Alien Amino Acids | The Obesity Virus | Stem Cell Inequalities

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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ OCTOBER 9, 2010

Visualizing the void

How to capture a black hole

Action Games Sharpen Brains

Solar Cells that Self-Repair

Antibiotics from Cockroaches

Pain relief breakthrough

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- ✔ Plantar Fasciitis
- ✔ Bone spurs
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- ✔ Morton's Neuroma
- ✔ Poor circulation
- ✔ Arthritis
- ✔ or just tired, aching feet

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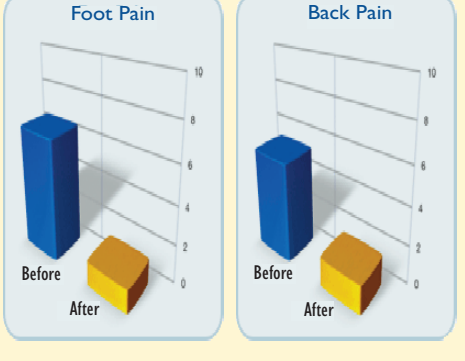

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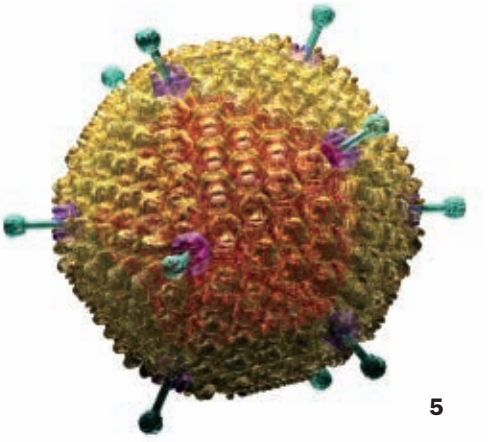
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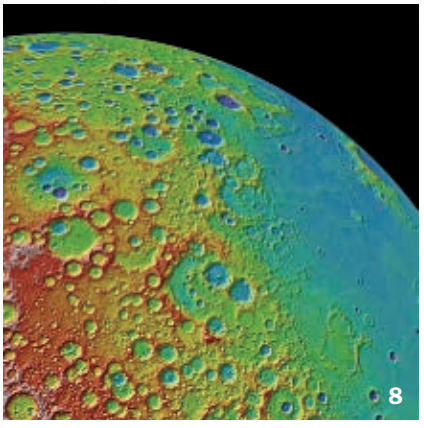
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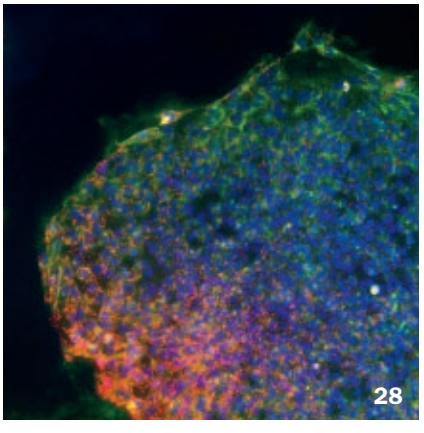
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ScienceNews

In The News

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COVER Astronomers' best model of the emission from the supermassive black hole at the Milky Way's center, based on an initial version of the Event Horizon Telescope.
Avery Broderick

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FROM THE EDITOR

Believing without seeing gives science more power

If believing really requires seeing, then physicists who study black holes must be delusional.

By their very nature, black holes can't be seen — they swallow light rather than reflecting it. Yet nearly all physicists believe that black holes exist.

Fortunately, the idea that something is real only if you can see it died (for the most part) in 1916 with the last of the 19th century's deniers of the reality of atoms, Ernst Mach. Mach, the Austrian physicist-philosopher whose writings had a profound influence on Einstein, contended uncompromisingly that the notion of atoms was only a useful idea, not an insight into something real about nature.

Mach insisted that science should concern itself only with phenomena that presented themselves to the senses. He therefore insisted that atoms were merely "mental artifices," convenient mathematical fictions conceptually valuable for explaining chemistry and physics — but only in a metaphorical way. Just because the cause-and-effect universe (of classical physics) could be understood as operating like a mechanical clock, that didn't mean the universe actually was a clock, after all.

"Atoms and molecules ... can never be made the objects of sensuous contemplation," Mach declared. "Have you ever seen one?"

It turned out that Mach, while a very deep thinker, had a rather limited view of science and its powers. He was wrong about atoms, of course, and he was also wrong to insist on artificial limits to what science should be allowed to consider. Scientists succeed not by observing philosophical prescriptions but by using their wits to figure out whatever will work in the quest to understand, explain and predict nature's machinations.

