sid Perkins

Scour power

Big storms shift coastal erosion into overdrive • By Sid Perkins

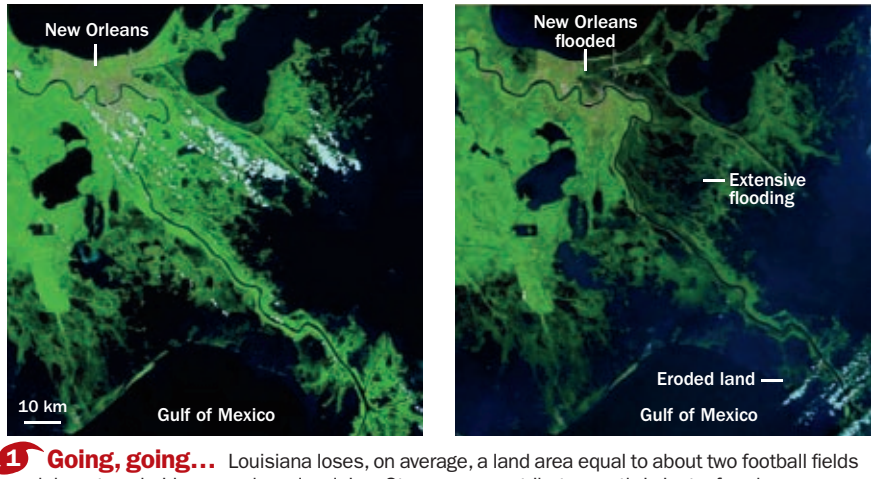
When Hurricane Ike struck the Gulf Coast in the early hours of September 13, 2008, Texas' Bolivar Peninsula was ground zero. Before the category 2 storm made landfall, large stretches of beachfront on this narrow, low-lying spit of land were chockablock with homes standing on stilts behind dunes up to 2 meters tall.

But those stilts — and the dunes — were too short: Most of the homes that didn't get blown away by Ike's 175-kilometer-per-hour winds were battered by waves and then swept off pilings by a 5-meter-deep, debris-filled storm surge. Terrain was swept clean, and dunes were decapitated. Across some stretches of shore, the ocean chewed inland more than 50 meters, while other sections of beach actually gained ground as storm water draining from marshes and bays carried sediment toward the sea, dropping the material at the water's edge.

Such resculpting of shorelines by storms has become a popular research topic lately, thanks to the availability of high-tech data collection equipment ranging from sonar-equipped ships to GPS-carrying all-terrain vehicles and small aircraft with laser altimeters. As few as a dozen years ago, field studies assessing storm-induced shoreline changes required an army of surveyors and hordes of graduate students, says Asbury "Abby" Sallenger, head of the U.S. Geological Survey's storm impacts research group in St. Petersburg, Fla.

Today, a single flight can collect high-resolution elevation data for a 300-meter-wide swath of coast stretching as far as from New York City to Boston. "It's just no comparison," Sallenger says. "I don't care how many grad students are out there; you could never reproduce that."

With these new, broader surveys,



1 Going, going... Louisiana loses, on average, a land area equal to about two football fields each hour to subsidence and sea level rise. Storms can contribute greatly in just a few days, as seen when comparing southeastern Louisiana three weeks before Katrina (left) and one week after (right).

TOP: MAP: ATLAS/MAP RESOURCES; ILLUSTRATION: T. DUBÉ;
BOTTOM: COLLECTION OF WAYNE AND NANCY WEIKEL/FEMA FISHERIES COORDINATORS

In recent years, several hurricanes have reshaped Gulf of Mexico shores, numbered here to correspond with images shown.

scientists are seeing better than ever how much land storms chisel from the edges of continents — not just in populated areas, where homes and infrastructure are damaged or demolished, but in the kinds of remote areas that previously went unsurveyed after storms. Along with improving damage estimates right after a major storm strike, researchers hope to do a better job of predicting future shoreline locations and assessing prospects for shore recovery after a storm.

The degree of earthmoving these studies are finding is impressive. A major storm can essentially pick up and relocate entire barrier islands, such as those that help protect Atlantic and Gulf coasts. Yet the analytical models that coastal planners use to estimate where coasts will lie in the future rely mainly on gradual, persistent rates of erosion in the past, not the effects of occasional large storms. Those transient effects have, until recently, been hard to estimate, since any given location is rarely hit by a big storm.

Backwash

The churning of sediments beneath a storm has always been hard to see. But by using shipboard sonar to map the underwater landscape, scientists got an in-depth view of massive movements of seafloor material by Hurricane Ike.

Beneath a storm's winds, rushing water can reshape the underwater landscape, especially when a storm surge blasts onto land and then recedes across barrier islands or through narrow inlets. Besides dramatically rearranging features in navigated areas such as shipping lanes, storms leave clues in the sediments that can help scientists interpret ancient sediments long since turned to stone.

When Ike's eye reached the eastern end of Galveston Island, just southwest of Bolivar Peninsula, hurricane-force winds — those measuring 119 km/hr or greater — covered a 180-kilometer-long stretch of coast. West of the eye, winds blew away from land and water was pushed offshore. But east of the eye, water surged inland across the Bolivar Peninsula and piled up in Galveston Bay to heights up to 5 meters.

As the storm passed and winds abated, that water returned to sea, says John A. Goff, a marine geologist at the University of Texas at Austin. As water levels in the bay dropped, flow was channeled through the inlet separating Bolivar Peninsula and Galveston Island. Buoys marking the shipping channel through the inlet, the main route leading to and from the port of Houston, were swept seaward as much as 13 kilometers — quite a feat considering the buoys' anchors weighed more than 5 metric tons each.

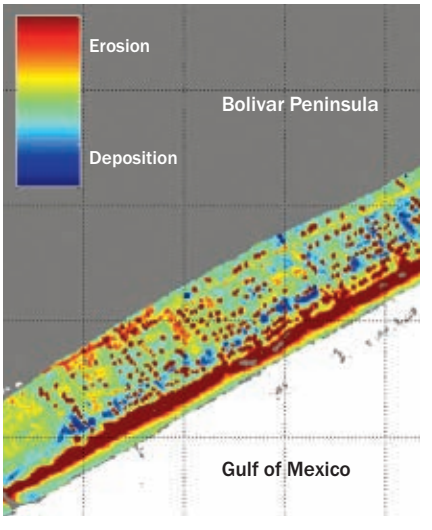
By comparing sonar data gathered in the inlet a week and a half after Ike made landfall with data gathered just four months earlier, Goff and his colleagues could readily assess the storm's erosive effects. Before the hurricane, several broad, 3-meter-tall ridges of shells and loose gravel, sculpted by the normal flow of tides in and out of the inlet, stretched across the inlet's floor, the researchers reported in the April *Geology*. Those ridges had been stable for decades, Goff says.

Flow rushing through the inlet after the storm pushed the ridges seaward 40 to 50 meters and scoured away as much as two-thirds of the ridges' height. Data gathered in May 2010, more than a year and a half after the hurricane, show that the shells and gravel are again being pushed into heaps, but those nascent ridges are accumulating where the post-Ike remnants were dropped, not where the ridges stood before the storm.

Finer material, such as sand and silt, was probably carried even farther out to sea, Goff notes. By analyzing sediment samples taken from the seafloor at varying distances from the Bolivar Peninsula, the researchers were able to estimate the amount of material stripped from shore.

The team estimates that fresh deposits of sand and mud stretched up to 15 kilometers offshore. Goff says that the piles include about 300,000 cubic meters — or about 37,500 large dump truck loads — of sand from each kilometer of coastline. And because previous studies of the seafloor in this area have suggested that material at water depths greater than 5 meters typically stays put under normal conditions, much of that sand probably won't be coming back to shore.

But scientists are still learning how to predict shoreline recovery. John B. Anderson, a marine geologist at Rice



On Texas' Bolivar Peninsula, Hurricane Ike eroded (red areas) or deposited (blue) a meter or more of sediment.

K.S. DORAN *ET AL*./USGS 2009

University in Houston, isn't so sure all that sand from Galveston Bay is lost. Because the researchers didn't determine the size distribution of grains in the sand layer, it's impossible to tell what proportion of those grains might be small enough to be bumped back to shore by normal wave action, even from waters up to 10 meters deep, he adds.

After looking at historical data, Goff and his colleagues contend that the sand is indeed gone for good. An extensive layer of sand dragged offshore by Hurricane Carla, which struck the Texas coast in 1961, stayed where the storm dropped it for at least a quarter of a century, they note.

Sometimes those layers of storm-shifted sand are buried by quickly accumulating sediment and thus preserved, leaving in the geological record a layer known as a "tempestite," Goff says. Studying and understanding the modern-day processes that generate such layers can aid researchers trying to interpret the geological record. The presence of a tempestite would indicate that an area was susceptible to major storms, for example, and the size and frequency of such layers within rock formations could yield clues about ancient climates.

