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MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ AUGUST 1, 2009

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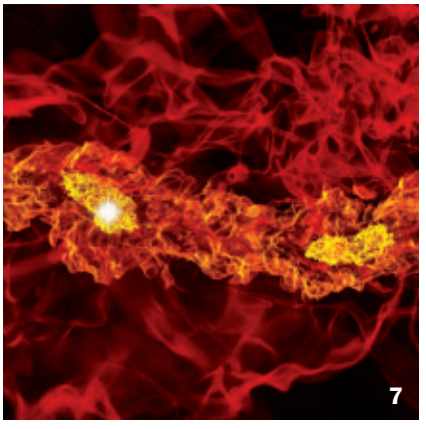

SECOND FROM TOP: ARPAT OZGUL; BOTTOM: ANDREW LEAKEY/UNIV. OF ILLINOIS

ScienceNews

In The News

Features

Departments

COVER Scientists hope to find ways to squeeze every last drop out of crops, such as this switchgrass, grown for biofuels. *Grass from Wintergreen Hill Farm. Photo by Cary Wolinsky*

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FROM THE EDITOR

It's not a joking matter: Science is complicated

Not so long ago, scientists studying schizophrenia had a hard time explaining the disease's genetic origins.

Numerous studies had identified genes that seemed to be linked to schizophrenia risk, but upon further review few of those links could be confirmed. Experts began to suspect that genes conferring a high risk of schizophrenia were too rare to be easily found, or that schizophrenia resulted from the combined effects of many common genetic variants, each alone adding risk so small as to evade detection.

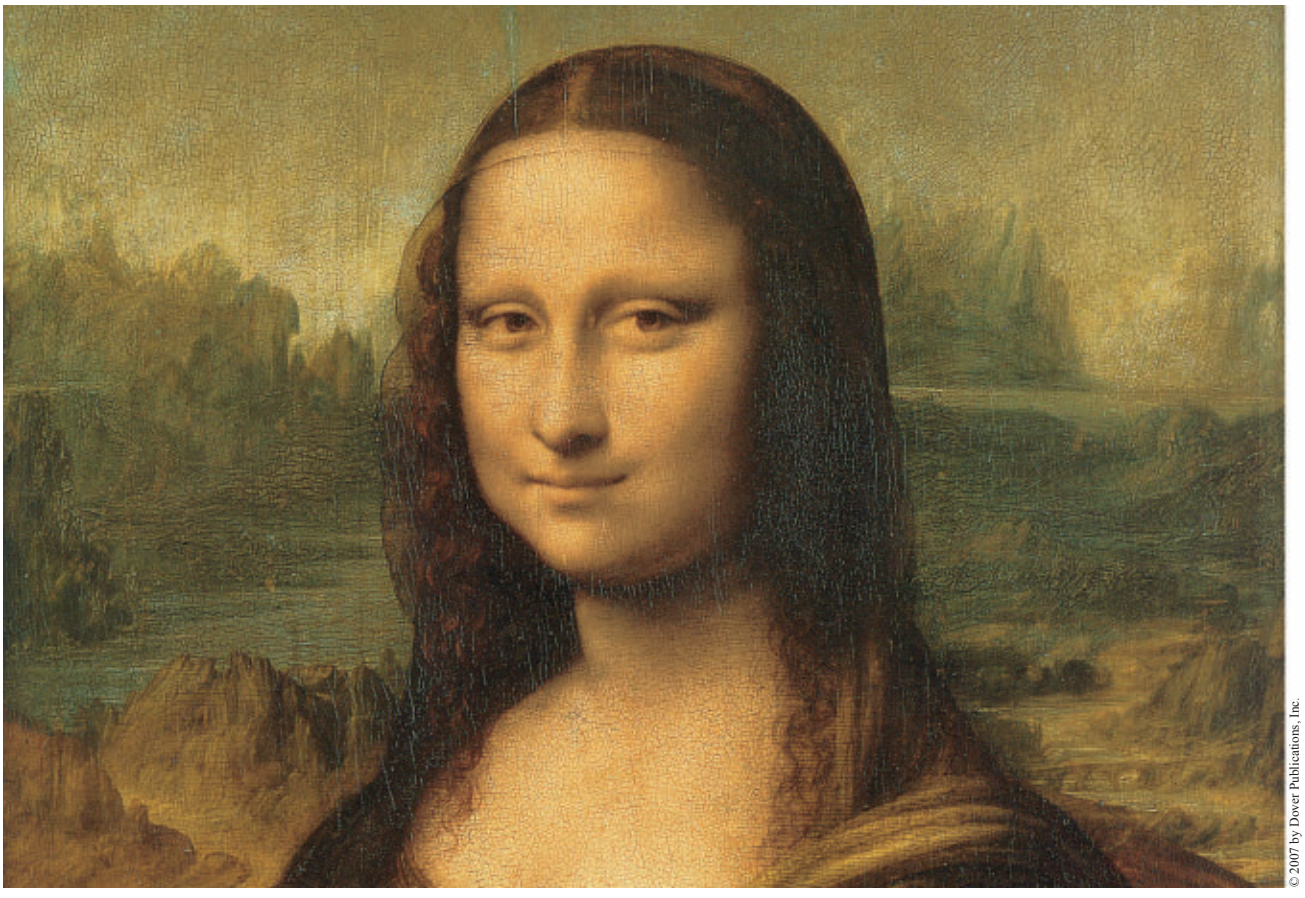
More recently, studies have shown that differences in the number of copies of certain genes also contribute to schizophrenia's likelihood. And the latest studies, described by Laura Sanders in this issue (Page 10), reveal that the number of common variants that raise the risk of the disease is surprisingly high, perhaps numbering in the thousands. These results elevate the complexity of schizophrenia's pathogenesis far beyond what most experts expected — and certainly beyond what everybody hoped.

In this and other cases, scientific progress does not always bring welcome news. But in addressing society's problems, whether medical, technological or monetary, appreciating the problem's complexity is essential. Underestimating your enemy's complexity renders victory much less likely. Success depends on first comprehending the complexity in order to better devise strategies to cope with it.

Such is certainly the case in efforts to find replacements for fossil fuels. As Rachel Ehrenberg reports (Page 24), the quest for liquid fuels from plants poses technical, logistic and economic challenges of enormous complexity. In analyzing what biofuel strategies are most likely to pay off (in terms of money, energy and environmental impact), it's not even clear what factors should be considered. Experiments underway along various fronts will be needed to sort out the strategies most likely to guarantee that the benefits of biofuels will exceed their costs.

All in all, the important thing in such endeavors is the realization that complexity lurks behind the seemingly obvious, and sophisticated science is necessary to uncover the unspoken assumptions that nurture self-defeating strategies. After all, you shouldn't even assume that everybody enjoys good-natured laughter in response to a funny situation, however commonsensical that might seem. See Page 18.

—Tom Siegfried, Editor in Chief



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Scientific Observations

"I think the problem we have in this country and maybe in many other parts of the world is that the public, especially in a democratic society, ... is not clued in to what science is, what science can do, what science cannot do and how important it is to educate people to have a voice in what their country is going to decide to do or not do."

PHYSICIST AND NOBEL LAUREATE LEON LEDERMAN, ON JUNE 2 AT "THE SCIENCE OF ANGELS AND DEMONS" LECTURE AT THE ILLINOIS INSTITUTE OF TECHNOLOGY IN CHICAGO

Science Past | FROM THE ISSUE OF AUGUST 1, 1959

RENAME DISCOMFORT INDEX — This summer you have a chance to "do something about," not the weather, but the combination of heat and humidity that often makes so many persons so uncomfortable. The Weather Bureau in June started experimentally ... publishing for the summer what it then called the "Discomfort Index." The immediate results were cries of outraged indignity from citizens who thought their particular home towns were being maligned when the Discomfort Index hit high numbers. So the Weather Bureau changed the name to "Temperature-Humidity Index." However, many ... find this a long and difficult-to-handle name. Therefore, the Weather Bureau is welcoming suggested new names....

Science Future

August 12–15
Scientists convene at the American Ornithologists' Union meeting in Philadelphia. Visit www.birdmeetings.org/aou2009

August 31
Proposals to digitize scientist Wernher von Braun's notes due to NASA. See www.nasa.gov/directorates/somd/home

September 12
The Smithsonian Institution hosts a symposium on Darwin in Washington, D.C. See www.mnh.si.edu/calendar.asp

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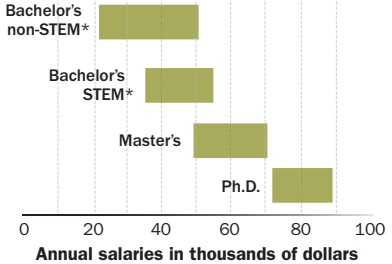
SCIENCE & SOCIETY
Mathematical analyses show something could be rotten with the state of Iranian election results. See "Statistical tests suggestive of fraud in Iran's election."

EARTH
When spring comes to a mountain hinges on more than just temperature, a new study shows. The distribution of dust and dirt on the peaks plays a role too. Read "Dirty snow may bring green burst to mountain peaks."

GENES & CELLS
No baggage fee applied, but commercial airline passengers could have carried the H1N1 virus around the world. See "H1N1 racks up frequent flier miles."

Science Stats | EDUCATION PAYOFF

Starting salaries for physics degree recipients in the private sector, classes of 2005 and 2006



**Jobs in science, technology, engineering and math (STEM)*

SOURCE: AMERICAN INSTITUTE OF PHYSICS STATISTICAL RESEARCH CENTER, INITIAL EMPLOYMENT SURVEY

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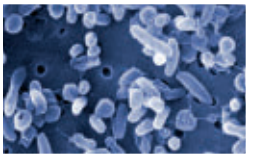
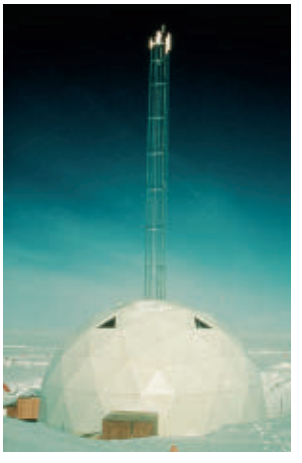


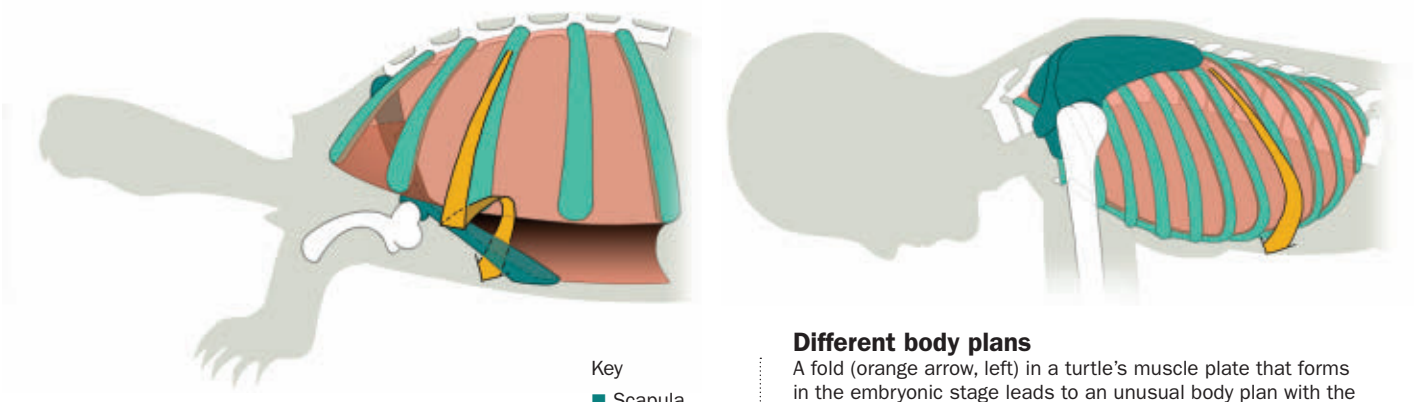
After at least 120,000 years in ice, tiny bacteria (near right) have emerged from dormancy and been declared a new species. *Herminiimonas glaciei* grow barely a tenth the size of *E. coli* and could have survived in the delicate veins and liquid films around ice crystals. Pennsylvania State University researchers discovered the species during a survey of organisms in kilometers-long ice cores (drill shown, far right) from a glacier in Greenland, the team reports in the June *International Journal of Systematic and Evolutionary Microbiology*.



CLOCKWISE FROM TOP LEFT: RUSSELL CONARD; MCKENZIE SKILES/SNOW OPTICS LABORATORY; MARK TWICKLER, UNIV. OF NEW HAMPSHIRE; ADAPTED FROM PENNSYLVANIA STATE UNIV.

“If the standard model were a movie, you wouldn’t get Robert De Niro to play the omega-b baryon.” — ANDREAS KRONFELD, PAGE 14

In the News



Different body plans
A fold (orange arrow, left) in a turtle’s muscle plate that forms in the embryonic stage leads to an unusual body plan with the scapulae, or shoulder blades, inside the ribs. The muscle plate in humans and other land-dwelling vertebrates doesn’t have the deep fold (orange arrow, right), and the scapulae sit outside the ribs.

SHIGERU KURATANI, H. NAGASHIMA

STORY ONE

A turtle’s shell isn’t so terribly bizarre after all

A critical fold may separate the reptile from its brethren

By Susan Milius

Turtles may be weird, but according to new research, they’re not that weird. Their funny arrangement of shell and shoulder is just the same old land-dweller vertebrate stuff — with a little fold.