And so it's entirely appropriate that scientists who believe in black holes have not been deterred by their supposed invisibility. In fact, as Charles Petit recounts in this issue (Page 22), some physicists have decided to take a black hole's picture, anyway. It's true that the picture they envision might best be described as a silhouette, but if the quest succeeds, it will nevertheless demonstrate once again that science can infer aspects of reality before they are available to "sensuous contemplation."

—Tom Siegfried, Editor in Chief

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Scientific Observations

"It used to be that scientists in academic research (and in some industries) would have the option of taking a sabbatical. It was an opportunity to leave one's institution, explore different science and technology fields and create new areas of investigation. But today, many harried researchers tell me that even if they were able to take a sabbatical, they would use it to divest themselves temporarily of their teaching duties and get caught up on their research activities. If the chance to examine other scientific realms is absent, scientists can go for years being completely locked into their careers. This can seem highly productive, at least for a while. But without the opportunity to explore, reflect or simply relax, anyone engaged in a creative endeavor such as scientific research runs the risk of intellectual and creative stagnation or worse: burn-out." **—PETER FISKE, CHIEF EXECUTIVE OF PAX WATER TECHNOLOGIES, IN THE AUG. 12 *NATURE***

Science Past | FROM THE ISSUE OF OCTOBER 8, 1960

DO SEA SERPENTS EXIST? — The flurry of interest in sea monsters gained new impetus in September 1959, when Dr. Anton Brunn of Denmark described captured larval eels six feet long.... [T]he unusually large size of the larvae suggested that the parents must be of huge size. The adult eels, perhaps 30 to 50 feet in length, hooping their way across the ocean waves, might account for some of the sea serpent legends. "I know that some of the stories told about sea monsters and sea serpents sound weird," Dr. [Robert] Menzies said. "But it would be even more ridiculous to pooh-pooh them completely and not even look for the monsters.... I am not prepared to say that there are such things; neither would I deny they exist."

Science Future

October 10–24
First USA Science & Engineering Festival, held in D.C. Go to www.usasciencefestival.org

October 15–22
Third annual Imagine Science Film Festival celebrated in New York City theaters. See http://imaginesciencefilms.com

October 16
New Smithsonian exhibit opens featuring a coral reef made of yarn crocheted into geometric patterns. Go to www.mnh.si.edu/exhibits/hreef

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BODY & BRAIN
Swimming laps may modify more than muscles. See "DNA-damaging disinfection by-products found in pool water."

GENES & CELLS
Two teams have drafts of the cocoa tree's genetic blueprint. Read "A taste of the chocolate genome."

ON THE SCENE BLOG
Hubble Space Telescope's successor is over budget, but cuts can't be made when no one's saying how much red is in the books. See "An uncomfortable silence."

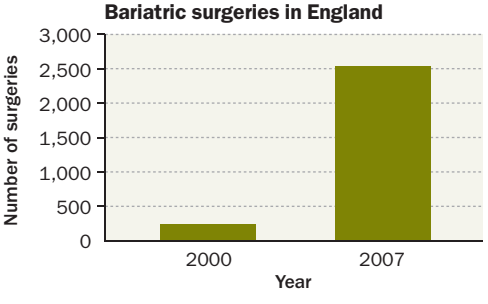
GENES & CELLS
Scientists find Prozac may control serotonin via microRNA. See "Mini-molecule may explain how antidepressants work."

For Daily Use

Keep angry people's attention with rewards, not threats. A recent study led by Brett Ford of Boston College measured the effect of volunteers' emotional states on their visual attention by tracking participants' eyes as they looked at pairs of threatening, rewarding and neutral images. The researchers, whose work appeared in *Psychological Science*, compared eye-gaze times and found that angry individuals fixated nearly 85 milliseconds longer on rewarding images than on threatening images, and 65 milliseconds longer than on neutral images. If anger is a reaction to an event that violates "what 'ought' to be," the authors suggest, the emotion may help a person resolve a situation by focusing attention on the desired (rewarding) solution.

Science Stats | TRIMMING THE FAT

Elective weight-loss surgeries (including gastric bypasses) for patients diagnosed with obesity increased tenfold between 2000 and 2007 in England.



SOURCE: E.M. BURNS *ET AL/BRITISH MEDICAL JOURNAL* 2010

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“Drivers should be aware that one’s attention is drawn away from current tasks by overhearing someone on a cell phone.”
—LAUREN EMBERSON, PAGE 13

In the News

STORY ONE

Exposure to cold virus linked to obesity epidemic among children

Research may partly explain why kids are getting heavier

By Tina Hesman Saey

Childhood obesity is not only an epidemic, it may be an infectious disease transmitted by a common cold virus, a new study suggests.

Children exposed to adenovirus-36 were more likely to be obese than were children who had no evidence of infection, according to a study published online September 20 in *Pediatrics*. The new study is the latest to link the virus to obesity in people. Recent studies of Korean children and American and Italian adults have shown that obese people are more likely to have antibodies against the virus — a sign of a prior infection — than normal-weight people.