2 **Images taken four days before Hurricane Ike struck (left) and two days after show erosion along the coast near Galveston, Texas. Arrows denote the same spot.**

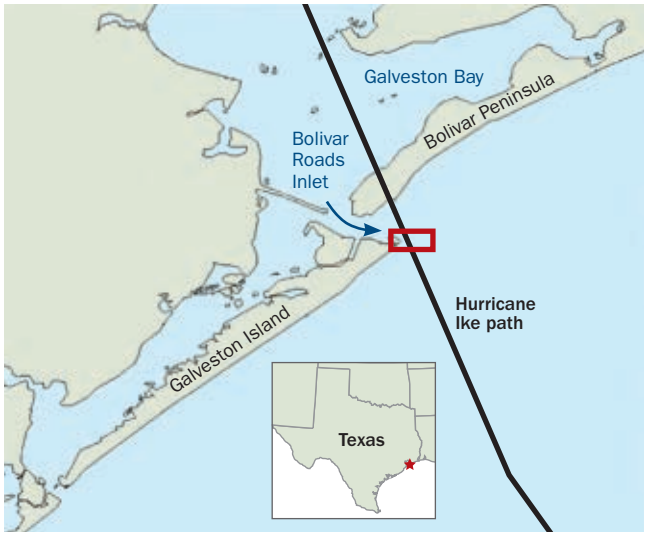
Diving deeper

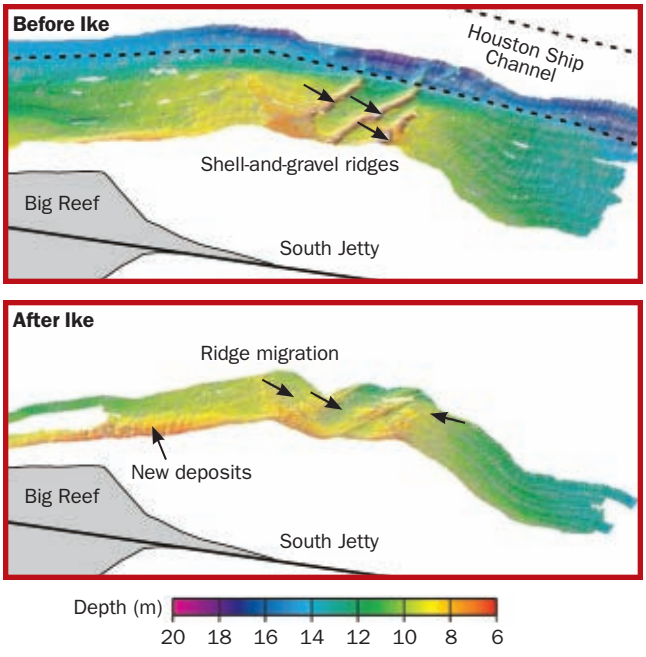
Because hurricanes strike any given stretch of coast rather infrequently, data on the storms' effects are hard to come by. On the broader scale, satellite observations give scientists a look at the speed and direction of currents that hurricanes generate at the ocean's surface, says oceanographer William J. Teague of the Naval Research Laboratory at NASA's Stennis Space Center in Mississippi. "But once you get below the surface, there's a void of data," he notes.

While buoys far off the Texas coast were blown or dragged southwest as far as 35 kilometers during Ike, researchers don't know how strong the storm-induced currents were, when the buoys moved or what path they took — it's clear only where the buoys ended up. But new analyses of data collected by seafloor instruments during another hurricane, 2004's Ivan, could let researchers make some reasonable guesses about water's scouring power beneath the surface.

Just before Ivan slammed into the Gulf Coast, it passed directly over an array of seafloor sensors deployed in mid-depth waters on the continental shelf south of Mobile, Ala. At that time, Ivan was a category 4 hurricane creeping northward at about 20 km/hr, Teague says. Previously, his team's analysis of data gathered during the event revealed the largest waves ever measured by instruments (*SN: 6/11/05, p. 382*). Now,

Hidden destruction Ike's winds forced a 5-meter storm surge into Galveston Bay. Much of that water rushed back to sea through the Bolivar Roads Inlet (below, arrow). The flow's force took the tops off shell-and-gravel ridges and dumped new deposits on the inlet floor (sonar images on right show area in red box on map).





TOP: USGS; BOTTOM LEFT: MAP: USGS, ADAPTED BY T. DUBÉ; MAP INSET: ATLAS/MAP RESOURCES; BOTTOM RIGHT: J. GOFF *ET AL/GEOLOGY* 2010

the group's work gives an unprecedented look at the effects of huge waves at depths normally undisturbed by events at the ocean's surface. "These data make it possible to study the physics underneath a hurricane," Teague says.

In normal conditions, currents crawl along the ocean bottom at about 1 millimeter per second. But as Hurricane Ivan passed over, seafloor currents rushed about a thousand times faster, Teague and colleagues report in the June 16 *Geophysical Research Letters*. And while steady currents are the norm for deep water, the researchers estimate that shear stresses induced in seafloor sediments by the waves were about four times higher than those triggered by everyday currents.

The strong back-and-forth action of Ivan's waves was particularly effective at stirring up sediment; upward-looking sonar detected sediment suspended in the water as much as 25 meters above the ocean floor.

The researchers did have one surprise, says Teague: Currents set in motion by the hurricane were strong enough to shuffle sediment across the ocean floor for nearly a week after the storm had passed. During that week, currents scoured more than 30 centimeters of material from beneath one of the sensors, he notes.

Results of this study will not only help scientists improve and calibrate models of subsurface currents, says Teague, but they'll also help engineers make seafloor pipelines more resilient in storms. This is no small problem: According to a report released by the Minerals Management Service in February, at least 17 pipelines that crisscross the Gulf seafloor were damaged by wind- or wave-induced currents during hurricanes Gustav and Ike in 2008.

Vulnerability varies

Scientists' next question is how much erosion will result from the powerful movement of water during a major storm in any given location. Though two stretches of coast may appear similar, their erosion rates can differ substantially. Along the Atlantic Coast, the shore erodes inland, on average, between 60 centimeters and a meter each year; annual rates of erosion along the Gulf Coast are double that (*SN: 7/8/00, p. 20*).

And while all Gulf shores are at risk of being struck by major storms, some areas are more vulnerable to erosion than others. In southern Louisiana, and particularly in the Mississippi Delta, long-term sinking, or subsidence — a phenomenon resulting from reduced deliveries of river sediment and the ongoing withdrawal of oil and gas from underground reservoirs — makes barrier islands unusually susceptible to storms. Rising sea levels only aggravate the problem.

Even along relatively stable shores such as Texas' Gulf Coast, long-term rates of erosion can differ dramatically from one swath of land to the next, says Rice's Anderson. Analyses of aerial photos suggest that Galveston Island and the Bolivar Peninsula each lost an average of 1.3 to 1.4 meters of beach each year between the 1930s and the 1980s, Anderson's team notes in the June 8 *Eos*.

3 Arrows show erosion over time on Alabama's Dauphin Island: before Hurricane Lili (top), just after Ivan and two days after Katrina (bottom).

USGS

The shore of Matagorda Island, southwest of Galveston Island, actually beefed up by about a meter a year over the same period, thanks to the convergence of sediment-laden currents there.

But long-term average rates of erosion don't tell the full story, says geophysicist Neil Frazer of the University of Hawaii at Manoa. His team's studies indicate that models that include only the average rates and ignore the temporary effects of storms don't do a good job of estimating what portions of the coastline are safe for development. That's been true in his research on Assateague Island along the Maryland and Virginia coast between 1995 and 2003, and in studies along the Delaware coast, where data have been collected since the 1920s.

With coastal populations growing at the fastest rates in the country, better estimates of future erosion are becoming more important than ever.

"If I were a shoreline manager, I could take long-term data and make a best bet about where the shoreline would possibly be in 2040," Frazer says. "But then I could consider the effects of a single major storm and argue that maybe I'd better not plan on the shoreline being there exactly, because that storm could come along and blow you away.... Things can look the same for 50 years, then 'Bang!' " he notes.