Early on, a turtle embryo grows much like a chicken or mouse. But then the developing body wall makes a critical fold, and the usual body plan starts to become an unusual turtle, Hiroshi Nagashima of the RIKEN Center for Developmental Biology in Kobe, Japan, and his colleagues report in the July 10 *Science*.

Nothing else has a body plan like a turtle. Its ribs don’t grow inside its chest as a cage but instead fuse in the developing skin layer on its back to create one bony armored covering.

“It is not just that turtles ‘grew a shell,’ ” says paleontologist Ben Kear of La Trobe University in Melbourne, Australia. In the evolution of that shell, bones and muscles had to shift around relative to other reptiles, birds and mammals, and turtle shoulders ended up inside the rib cage. “In essence this means that the turtle skeleton is inside out,” he says.

Odd as they are, turtles clearly belong to the lineage of amniotes, which includes mammals, birds and reptiles. Turtles, which have existed for at least 200 million years, “have survived all kinds of stuff — we’re talking extinction of the dinosaurs and myriad climate changes,” Kear says. Yet there’s scant fossil evidence of turtles-in-the-making to explain how the shell-and-shoulder arrangement arose as turtles split off from birds and crocodiles.

Knowing how a basic amniote embryo ends up developing into something so radically different could shed light on turtle history, says paleontologist Michael Lee of the South Australian Museum at the University of Adelaide. “Some intermediate stages in this process might resemble real intermediate — fossil — stages in evolution,” he says.

To sort out how turtles develop, Nagashima and his colleagues worked with eggs of Chinese soft-shelled turtles (*Pelodiscus sinensis*) bought from farms. The researchers used tissue-specific stains as well as substances that detect activity of particular genes to figure out which bits of the tiny embryos were on their way to becoming the bones and muscles of the adult.

At each stage in development, the researchers compared their embryos with developing chickens and mice at equivalent stages.

Any features shared by all three embryos probably came from distant common ancestors of all amniotes, the researchers note.

In turtles, chickens and mice, the earliest stages of development looked much the same, the researchers say. Then the

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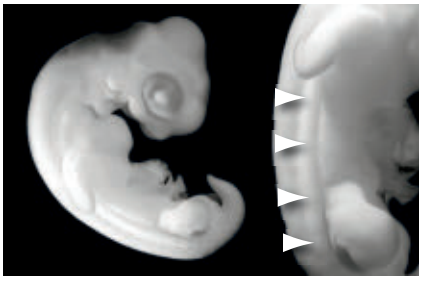
turtle embryos veered off on their own path. The developing muscle tissue that would lie along adult ribs in a standard amniote began to fold underneath itself in the turtle. This tissue tucked inward, bending up to lie below the developing ribs. On this kinked-under section, the shoulder blades, or scapulae, formed.

If this fold could be straightened out, the scapulae would lie outside the rib cage, as they do in chickens, mice and people. For turtles then, "the position of the scapula is not a novelty," Nagashima says. Essentially, "turtles have the same body plan as other amniotes."

That critical fold in the tissue maps out a line that becomes an important embryological feature of turtle embryos called the carapacial ridge. Earlier research has shown that this ridge drives the development of the bony back of the animal. The fold also allows developing muscles to form connections in ways that they don't in the mouse and the chicken.

The researchers also note that the turtle ribs stop short in comparison with mice and chickens. Turtle ribs grow out only along the sides of what will become the backbone instead of curving into the body wall to form the whole rib cage. Those short turtle ribs mingle with the skin tissue, creating the fused bony shell on the turtle's back.

In a new study, researchers tracked developing embryos from Chinese soft-shelled turtles (grown turtle, left) and found that, compared with chickens, ribs in turtles are shorter. The ribs stop at a ridge of tissue (arrows in embryo, below) and fuse to form the shell.



"Very, very sophisticated work," says reptile paleontologist Olivier Rieppel of the Field Museum in Chicago in describing the extensive detective work required to trace all the tissues and muscles.

He has studied the oldest known fossil of an ancestral turtle, and he says the new interpretation of turtle embryology may fit well with the fossil record.

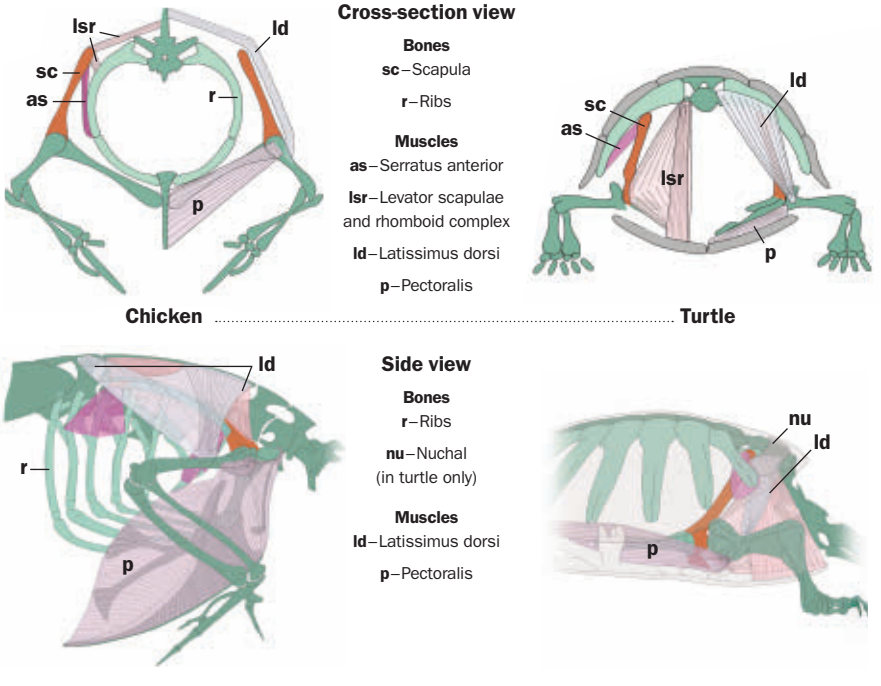
Last year he and colleagues described *Odontochelys semitestacea* from a fossil collected in 220-million-year-old marine sediments in southwestern China. The turtle had a standard armored underside but not a full shell on its back. Its ribs widened, but its shoulder blades still lay forward of the ribs instead of inside them.

Nagashima speculates that the embryonic fold was evolving a bit at a time and maybe hadn't reached as far around the body in this ancestral turtle as it does today. Clever suggestion, Rieppel says.

To understand turtle history, paleontologists really need more fossils, says Robert Reisz of the University of Toronto's Mississauga campus in Canada. In the meantime, the new Japanese paper "clarifies a unique evolutionary event, one that gave rise to a really neat group of animals, our beloved turtles." ■

Back Story | TURTLES' ALTERNATIVE ANATOMY

Growing a shell of fused ribs means that skeletons and muscles are connected in different ways in turtle bodies than in bird, mammal and other reptile bodies. Here the turtle is compared with a chicken.



TURTLE PHOTO: FRANK GREENAWAY/GETTY IMAGES; ALL OTHERS: SHIGERU KURATANI, H. NAGASHIMA

Atom & Cosmos

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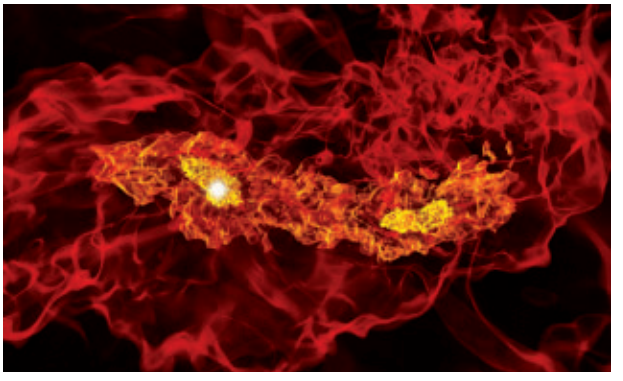
First stars not all so lonely

Simulations suggest cosmic partnerships

By Ron Cowen



A simulation of a star-forming region about 200 million years after the Big Bang shows two embryonic stars (yellow) separated by 800 times the Earth-sun distance.

It's always nice to have a companion. And in the lonely, dark expanse of the early universe, even some of the first stars had soul mates, new simulations reveal.

Previous work had indicated that the first stars were extremely massive — at least 100 times as heavy as the sun — but were loners (*SN: 6/8/2002, p. 362*).

Now, more detailed modeling, including a careful consideration of how atomic and molecular hydrogen interact at low densities, reveals that at least 5 percent and perhaps as many as half of these heavyweights were gravitationally bound to similar-mass companions, says Tom Abel of Stanford University. He and his colleagues, Matthew Turk of Stanford and Brian O'Shea of Michigan State University in East Lansing, report their findings online July 9 in *Science*.

Pairs of massive stars are intriguing, notes Abel, because each star will probably collapse into a black hole. The eventual coalescence of the adjacent black holes would be a key source of gravitational waves, ripples in spacetime predicted by general relativity but never directly detected.

A second star's presence could also add to its partner's spin, and the resulting more rapid rotation would enhance the production of gamma-ray bursts, flashes of high-energy light that have long-lasting afterglows and provide a window on the early universe.

Only one in five of the team's simulations, which model star formation about 200 million years after the Big Bang, produced pairs. And the team can only provide a rough estimate of the percentage of partnered stars.

"The simulations make good sense," says theorist Volker Bromm of the University of Texas at Austin. Bromm says that his own team's simulations track the evolution of pairs further, long enough to see the stars mature, and suggest that the fledgling stars remain close partners. His team plans to post a paper online describing the results.

Study sizes up extra dimensions

Small, old black hole places new limit on hidden spaces

By Ron Cowen

The size of any hidden extra dimension beyond the familiar three must be less than 3 micrometers, a new analysis based on an old black hole has found.

That new size limit is less than half that of previous such limits, Oleg Gnedin of the University of Michigan in Ann Arbor and his colleagues report in a study posted online June 30 at arXiv.org.

Dimensions beyond the common three of space and one of time might explain why the strong nuclear force is roughly 10^{40} times stronger than gravity. If the gravitational force leaks out along an extra dimension, as some versions of string theory suggest, it would be weaker in the observable 3-D space.

In basic string theory, which describes subatomic particles as tiny vibrating loops or strands of energy, extra dimensions are too small to be directly detected. But some versions of string theory allow larger extra dimensions, detectable by measuring the force of gravity at small distances or from the results of atom-smasher experiments or astrophysical observations (*SN: 2/19/2000, p. 122*).

"The existence of large extra dimensions seems like an attractive idea in theoretical physics, but they have not revealed themselves in any experiment so far," Gnedin notes.

Enter small, old black holes. All black holes radiate energy, known as Hawking radiation. As it radiates, the black hole shrinks, and the shrinking proceeds more rapidly as the black hole gets smaller. In some models, extra dimensions dramatically speed up that rate, hastening the black hole's demise, notes theorist Igor Klebanov of Princeton University. The larger the extra dimension, the faster the black hole evaporates.

Two years ago, astronomers reported evidence for a black hole, only about 10 times as heavy as the sun, in the galaxy NGC 4472, some 50 million light-years from Earth. The cluster containing the black hole is about 10 billion years old, researchers say. The very existence of a black hole this small and old suggests that any extra dimension cannot exceed 3 micrometers, the team calculates.

But Paul Steinhardt of Princeton University cautions that the details of the new limit depend on exactly which model for extra dimensions scientists rely on.

Body & Brain

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

Antibody may stop leukemia early

Molecular approach shows promise against blood cancer

By Nathan Seppa

A new drug can halt budding leukemia in mice by binding to a key protein on the surface of blood cells predisposed to becoming cancerous, researchers report in the July 2 *Cell Stem Cell*.

This and other studies have paved the way for preliminary testing of a version of the drug for people with acute myeloid leukemia, a particularly lethal form of blood cancer.

The promising drug is an antibody that blocks a receptor called CD123 found on the surface of stem cells at risk of developing into leukemia cells. Normal blood stem cells serve as the templates for blood cells and various immune cells, but aberrant versions may fail to develop properly and result in leukemia.

Earlier studies have shown that leukemia stem cells are loaded with CD123, whereas normal blood stem cells have little or none of it, says study coauthor John E. Dick, a molecular biologist at the University of Toronto.

CD123 serves as a receptor for a signaling protein called interleukin-3. When interleukin-3 binds to CD123 on an aberrant cell, the link-up tilts the cell's path toward proliferation, ultimately causing acute myeloid leukemia.

The promising drug is an antibody that blocks a receptor called CD123.

To intervene in this cycle, Australian researchers working with a mouse model of leukemia devised an antibody, called 7G3. Dick teamed with the Australians to analyze the antibody's effectiveness in lab dishes of normal and aberrant blood stem cells obtained from people with leukemia. These tests showed that the antibody specifically targeted the leukemia stem cells, blocking interleukin-3 binding and preventing replication. The antibody had little effect on normal blood stem cells.

Tests on mice implanted with human leukemia stem cells showed that antibody-treated animals survived on average for 24 weeks, compared with 12 weeks for mice not getting the drug. Treated mice also showed less evidence of leukemia stem cells migrating to bone marrow, necessary for the development of full-blown leukemia. In general, the authors note, the antibody worked best when given early in the disease.

These findings, along with previous work, "suggest that the targeting of CD123 is a strategy clinically relevant and with a potentially acceptable safety profile," says Ugo Testa of the Italian National Institute of Health in Rome.

The Australian team has started treating leukemia patients with a synthetic version of the drug that caused no ill effects when tested in monkeys.

New drug offers relief for arthritis

Anti-inflammatory injections work when other meds don't

By Nathan Seppa

Rheumatoid arthritis patients who have failed to benefit from other medications may get relief from a new drug, according to a study released online June 29 in *The Lancet*.