Adenoviruses are among the many viruses responsible for causing colds and stomach ailments in people.

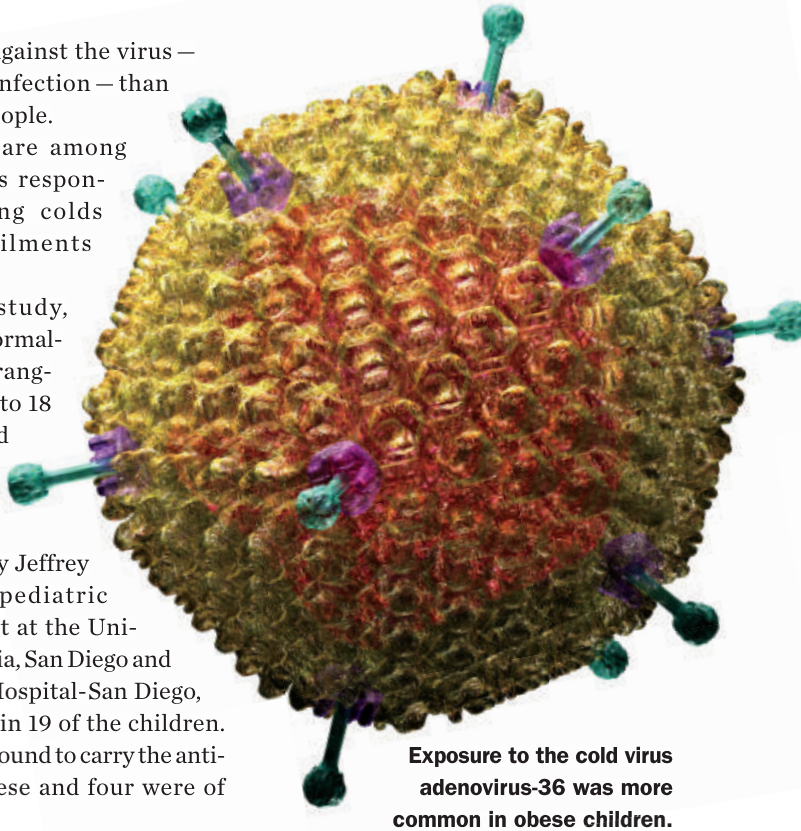
In the new study, 67 obese and 57 normal-weight children ranging in age from 8 to 18 had their blood tested for antibodies against adenovirus-36. Researchers led by Jeffrey Schwimmer, a pediatric gastroenterologist at the University of California, San Diego and Rady Children’s Hospital-San Diego, found antibodies in 19 of the children. Of those children found to carry the antibody, 15 were obese and four were of normal weight.

Not only were obese children more likely to have antibodies to the virus — 22 percent of obese children had the antibodies compared with 7 percent of normal-weight kids — but obese kids with evidence of previous adenovirus-36 infections were about 35 pounds heavier on average than obese children who hadn’t caught the virus.

“That’s enormous,” says Richard Atkinson, an endocrinologist at Virginia Commonwealth University in Richmond and founder of Obetech, a company that tests for antibodies against adenovirus-36. Atkinson also holds a patent on a vaccine against the virus.

The new work bolsters evidence from previous studies in both animals and people showing that adenovirus-36 is associated with obesity, Atkinson says. Chickens, mice, rats and monkeys infected with the virus all get fat even though the animals don’t eat more or exercise less than they did before they were infected (*SN: 8/5/00, p. 87*). Experiments on human cells in laboratory dishes explain how the virus promotes weight gain — adult stem cells infected with the virus make more fat cells, and those fat cells store more fat than normal (*SN: 8/25/07, p. 115*).

The timing is right for adenovirus-36 to be one factor stimulating the obesity epidemic, Atkinson says. The virus, one of 55 different types of adenovirus, was

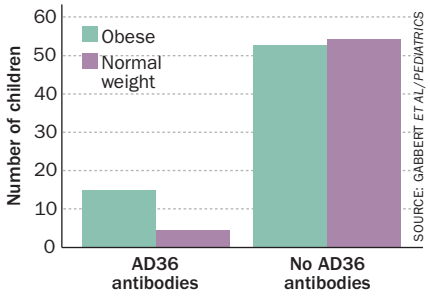


Exposure to the cold virus adenovirus-36 was more common in obese children.

R. KIGHTLEY/PHOTO RESEARCHERS, INC

Viral burden In a study, children who had been exposed to adenovirus-36 were more likely to be obese than normal-weight.