That happened on the Bolivar Peninsula with Hurricane Ike, where erosion averages 1.3 meters per year, but Ike sluiced away at least 30 times that in one fell swoop. Using predictions of erosion based on average rates but also including the temporary impacts of a major storm might have made prudent developers think twice about building structures on the low-lying land — or at least let the developers know that their buildings needed taller stilts. ■

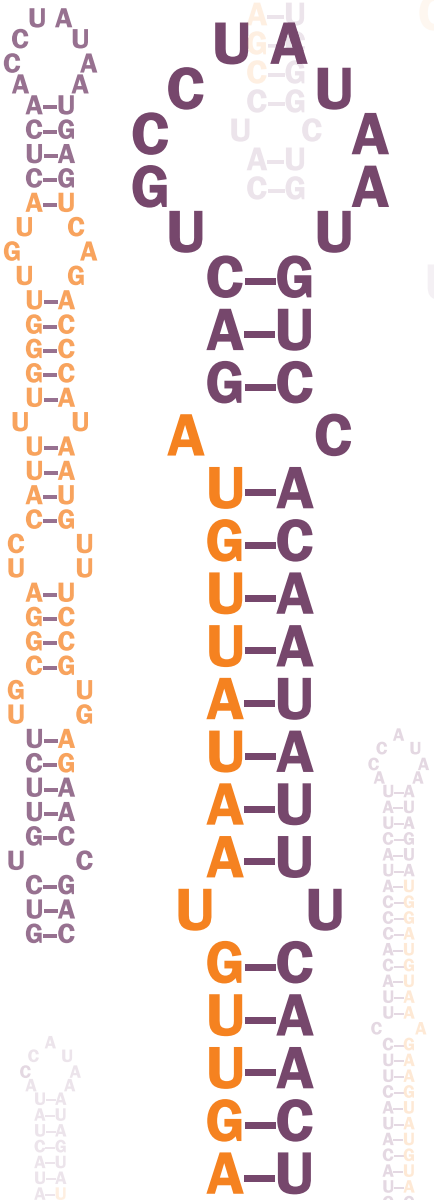
Explore more

- K.S. Doran *et al*. "Hurricane Ike: Observations and analysis of coastal change." U.S. Geological Survey Open-File Report 2009-1061. Report available at pubs.usgs.gov/of/2009/1061

Cancer's little helpers

Tiny pieces of RNA may turn cells to the dark side

By Tina Hesman Saey



When tiny hairpin-shaped molecules act up, they don't rebel loner-style like James Dean. Instead they take on the persona of Darth Vader, crushing proteins under their command and turning acquaintances to the dark side as well. In this case, though, the fight is for control not of the universe, but of the body. And a dark-side victory could end in cancer.

No one would have predicted a decade ago that these microRNAs, as the hairpins are called, were involved in cancer, because no one even knew that they existed in people. Mere snippets of RNA — DNA's underappreciated cousin — these micromolecules are about 22 chemical letters long. But their size belies their power.

When on their best behavior, the molecules are competent and capable managers of the protein-building process that keeps a cell humming in perfect harmony. But when microRNAs go rogue, the results can be disastrous.

New research is revealing just how important these newly discovered molecules are. An imbalance of microRNAs can cause cancer by encouraging runaway cell growth or by dampening a cell's defenses, and can also make the disease more stubborn. But just as Darth Vader never completely lost the young Jedi Anakin Skywalker within him, even bad microRNAs may have good in them yet. Some scientists think that therapies aimed at soothing riled-up microRNAs may help cure the very cancers that the molecules help cause.

Most of the discoveries linking microRNAs and cancer have come in the past five years. "This is extremely rapid progression," says Curtis Harris, chief of the human carcinogenesis lab at the National Cancer Institute, based in Bethesda, Md.

Micro middle managers

The realization that such small molecules could play a big role in disease was late in coming, says Carlo Croce of Ohio State University in Columbus. "In the beginning there was no interest in microRNAs at all," he says.

The first microRNA was discovered in 1993 in roundworms. It took another seven years before the next microRNA was found in the same organism. Though both of those microRNAs help control worm development, most scientists regarded them as biological curiosities.

But then researchers found microRNAs at work in fruit flies, people and other organisms. Those discoveries suggested that microRNAs might be important regulatory molecules for all animals, not just flukes of worm biology.

MicroRNAs work in middle management in most plant and animal cells, scientists now know. The molecules help regulate the protein-manufacturing process by essentially issuing permits decreeing when and where proteins may be built. By riding piggyback on messenger RNAs, which are copies of the protein-building blueprints contained within DNA, microRNAs prevent the instructions from reaching protein-building machinery inside cells.

While it may sound nefarious, microRNAs' interference with protein production helps a cell maintain balance. MicroRNAs ensure that cells save energy by not making unnecessary proteins and help prevent levels of potentially harmful proteins, such as those that initiate the self-destruct program known as apoptosis, from reaching critical mass.

Each type of microRNA in a cell may potentially pair with hundreds of different types of messenger RNA, says Isidore Rigoutsos, a computational and molecular biologist at Thomas Jefferson University in Philadelphia. And each messenger RNA may have many different microRNAs piling on its back.

"It's safe to say that microRNAs are important," Rigoutsos says. "The difficulty is saying what are the limits of importance, and they keep being expanded more and more and more."

Cancer connection

Croce's lab was among the first to illustrate just how big a role the little molecules could play in people. His group showed that genes encoding microRNAs frequently go missing in tumor cells. In

particular, two microRNAs, *miR-15* and *miR-16*, are missing or found at lower than normal levels in 68 percent of chronic lymphocytic leukemia cases.

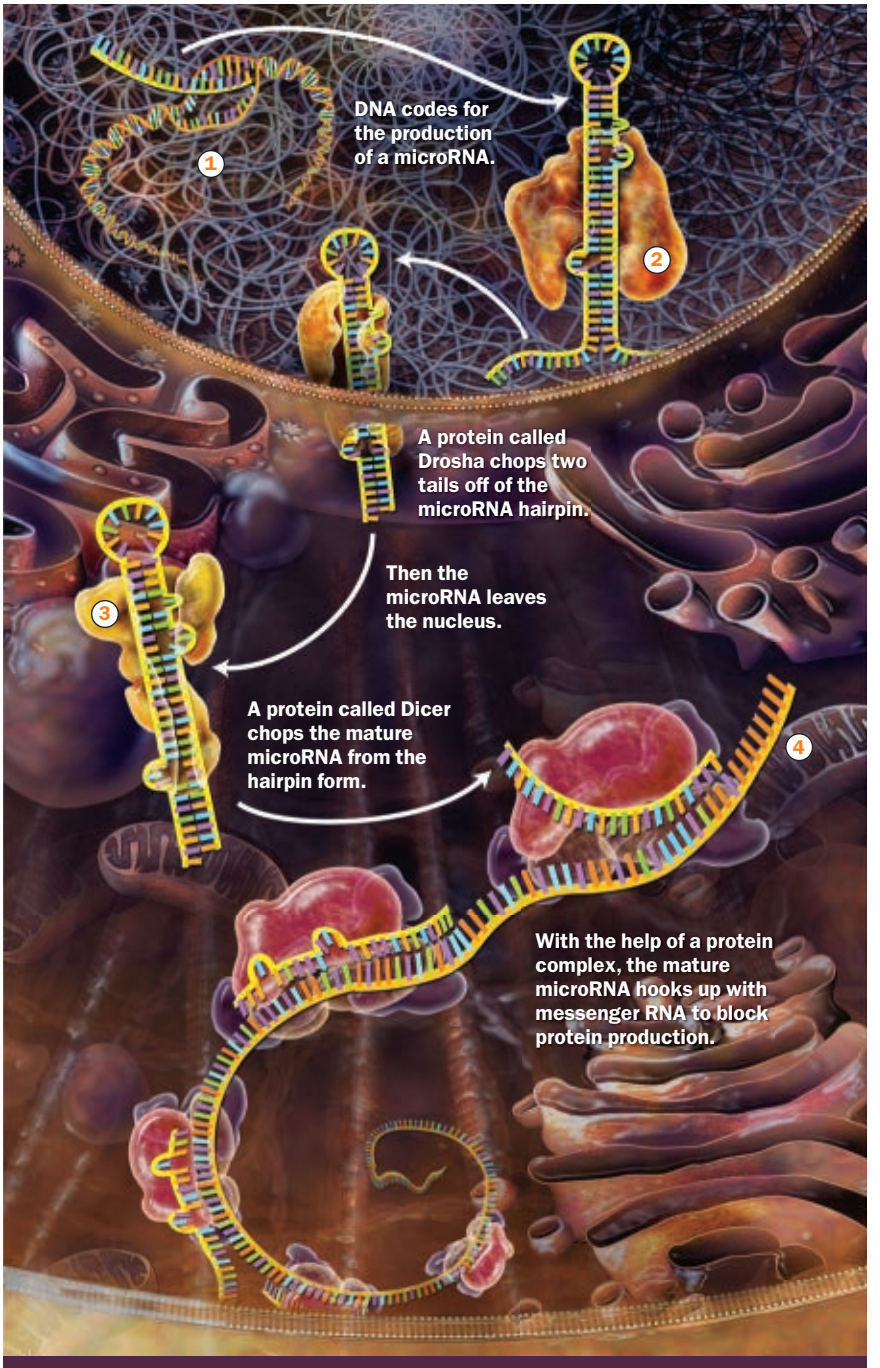
Cancer biologists usually lump microRNAs into two groups: those that protect against cancer and those that promote it (though the distinction isn't perfect). Cancer cells tend to have lower levels of most microRNAs but have an oversupply of a few others.