The findings may clear the way for European approval of the anti-inflammatory drug, called golimumab, which was approved in the United States in April.

Rheumatoid arthritis results from inflammation of the joints, causing swelling and tenderness. Golimumab, marketed under the brand name Simponi, inhibits an immune protein called TNF-alpha that contributes to this runaway inflammation. While three other TNF-alpha inhibitors are already in use for rheumatoid arthritis, many people stop taking these drugs because of side effects or a lack of effectiveness.

In the new study, physician Josef Smolen of the University of Vienna and an international research team identified 461 patients, average age 55, who stopped taking one or more other TNF-alpha inhibitors for any of a number of reasons. Patients had a median number of 26 tender joints and 14 swollen joints when they started the trial.

Patients received an injection every four weeks. Two-thirds received golimumab, and one-third got a placebo. Most patients also continued to take other anti-inflammatory drugs, but not other TNF-alpha inhibitors.

After 14 weeks, researchers determined how many patients had improved by at least 20 percent since the start of the study, using standard scoring of symptoms. The team found that 37 percent of the patients getting golimumab but only 18 percent of those receiving the placebo hit that improvement mark.

The drug showed similar benefits when researchers looked only at patients who stopped taking other TNF-alpha inhibitors because they weren't working.

The team also found that, on average, those receiving golimumab had 14 tender joints after 14 weeks, compared with 20 in those getting placebo injections.

"Switching patients from one TNF-alpha inhibitor to golimumab is effective and generally well tolerated," the authors conclude.

The drug offers patients another option, says Yusuf Yazici, a rheumatologist at the New York University Hospital for Joint Diseases. "We now have four valid anti-TNF-alpha drugs," he says.

"When you try to describe swearing in moral terms … it keeps you from getting at the deeper evolutionary links." —TIMOTHY JAY

Monkeys show healthier aging on low-cal diet

Study suggests restricting food intake may lengthen life

By Tina Hesman Saey

Canto (left), 27, and Owen, 29, are among the oldest surviving rhesus monkeys in an ongoing study of calorie restriction. Monkeys in Canto's group eat 30 percent fewer calories than those in Owen's group and have fewer age-related diseases.

People who believed calorie restriction wouldn't extend life in primates might now have to declare themselves monkey's uncles.

A 20-year study finds that rhesus monkeys fed a nutritious but low-calorie diet have fewer age-related diseases than counterparts on a normal diet, researchers report July 10 in *Science*. Also, MRIs reveal less shrinkage with age in areas important for decision-making and controlling movement in the brains of calorie-restricted animals, report Ricki Colman and Richard Weindruch of the Wisconsin National Primate Research Center at the University of Wisconsin–Madison and colleagues.

The findings may have ramifications for fighting aging and disease in humans, says Luigi Fontana of Washington University in St. Louis and the Italian National Health Service in Rome. "I'm confident that everything that happens in [nonhuman] primates will happen in humans," he says.

Calorie restriction has already been shown to extend lifespan in fruit flies, yeast, worms, mice and dogs.

The primate study began in 1989 with 30 adult male monkeys. In 1994, 30 female and 16 more male monkeys were added. Over the course of the study, monkeys on the full-calorie diet were three times more likely to die from an age-related disease than monkeys that ate 30 percent fewer calories, the researchers found.

Since the study began, 21 of 38 control monkeys and 14 of 38 calorie-restricted monkeys have died. Of the control monkeys, 14 died of age-related causes, such as cancer, heart disease or diabetes. In the calorie-restricted group, only five died from aging-associated diseases, and none have developed symptoms of diabetes.

"We were frankly blown away by these findings," Weindruch says.

The maximal lifespan of rhesus monkeys is about 40 years, so researchers won't know for another decade or two if — or for how long — calorie restriction can prolong life in primates.

'%&*#$!' makes you feel better

New study finds swearing like a sailor may alleviate pain

By Laura Sanders

Although the news probably won't stop parents from washing kids' mouths out with soap, it turns out that cussing a blue streak may be a good thing. Four-letter words may help alleviate pain, suggests a study in the August 5 *NeuroReport*.

"Swear words are unique," says psychologist Timothy Jay of Massachusetts College of Liberal Arts in North Adams. "They're really the link between the language system and the emotional system."

Inspiration for the study came to psychologist Richard Stephens as he listened to his wife let loose with some unsavory language during the throes of labor. He and colleagues at Keele University in England wanted to see whether uttering emotion-laden choice words could change the amount of pain people feel.

Undergraduate students immersed one hand in cold water (about 5° Celsius) for as long as they could stand it, up to five minutes, while repeating either a swear word or an innocuous word. When people had a swear word for their mantra (popular choices: the s-word, f-word, two b-words and a c-word), they were able to keep a hand in the chilly water longer. What's more, after the ordeal, people who swore reported less pain.

Swearing also increased heart rate. Researchers suspect the increase might signal the beginning of a fight-or-flight response, which may allow the body to tolerate or ignore pain.

Jay says the study goes beyond whether swearing should be frowned upon in polite society: "When you try to describe swearing in moral terms — is it good or bad — it keeps you from getting at the deeper evolutionary links."

Genes & Cells

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New studies link schizophrenia risk to thousands of common variants

Specific chromosome regions may play role in the disease

By Laura Sanders

Large collections of common genetic variants, rather than just the harmful actions of a few key mutations, probably predispose people to schizophrenia, three large genetic studies suggest.

The studies, all published online July 1 in *Nature*, sifted through genetic data from patients with schizophrenia and people without the disease looking for spelling differences in the sequence of DNA "letters" making up the genome. The studies turned up specific chromosome regions that probably play a role in the disease. Understanding genetic factors, estimated to account for 80 percent of the risk of getting schizophrenia, may ultimately lead to better treatments.

"This is a pretty major breakthrough for us," said Michael O'Donovan of Cardiff University's School of Medicine in Wales at a July 1 press briefing. O'Donovan, who coauthored one of the studies as part of the International Schizophrenia Consortium, says a person with schizophrenia probably has hundreds or thousands of risk-increasing variants.

Using a method called genome-wide association, each of the three studies compared DNA samples from several thousand people diagnosed with schizophrenia with samples from thousands of others, some healthy and some with other diseases. Association studies are designed to find single letter differences, called SNPs, at many points along the DNA. Variants popping up more frequently in the schizophrenia patients' DNA are presumed to be markers of regions of the genome that contribute to the disease.

Many thousands of common DNA variants (those found in about 5 percent of the total population) turned up more often in people with schizophrenia, the studies found. "This is the first empirical DNA-based evidence" for many small genetic effects adding up to schizophrenia, says Pamela Sklar of Massachusetts General Hospital and Harvard University, who coauthored the consortium study.

On their own, each variant identified in the new studies raises the risk of schizophrenia just slightly — from 1 percent (the risk in the general population) to, in some cases, around 1.2 percent. Collectively, common variants may account for about a third of the genetic risk, Sklar says. Other factors include variations in the number of copies of certain genes and rare but high-risk variants of specific DNA letters.

Researchers will need many more DNA samples to identify all the genetic variants that heighten risk, Sklar says.

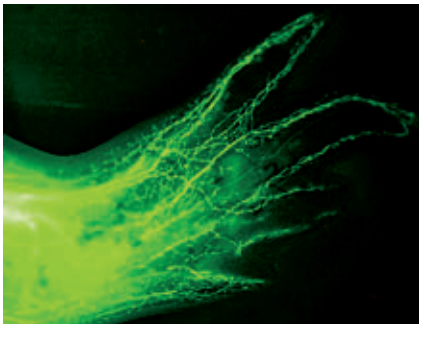
Although few of the variants could be identified conclusively by these studies, some variants were found in stretches of chromosomes previously linked to schizophrenia. Such regions occurred near genes involved in the formation of brain cell connections and genes involved in controlling the activity of other genes.

"The interesting thing about taking these together is that we start to identify pathways involved in the disease," David Collier of King's College London, a coauthor of the second paper, said in the briefing. Such pathways could point to potential therapeutic interventions.

DNA variations in a region of chromosome 6 called the major histocompatibility complex were also found in the schizophrenia patients' DNA in all three studies. This region contains genes that make proteins important for immune system function. Earlier studies have suggested a link between disruptions in the immune system and a heightened risk of schizophrenia.

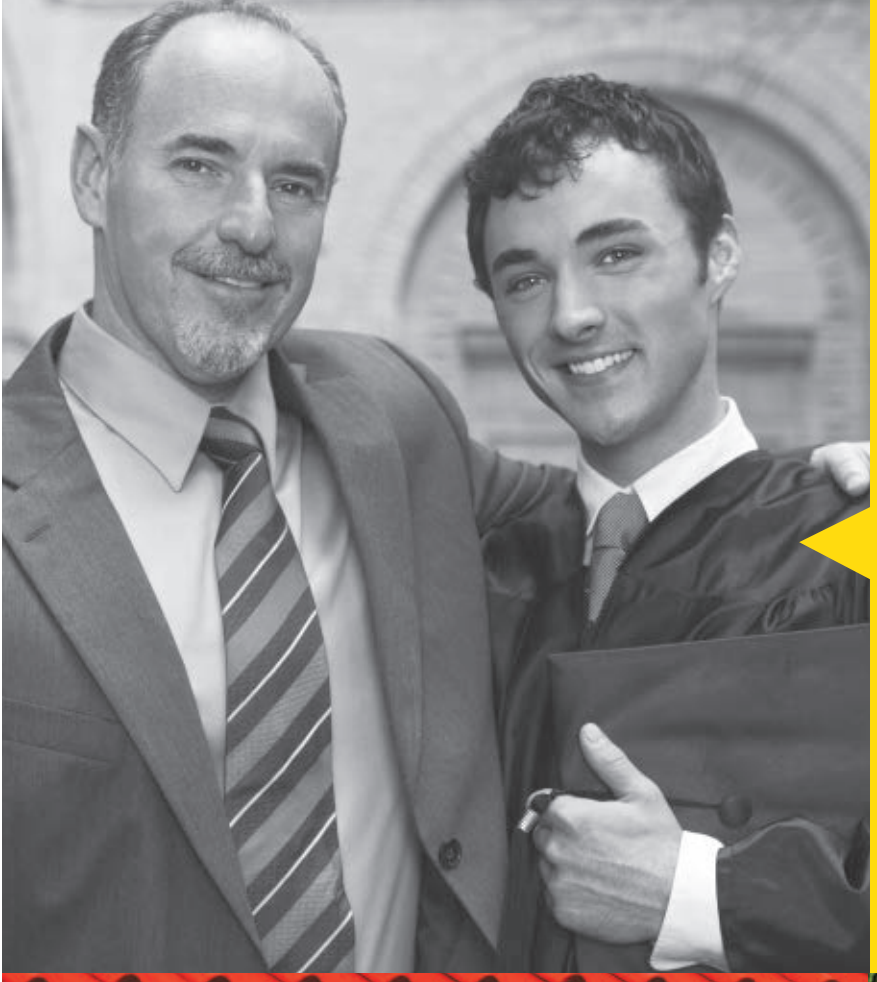
"It's extremely provocative to have an association there," says Pablo Gejman, a psychiatric geneticist at NorthShore University HealthSystem Research Institute in Evanston, Ill., and coauthor of the third study. "This is the start. This is not the last chapter."

Limb doesn't regrow from scratch



DUNJA KNAPP, E. TANAKA

Given a chance to regrow a limb, salamanders don't change a thing, a study in the July 2 *Nature* finds. Scientists had thought that in axolotls, a type of salamander, some stem cells at amputation sites became pluripotent, giving rise to all new tissues in a generated limb. Now Elly Tanaka of the Dresden University of Technology in Germany and colleagues show that cells at the wound site retain their identity and replicate into the same cell types in the new limb. Scientists used green fluorescent protein to track the origins of the new growth in a regenerated axolotl leg (shown). Schwann cells in the new limb arose from Schwann cells in the original tissue. "Definitely it's putting the conventional wisdom upside-down," says Alejandro Sánchez Alvarado, a Howard Hughes Medical Institute investigator at the University of Utah School of Medicine in Salt Lake City. This gives scientists hope that human cells remaining at an amputation site could someday be coaxed into generating a new limb, Tanaka says. —*Tina Hesman Saey*



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Life

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Soay sheep have lived as isolated populations on the islands of St. Kilda archipelago for thousands of years.

Climate change offsets evolution to shrink the wild sheep of St. Kilda

More lambs survive milder winters, upping food competition

By Susan Milius

Climate change now hits home for tongue twister fans. Shorter, sweeter winters shrink sheep, scientists say (slowly).

Female wild Soay sheep on the remote North Atlantic island of Hirta in the St. Kilda archipelago have shrunk by about 5 percent during the past two decades, says Tim Coulson of Imperial College London's campus in Berkshire. To see what's driving that change — a weight loss averaging 81 grams per year — Coulson and his colleagues applied a new analytical approach to a mountain of data. It turns out that evolutionary forces favor the opposite trend, toward bigger sheep. But environmental changes have softened winters, overwhelming those evolutionary effects, the team reports online July 2 in *Science*.

For climate change, "the effects people tend to focus on are the ecological ones," Coulson says. Studies have documented creatures shifting their ranges or changing the timing of migrations or blooming. "We're showing that the effects extend beyond the ecology, down to individual attributes," Coulson says.

The results show that influences on size are complex, says Kaustuv Roy of the University of California, San Diego. "We urgently need more case studies like this to really make sense of how populations and species will respond to ongoing warming," he says.

Thanks to detailed monitoring that began on Hirta in 1986, the team could figure out why females in this population are shrinking. Soay sheep, with brown coats and curling rams' horns, resemble early forms of domesticated sheep and have roamed for several thousand years on the archipelago, "a group of godforsaken rocks halfway to Iceland," Coulson says.