Obesity and exposure to AD36



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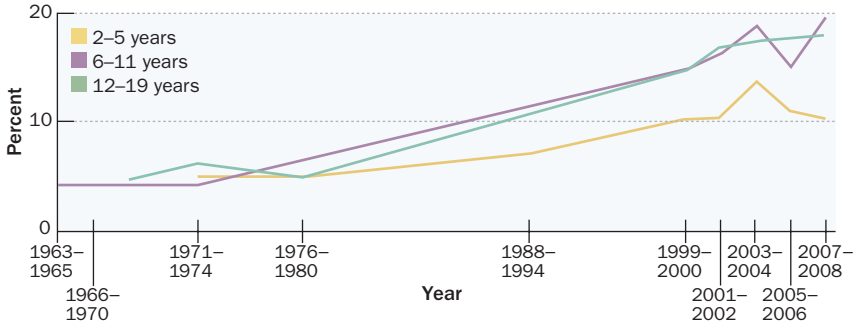
U.S. childhood obesity rates



Kids getting bigger
Health surveys by the U.S. Centers for Disease Control and Prevention have documented a steady rise, beginning around 1980, in the proportion of children ages 2 to 19 who are obese.
SOURCE: CDC

first isolated in the late 1970s. Obesity rates began to climb at about the same time, with the Centers for Disease Control and Prevention documenting increases starting around 1980.

About 30 percent of obese adults carry antibodies against adenovirus-36, while about 10 percent of normal-weight people do, Atkinson and others have shown.

The 10 percent of lean people with antibodies against the virus may have gotten infected recently and not yet gained weight, or they may have had a mild infection that never reached fat cells, Atkinson speculates. He discounts two studies that failed to show a link between the virus and body weight on the basis of those studies' methods — one involved military subjects, for example, who have incentives to control their body weight.

The new study may encourage other investigators to look to viruses as an additional factor contributing to obesity, especially in the developing world where television and computers aren't as prevalent but obesity rates are increasing as fast as in the United States, Atkinson says. "It gets real hard to explain their fat without McDonald's and Game Boys, et cetera," he says of places such as Thailand, where more than 15 percent of children are obese.

Still, studies demonstrating a link between adenovirus-36 and obesity don't provide evidence that the virus causes people to gain weight, Schwimmer says.

"I don't think we know enough to say, 'Oh, if you get this virus you're going to be obese.' Nor can we say, 'If you do all the right things this virus won't matter,'" says Schwimmer. "We just don't have the data to be able to honestly and accurately predict the outcome with any fidelity."

Even if adenovirus-36 does prove to increase body weight, overweight people need not be quarantined.

"You can't catch obesity from a fat person," Atkinson says. By the time a person becomes obese, the virus is long gone and the person is no longer infectious. "It's the skinny person with a cold you have to watch out for." ■

Back Story | AN EPIDEMIC OF HYPOTHESES

Obesity has risen dramatically in the United States and many other countries during the past 30 years. A combination of increased calorie intake and decreased physical activity is the most obvious explanation, but other factors may play a role as well. A team of researchers led by David B. Allison of the University of Alabama at Birmingham considered some of those possible contributors in a 2009 paper in *Critical Reviews in Food Science and Nutrition*, including these:

Older mothers
Studies have shown that the offspring of older mothers are more likely to be obese; birthrates have increased since the 1970s among women 30 and older.