In the protective corner are microRNAs such as *miR-15* and *miR-16*. One of the many proteins regulated by those two microRNAs is BCL2, which keeps cells from pushing the self-destruct button. Cells commit suicide when they become too damaged to operate properly — an important self-defense mechanism for an organism that doesn't want to walk around with malfunctioning cells. So cells need just the right amount of BCL2 to keep from killing themselves unnecessarily, but not so much of it that they can never die.

The microRNAs pair with messenger RNA to strike the right balance of BCL2. But when *miR-15* and *miR-16* levels are knocked down — which can happen if a copy of a gene is lost or if something goes wrong during microRNA manufacturing — cells make far too much BCL2, essentially disabling the self-destruct mechanism and making cells immortal. Immortality is one hallmark of cancer.

At the opposite end of the spectrum is one of the baddest microRNA bad boys, *miR-21*. Elevated levels cause cancer in mice, researchers from Yale University reported online August 8 in *Nature*. And higher than normal levels have been linked to at least 13 major types of cancer in people and to poor prognoses for people with colon, lung, breast, pancreatic or head and neck cancers, Harris says (*SN: 2/2/08, p. 70*).

High levels of *miR-21* can slow an important cellular security system involving a protein named p53, researchers from the University of California, Santa Barbara have found. This protein performs multiple protective services, including spurring repair of damaged DNA, halting growth until damage is



Making microRNAs The process by which microRNAs are produced and pair up with messenger RNA (above) is complex, leaving a lot of room for errors like these:

1. Genetic variations, breaks in the chromosome, inserted viruses or a lost or duplicated microRNA gene can cause too much or too little of the microRNA to be produced.

2. Drosha may fail to trim the microRNA due to variations in the microRNA, the protein or its partners.

3. If Dicer levels are too low or if the protein doesn't work properly, not enough microRNAs will be liberated from the hairpins.

4. Messenger RNA decoys could distract the microRNAs from their intended target, or mutations in either the messenger RNA or the microRNA could prevent pairing. Something could also go wrong with the proteins that help the microRNA find the proper messenger RNA.

NICOLLE RAGER FULLER

repaired or ending it all if repair isn't possible (*SN: 12/6/08, p. 22*). Last year researchers reported in *Nature* that p53 helps slice microRNAs into their mature form. Too much *miR-21* can strip cells of their p53 defenses, leading to cancer.

Though *miR-21* has stood out among the troublemakers, Croce's team has shown that this microRNA and others don't work alone. The molecular managers are master networkers. In 50 different normal human tissues, microRNAs collaborate to direct cellular activities, Croce and colleagues reported online May 3 in *Genome Research*. The networks consist of microRNAs that help direct production of proteins, some of which, in turn, control production of other microRNAs, and so on.

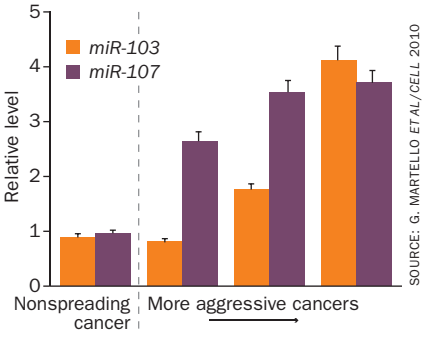
But time and again, in 51 different types of cancer, Croce's team found that the microRNAs' teamwork had broken down. The cohesive networks disintegrated into rogue hubs of activity. These anarchist factions throw a wrench into the well-oiled machinery that usually keeps a cell healthy.

It's a rather small wrench, though. MicroRNAs wield their power subtly, tweaking and massaging protein levels up or down a wee bit here and there instead of stopping production altogether.

"A microRNA doesn't function like an 'off' switch," says cancer biologist Dihua Yu of the University of Texas MD Anderson Cancer Center in Houston.

Even a little bump or dip in protein levels, maybe by just 5 to 10 percent, is enough to send a cell careening down the path to cancer, Croce says.

MicroRNA levels and cancer aggressiveness



Getting a move on Imbalances in microRNA levels can spur cancer cells to spread. Too much *miR-103* or *miR-107* has been linked to increased mobility among cancer cells.

One of the most delicately balanced cancer-associated proteins is PTEN. It reins in cell growth to prevent wild replication, as seen in cancer. In the parlance of cancer research, PTEN is known as a tumor suppressor, and it works best when there is just the right amount of it.

Losing one copy of the gene for PTEN—essentially cutting protein levels in half—is enough to turn a cell cancerous, previous studies have shown. Other research has demonstrated that microRNAs, including *miR-21*, help govern production of PTEN. And a study reported June 24 in *Nature* found that a messenger RNA doppelgänger of PTEN found in healthy cells distracts PTEN-stifling microRNAs, allowing more of the protein to be made. If the twin is missing, the weight of microRNAs on messenger RNA's back can crush protein production.

New research from Yu's lab also suggests that reducing the amount of PTEN protein in a tumor cell even slightly is not a good idea. Higher levels of *miR-21* slow down PTEN production and make breast cancer cells resistant to an anticancer agent called Herceptin, Yu and colleague Sumaiyah Rehman reported in April in Washington, D.C., at the annual meeting of the American Association for Cancer Research.

Dicer danger

PTEN isn't the only protein that can make cancer worse. A new study shows that small changes in the amount of a protein involved in producing microRNAs can determine whether tumors stay put or spread to the rest of the body.

That discovery grew from efforts to figure out why most microRNAs are at lower levels in cancer cells but some microRNAs are overproduced. "We were intrigued by this paradox," says Stefano Piccolo, a cellular and molecular biologist at the University of Padua in Italy.

The resolution came from an unexpected source, a protein that helps slice larger RNAs into microRNAs. This protein, Dicer, is a key component of the microRNA manufacturing machinery. Cutting levels of Dicer in half spurs on cancer because less of it leads to less microRNA, which can mean increased production of proteins that drive rapid growth. Still, cancer cells need some Dicer to survive and reproduce, since Dicer helps make microRNAs that regulate production of proteins.

So cancer cells need to control Dicer levels the way a student sets the volume on an iPod to provide background study music. The volume shouldn't be too quiet or too loud. "You need to find that perfect middle," Piccolo says.

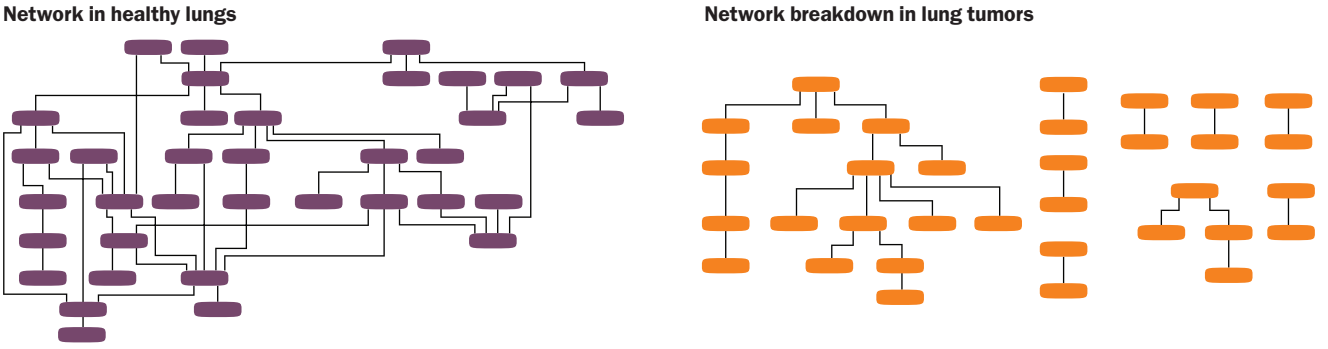
Cells dial in just the right amount of Dicer by using a family of microRNAs, *miR-103.1*, *miR-103.2* and *miR-107*, Piccolo and his colleagues reported in the June 25 *Cell*. Those three

Little differences Some studies have linked single letter changes in the genes encoding microRNAs to various types of cancer. Genetic variations in the genes may interfere with the production or function of the molecules.

Variations in microRNA genes linked to cancers

Gene for:	*miR-146a*	*miR-196a*	*miR-423*	*miR-27a*	*miR-492*	*miR-499*
Lung cancer		X				
Esophageal cancer		X	X			
Breast cancer		X	X	X		X
Stomach cancer		X				
Liver cancer	X	X				
Bladder cancer			X		X	
Papillary thyroid	X					
Brain cancer		X				

SOURCE: B.M. RYAN *ET AL/NATURE REVIEWS CANCER* 2010



Going rogue The networks through which microRNAS (colored boxes) indirectly regulate each other can break down in cancer. In healthy lung tissue (left), researchers found a complete microRNA network, but cancerous tissue possessed one main network along with eight subnetworks (right).

microRNAs, which occur at high levels in some cancer cells, latch on to messenger RNAs encoding Dicer and ratchet down its production, meaning less of other microRNAs get made. But Dicer levels never drop to nothing, because the same microRNAs rely on the protein to snip them free from larger pieces of RNA.