To parse out what governs body size in such a harsh climate, Coulson and his colleagues started with basic equations that population biologists use to describe how traits change over time. The team combined and refined these equations to create a type of bookkeeper's ledger that describes all the factors that in theory could cause a trait to vary. Plugging in female sheep data, the researchers found conflicting forces at work.

The evolutionary force of natural selection favored bigger body sizes, the researchers concluded. Size is partly inherited, and larger youngsters survived better than smaller, weaker ones because sheep need to draw on fat reserves during the winters.

A quirky effect of milder winters, however, drove body size toward the diminutive. Over the past 25 years, spring has shifted two to three weeks earlier in Northern Europe. In years with shorter winters, more of the small, weak lambs survived. With more sheep competing for food in spring, growth rates slowed among the surviving youngsters. Environmental factors linked to less-violent winters were the most important determinant of body size and overcame the evolutionary effect, the researchers say.

Biologists have been trying to distinguish genetic from environmental effects for decades, often by comparing the specific forms, or phenotypes, of individuals of the same species at different altitudes, says evolutionary geneticist Mark Rausher of Duke University in Durham, N.C. "What's nice about this new study is that it may be the first that convincingly shows that a change in phenotype over time is driven by the direct action of the environment on phenotype," he says.

Data reveal that environmental factors are to blame for the shrinking of female Soay sheep over the past two decades.

BOTH: ARPAT OZGUL

88 Percent of change in Soay sheep size attributed to environmental factors

Enemy hornets suffocate within honeybees' ball

Heat may boost vulnerability to carbon dioxide increase

By Rachel Ehrenberg

Stingers are lousy weapons against the exoskeleton of an attacking hornet. But by forming a ball (above), bees can kill a hornet with heat and with a spike in CO_2.

Call it death by a thousand breaths. When hundreds of honeybees envelop a giant, predatory hornet in a ball, the bees aren't just putting on the heat, as researchers had thought. Carbon dioxide levels spike along with temperature, fingering suffocation as the hornet's cause of death, scientists report in an upcoming *Naturwissenschaften*.

Bees inside the ball can apparently cope with the smothering heat and low oxygen levels, but the high temperature appears to make giant hornets, *Vespa mandarinia japonica*, less tolerant of cranked-up carbon dioxide levels. The concentration of CO_2 in the bee ball–enclosed air increases to about 3.6 percent after the ball forms, dropping sharply to lower levels five minutes later, report Michio Sugahara and Fumio Sakamoto, both of Kyoto Gakuen University in Japan.

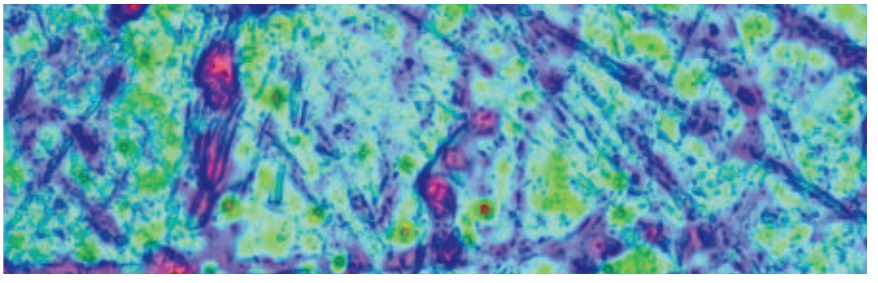
The researchers taped anesthetized giant hornets to gas detectors and thermometer probes to measure CO_2 concentrations and temperatures inside bee balls. When the probes touched open bee nests, the bees formed balls around the hornets. All 24 test hornets died within 10 minutes of bee ball formation, the team reports. Hornets bore no sign of stings, pointing to smothering as the cause of death.

The spike in CO_2 might be just a metabolic by-product of the frenetic activity of the bees. But, says Stan Schneider of the University of North Carolina at Charlotte, bees might regulate this "panting," perhaps in response to odor or behavioral cues from the giant hornets. "The specificity of the behavior suggests a very long coevolution in this predator-prey relationship," Schneider says.

Although ball forming is unusual among bee species, coordinated defensive behavior is not, says entomologist P. Kirk Visscher of the University of California, Riverside. Giant honeybees form rippling waves en masse, startling predators (*SN: 10/11/08, p. 10*). There are even bees that mount a collective attack by yanking individual hairs on the enemy's body. "It's not like being stung by a swarm, but it is still pretty annoying," Visscher says. ■

A grazing diet for duck-billed dinos

Duck-billed dinosaurs may have been the sheep of their ecosystems. Patterns of tiny scratches (shown) in the fossilized teeth of *Edmontosaurus*, a type of hadrosaur, suggest the dinos had more complex jaw movements than previously thought and may have eaten grasslike plants, researchers report online June 29 in the *Proceedings of the National Academy of Sciences*. Dinosaur jaws were simple hinges that allowed biting but didn't allow the side-to-side motions that mammals use to grind food, so it was unknown how hadrosaurs, the dominant plant-eating vertebrates of the Late Cretaceous, chewed plant material. Looking at the direction of the most dominant scratches, study coauthor Mark Purnell of the University of Leicester in England and his colleagues conclude that *Edmontosaurus* probably had hinges in its upper jaw, allowing the top teeth to flare out as the mouth closed. The upper teeth would have scraped against the bottom ones, grinding food and creating the micrometer-sized scratches. The absence of pits and chips on the teeth suggests that *Edmontosaurus* may have eaten grasses rather than tree parts, questioning accepted ideas about hadrosaurs' role in the ecosystem, the researchers say. —*Jenny Lauren Lee*



FROM TOP: M. SUGAHARA, F. SAKAMOTO; M. PURNELL/UNIV. OF LEICESTER

Matter & Energy

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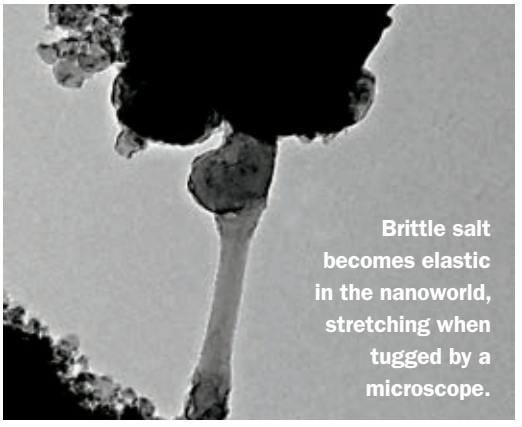
Salt turns to taffy at the nanoscale

Find suggests new technique for making miniature wires

By Rachel Ehrenberg

Inflexible old salt becomes a softy in the nanoworld, stretching like taffy to more than twice its length, researchers report in the June 10 *Nano Letters*. The findings may lead to new approaches for making nanowires that could end up in solar cells or electronic circuits. The work also suggests that these ultra-tiny wires may already exist in sea spray and large underground salt deposits.

Metals such as gold or lead, in which bonding angles are loosey-goosey, can stretch out at temperatures well below their melting points. But scientists don't expect this superplasticity in a rigid, crystalline material like sodium chloride, says study coauthor Nathan Moore of Sandia National Laboratories in Albuquerque.



Brittle salt becomes elastic in the nanoworld, stretching when tugged by a microscope.

This unusual behavior highlights that different forces rule in the nanoworld, says Krzysztof Kempa of Boston College. "Forget about gravity," he says. At this scale, surface tension and electrostatic forces are much more important.

Moore and colleagues guided a microscope that detects various forces toward a chunk of salt. When the microscope's diamond tip was far away, there was no measured force, but within about seven nanometers, a strong attraction developed between the tip and the salt. The salt then stretched out to glom on to the tip.

Using an electron microscope to see what was happening, the researchers observed that "nanowires" had formed.

The initial attraction between the tip and salt might be due to electrostatic forces, the researchers speculate. Several mechanisms might lead to the elasticity, including the excessive role of surface tension in the nanoworld. (The same tension allows a water strider to skim the surface of a pond in the macroworld.)

The surface tension is so strong that as the microscope pulls away from the salt, the salt stretches, Kempa says. "The inside has no choice but to rearrange the atoms, rather than break," he says.

Mass mismatch leads to mystery

Omega-b-minus is detected again, but it's lighter this time

By Jenny Lauren Lee

A heavy, strange cousin of the proton has been seen a second time, but it seems to have lost a little weight.

Omega-b-minus is a three-quark particle related to protons and neutrons. It has been observed at CDF, a detector at the Fermi National Accelerator Laboratory in Batavia, Ill., scientists report online May 19 at arXiv.org. But CDF's measurement of the particle's mass is significantly lower than a previous measurement, leaving researchers wondering what caused the discrepancy.

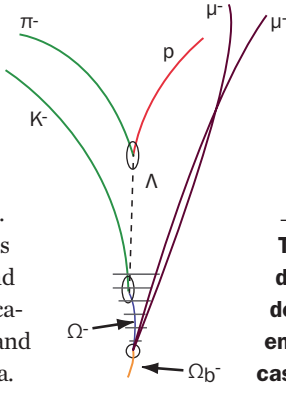
"One or both of the measurements are missing the mark," says CDF physicist Pat Lukens, a coauthor of the paper.

DZero, CDF's sister detector, had observed the omega-b-minus in fall 2008 using the same accelerator, the Tevatron, at Fermilab (*SN: 9/27/08, p. 9*). Although CDF's recent mass measurement of 6.054 billion electronvolts agrees better with the expected mass for an omega-b-minus particle than DZero's measurement of 6.165 billion electronvolts, the mismatch in the results is disconcerting, the researchers say.

"We don't have an explanation," says Darien Wood of Northeastern University in Boston, cospokesman for DZero. "We checked for obvious errors, and we haven't found any." Such discrepancies occasionally come up, he says, and are resolved with more data.

The standard model of particle physics predicts the existence and mass of this particle, which is a baryon, like protons and neutrons, and is made up of two strange quarks and a bottom quark.

The elusive particle is rarely seen but does play a supporting role in a grander enterprise, says Fermilab's Andreas Kronfeld. "If the standard model were a movie, you wouldn't get Robert De Niro to play the omega-b baryon," Kronfeld says. But understanding the properties of such particles helps scientists answer larger questions, such as why the universe is made mostly of matter instead of antimatter.



The omega-b-minus baryon decays too quickly to be detected directly, but its presence is signaled by a telltale cascade of particles.

FROM TOP: N. MOORE *ET AL.*/*NANO LETTERS*; CDF COLLABORATION

Earth

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Warming in central Pacific Ocean may offer better cyclone predictor

Find suggests shifts in activity are more reliable than El Niño

By Sid Perkins

Warmer than normal sea-surface temperatures in the central Pacific lead to stronger, more frequent tropical storms and hurricanes in the North Atlantic, a new analysis suggests. Unlike the more familiar El Niño, or warming in the equatorial region of the eastern and central Pacific, patterns in central Pacific warming alone are more predictable and may offer forecasters a more accurate method of anticipating hurricane activity during the upcoming year.

The sea-surface warming characteristic of El Niño typically stretches along the equator from the coast of South America to the international date line, with the largest temperature anomalies in the eastern Pacific. During El Niño episodes, the number of tropical storms and hurricanes—both called cyclones—is lower than average across the North Atlantic, says Peter J. Webster of Georgia Institute of Technology in Atlanta. But when the equatorial sea-surface warming is concentrated mostly around the international date line, hurricane activity is much higher than normal, Webster and his colleagues report in the July 3 *Science*.

"This is a pattern that we [scientists] hadn't really recognized before," comments Chris Landsea of the National Oceanic and Atmospheric Administration's hurricane research division in Miami.

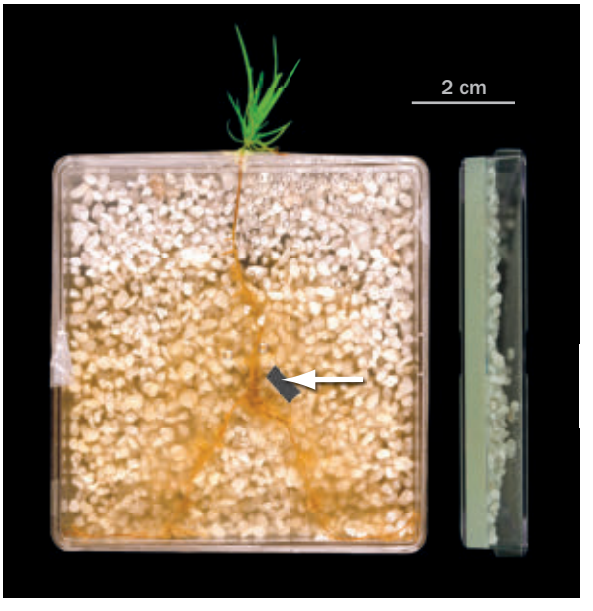
Webster and his colleagues analyzed patterns in North Atlantic cyclone activity from 1950 through 2006 during August, September and October, the height of hurricane season. As many previous studies had noted, the number and strength of tropical cyclones were markedly lower in El Niño years than during La Niña episodes, when sea-surface temperatures in the eastern and central Pacific are substantially cooler than normal. Unlike previous research, says Webster, the new study reveals that when sea-surface warming is confined to the central Pacific, hurricane activity is higher, particularly in the Caribbean, the Gulf of Mexico and along the eastern coast of the United States.

Models suggest that high-altitude wind shear over the North Atlantic is stronger than normal during El Niño events, disrupting the formation and strengthening of tropical storms there, Webster notes. During La Niña years, wind shear is low, and storms more readily form and gain strength. When sea-surface warming is confined to the central Pacific, wind shear in the North Atlantic region is about average but not large enough to totally disrupt cyclone formation.