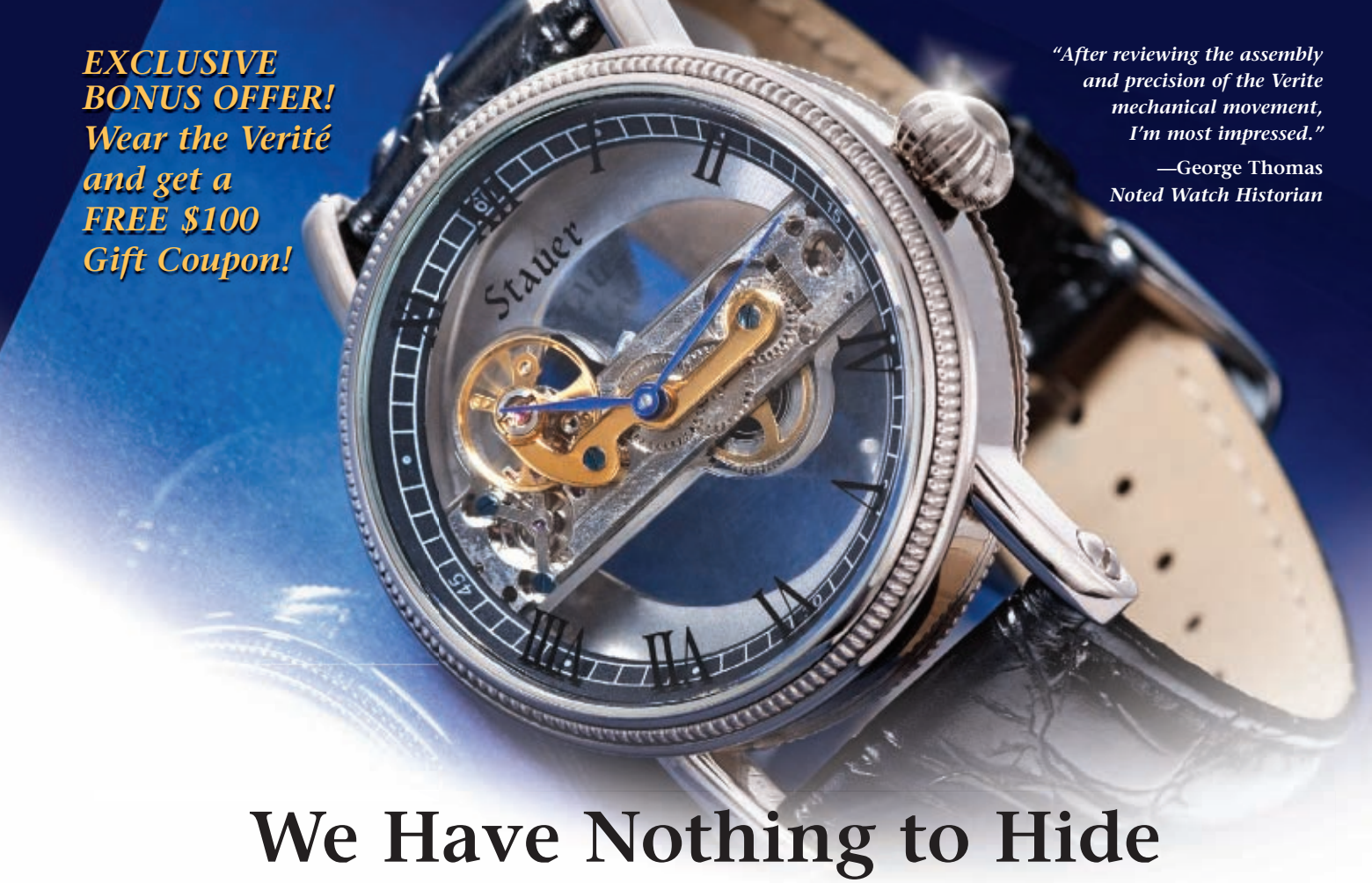
Air-conditioning
It takes energy both to keep cool in hot weather and warm when the mercury drops. Some researchers have proposed that increasingly climate-controlled lifestyles have made people soft in more ways than one.

Medication
Certain antidepressants, birth control drugs and other medications that have become more common in recent decades produce weight gain as a side effect.

Less sleep
Sleep deprivation leads to metabolic changes that foster weight gain; epidemiological data suggest that sleep duration has fallen steadily over the past century.

Environmental contaminants
The increase of endocrine-disrupting chemicals in the environment over the past few decades has raised a number of concerns, including the possibility that the compounds might interfere with hormones that regulate metabolism.

I. HOOTON/PHOTO RESEARCHERS, INC



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Craters tell tales about moon's past

Orbiter data help scientists analyze history of lunar surface

By Camille M. Carlisle

The moon's face can hide its age but not its past.

Data from NASA's Lunar Reconnaissance Orbiter describe a moon with a more complex history than previously thought and highlight what could be the oldest lunar regions, planetary scientists report in the Sept. 17 *Science*. Two papers present measurements of the chemical composition of the moon's surface, and a third details findings from a comprehensive crater catalog. The results support previous theories about the moon's past and suggest targets for future missions.

Craters' density and arrangement can help scientists determine the age of a planetary body's surface. In general, fewer craters mean a younger surface, because fewer meteorites have had time to hit it. Scientists have linked crater density to age for locations on the moon using radiometric dating of samples from Apollo missions. Ages for other surfaces can be estimated by comparing their crater numbers with the numbers in dated regions.

The problem with this method is that old lunar surfaces can reach what is called "saturation equilibrium" — for every new crater formed by a meteorite, an old one is erased. But one of the new papers puts saturation equilibrium to good use. Researchers surveyed lunar craters and compared the catalog with theoretical models of how impact features interact as they accumulate, explains study coauthor Caleb Fassett of Brown University. The predicted saturation densities were similar to densities observed on the moon in two locations: the southern nearside and the north-central farside.

These locations would be targets for future missions seeking the most ancient lunar samples available. "Absolute age dates from new missions to the ancient highlands of the moon will be absolutely critical in tying down what the relative crater densities that we observe mean," Fassett says.

The study also confirms previous work by Robert Strom of the University of Arizona in Tucson and colleagues suggesting that the moon and other solar system bodies have suffered bombardment from two separate asteroid populations. The survey found that the highlands, unlike younger, smooth areas called maria, have a higher density of large craters, indicating that impactors tended to be larger during the moon's early history.