Piccolo's finding neatly solves the paradox of why most microRNA levels can be low in cancer cells while some are high, but his study didn't stop there. The research also provides further evidence that low Dicer levels make cancer more dangerous.

In the study, Piccolo's team discovered that some aggressive tumors had higher than normal levels of the microRNAs that regulate Dicer, and thus less of the protein. More of these microRNAs were also associated with breast cancer's spread and poor prognosis in patients.

Additional experiments with tumor cells growing in lab dishes showed that the cells usually tend to cluster. But when Dicer levels are lowered to about 50 to 60 percent of normal, or levels of *miR-107* are increased, cells begin migrating across the dish. Dips in Dicer levels make cells mobile, the team suggests. Less Dicer may mean less of other microRNAs that hold back production of proteins that are responsible for getting cells in gear. With fewer inhibitory microRNAs around, go-proteins can be made and cells get a move on.

Tumor cells may be taking advantage of one of Dicer's jobs in normal cells—helping cells move around. "Cancer doesn't invent anything," Piccolo says.

Tiny treatment options

Getting a clue that a microRNA is involved in a problem also gives researchers a potential solution. In experiments with mice, inhibiting *miR-21* made resistant tumor cells more susceptible to Herceptin, Rehman reported at the cancer research meeting.

Increasing susceptibility to anticancer drugs is just one way that microRNAs could be useful in the clinic, says oncologist Muller Fabbri of Ohio State.

Specific microRNA levels rise or fall in different tumor types, creating a signature for that type of cancer, studies have shown. Such signatures could help correctly diagnose cancer in people whose tumors have migrated. Often pathologists can examine a brain tumor and determine that it arose from breast cancer cells, but sometimes cancer cells conceal their real birthplace. Characteristic patterns of microRNA could help identify where tumor cells originated in the 8 to 10 percent of cases when "even the pathologist doesn't have a clue," Fabbri says. Examining the pattern of microRNA levels in a patient's tumor may also help doctors identify aggressive forms (*SN: 2/2/08, p. 70*).

In diseases such as liver cancer, researchers may be able to replace missing microRNAs or boost levels to stop the cancer, a team reported last year in *Cell*. And in cancers in which levels of certain microRNAs are too high, researchers can deploy decoy molecules to pull microRNAs from their targets. A team reported in January in *Science* that the strategy appears to work for treating hepatitis C infection in monkeys (*SN: 1/2/10, p. 14*).

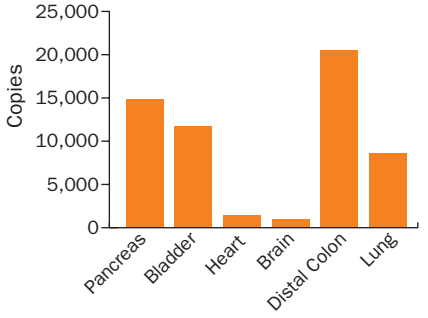
Croce thinks that targeting several microRNAs in anarchist networks may help treat cancer with little chance of resistance developing. But such therapies are still years away. "We have to show that it is really true," he says, "not just in experiments with mice, but in clinical trials."

For now, no microRNA therapies are available for cancer, but researchers are watching trials of the anti-microRNA therapy against hepatitis C in people.

"The rapidity of what's going on is what gives some of us optimism that this could have value," Harris says. "Relatively shortly, we're going to know the degree of importance of microRNAs." ■

Levels by organ MicroRNA levels that are too high for one organ may be just right for another. Healthy brain cells, for example, have fewer copies of *miR-21* molecules than healthy cells in the last portion of the colon.

***miR-21* copies in different cell types**



SOURCE: LIANG *ET AL/BMC GENOMICS* 2007

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- *Nature*'s web focus: www.nature.com/reviews/focus/microrna

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Mining for missing matter

In underground lairs, physicists look for the dark stuff

By Ron Cowen

More than 700 meters beneath the Earth's surface at the Soudan Underground Laboratory, researchers install a detector for recording dark matter collisions.

On an early summer morning in northern Minnesota, a crew of about a dozen waits by the top of mine shaft No. 8. Donning hard hats, the engineers and physicists pile into a creaky, double-decker elevator cage. It is pitch black for most of the three-minute descent. Ears pop, the cage floor vibrates and a giant motor dating from 1925 thunders overhead.

When the cage door slides open, the team is 713 meters below the surface. Directly ahead lies a maze of tunnels — an abandoned mine where laborers once extracted iron ore of uncommon purity. But the scientific crew takes a U-turn into a huge and unexpectedly spacious two-room cavern known as the Soudan Underground Laboratory.

The workers have journeyed deep into the Earth to plumb the darkest depths of the cosmos, hunting for the missing material believed to account for 83 percent of the universe's mass.

That material, known as dark matter, must exist, astronomers say, because the cosmic allotment of ordinary, visible matter doesn't provide enough gravitational glue to hold galaxies together. Although the missing material shouldn't be any more prevalent in the underworld than above ground, dark matter hunters have good reason to frequent Soudan and other subterranean lairs. Because dark matter particles would interact so weakly, experiments designed to detect the dark stuff could easily be overwhelmed by the cacophony of other particles. So scientists at Soudan and elsewhere use Earth's crust to filter out cosmic rays — charged particles from space that bombard Earth's atmosphere.

Physicists have been directly searching for dark matter for more than two decades. But until recently, only one experiment, beneath a mountain in central Italy, had consistently reported evidence of the invisible particles. Now two more experiments have found similar hints. When taken together, the findings suggest that the most popular models for dark matter may not be correct — the particles pegged have a lower mass than many physicists had proposed.

"Any discovery of dark matter would be a major revolution," says theorist Neal Weiner of New York University. "But if these results are right, I think it's even more exciting than that."

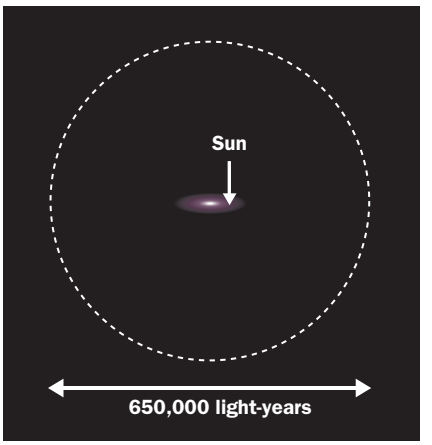
If the low-mass measurements are confirmed, a second revolution is in the making: In addition to dark matter, a new force may be needed to explain the workings of the universe. Favorite particle physics theories may require revision or may even have to be discarded.

But not so fast, some scientists say. Other recent work questions whether researchers have actually spotted low-mass dark matter particles. And with so much at stake, including the likelihood of a Nobel Prize for whoever discovers dark matter first, rival teams have resorted to name-calling. One team has twice publicly ridiculed the results of a second, while the team whose analysis has come under fire has likened the attacks to the Spanish Inquisition.

It's an exciting but confusing time, Weiner says.

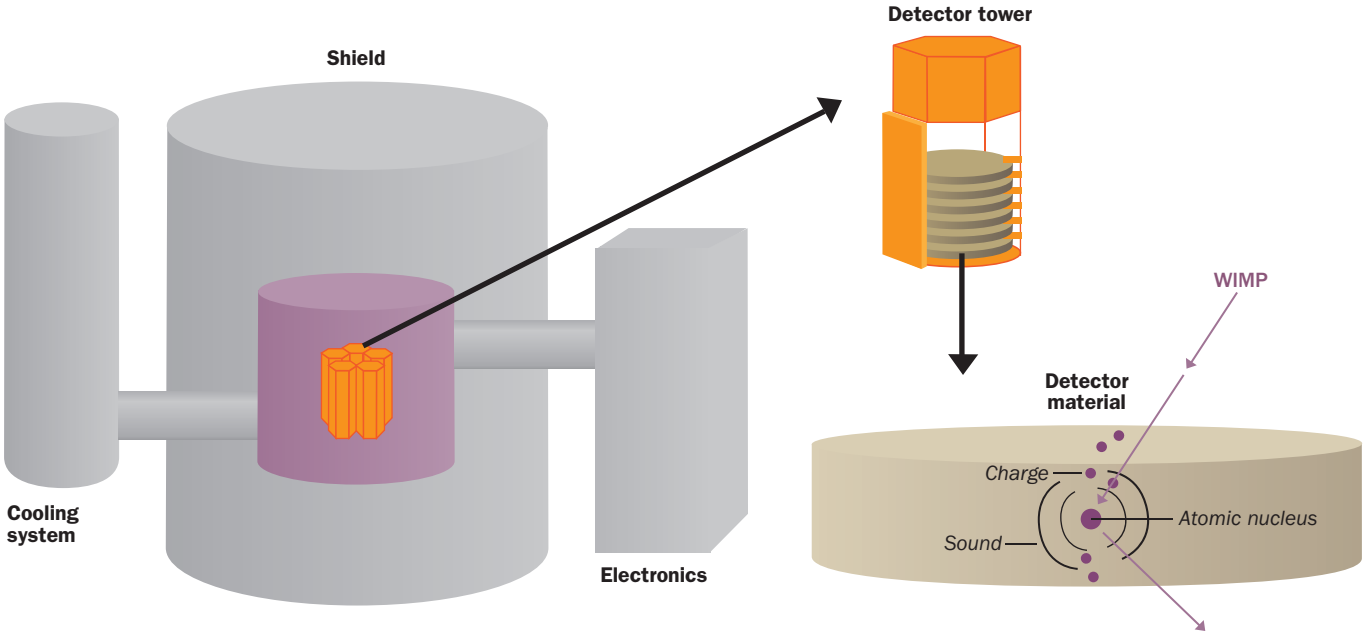
Catching some WIMPs

Physicists have long had a leading model for dark matter. They believe that it consists of a proposed particle left over from the Big Bang called the WIMP, for weakly interacting massive particle. WIMPs sense only gravity and the weak force, the interaction that governs radioactive decay. Particle physicists like WIMPs



Into the darkness The visible extent of the Milky Way galaxy (center), which has a diameter of about 100,000 light-years, is dwarfed by a surrounding halo of dark matter.