Identifying the new central Pacific warming pattern is important because the transition between El Niño warming and La Niña cooling isn't always predictable, says Webster. Sometimes, just when it looks like a shift will occur from warm to cool, for example, temperatures will swing back to warm again, thwarting forecasters' attempts to predict cyclone activity for the upcoming season. But shifts in central Pacific warming seem to follow a more predictable path, the new analysis suggests.

Erosion, on the down low

Scientists have for the first time observed how the tiny fungi that live on plant roots physically erode rocks and set the stage for chemical breakdown. Steeve Bonneville of the University of Leeds in England and his colleagues set up a lab test to study the effects of the fungi *Paxillus involutus* on biotite, a potassium-rich mineral found in granite and other rock types. In the test, reported in the July *Geology*, the researchers planted a pine seedling with fungi-covered roots in a dry nutrient-poor soil free of other microorganisms (right). A flake of biotite (arrow) near the tree's roots provided nourishment and was the only source of potassium in the soil, Bonneville says. After three months, the team analyzed the flake in areas where fungi filaments, known as hyphae, had attached. Microscopy revealed that mineral layers beneath the attachments were wedged apart by at least 14 degrees. Material near the attachment had lost as much as 70 percent of its potassium. These changes allowed iron-bearing compounds in the rocks to react with oxygen from the air, encouraging further erosion, the team reports. —*Sid Perkins*



S. BONNEVILLE *ET AL./GEOLOGY*

Humans

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2-year-olds don't talk in sentences but can still tell nouns from verbs

New brain study suggests that toddlers know basic grammar

By Bruce Bower

Two-year-olds know more about grammar than they can say. Budding toddlers recognize the difference between nouns and verbs in simple sentences, even though the kids don't utter such sentences for at least another year, say Anne Christophe of the Laboratory of Cognitive Sciences and Psycholinguistics in Paris and her colleagues.

Children begin to use two or more words at a time by age 2, but their statements are typically incomplete and show no signs of grammatical knowledge. Yet upon hearing a sentence in which a noun incorrectly replaces a verb, or a verb incorrectly replaces a noun, toddlers display split-second brain responses that signal awareness of the rule violations, Christophe's team reports online June 29 in *Developmental Science*.

Youngsters fitted with electrode caps show characteristic brain responses after hearing mixed-up nouns and verbs.

Electrical activity, mainly relegated to the left-frontal brain, spiked when toddlers heard nouns in a verb position. Electrical responses farther back on the brain's left side, in the temporal lobe, jumped as toddlers heard verbs in a noun position. Both patterns resembled those that have already been implicated in noun and verb knowledge in adults.

"This experiment suggests that brain networks responsible for language processing get organized extremely early, showing striking similarities with the adult system long before children start producing adultlike language," Christophe says. A basic grasp of native-language rules may assist youngsters in learning the meanings of new words and other elements of language, she says.

In contrast, some scientists suspect that toddlers memorize a large repertoire of verbal phrases before making generalizations about object and action words at around age 3. A related hypothesis holds that language learning depends partly on a quantitative ability to notice features of speech that regularly go together.

"Children could well have some basic syntactic knowledge by age 2, which continues to develop throughout early childhood as they identify the statistical regularities of their language," remarks psychologist Erik Thiessen of Carnegie Mellon University in Pittsburgh.

Ancient Andean civilization likely spurred by maize

Farming the crop may have led to an early state society

By Bruce Bower

Prehistoric communities in one part of Peru's Andes may have gone from maize to amazingly complex. Bioarchaeologist Brian Finucane's analyses of human skeletons excavated in this region indicate that people living there 2,800 years ago regularly ate maize. This is the earliest evidence for maize as a staple food in the rugged terrain of highland Peru, he says.

Maize agriculture stimulated ancient population growth in the Andes and allowed a complex society, the Wari, to develop, Finucane contends in the August *Current Anthropology*. Wari society included a central government and other elements of modern states. It lasted from around 1,300 to 950 years ago and predated other Andes civilizations, including the Inca.

Scientists disagree about when and how civilizations formed in the Andes, but Finucane says his analysis indicates that "intensive maize agriculture was the economic foundation for the development of the Wari state."

Finucane, now a law student at Yale University, analyzed the chemical composition of bones from 103 individuals excavated by other researchers at six prehistoric sites in Peru's Ayacucho Valley, one of several Andean regions where early civilizations arose. Chemical signatures of substantial maize consumption appeared in the bones of individuals from every Ayacucho site, Finucane says.

Finucane "makes a strong case" for maize as a key food in the Ayacucho Valley by about 1,800 years ago, but not 2,800 years ago as argued in his new paper, remarks Yale University anthropologist Richard Burger, who was not involved in the study.

A skull found at a roughly 1,000-year-old Ayacucho Valley site in Peru's Andes yielded chemical evidence of substantial maize consumption.

FROM TOP: LSCP, CNRS PARIS; B. FINUCANE

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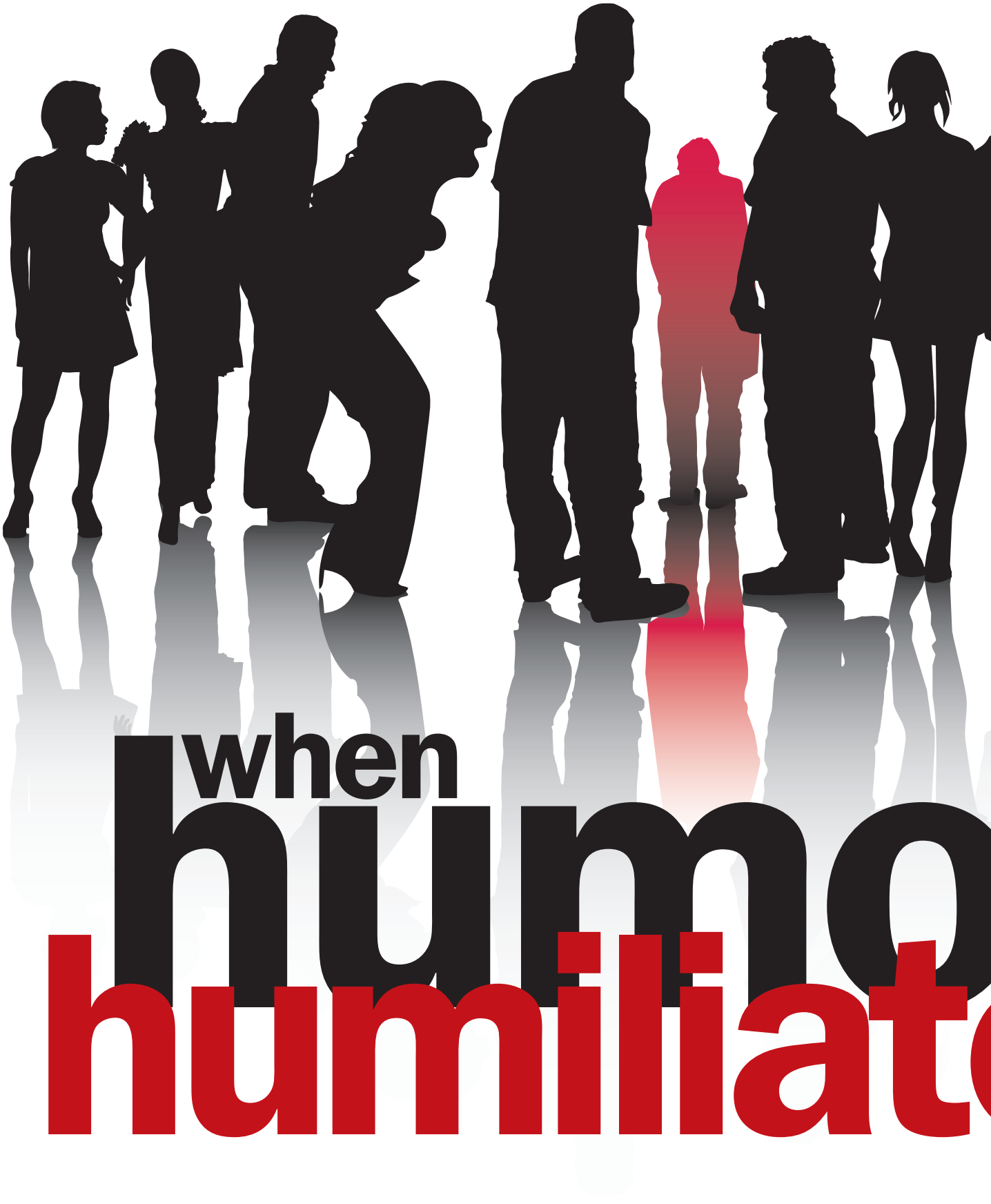


when humo humiliat

For gelotophobes, even good-natured laughter can sound a lot like ridicule

By Susan Gaidos

It started as a quiet dinner conversation, punctuated with laughter. Soon, the rapid-fire "ha-ha-has" took on the tone of gunfire. Convinced it was directed at him, the young man got up to confront the noisy diners.

Naturally, the guests at the next table had no idea what the problem was. They were simply enjoying themselves and ... laughing. Embarrassed by his outburst, the young man left the restaurant and never returned.

By most accounts, laughter is good medicine, the best even. But for some, such as the embarrassed diner, a good-natured chuckle isn't funny at all. Morbidly averse to being the butt of a joke, these folks will go out of their way to avoid certain people or situations for fear of being ridiculed. For them, merely being around others who are talking and laughing can cause tension and apprehension.

Until recently, such people might have been written off as spoilsports. But in the mid-1990s, an astute German psychologist recognized the problem for what it is: a debilitating fear of being laughed at. Over the past decade, psychologists, sociologists, linguists and humor experts have examined this trait, technically known as gelotophobia. Though it sounds like an ailment involving Italian ice cream, scientists worldwide now recognize it as a distinct social phobia. Studies of causes and consequences of gelotophobia were among the topics presented in June in Long Beach, Calif., at a meeting of the International Society for Humor Studies.

Most people fear being laughed at to some degree and do their best to avoid embarrassment. One thing that sets gelotophobes apart is their inability to distinguish ridicule from playful teasing. For them, all laughter is aggressive, and a harmless joke may come across as a mean-spirited assault.

"They seem to have problems interpreting humor correctly," says psychologist Willibald Ruch of the University of Zurich. "They probably do not understand the positive side of humor, and cannot experience it in a warm way but rather as a means to put others down."

Ruch and colleagues have developed assessment tools to help clinicians demarcate the merely flustered from the truly fearful. In recent years, his team has surveyed more than 23,000 people in 73 countries and found gelotophobia present to some degree in every nation, affecting from 2 to 30 percent of the population. In the United States, the incidence is about 11 percent, researchers said at the meeting in California.

When asked about recent occasions where they were laughed at, gelotophobes don't list more occurrences than others do. They do, however, experience such events as more painful.

"The gelotophobes reported a much higher intensity of being laughed at, and for a longer duration," says Ruch. "Also, it takes them much longer to calm down."

Studies using cartoons to illustrate people laughing in various situations show that those with a fear of being laughed at are more likely to assume that the laughter is directed at them. Other studies using laugh tracks show that gelotophobes have problems distinguishing a happy har-de-har from a scornful snicker.

Scientists studying the negative effects of being the target of others' laughter say such studies may help psychologists and psychiatrists treat patients with various

ILLUSTRATION: A. NANDY

types of social anxieties. The findings may also be used to better assess incidents of bullying at school and work, where nonphysical belittling and intimidation are commonplace.

"It's not yet studied how many impulsive violent acts were carried out in response to ridicule," Ruch says. Similarly, acts of revenge are often based on sensitivity to mocking and ridicule, he adds, pointing to a number of tragic school shootings where the gunmen left notes indicating that their classmates had laughed at them.

"Obviously, those experiences were so salient for them that they put it into their last letter," he says.

It's a shame

The funny thing about laughter is, it's seldom about what's funny. When Robert R. Provine, a professor of psychology at the University of Maryland, Baltimore County took to the streets and coffee shops to record instances of laughter, he found that most laughter has little to do with humor. People laugh when they're nervous, hesitant or just making polite conversation. Most smiles and laughs occur when other people are around. In his 2000 book, *Laughter: A Scientific Investigation*, Provine says laughter serves as a way to form alliances and make connections with others. For most, laughter serves as a signal for mutual liking and well-being.

But, like the young man whose dinner was ruined, not everyone feels the joy of laughter. Psychologist Tracey Platt, who ran across that man's case in her studies at the University of Zurich, says gelotophobes tend to have a fear and shame response to laughter, even in the best circumstances.

"While most people feel joy and surprise during playful teasing, gelotophobes feel the same anger, shame and fear that they would feel during ridicule," she says. "In fact, shame is at the forefront of their emotions."

The fact that shame is a predominant emotion in gelotophobia explains, in part, why the affliction received little scrutiny from scientists for so long. Burning shame can create more feelings of shame and is rarely acknowledged to others. In the late 1990s, a patient of German psychologist Michael Titze revealed how a series of childhood humiliations led to a morbid fear of being laughed at and a life of inhibition. In her report, the patient acknowledged that she had waited more than a year to tell the therapist about it.

Upon reading an account of this patient, Ruch set out to see if gelotophobia exists in the real world, where day-to-day mishaps, blunders and bloopers provide innumerable opportunities for mockery, both real and imagined. He developed a 46-item questionnaire and later a modified 15-item version called the GELOPH, which could be used to score people's fear of laughter on a scale from slightly fearful to extremely fearful. The questionnaires were also designed to identify those with shame-based fear.