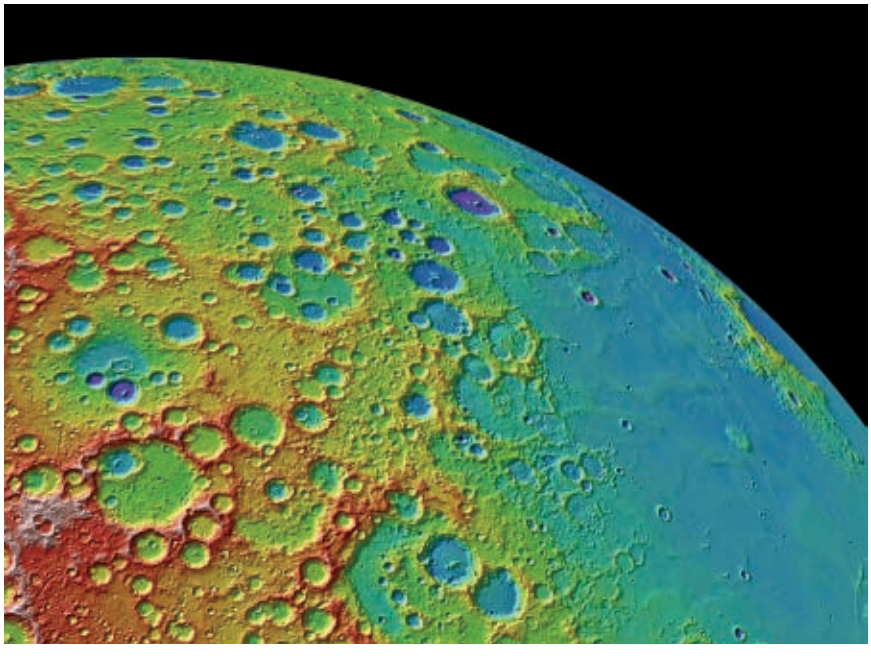
The results match exactly what would be expected if the moon were hit first by objects from the main asteroid belt during a period called the Late Heavy Bombardment, roughly 3.9 billion years ago, and then later by smaller near-Earth asteroids that had been ejected from the belt, says Strom. "It's a very good paper," he says. "This is further confirmation to me that there are two crater populations."

In the two other papers in *Science*, a team reports on silica-rich materials that point to past lunar volcanism. These include silicic materials like quartz, with high silicon and oxygen content.

Highly silicic minerals have never before been directly detected on the moon, says study coauthor Timothy Glotch of Stony Brook University in New York. While astronomers have known since the 1970s that the lunar highlands largely comprise silica- and calcium-rich feldspar minerals, the new data distinguish between different types, such as the known calcium-rich feldspars and newly discovered sodium-rich deposits.

The distribution of highly silicic materials suggests that there were once thick magmatic flows on the moon, with melts spreading above and below the surface.

The prevalence of silicates runs counter to evidence from rock samples brought back by moon missions, in which silicates were rare, says study coauthor Paul Lucey of the University of Hawaii at Manoa. The minerals' commonness raises their importance in understanding the moon's early history.



LOLA/LRO/GSFC/NASA, MIT, BROWN

This image, generated with data from the Lunar Reconnaissance Orbiter, shows the lava-smoothed Oceanus Procellarum (right) and heavily cratered highlands (left).

10 meters | Estimated diameter of asteroid exploding over Indonesia in Oct. 2009

5.56 kilograms | Approximate mass of meteorite striking Ann Hodges of Sylacauga, Ala., in Nov. 1954

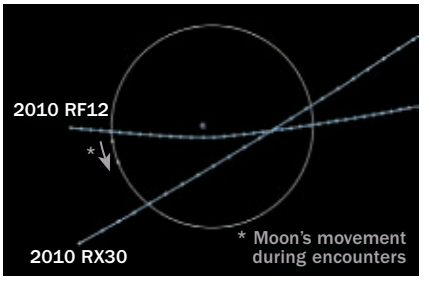
Close encounter fascinates media

Small space rocks often pass within radius of moon's orbit

By Ron Cowen

The only thing that was particularly unusual about two asteroids that zipped past Earth September 8, astronomers say, was that anybody noticed them.

Such approaches inside the moon's orbit — one asteroid passed within 79,000 kilometers of Earth — happen several times a week, scientists calculate. Yet some media outlets reacted as if it were a brush with Armageddon. "Quite frankly, I don't know why they're making such a fuss about it," says astronomer Brian Marsden of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass. "This is essentially nothing."



Two small asteroids passed within the moon's orbit of Earth on September 8.

Astronomers first spotted the asteroids three days before the close encounter, using the Catalina Sky Survey telescope near Tucson, which scans the skies for near-Earth objects. The larger asteroid was estimated to be 10 to 20 meters in diameter, and the smaller 6 to 14 meters across. But subsequent observations by Richard Binzel and Francesca DeMeo of MIT using NASA's Infrared Telescope Facility in Hawaii indicated that the objects were only about half that size.