LEFT PAGE, BOTH: CDMS COLLABORATION; RIGHT PAGE: J.YOO/FERMILAB, ADAPTED BY E. FELICIANO



SOURCE: D. BAUER/FERMILAB

Building a detector To spot rare collisions with WIMPs, dark matter detectors are placed underground so they are shielded from background particles. Another layer of shielding provides further protection, and cooling minimizes natural vibrations of atoms in the device itself. If the detecting material is solid, the collision between WIMPs and atomic nuclei can liberate electrons and release sound waves, which can later be analyzed.

because they fit neatly into a theory known as supersymmetry, which unifies the two basic types of elementary particles—force carriers and matter particles.

Supersymmetry requires that every force carrier has a heavier matter particle for a partner, and every matter particle has a heavier force-carrying partner, doubling the number of particles in nature. The lightest supersymmetric partner would be stable, making it an ideal candidate for the WIMP that physicists propose.

Astronomers favor WIMPs as much as physicists do because of an intriguing cosmic coincidence. The predicted abundance of WIMPs in the universe today would account for the amount of dark matter needed to keep rotating galaxies from flying apart and galaxy clusters intact. The heavenly match between WIMPs and dark matter is known as the WIMP miracle.

Miracles are all well and good, but actually detecting the stuff is another matter.

At Soudan and other underground laboratories, scientists use ultrapure solid crystals or liquefied noble gases to try to record the rare collision of a WIMP with an atomic nucleus. Like a struck billiard ball, the jostled nucleus travels a short distance in the detector, hitting neighboring nuclei or electrons. In a solid, like a germanium crystal, the motion of the nucleus generates sound waves that reverberate throughout the detector and cause a tiny but detectable rise in temperature. The interaction of the nucleus with its neighbors also ionizes atoms, liberating some of their outermost electrons. Some experiments measure a different signal, the emission of light generated by a collision.

But ordinary matter can jostle a detector's atomic nuclei too. Going underground helps by shielding experiments from the shower of high-energy particles that cosmic rays produce when they hit the atmosphere. In some cases, researchers also have to cool experiments to a few hundredths of a degree above absolute zero to reduce the constant motions of atoms and molecules in the detectors.

And the experiments need additional shielding because of natural radioactivity in the walls of the mine and the cooling apparatus. For instance, the current version of the Cryogenic Dark Matter Search experiment, called CDMS II, at Soudan is made up of five stacks of germanium and silicon wafers, all sheathed in five nested copper containers. Those containers are then surrounded by lead and polyethylene.

These efforts win only part of the battle. Some ordinary particles still make it through. Neutrons, most notably, are the bane of dark matter experiments because the particles mimic the interaction of WIMPs, confounding scientists. So experimenters analyze the collected signals—sound, light, ionization—to try to discriminate a WIMP collision from an interaction between a nucleus and a spurious background particle.

After accounting for every possible background source, scientists currently expect to find only a few candidate WIMP events a year, says Dan Bauer of the Fermi National Accelerator Laboratory in Batavia, Ill. "So if you get fooled by even one event per year, you've failed," he says.

A recent analysis of data recorded by CDMS II in 2007 and 2008 identified two interactions that might be attributed to WIMPs, scientists reported late last year (*SN: 1/2/10, p. 8*). The detection was not definitive, as radioactive

E. FELICIANO

decay of ordinary material could be responsible for about 0.8 events during the same time period.

In a clean room accessible only by researchers dressed in full protective regalia — white jumpsuit, booties and gloves — the team is now building a new experiment at the Soudan mine, SuperCDMS. With nearly four times the mass of the old experiment and many times the sensitivity, SuperCDMS has the capability to find more WIMPs per year than its predecessor.

Going lower

Tucked away in another part of the Soudan cavern, a smaller experiment, consisting of a single hockey puck of germanium encased in a cooler, has recently made its own mark in the dark matter game.

The Coherent Germanium Neutrino Technology experiment, COGENT, began operating at Soudan in 2009 and is designed to record lower-mass WIMPs than CDMS II can. In February, Juan Collar of the University of Chicago and his collaborators reported a few hundred collisions that his team says could be explained by dark matter interactions. The new finding, which Collar emphasizes must be confirmed by analyzing more data, points to a WIMP weighing between about seven and 11 times the mass of a proton, about one-tenth as massive as particles in many of theorists' WIMP models.

Though the preliminary result is based on only two months of data, the COGENT finding has taken on added importance because it dovetails with results recorded over the past decade by an experiment named DAMA/LIBRA, say Weiner and theorist Dan Hooper of Fermilab. DAMA/LIBRA, short for Dark Matter Large Sodium Iodide Bulk for Rare Processes, hunts for dark matter at Gran Sasso, an underground laboratory in central Italy, and was the first to consistently report evidence of the particles.

> **"The low-mass region — that's the one that everyone is excited about, up, down and sideways."**
>
> KATHERINE FREESE

The experiment sidesteps the problem of contamination from ordinary background particles by looking for a variation in the number of particle collisions it records over a year. A collision rate that is higher in summer than in winter could be a sign that Earth is plowing through a WIMP wind during half its annual trip around the sun. DAMA/LIBRA has seen just such a seasonal increase for more than a decade (*SN: 5/10/08, p. 12*); researchers recently reported the latest results online at arXiv.org/abs/1007.0595.

No other experiment has ever seen such a seasonal modulation, but scientists might not spot it if dark matter particles are very light, only a few times the mass of a proton — the same mass range that may have been detected by COGENT, notes Weiner. That's because most other detectors feature nuclei that are too heavy to be jostled by a light WIMP.

Yet another experiment at Gran Sasso has also found possible evidence of a lighter-than-expected WIMP. At the annual Identification of Dark Matter meeting in Montpellier, France, physicists working on an upgraded version of an experiment called the Cryogenic Rare Event Search with Superconducting Thermometers, CRESST-II, reported data consistent with a lighter-than-expected WIMP. But another team that reanalyzed data from a different experiment at Gran Sasso reported evidence to the contrary.

CRESST-II consists of ultracold crystals of calcium tungstate ($CaWO_4$). The experiment detects both the tiny amount of light and heat generated in each collision with any of the nuclei in the crystals — calcium, tungsten or oxygen.

So far, the signals recorded by CRESST-II suggest that dark matter particles collided with the lightest nuclei in the crystals, oxygen, instead of tungsten, the heaviest. That further suggests that the WIMPs striking the CRESST-II detectors had a low mass and therefore couldn't jostle the heavy tungsten nuclei, the team reported July 26.

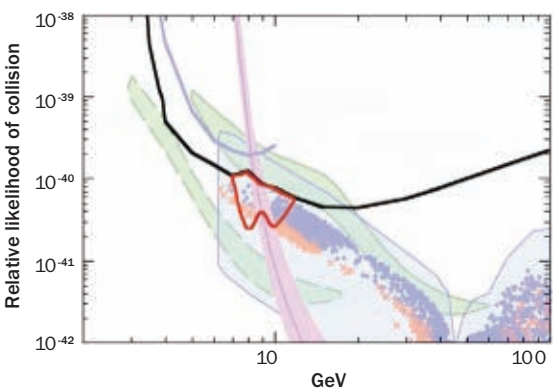
But Peter Sorensen of the Lawrence Livermore National Laboratory in California and colleagues presented a new analysis of data taken in 2006 with XENON10, a predecessor to an ongoing experiment that uses liquid xenon to search for WIMPs.

Sorensen and colleagues looked back at just one signal, ionization, to search for the particles, rather than the two signals that the experiment was originally designed to detect. Although this strategy made background interference more of a problem, it also made the analysis more sensitive to low-mass WIMPs.