Ruch's team also created a pictorial assessment tool similar to the GELOPH, with cartoons showing people laughing in various circumstances. One picture, for example, shows someone observing two other people laughing. Participants were then asked what the observer might be saying or thinking. While those with no fear might say something like, "Look at those youngsters, they know how to have fun," a typical response from a gelotophobe would be, "Why are they laughing at me?"

GELOPH testing in dozens of countries shows that the fear of being laughed at is everywhere, says University of Zurich psychologist René Proyer, who directed a multinational study on the subject. Though scientists are still sifting through the data, preliminary findings show that the incidence of gelotophobia is especially high in Asia, where the concept of "saving face" is important. The results were published in the February issue of the journal *Humor*.

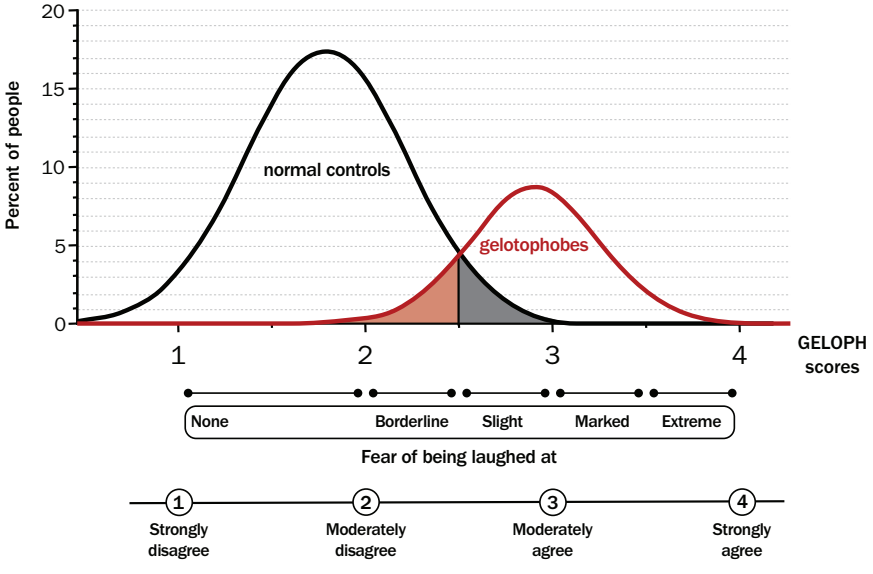
Based on the findings of the multinational study, the scientists now view gelotophobia as a personality trait, not as an illness.

"Everyone has a fear of being laughed at to a certain degree," Proyer says, ranging from nearly no fear to an exceedingly high, or pathological, fear.

Realizing that there's often a gap between what people say in a self-report and what they actually do in real life, the scientists also collected questionnaires from friends and family members. In

Continuum of fear

Many admit to some fear of being laughed at, but gelotophobes feel this fear, often along with shame, to the extreme. This chart shows the distribution of gelotophobes' responses to statements about being laughed at on the GELOPH assessment tool, compared with normal volunteers. The overlap leads psychologists to call this a personality trait instead of a pathology.



SOURCE: W. RUCH/*HUMOR*

addition, the team designed studies to look for behavioral evidence of people's symptoms.

In one study, Proyer and his colleagues hired an actor to record 20 different laughs — from playful peals and embarrassed giggles to belly laughs and jeers. The researchers then played the sound tracks for 40 people who had scored extremely high or low on the GELOPH and asked them to rate the laughter as pleasant or unpleasant, domineering or less domineering.

To scientists' surprise, those that scored high for fear of being laughed at didn't react more strongly to the sounds of negative laughter than did those with no fear. The gelotophobes did, however, perceive positive laughter, such as hearty or cheerful laughter, as unpleasant or spiteful.

The scientists also measured participants' moods before and after the experiment. Those with no fear of laughter reported feeling more cheerful after hearing the sound tracks, while gelotophobes reported no change in mood, the researchers reported in the February *Humor*.

Ruch says those findings agree with Titze's theory that those with a high fear probably have a history of being laughed at. "If someone has always experienced laughter as a weapon, not as something you share, then all laughter will sound like negatively motivated laughter," Ruch says.

But findings from recent studies show that additional factors may be at play. When W. Larry Ventis, professor of psychology at the College of William & Mary in Williamsburg, Va., reviewed information collected from the GELOPH studies, he found that repeated traumatic experiences during childhood and youth may exert some influence but don't tell the whole story.

"Those types of experiences don't clearly account for differentiating people who would be identified as gelotophobic from those who are not," Ventis says. "This suggests that there are other significant variables which we need to flesh out."

At the International Society for Humor Studies conference, Ventis discussed several other possible influences. People with a more reactive autonomic nervous system, for example, may respond with fear more readily than do others. And those who have witnessed instances where laughter was used to put people down may more readily believe that laughter translates into insult.

Gelotophobia around the globe

An international team surveyed more than 20,000 people from 73 countries to find out whether gelotophobia exists in different cultures and to determine its relative prevalence. All participants were asked to rate their agreement with 15 statements designed to gauge the level of fear associated with different social situations. Ten of these statements are shown here. Results show a score related to how intensely participants agreed with each statement; higher scores indicate greater fear.

Example GELOPH statements	Median score (All samples)	Country with most agreement	Country with least agreement
When they laugh in my presence, I get suspicious.	28.54	**Thailand** (80.00)	**Finland** (8.51)
I avoid displaying myself in public because I fear that people could become aware of my insecurity and could make fun of me.	19.98	**Turkmenistan** (59.00)	**Netherlands** (3.28)
It is difficult for me to hold eye contact because I fear to be assessed in a disparaging way.	13.23	**Cambodia** (55.50)	**Serbia** (3.48)
I control myself strongly in order not to attract negative attention so I do not make a ridiculous impression.	32.32	**Indonesia** (72.65)	**USA–Cincinnati** (7.98)
I believe that I make involuntarily a funny impression on others.	22.89	**Indonesia** (69.42)	**Sri Lanka** (4.00)
Although I frequently feel lonely, I have the tendency not to share social activities in order to protect myself from derision.	11.80	**Hong Kong** (71.60)	**Denmark** (0.41)
When I have made an embarrassing impression somewhere, I avoid the place thereafter.	27.58	**Gabon** (64.71)	**Denmark** (6.88)
If someone has teased me in the past I cannot deal freely with him forever.	21.72	**Egypt** (58.59)	**Norway** (3.16)
It takes me very long to recover from having been laughed at.	23.49	**Japan** (55.66)	**USA–Cincinnati** (7.18)
While dancing I feel uneasy because I am convinced that those watching me assess me as being ridiculous.	21.43	**Macao** (46.94)	**USA–Florida** (3.80)

Taking a cue from laughter

Platt's studies of gelotophobes' emotions show that they may also have problems picking up on the social cues related to smiling and laughter. Fake laughs, belly laughs, malicious laughs and chuckles all come with their own set of cues — such as vocal tones and facial expressions — that signal whether you're being laughed at or laughed with.

Not picking up on these cues may lead some people with gelotophobia to misinterpret playful laughter as something much more menacing, Platt says.

"If all the cues are all there, the overexaggeration and the facial mannerisms, to say 'I'm only playing with you and this is fun,' then it may be fine," Platt says. "But there's a danger that those cues might be misunderstood by someone who fears being ridiculed, and they will say that they're being bullied when they're just being teased."

R. PROYER *ET AL./HUMOR*

In a recent study, Platt created different scenarios to simulate teasing and bullying situations where laughter frequently occurs. The results, published in the June *Psychology Science Quarterly,* found that gelotophobes had problems discriminating between the two.

"Teasing is ambiguous at best," she says. "It's play, and it's quite sophisticated, and some people aren't going to get that."

While teasing is about group cohesion and being included, ridicule and bullying are about social exclusion, Platt says.

"Teasing would be dying your hair a lighter color and having your friends call you a dumb blonde," she explains. "They know that you're not dumb. They have a trust element in the relationship. The people in the group are saying, 'We're so close we can have fun with some element.'"

If someone misinterprets playful banter at work or school and then overreacts, it could make everything worse, she adds. "Then they would be reacting inappropriately, and that could make them the target of ridicule if they weren't before."

Platt is now developing a program based on the "mental toughness" coaching techniques that sports psychologists use to help athletes succeed and take control of situations. Once in place, the program may be used to help gelotophobes better deal with laughter.

"Avoiding laughter situations is only going to make them feel worse, so we want to set up challenges to help them recognize the appropriate cues and take control of their fear," she says.

To provide a more complete picture of how people deal with laughter, Ruch and his colleagues have recently expanded their studies to describe two other humor-related concepts: The joy of being laughed at — or gelotophilia — and the joy of laughing at others, or katagelasticism.

"Humor and mockery are part of a complex interaction — namely, someone does something wrong and gets laughed at," Ruch says. "But there's also someone who laughs, and likely a bystander who maybe doesn't do the ridiculing but approves of it. If we want to understand the phenomenon of gelotophobia in a broader sense, we need to study these different roles."

While recent studies provide a basis for understanding gelotophobia, scientists say the research is still in its infancy.

Some scientists are now investigating how gelotophobia relates to other types of social anxiety and phobias. Others are initiating work to peer inside the brains of gelotophobes using functional MRI to see if those who fear being laughed at show neural activity more typical for "fear" rather than laughter or enjoyment.

Still others are studying the relationships of gelotophobes to see how their fears play out with friends and families or change with age.

Platt says preliminary data with young adults suggest that people might be more susceptible to being laughed at during puberty. To better understand how, and when, such fears take hold in children, she is working to complete a version of the GELOPH that can be administered to children as young as 3 to 5 years old. The studies may help teachers and administrators sort out accusations of bullying and teasing. Other researchers are studying whether gelotophobia runs in families by checking to see if gelotophobic parents have gelotophobic children.

Ruch says that recognizing that humor is not necessarily contagious is especially important for teachers and others who work with groups of people. "We need to know why is it that something so human, which brings enjoyment to most everyone, is actually experienced so negatively by a few." ■

Susan Gaidos is a freelance science writer in Maine.

Explore more

- Information about gelotophobia: www.gelotophobia.org

Missed cues?

Knowing that gelotophobes can't hear the difference between good-natured and malicious laughter on recorded sound tracks, the University of Zurich's Willibald Ruch and his colleagues are looking to see if gelotophobes also have problems reading facial expressions. Drawing from the work of psychologist Paul Ekman, who while at the University of California, San Francisco, designed a coding system to read and interpret subtle emotional cues from the face, Ruch and his colleagues have developed a series of photos showing wide toothy grins, warm genuine smiles and phony smiles to see how well gelotophobes can read such facial cues. Ruch expects the study to reveal more about how gelotophobes may misinterpret the intentions of humor.

W. RUCH

Phony smile

- Lips retracted at corners only
- Eyes not involved
- Not indicative of genuine joy

Duchenne smile

- Lips fully retracted and closed
- Mouth and eyes involved (orbicularis oculi muscles raise cheeks and form crow's feet)
- Indicates genuine joy

Duchenne laughter

- Lips fully retracted and parted
- Mouth and eyes involved
- Indicates genuine joy

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the biofuel future

Scientists seek ways to make green energy pay off

By Rachel Ehrenberg

Biofuels are liquid energy Version 2.0. Unlike their fossil fuel counterparts — the cadaverous remains of plants that died hundreds of millions of years ago — biofuels come from vegetation grown in the here and now. So they should offer a carbon-neutral energy source: Plants that become biofuels ideally consume more carbon dioxide during photosynthesis than they emit when processed and burned for power. Biofuels make fossil fuels seem so last century, so quaintly carboniferous.

And these new liquid fuels promise more than just carbon correctness. They offer a renewable, home-grown energy source, reducing the need for foreign oil. They present ways to heal an agricultural landscape hobbled by intensive fertilizer use. Biofuels could even help clean waterways, reduce air pollution, enhance wildlife habitats and increase biodiversity.

Yet in many respects, biofuels are in their beta version. For any of a number of promising feedstocks — the raw materials from which biofuels are made — there are logistics to be worked out, such as how to best shred the original material and ship the finished product. There is also lab work — for example, refining the processes for busting apart plant cell walls to release the useful sugars inside. And there is math. A lot of math.

The only way that biofuels will add up is if they produce more energy than it takes to make them. Yet, depending on the crops and the logistics of production, some analyses suggest that it may take more energy to make these fuels than they will provide. And if growing biofuels creates the same environmental problems that plague much of large-scale agriculture, then air and water quality might not really improve. Prized ecosystems such as rain forests, wetlands and savannas could be destroyed to grow crops. Biofuels done badly, scientists say, could go very, very wrong.

"Business as usual writ larger is not an environmentally welcome outcome," states a biofuels policy paper authored by more than 20 scientists and published in *Science* last October.

Many scientists have expressed concern that political support for the biofuels industry has outpaced rigorous analyses of the fuels' potential impacts. Others see this notion as manure. Research needed to resolve that disagreement is now underway, as scientists in industry, national labs and universities across the country are assessing every aspect of these fuels, from field to tailpipe. Researchers are growing crops, evaluating yields and comparing harvesting techniques. Computer models are providing stats on each crop's effect on environmental factors such as soil nutrients and erosion. The plant cell wall is under attack from several angles. And chemists and microbiologists are cajoling an

S. LONG/UNIV. OF ILLINOIS; USDA-NRCS PLANTS DATABASE

Perennial plants, like this *Miscanthus giganteus* in a University of Illinois test plot, could replace corn as a source of plant-based liquid fuel.

expanding menagerie of microorganisms into producing higher fuel yields.

Green goals

Ideally, high biofuel yields come with minimal environmental baggage and maximum efficiency at every step. The raw materials for these fuels run the gamut from corn to municipal waste to algae, and each has its own benefits and headaches. To make fuels, researchers must first process the raw material to create fermentable sugars or a crude oil-like liquid. Further refinement yields fuels such as ethanol, butanol, jet fuel or biodiesel.