The discovery of the two space rocks demonstrates that programs like the Catalina survey, designed to find larger near-Earth asteroids with the potential to cause devastating collisions, can also find smaller bodies, Marsden notes.

Mars organics were possibly missed

Viking's tests could have destroyed building blocks of life

By Ron Cowen

Martian soil could contain the building blocks of carbon-based life after all, a new study suggests, despite the negative results of an analysis performed by the Viking missions 34 years ago.

When two Viking landers visited Mars in 1976 and scooped up soil samples, scientists were surprised that the craft failed to unearth evidence of organic compounds. The apparent lack of organic molecules helped cement the notion that Mars would not easily support life.

But a new study, relying on soil samples from Earth, now suggests that the Viking craft may have found organic compounds from Mars but failed to recognize them. The finding represents a sea change in the way many scientists think about Mars and suggests a specific strategy for searching for vestiges of life on the planet, says study coauthor Rafael Navarro-González of the National Autonomous University of Mexico in Mexico City.

Navarro-González and collaborators, including astrobiologist Chris McKay of NASA's Ames Research Center in Moffett Field, Calif., describe their work in an upcoming *Journal of Geophysical Research–Planets*. They also reported the findings September 6 in a press briefing at the National Autonomous University.

The study was inspired by a soil analysis conducted by the Mars Phoenix Lander, which arrived on Mars in 2008. Phoenix found that most of the chlorine at the landing site was in the form of perchlorate, rather than a chloride salt as had been assumed (*SN: 4/11/09, p. 12*).

> "The bottom line ... is that the Viking landers did detect organics on Mars."
>
> CHRIS McKAY

When heated, perchlorate breaks down into fragments that destroy organic compounds. These reactions take place at the same temperatures — 200° to 500° Celsius — to which Martian soil was heated by the Viking craft. The only organic compounds found by Viking, chloromethane and dichloromethane, were interpreted as contaminants from Earth, since they are common in cleaning fluid and explosives.

But when researchers added magnesium perchlorate to soil from Chile's Atacama Desert, known to contain organic compounds, and heated the soil as in the Viking experiments, the same chlorinated compounds were found. Most organic compounds originally in the Chilean soil were destroyed by the heat.

Similarly, the team says, the soil at the two Viking sites probably contained plenty of organics that were destroyed upon heating and were turned into chlorinated methane compounds due to the presence of perchlorate.

"The bottom line of this work is that the Viking landers did detect organics on Mars, we just did not realize it," McKay asserts. He and his colleagues estimate that Martian soil contains a few parts per million of organics, comparable with the driest parts of the Atacama Desert.

But astrobiologist David Des Marais of NASA-Ames cautions that scientists can't be sure that the desert soil closely resembles the Martian soil. And inorganic compounds in the Chilean samples could alter the nature of the materials released during the heating process, he notes.

NASA/JPL-CALTECH

Environment

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Arctic melt third highest since '79

This year's sea ice minimum reflects polar warming trend

By Alexandra Witze

The verdict is in on this year's Arctic sea ice melt: third worst since satellites began keeping track of the northern polar cap in 1979.

Satellites and scientists continually monitor the Arctic Ocean's skin of ice, which melts back in summer and expands again in winter. Researchers have watched the seasonal ice decline with increasing alarm, especially after the summer of 2007 brought a record-breaking minimum. Ice extent recovered a bit in 2008 and 2009, but the long-term trend is unmistakable.

On September 15, the National Snow and Ice Data Center in Boulder, Colo., announced that this year's ice apparently reached its minimum five days earlier, when it covered 4.76 million square kilometers. At its summer low, ice has covered less than 5 million square kilometers in three of the past four years — an arbitrary cutoff, but an indicator of how the entire ice ecosystem appears to be changing.

How much sea ice remains each year depends on a complex mix of factors including atmospheric patterns, ocean and air temperature and winds (*SN: 6/19/10, p. 22*). This August, for instance, high pressure over the Beaufort Sea meant that ice began breaking up rapidly there compared with the previous month.

By at least one measure, this year's minimum wasn't that surprising. The Study of Environmental Arctic Change program runs an informal "sea ice outlook" in which people predict how much ice they think will be left at the end of the season, and why. This year's predictions — 16 from scientists, two from the general public — ranged from 2.5 million to 5.6 million square kilometers. Average the estimates and you get a mean of ... 4.8 million square kilometers, almost exactly what has been seen. ■

Natural gas dominates Gulf plumes

Microbes are degrading easily digested hydrocarbons first

By Janet Raloff

The plumes that formed in the Gulf of Mexico's depths this spring and summer in the aftermath of the BP oil well blowout were actually only about one-third oil, scientists estimate, with the remainder consisting of natural gas.

In June, marine microbes were primarily feeding on propane and ethane gases in the plumes, researchers report online in *Science* September 16.