The XENON10 results are incompatible with those from DAMA/LIBRA, COGENT and CRESST-II, Sorensen says. "If these experiments were in fact seeing dark matter, that would imply that we should also be seeing a lot, which we don't," he notes. "At some level it's a bummer, because it would be nice to see something finally."

Leo Stodolsky of the Max Planck Institute for Physics in Munich, Germany, a CRESST-II team member, says he and his colleagues have to make sure they aren't being fooled by neutrons or another background source before making any definite claim.

Low-mass hints New data taken by COGENT at the Soudan Underground Lab (solid black curve) may be explained by a low-mass WIMP between 7 and 11 GeV (red contour).



C.E. AALSETH *ET AL./ARXIV.ORG*

Nonetheless, says dark matter theorist Katherine Freese of the University of Michigan in Ann Arbor, "the low-mass region — that's the one that everyone is excited about, up, down and sideways."

Hooper, who has been in the field for a decade, says it is hard to explain why XENON10 is not seeing a signal, but he still has hope that some of the hints of low-mass WIMPs will be credible.

"This is the first time in my career that I'm prepared to make bets with my colleagues that we're actually seeing something," he says.

New physics, hot debate

There's a delicate balance in trying to make sense of the existence of a light WIMP, explains Weiner. On the one hand, a low-mass WIMP would have to interact with ordinary matter in an unusually weak way — otherwise, atom smashers would have already revealed hints of its existence. On the other hand, WIMPs that interact so weakly would tend to have too large an abundance in the universe today to fit with the WIMP miracle. They would have been less likely to be destroyed in the dense, early universe, when collisions between particles were more common.

One solution proposed by Weiner and other researchers is that nature harbors not only a low-mass WIMP but also a new force in the dark sector. The low-mass WIMP would account for the results of the experiments, and the dark force could have depleted enough WIMPs in the early universe so that there would not be too many around today.

"It would also mean that all these simple supersymmetric models that we've been thinking about all these years are going to be thrown out the window," says Hooper. "We're going to have to think about new kinds of theoretical frameworks, symmetric and otherwise."

If the recent results prove correct, physicists might have to invoke a new kind of force along with dark matter.

Weiner would still like to better understand why different underground experiments don't seem to agree with each other. Though he went to the July meeting enthusiastic about a low-mass WIMP, now he says he is less so. "It's a very confusing picture at the moment."

Researchers are hoping that new results expected this fall from XENON100, the newer and larger version of the XENON10 experiment, will provide some clarity.

"For the next year, it's no question that the experiment to watch is XENON100," Freese says. That experiment, which began operating last fall at Gran Sasso, features the most massive detector now in operation, with 160 kilograms of liquid xenon.

The liquid sits in a stainless steel cylinder surrounded by lead and polyethylene to provide shielding from background particles. One set of sensors records the light emitted when a particle strikes one of the nuclei; another set records the signal generated if the colliding particle ionizes the xenon atoms. Together, the signals help discriminate WIMPs from other particles and pinpoint the location of the collision.

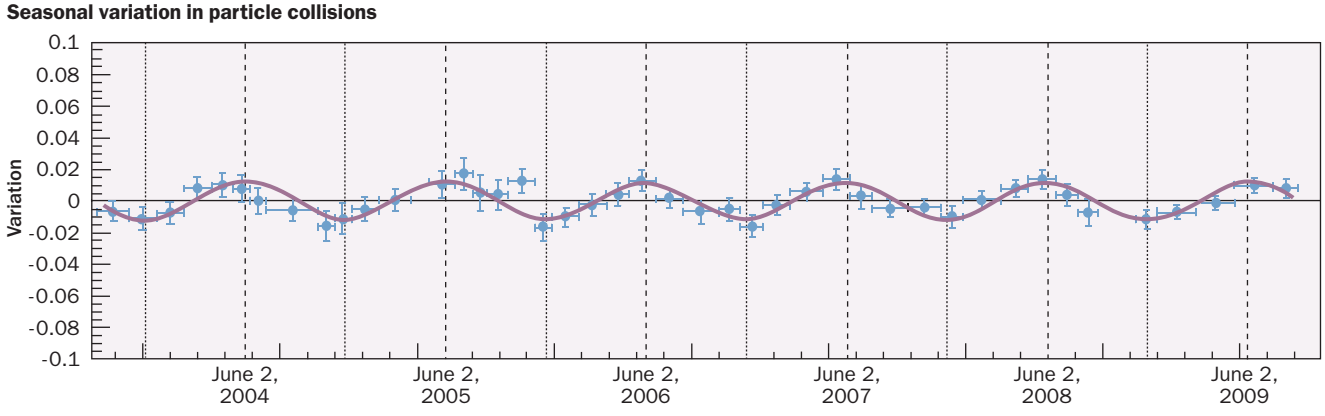
To further distinguish background particles from WIMPs, only the central 40 kilograms of xenon is used as the active detector. Any particle that interacts with both the outer 120 kilograms of liquid and the xenon in the central volume will automatically be rejected because it would be extraordinarily unlikely for a bona fide dark matter particle to interact in both places.

In May, XENON100 team leader Elena Aprile of Columbia University and her colleagues posted results from the first 11 operating days of the experiment at arXiv.org/abs/1005.0380. The initial data appear to rule out the preliminary findings from the much smaller COGENT experiment, which has led to a war of words between the XENON100 and COGENT teams ("A dark debate," *SN Online: 5/13/10*).

In two scathing articles posted online, Collar and colleagues accused Aprile and her team of conducting a sloppy, misleading analysis.

"You have experimentalists essentially trying to get blood out of a turnip," Collar said in an interview. "I'm not even convinced that everybody signing

WIMP wind The DAMA/LIBRA experiment has recorded seasonal variation in particle collisions. Since ordinary matter collisions shouldn't vary as the Earth revolves around the sun, the team suspects that Earth is traveling into a WIMP wind in the summer and away from it during the winter.



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that paper believes what they wrote."

Says Aprile of Collar's reaction: "The Inquisition comes to mind."

At the heart of the debate is an unknown: how much light xenon generates in response to collisions with particles that have very low energies or masses. Aprile acknowledges that further measurements, which colleagues in her lab in Irvington, N.Y., are now conducting, are needed to settle the question.

That brouhaha aside, most dark matter researchers are awaiting the results from XENON100's first 100 days of data. Aprile says that the findings will be unveiled this fall in a dramatic protocol known as an unblinding, in which all members of the international team gather around their computers as preprogrammed software analyzes the results.

"We will be able to make a very big statement about dark matter," Aprile predicts.

Like other teams, she and her collaborators are already planning a larger version of their experiment. This successor to XENON100 would use 2,300 kilograms of liquid xenon.

"My hope is that the next generation of experiments will discover dark matter" within the next few years, says CDMS II researcher Jodi Cooley of Southern Methodist University in Dallas. After making their initial discovery, researchers could then tailor experiments to unveil dark matter's detailed nature, she says.

By then, the deepest physics laboratory ever built — a proposed facility at the Homestake mine in South Dakota — may be ready. There, some 2,200 meters underground, modern-day miners will attempt to unveil the darkest secrets of the universe as never before. ■

Explore more

- Robert H. Sanders. *The Dark Matter Problem*. Cambridge University Press, 2010.
- Dan Hooper. *Nature's Blueprint: Supersymmetry and the Search for a Unified Theory of Matter and Force*. HarperCollins, 2008.

Climatopolis

Matthew E. Kahn

Dire predictions about global warming make it hard to imagine how the human race will cope with the droughts, heat waves and advancing seas that climate change is expected to bring later this century. But economist Matthew Kahn has a message for prosperous urbanites in developed (and rapidly developing) nations who worry about the fate of their children and grandchildren in a greenhouse world: Don't.

In cities, where the world's population is increasingly concentrated, market forces will ensure that all but the poorest have little to fear, Kahn argues. As long as the market is allowed to set fair prices that reflect the environmental costs of energy and the scarcity of finite resources like water, he says, people and cities will adjust. Some cities may even find themselves better off, Kahn contends, as warmer winters transform today's snowbelt into the cool place to be. He even offers a list of the most climate-resilient U.S. cities.

These specifics make Kahn's book more vivid and accessible than a typical policy tome on global warming.

Perhaps many looming climate problems can be solved with a dose of the heady cocktail that is one part human ingenuity and one part profit motive. But Kahn's analysis gives short shrift to two aspects of climate change that make it especially daunting. First, waiting for markets to feel the effects of global warming before getting serious about limiting greenhouse gas emissions will guarantee that the disruption is extreme and long-lasting. Second, the world is finite. It may be true that wealthy nations can easily import food if agricultural patterns change, but only up to a point. As the recent global economic recession illustrates, when a crisis is bad enough, it hurts pretty much everywhere. — *Matt Crenson*

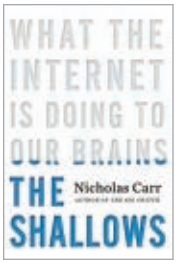
Basic Books, 2010, 288 p., $26.95.