In some cases, such as algae-based biodiesel, the technologies are far from mature. Squeezing ethanol from crops such as corn, on the other hand, uses a technology as old as whiskey. An infrastructure already exists for growing and moving grain, and distillation and fermentation techniques work at large scales.

But grain-based fuels raise several environmental issues, such as emissions of the potent greenhouse gas nitrous oxide from heavy fertilizer use. So, many scientists see corn ethanol as a bridging technology for use until the next-generation feedstocks fulfill biofuels' real promise. Nonfood plants rich in cellulose or even residual waste diverted from landfills may define the biofuel future.

Several studies attest to the benefits of fuels made from such feedstocks, although the degree of benefit varies depending on what factors are included in the analysis. Overall, dedicated energy crops such as switchgrass and waste residues from sources like commercial logging fare better than corn-based ethanol, concludes a recent modeling analysis and literature review citing more than 100 papers. Published online May 27 in *Environmental Science & Technology*, the analysis reports that municipal waste-based ethanol production emits an estimated 60 to 80 percent less greenhouse gas than corn-based ethanol production. Dedicated energy crops, especially when grown on marginal land, also fare better than corn in terms of greenhouse gas emissions, and require less water and generate less air pollution, report researchers from the National Renewable Energy Laboratory in Golden, Colo., and E Risk Sciences in Boulder, Colo.

Research also suggests that these new fuels will be priced competitively with gasoline from petroleum. A new assessment coauthored by Lee Lynd, head scientist and cofounder of the Boston-based ethanol start-up Mascoma Corp., found that the production costs of cellulose-based ethanol, when made on a commercial scale, could be competitive with gasoline at oil prices of $30 or more per barrel.

Both of these recent big-picture studies, while optimistic, call for continued research to improve existing production processes and better define each fuel's associated trade-offs.

Such research is in progress at the Idaho National Laboratory in Idaho Falls, where scientists David Muth Jr. and Thomas Ulrich take part in a coordinated, national effort to watch grass grow. In partnership with scientists at Oak Ridge National Laboratory in Tennessee and at several universities, Muth and Ulrich are keeping track of more than 50 field trials of various feedstocks across the country. The researchers are growing switchgrass and *Miscanthus*, an 11-foot tall perennial grass. Energy cane, an über-biomass relative of sugar cane, is also under study.

The research suggests that there is not one silver bullet source for biofuels. While there are some generally desirable plant characteristics — such as needing few nutrients and flourishing on degraded land — the future biofuels landscape will likely be a patchwork of different sources that work best in different regions.

"What's emerging pretty quickly is how site-specific both the production systems and problems are," says Muth.

Energy cane, for example, has "huge yields, but it is a water sink," he says. So it may be best for water-rich Gulf Coast states. *Miscanthus*, which has been tested in Europe for several years, produces very high yields and has the genes to withstand cold climates.

Part of biofuels' allure lies in the variety of ingredients from which the fuels may be spun. The Idaho National Lab is also investigating strains of algae that pump out oils as a raw material for biodiesel. At other sites agricultural and municipal waste, such as straw stalks, corn cobs and tree cuttings, are under investigation. Some researchers are focused on crops dedicated to energy, such as prairie grasses, and fast-growing softwoods, such as willow, poplar and eucalyptus. A pilot-scale system for growing the diminutive pond plant duckweed on wastewater is underway at North Carolina State University.

In Idaho, Muth is also using several computer models to calculate the effect that growing and removing the feedstocks has on factors such as soil's nutrients, carbon and water content.

Biomass benefits

Greenhouse gas emissions drop, and air and water quality improve, when switchgrass and forest residues from logging replace corn as a raw material for fuel, suggests a recent life cycle analysis. The chart below shows the improvement relative to corn for these two next-generation biofuel hopefuls.

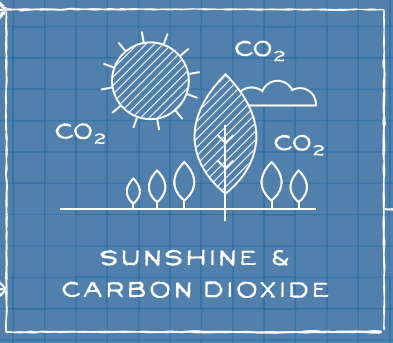
		Potential percent reduction	
What	**Type**	**Forest residue**	**Switchgrass**
Greenhouse gases	Carbon dioxide	93%	90%
Air pollutants	Lead	87%	88%
	Ozone	99%	89%
Water use	Groundwater	100%	100%
Water pollutants	Nitrates	100%	100%

SOURCE: WILLIAMS *ET AL./ENVIRONMENTAL SCIENCE & TECHNOLOGY* 2009

FACING PAGE: NEWHOUSE DESIGN

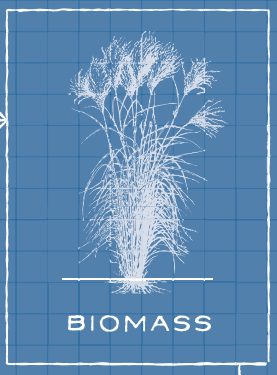
Power from plants

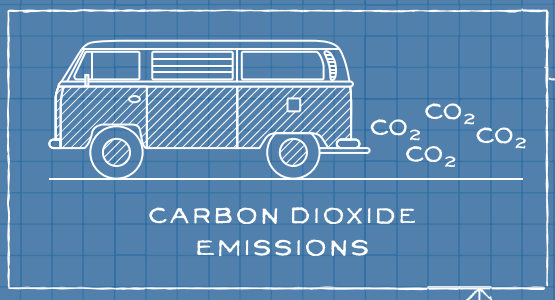
Scientists are studying biofuels from the field to the pump to make each step more efficient and environmentally friendly. Here's a typical blueprint for ethanol production.



On the farm

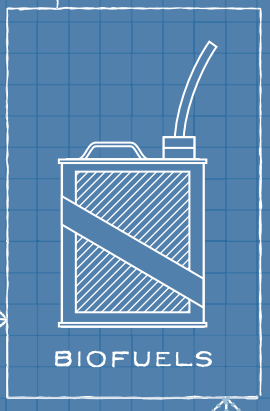
Plants thrive on sunshine and carbon dioxide. To minimize environmental impact, biofuel scientists are studying plants that don't require irrigation or fertilizer.

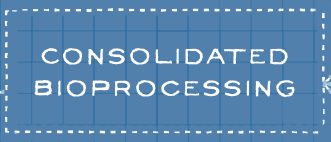


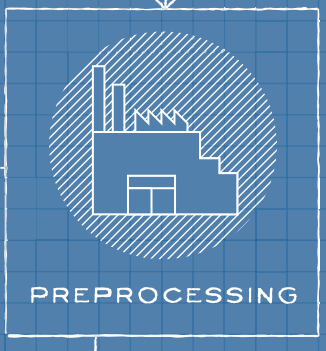


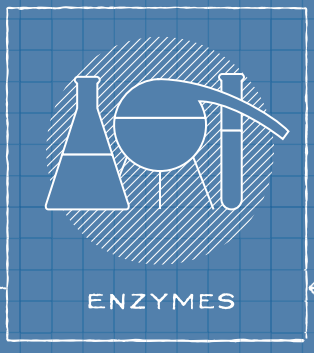
Burning biofuels

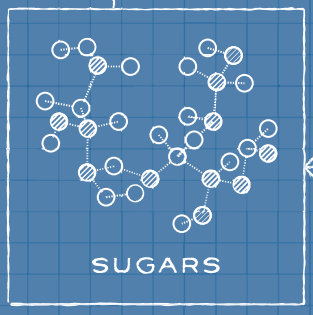
Producing biofuels and burning them in an engine does create carbon dioxide emissions, but ideally those emissions are less than what is consumed by plants during photosynthesis.

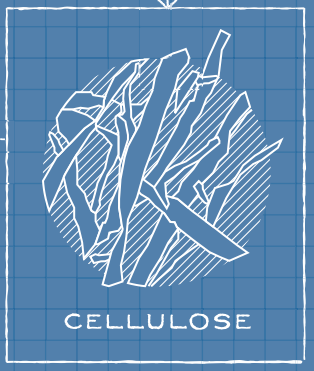












Conversion to fuel

After harvesting, plants are pretreated to soften them up with ammonia, water or dilute acids. Enzymes attack the exposed cellulose, breaking it down into sugars that can be fermented by microbes into ethanol.

This information, along with yields and quality of plant material, is all being entered into a database to help predict which plants will grow best where.

Biomass breakdown

Bioenergy is not just about growing crops up, though. It's even more about tearing them down. Biomass must be harvested from the field or forest, perhaps stored, and then shipped to a refinery for processing. Harvesting equipment, travel distances and processing methods must all be considered to determine whether biofuels make economic and energy sense.

"What is becoming a bigger and bigger issue to people is the logistics of it all — that's becoming a barrier to the whole thing," says J. Richard Hess, the technology manager of the Idaho National Lab program.

An essential part of biofuel logistics is the preprocessing of plants — cutting, baling and hauling the bales somewhere for storage before transporting them to a refinery. Those preprocessing steps pose problems with a material that isn't very dense or evenly shaped. "It's like moving air or feathers," Hess says.

Ideally, preprocessing would provide an end product that is uniform and easy to handle, like grain — the biomass equivalent of crude oil. "We're not aiming for a certain size, but a certain density that's easy to ship, is flowable," says INL's Christopher Wright.

Wright and Neal Yancey, also of INL, are trying to achieve the optimal density by finding the right balance of shredding and compacting, ultimately producing something like the alfalfa pellets fed to pet rabbits, or perhaps Matchbox car–sized blocks. This crude can then be shipped to a refinery to be heated into an oil-like liquid or broken down by enzymes into the desired fuel.

Breaking biomass down into fuel is no small task. The dominant method is known as biochemical conversion: processes that use heat, chemicals or enzymes to turn the biomass into sugars that can be fermented by microbes such as yeast into ethanol. This ethanol is the same whether its origins are corn or other biomass. But it is currently a lot easier to get the fermentable sugars out of a starchy corn kernel than from something like wood chips or a weedy grass.

Plant cell walls are about 75 percent complex sugars, but getting at these sugars is a bit like trying to get the mortar and minerals out of a castle's rampart. Cell walls, one of the defining features of plants as a life-form, were made to resist degradation. Even termites and cows need special microbes in their guts to get the job done.

That's because those sugars are embedded in a complex architectural structure called lignocellulose — cellulose (long, unbranched chains of glucose) embedded in a matrix of more sugars (hemicellulose) embedded in the tough, glue-like lignin. (Biofuels researchers refer to the "recalcitrance" of the cell wall, as if it were an obstinate child.) Not only did cell walls evolve for strength, they also are a primary defense against microbial attack, and critters that are up to the task aren't common.

"Lignin is a highly problematic polymer from the point of view of processing, but an exemplary evolutionary achievement," researchers at the University of York in England commented in May 2008 in *New Phytologist*.

To prep for the cell wall attack, plant matter is usually pretreated: the shredded, chopped or pelletized biomass is typically mixed with dilute acids or ammonia. At a biofuels symposium held in May in San Francisco, scientists presented work describing pretreatment with proton beam irradiation, steam explosion and microwave reactors. Ionic liquids — basically liquid salts — are also under investigation.

"Cellulose doesn't liquefy in minutes to hours — it's hours to days," says Jim McMillan of the national lab in Golden. This step is the main bottleneck in cel-

Running on algae

Pond scum gets a bad rap. But microalgae — tiny, single-celled aquatic organisms — are rising stars in the renewable energy sector. They can provide oil that can be turned into liquid fuels such as biodiesel and jet fuel.

Algal oil is mostly triacylglycerides — long fatty acid chains with glycerol backbones — that can be converted to diesel and other fuels in relatively few steps. Algae's potential lies in their speedy growth rate, efficient photosynthesis and flexible habitat preferences. Many strains can grow in saltwater or wastewater from treatment plants. In open ponds or closed bioreactors, the microorganisms can potentially make more than 50 times as much oil as land plants on the same area.

This potential fuel has a long history. In 1978 the Department of Energy launched the Aquatic Species Program to develop fuels from algae, but the program was shut down in 1996. In the intervening years, more than 3,000 strains were investigated, included species from Yellowstone National Park's hot springs and the Caribbean Sea.

Now algae research is surging once again in both the private and public sectors. Problems still loom, including how to best extract the oil, scale up algae farms and control contamination by unwanted strains or tiny critters like rotifers that graze on the algal crop. But in June the algae-to-ethanol company Algenol Biofuels announced plans for a pilot plant with Dow Chemical Co. in Freeport, Texas. And in January, Continental Airlines conducted a 90-minute test flight of a Boeing 737 fueled in part by a blend derived from algae and *Jatropha* plants. Prospects for fuel from pond scum are starting to look up. — *R.E.*

PAT CORKERY, NATIONAL RENEWABLE ENERGY LABORATORY

lulosic fuel production, Lynd and several other researchers conclude in a February 2008 commentary in *Nature Biotechnology*.

Lignin is typically removed after pretreatment and then burned in the refinery's boiler, replacing some fossil fuel use. The remaining plant matter is then broken into simple sugars, typically by a cocktail of microbial enzymes known as cellulases. Other microbes are then called in to ferment the sugars into ethanol.