The Shallows: What the Internet is Doing to Our Brains

Nicholas Carr

In 2008, science and technology writer Nicholas Carr asked in *The Atlantic* if Google is "making us stupid." His latest book is an effort to answer that question and, more broadly, to explore how the tools of the Internet age are altering the way people find and use information.

Carr spends much of the book exploring how technology has shaped human habits of information consumption. Written language, for instance, made the poet-historian's memory less crucial. With Gutenberg's printing press, reading became widespread and the human brain, ever plastic, adapted to new demands. Now, the shift to online information is causing further neural changes but, Carr argues, mostly to ill effect.



Carr maintains that the Internet encourages distraction and superficiality. The sheer volume of information overwhelms anyone's ability to absorb it. So instead of becoming absorbed, users browse from link to link to Twitter feed, gaining a broad but shallow appreciation of the available information. Carr cites psychology and neuroscience experiments to illustrate how vulnerable the human brain is to distraction and how such inattention can reduce comprehension and memory.

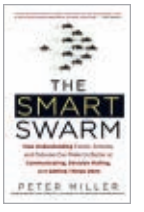
While Carr's social history of an information revolution is solid, his concerns about how the Internet may alter neural mechanics are based on data that are still sparse. His take on the problems of the plugged-in brain is sure to spur debate, though — both online and off. — *Rachel Zelkowitz*

W.W. Norton & Co., 2010, 276 p., $26.95.

Fixing the Sky: The Checkered History of Weather and Climate Control

James Rodger Fleming

Humans have long tried — and mostly failed — to engineer weather and climate, a historian of science shows. *Columbia Univ. Press, 2010, 344 p., $27.95.*



The Smart Swarm

Peter Miller

The behavior of animal swarms, schools and colonies holds lessons for technology and design. *Avery Press, 2010, 336 p., $20.*

Brilliant: The Evolution of Artificial Light

Jane Brox

The history of lighting is a microcosm of scientific and technological advances since the Stone Age. *Houghton Mifflin Harcourt, 2010, 368 p., $25.*

The Matchbox That Ate a Forty-Ton Truck

Marcus Chown

A cosmology writer puts basic physics principles in an everyday context. *Faber and Faber, 2010, 269 p., $25.*

101 Things Everyone Should Know About Math

Marc Zev, Kevin B. Segal and Nathan Levy

Simple questions and answers teach math concepts and problem-solving skills. For kids age 10 to 14. *Science, Naturally!, 2010, 208 p., $9.95.*

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Misunderstood males?

I grew up on a farm, and it was not uncommon for male horses, male goats and even male deer to let out a snort whenever anxiety surfaced in them — whether it be from a predator in the area, the removal of food from their eating area or the wandering off of a female that the male had his eyes on. Maybe the topi antelope in "Deceptive cads of the savanna" (*SN: 6/19/10, p. 14*) is the same. Maybe he is not trying to trick the female into thinking a lion is near, but simply expressing the anxiety that surfaces when a potential imminent loss is sensed — in this case copulation. I could be wrong, but that's how I always read it.

John M.R. Kuhn, Weston, Wis.

Lying requires a brain complex enough for abstract thinking. Very few species demonstrate this ability, and I find it hard to believe a grazing herd animal like the topi would. Without this capability, you're left with instinct and/or learning to explain this behavior. Maybe these males fear lions *and* lost love.

Gretchen Dean, Bloomington, Minn.

Cell phones and cancer risk

From "Cell phone–cancer study an enigma" (*SN: 6/19/10, p. 13*), it appears that the epidemiologists cited desperately want to show that cell phone use increases the risk of cancer. One statement deserves to be challenged: "None of today's established carcinogens, including tobacco, could have been firmly identified as increasing risk in the first 10 years or so since first exposure." Many of tobacco's physiological effects have been known for centuries. Were it not for some of these effects, it would not be smoked. Smoking leads to "smoker's cough," suppresses appetite and causes an almost immediate increase in heart rate. No epidemiological studies are necessary to establish that smoking affects living organisms in many different ways, some deleterious. It is biologically potent. In contrast, exposure to microwave radiation at levels sufficiently low to not result in a temperature increase has not been shown unambiguously to have biological effects.

Craig Bohren, Centre County, Pa.

Fat burn

My initial reaction to "Fat chance" (*SN: 7/3/10, p. 18*), about using the body's own brown fat to combat obesity, was hope and excitement. But upon further consideration, it seems to me there is a downside to finding ways to more quickly burn off energy from food. In a world with limited resources for producing food, it would not be an unalloyed good to find ways of making it easier to consume more.

Jim Nicholas, Ely, Minn.

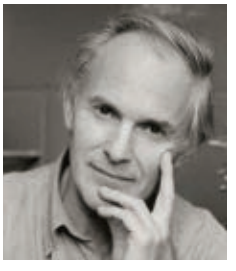
Send communications to: Editor, Science News, 1719 N Street, NW, Washington, D.C. 20036 or **editors@sciencenews.org**. Letters subject to editing.

Harold Kroto

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

Treat science right and it could help save the world

Harold Kroto, who shared the 1996 Nobel Prize in Chemistry for the discovery of buckminsterfullerene (the molecules commonly known as buckyballs), is a chemist at Florida State University in Tallahassee. His research interests extend from the microworld of nanoparticles to the chemistry of interstellar space. He also campaigns for a new vision of science education, emphasizing the responsibilities that scientists have for cooperating internationally to support efforts aimed at securing a sustainable future for the planet. He spoke on such matters recently at the Euroscience Open Forum 2010 conference in Turin, Italy. Science News *editor in chief Tom Siegfried reports excerpts from Kroto's talk.*



Saving the planet.... I don't know whether we can do it, but we need everybody in the world to recognize [that] this is our biggest problem.

My definition of science — and it's an arid term, and almost no one really understands it as far as I'm concerned: The most important aspect of science is that it's a philosophical construct, which man (and woman) has developed to determine what is true, might be true and can be true.

Once one [accepts] that, one puts science on a very interesting philosophical level, because truth must be universal and must not vary from country to country or planet to planet. Truth assumes that the experiment will always work the same way. That suggests that, basically, it won't work differently if you pray to the experiment....

Truth is an intellectual integrity issue. I want to stress that.... So for science education, this is an ethical issue. We should be teaching our children how to determine what is true. It depends on evidence. Without evidence, anything goes. And we must teach young people how to recognize the truth. And that's why there is a conflict between science and dogma, both political and religious. Texas is desecrating science textbooks, and thus the truth....

We have to weigh the evidence in the balance, and science therefore equals truth. John F. Kennedy said, "The great enemy of the truth is very often not the lie — deliberate, contrived and dishonest, but the myth — persistent, persuasive and unrealistic. Belief in myths allows the comfort of opinion without the discomfort of thought."...

I have a four-out-of-five rule for scientific method. Here it is: If you make an observation, develop a theory you think can explain it. Then design some further experiments to test the validity of that theory. If four observations out of five fit, the theory is almost, and I stress almost, certainly right. If only one out of five fits, the theory is almost, almost certainly wrong. We can never say it was wrong. But we can say it's almost certainly wrong. We must leave the way open for that element of doubt....

This is a moral issue. Let's get it straight. Science is about evidence and truth. And that's why we have to think about these things....

The issue we face today is sustainability. Saving the planet — it's a global citizenship project. We cannot do it by ourselves.... I don't know whether we can do it, but we need everybody in the world to recognize [that] this is our biggest problem. We've got to recognize science as the one community that is international. It doesn't matter what color you are, what nationality, language you speak. Scientific language is fundamental.... And that makes us different from every other culture. We're international, we're global....

I want to make sure that you understand what science and what the responsibility of the scientist is. If you're a scientist, you have a responsibility. We have created this world, this technology. We've done the science. And I think, and I personally believe, we should take some responsibility to ensure it is used for the benefit of mankind, and not to its detriment. If you're a physicist, we don't need any more atomic bombs. If you're a chemist, we don't need any improvements in napalm, and if you're an engineer, we don't need any more land mines. There are people who really feel strongly. Leon Lederman, [who was] head of [Fermilab] and got the Nobel Prize in physics, said, "So many years have passed and the human race is still saddled with enough nuclear weapons to destroy the planet. We must redouble our efforts to unify the science community against this huge stupidity."...

Scientists have enemies now out there who are trying to destroy science.... It's not just against evolution. It's about truth. It's much more fundamental.... It's about science, it's about your culture, it's about how children and adults should determine what is true. And therefore you have an enemy, the enemies who want to undermine the ability of young people and adults to find out what is actually true, on the basis of evidence. Don't underestimate that one....

Destroy the planet? It doesn't look good. I look at the evidence. Four out of five [indicators] suggest ... that we've got a problem. Not only that, our children have a problem, and our grandchildren almost certainly seem to have a problem. I'm not sure. But I said almost certainly. ■

NICHOLAS SINCLAIR

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