Breaking down cellulose with enzymes is usually a separate step from fermentation — and a very costly one. But recent attempts to combine the conversion of cellulose to sugars with the conversion of sugars to fuel — called consolidated bioprocessing — have been successful. A strain of the soil-dwelling bacterium *Clostridium phytofermentans* will happily munch biomass such as wood pulp waste and will ferment it into ethanol. That discovery, by microbiologist Susan Leschine of the University of Massachusetts Amherst, led to the development of Qteros, a cellulosic-ethanol start-up in Marlborough, Mass. And in May, Mascoma researchers reported the engineering of a yeast and the bacterium *Clostridium thermocellum* to produce cellulases and ethanol in a single step.

At the San Francisco conference, posters reported on investigations of even more enzymes from various sources: bacteria that live in the deep sea, penicillin, diseased sea squirts, the bread mold *Neurospora*, a yeast that grows on wood-boring beetles and soil microbes from a Puerto Rican rainforest. Scientists are also fighting recalcitrance from the inside out by breeding lines of low-lignin plants.

Of course, getting a lot of ethanol in a benchtop flask is one thing. Scaling up to a silo-sized bioreactor is another. Industrial models exist — such as wringing pulp from trees for the paper industry or mass-producing cornstarch. "But we haven't done it with cellulose yet," says McMillan.

More than a dozen pilot plants for producing cellulosic ethanol are under construction and a handful are operating, with 2011 seen as the year for cellulosic technologies to walk the walk. The group at Idaho National Lab hopes to be able to demonstrate a system from field to refinery by autumn of 2010.

Environmental cost

Yet concerns remain that the environmental side of the biofuels equation is still not worked out. Some argue that the numbers are too fuzzy to proceed with confidence that environmental burdens and benefits have been fully considered.

"There are people who say we don't have enough knowledge to move forward — to some extent that is true," says Michigan State University's Philip Robertson, coauthor of the *Science* policy paper. "But we do know a lot about sustainability — enough to implement logical science-based standards." This includes things like the strategic use of cover crops, fertilizer and tilling.

There is also the consideration of land-use changes — if forests are cleared for biofuels production, far more carbon will be released than is saved by the nonpetroleum fuels, several studies suggest. Such findings have led to scrutiny that has stung many in the industry who argue that biofuels are being held to a much higher standard than fossil fuels. If the petroleum isn't "charged" for the greenhouse gas emissions of the U.S. military keeping supply lanes open in the Persian Gulf, why should emissions from cleared forests be included in the biofuels ledger? asks Bruce Dale of Michigan State University in a recent editorial in the journal *Biofuels, Bioproducts & Biorefining*.

Congress is now considering legislation that may determine whether indirect land use can or cannot be a mark on the ruler used by the U.S. Environmental Protection Agency to measure biofuels' impacts. Eventually, many researchers hope, a more detailed picture will emerge of the benefits and costs across all stages of the life cycles of fossil and next-generation fuels.

"Some really interesting services are going to emerge from these crops," says Muth, of the Idaho National Lab. Some biofuel plants help sequester carbon in the soil, for example. A 2002 analysis reported that by the second or third planting year, switchgrass plots experience far less soil erosion than annual crops such as corn. Species that do well near wetlands can act as filters, preventing nitrates and phosphates from getting into the water, Muth says. "If there is a value on carbon sequestration ... a value on clean water, there may be economic benefits for a lot of these crops."

Robertson adds, "If certain practices were being promoted with incentives, it would ensure that we have a biofuels industry that is sustainable with a net benefit, not a cost. We don't have that yet — I say 'yet' hopefully."

With appropriate carrots and sticks, biofuels could play a big role in the energy portfolio of the future. There may even be a day when, *Back to the Future* style, garbage can be thrown into a personal-sized bioreactor that yields fuel. (Trash biomass in the form of sugar beet pulp, tomato pomace, cashew apple, grape pomace, sweet gum and coffee pulp are all being investigated.) Several lines of research are investigating biofuel "coproducts," high-value molecules that can be extracted during processing, such as proteins for animal feed or aromatics for perfumes and drugs. These products will also bring the net costs of these fuels down, one of several variables that can help the biofuels math add up to success as a fossil fuel substitute.

"It's difficult to compare the costs of not changing with the costs of changing," Lynd said at the May meeting in San Francisco. "Asking is this or that realistic is well-intentioned, but all solutions involve changes — we don't have an option. Business as usual? Well, we think of it as a baseline, but it is a fantasy — even if you don't care about carbon — just as a supply issue. Fossil fuels will all be gone. They'll all be gone." ■

Explore more

- Robertson *et al*. "Sustainable biofuels redux." *Science*. October 3, 2008.
- The National Renewable Energy Lab project: www.nrel.gov/biomass

Conservation Refugees: The Hundred-Year Conflict Between Global Conservation and Native Peoples

Mark Dowie

Wilderness: The word evokes ideas of a land pristine, where native flora and fauna thrive untouched by humans. But Dowie, an investigative journalist, argues that the notion of virgin wilderness is largely a fantasy and shows how efforts to preserve land have upset the lives of millions of indigenous people around the world.

This thought-provoking book traces the story of ecological protection from its early days in the late 19th century. That's when naturalist John Muir lobbied to evict American Indians from their ancestral lands in today's Yosemite National Park, arguing that they threatened the land's "natural" splendor.

The Yosemite Park model—which held that human activity and biological diversity are almost always mutually exclusive—became the standard philosophy of conservation organizations such as the World Wildlife Fund and the Nature Conservancy, Dowie writes.

As a result, a number of indigenous peoples have become "conservation refugees." The Maasai hunters of the Serengeti, the Adivasi people of India's forests and the Karen people in Thailand all faced eviction or severe restrictions after their land was declared a park or a reserve. Divorced from ancestral land and traditions, many societies have slid into poverty. Some even face extinction.

Dowie sympathizes, but he doesn't romanticize these peoples' lifestyles or capacity as land stewards. Not all indigenous societies have cared for their homes, just as not all conservationist groups prioritize biological diversity over human culture, he notes.

True ecological conservation requires balancing both interests, he writes. "If we really want people to live in harmony with nature, history is showing us that the dumbest thing we can do is kick them out of it." —*Rachel Zelkowitz*

MIT Press, 2009, 336 p., $27.95.

Historic Photos of the Manhattan Project

Timothy Joseph

Atomic bombs were dropped on Hiroshima and Nagasaki 64 years ago this month, bringing World War II to an end. The research and development program that spawned those weapons had been officially launched only three years earlier. *Historic Photos of the Manhattan Project* is a captivating pictorial chronicle of this supersecret race to develop atomic weapons.

The book is jampacked with images from the National Archives, Library of Congress and the Department of Energy, among other sources, and includes photos of all the Manhattan Project's familiar characters. More interesting, perhaps, are images of the welders, technicians and, yes, even switchboard operators who toiled in closed-lipped anonymity in what Joseph describes as "the most significant and far-reaching challenge the United States ever embarked on."

Aerial images of Manhattan Project facilities in New Mexico, Tennessee and Washington reveal the magnitude of the effort. Many of the largest facilities were built even before the processes used to separate bomb-grade uranium from its ore were fully developed. Despite the grand scale and unprecedented technology developed during the project, some milestones were surprisingly low-key: The plutonium core of the bomb tested in the New Mexico desert in July 1945 was ferried to the blast site in the back seat of a '42 Plymouth.

Overall, Joseph's book provides an extensive, behind-the-scenes look at a project that changed the course of human history. —*Sid Perkins*

Turner Publishing, 2009, 205 p., $39.95.

Building a Meal: From Molecular Gastronomy to Culinary Constructivism

Hervé This

A chemist trained in culinary arts explores the science of a good meal, with tips for how to make one. *Columbia Univ., 2009, 135 p., $19.95.*

Understanding Perennials: A New Look at an Old Favorite

William Cullina

An intimate portrait of perennials aims to give a deeper understanding of these garden standbys. *Houghton Mifflin Harcourt, 2009, 247 p., $40.*

Cogent Science in Context: The Science Wars, Argumentation Theory, and Habermas

William Rehg

A philosopher reflects on the best way to validate a scientific claim. *MIT Press, 2009, 345 p., $40.*

Alien Ocean: Anthropological Voyages in Microbial Seas

Stefan Helmreich

Research reveals the complexity and diversity of microbial life in the sea. *Univ. of California, 2009, 403 p., $24.95.*

Decoding the Heavens

Jo Marchant

A science writer takes readers on a quest to decode the Antikythera Mechanism, the first analog computer. *Da Capo Press, 2009, 328 p., $25.*

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Lead or poverty's later toll

Most toxic materials have the most deleterious effects at the earliest exposure ages, so I was puzzled by the study outcome in "School-age lead exposures may do more harm than earlier exposures" (*SN: 6/6/09, p. 13*). Did the study control for social and financial background? It would make sense for effects of background to be greater at age 6 than age 1.
Tom DuBois, Glens Falls, N.Y.

Richard Hornung of Cincinnati Children's Hospital Medical Center says the study looked at socioeconomic status indirectly through maternal IQ and a standard measure of the home environment. He also notes that each of the study populations was relatively homogeneous, made up almost exclusively of inner city children, further reducing the chance that the findings were a result of differences in social and financial factors rather than lead exposures. —Janet Raloff

Multiversal logic

Dealing with the question of multiverses requires coping with logic as well as with infinity ("Success in coping with infinity could strengthen case for multiple universes," *SN: 6/6/09, p. 26*). Alex Vilenkin's argument "is based on the belief that people aren't special" and thereby is circular. "Humans would most likely live in an average bubble" only if A) the distribution of bubbles under consideration resembles a normal distribution (such that near-average examples are more likely than far from average ones) and B) the sample of studied universes is randomly selected and large enough to be statistically representative. B is certainly untrue; A might not be true. Similarly, an infinite universe alone is not sufficient to produce Boltzmann brains—there must be an infinite supply of appropriate matter in it (all neutrons wouldn't do, for example) with a sufficiently random distribution to cover all possible configurations. As the laws of physics and chemistry constrain the distribution of matter, matter distribution may not be random enough to include Boltzmann brains. Conversely, the existence of humans in no way disproves the existence of Boltzmann brains. Just because the highly nonrandom sample of the brains that we know of are all in animals doesn't tell us what the average randomly sampled brain in the universe is like. These difficulties go both ways—without a statistically significant random sample of universes, we cannot tell scientifically what is normal.
David Campbell, Tuscaloosa, Ala.

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All letters subject to editing.

Eugenie Scott

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Accept it: Talk about evolution needs to evolve

Watch your language! It's a common message from Eugenie Scott, a physical anthropologist and director of the National Center for Science Education (www.ncseweb.org), an organization dedicated to promoting and defending the teaching of evolution in public schools. Scott recently spoke with Science News *writer Susan Milius.*

So you urge scientists not to say that they "believe" in evolution?!

Right. What your audience hears is more important than what you say.... What [people] hear is that evolution is a belief, it's an opinion, it's not well-substantiated science. And that is something that scientists need to avoid communicating.

You believe in God. You believe your sports team is going to win. But you don't believe in cell division. You don't believe in thermodynamics. Instead, you might say you "accept evolution."

How does the language used to discuss new discoveries add to the problem?

To put it mildly, it doesn't help when evolutionary biologists say things like, "This completely revolutionizes our view of X." Because hardly anything we come up with is going to completely revolutionize our view of the core ideas of science.... An insight into the early ape-men of East and South Africa is not going to completely change our understanding of Neandertals, for example. So the statement is just wrong. Worse, it's miseducating the public as to the soundness of our understanding of evolution.

You can say that this fossil or this new bit of data "sheds new light on this part of evolution."

So people get confused when scientists discover things and change ideas?

Yes, all the time. This is one of the real confusions about evolution. Creationists have done a splendid job of convincing the public that evolution is weak science because scientists are always changing their minds about things.

So how do you explain what science is?

An idea that I stole from [physicist] James Trefil visualizes the content of science as three concentric circles: the core ideas in the center, the frontier ideas in the next ring out and the fringe ideas in the outermost ring....

[We need to] help the public understand that the nature of scientific explanations is to change with new information or new theory—this is a strength of science—but that science is still reliable. And the core ideas of science do not change much, if at all.

The core idea of evolution is common ancestry, and we're not likely to change our minds about that. But we argue a lot about ... how the tree of life is branched and what mechanisms bring evolutionary change about. That's the frontier area of science.

And then of course you have areas that claim to be science, like "creation science" and "intelligent design," that are off in the fringe. Scientists don't spend much time here because the ideas haven't proven useful in understanding the natural world.

You've been on talk radio a lot. What's your sense of what the public understands about evolutionary biology?

The public has a very poor understanding of evolution. People don't recognize evolution as referring to the common ancestry of living things. Even those who accept evolution often don't understand it well. They think it's a great chain ... of gradual increases in complexity of forms through time, which is certainly an impoverished view of evolutionary biology. That view is the source, in my opinion, of: "If man evolved from monkeys, then why are there still monkeys?" ... That's probably the second most common question I get on talk radio.

"'If man evolved from monkeys, then why are there still monkeys?'... That's probably the second most common question I get on talk radio."

It's like saying, "If you evolved from your cousins, why are your cousins still here?" And of course the answer is, well, in fact, I didn't evolve from my cousins. My cousins and I shared common ancestors, in our grandparents.

What's the current state of the effort to keep schools teaching evolution?

Sometimes it feels like the Red Queen around here, where we're running as hard as we can to stay in the same place. The thing is, creationism evolves. And for every victory we have, there's pressure on the creationists to change their approach. We constantly have to shift our response. Ultimately the solution to this problem is not going to come from pouring more science on it.

What should scientists and people who care about science do?

I'm calling on scientists to be citizens. American education is decentralized. Which means it's politicized. To make a change ... you have to be a citizen who pays attention to local elections and votes [for] the right people. You can't just sit back and expect that the magnificence of science will reveal itself and everybody will ... accept the science. ■

STEVE MIRSKY

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