"We estimate that there's about two times as much gas sitting in those subsurface plumes as there is oil — and there's about a million barrels of oil in them," says David Valentine of the University of California, Santa Barbara, speaking by phone from a National Oceanic and Atmospheric Administration research vessel in the Gulf.

Chemists had been trying to estimate how much oxygen might disappear as microbes degraded BP's spilled oil. It turns out that the oil is only part of the issue. "Probably 66 to 75 percent of the oxygen loss — maybe even a bit more — will ultimately come from bacterial metabolism of the gases," Valentine projects.

Microbes were not consuming much methane, a gas molecule that is biochemically much harder to crack than propane and ethane. That suggests that the most digestible components of the plumes were the first to be attacked by microbes.

The new research "is quite solid and something people will be taking seriously," says Benjamin Van Mooy, a chemical oceanographer at the Woods Hole Oceanographic Institution in Massachusetts. He was part of a team that recently reported finding substantial undegraded oil in the Gulf's deep-sea plumes.

Van Mooy expressed surprise at the amount of gas that the new report measured in the plumes. But then again, he adds, "It's amazing how little we still know about what's down there," especially regarding the gases contained in the spill plume. "This is the first paper that really takes that issue head-on."

Another team has used a new technique to provide what may be a more accurate estimate of the total release of oil from the damaged well. By following the movement of billows in the plume visible in two snippets of seafloor video, Timothy Crone and Maya Tolstoy of Columbia University gauged the minute-by-minute flow of oil. Their projected total — 5.2 million barrels by the well's shutdown on July 15 — appears online in *Science* September 23. The figure slightly exceeds an earlier federal estimate.

***Deepwater Horizon*'s spill leaked large amounts of natural gas, a study finds.**

D. VALENTINE/UCSB

One big concern since the initial discovery of deep-sea hydrocarbon plumes has been what will happen to oxygen concentrations near the seabed. Some scientists have questioned whether fish-suffocating dead zones might develop. But a September 7 federal study looked for evidence of such oxygen deprivation in zones affected by plumes and found none.

"It's amazing how little we still know about what's down there." —BENJAMIN VAN MOOY

Streetlamps turn bird duds into studs

Young male blue tits that sing earlier attract more females

By Susan Milius

Nesting near a streetlight brightens the chances of philandering for young male birds.

Among birds called blue tits residing in a forest on the outskirts of Vienna, a yearling male often fathers at least one illicit chick if he nests within 50 meters of a lamppost, says Bart Kempenaers of the Max Planck Institute for Ornithology in Seewiesen, Germany.

Among blue tits, nesting near artificial lights gets males singing earlier in the morning, giving youngsters an edge in seducing a neighbor's mate.

In dark nests in the woods, though, roving females generally overlook youngsters in favor of older males, Kempenaers and his colleagues report in a paper to be published in the Oct. 12 *Current Biology*.

The young males' strange success may come from a quirk linked to light pollution, the researchers suggest. Males near night lighting start singing on average about three minutes earlier during the dawn chorus of birdsong than naturally lit birds do, the team found.

That doesn't sound like a long time, but a female taking a quick break from her usual mate often visits a neighbor for only a matter of minutes. Kempenaers' previous work has shown that early serenading has extra appeal for wandering females.

"Birds are very sensitive to light cues," says Michael Murphy of Portland State University in Oregon. His own studies of eastern kingbirds in North America found that large males that sang early were especially successful in fathering chicks with other males' mates.

From an otherwise unattractive male's point of view, streetlights must be great. But Kempenaers says he doesn't have data on what will happen to the blue tit population as a whole if artificial light inspires many females to mate with males that would normally be shunned.

Unlike noise or noxious chemicals, light gets ignored because it's "a gentle form of pollution," he says. But he predicts that its effects on reproduction are widespread among species.

Streetlights affect blue tit females too, the researchers found. In nests near lights, females started to lay eggs an average of 1.5 days earlier.

A growing body of research documents that artificial light is a disruptive pollutant for wildlife, says biogeographer Travis Longcore, science director of The Urban Wildlands Group in Los Angeles.

Warming throws off cuckoo timing

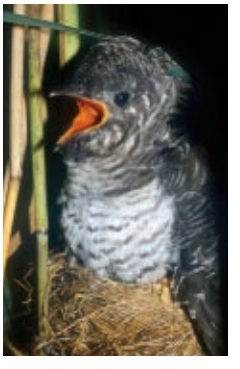
Birds fool a different species mix when spring comes early

By Susan Milius

Warming temperatures in parts of Europe may be knocking local cuckoos out of sync with some of their usual targets for illicit egg laying. Cuckoos swoop in on the nests of other bird species and lay eggs. After hatching, a cuckoo chick kills its foster siblings and hogs food for itself.

In parts of Europe that have warmed since 1990, the common cuckoo, *Cuculus canorus*, appears to be shifting its laying away from species that don't migrate or that travel a short distance each year, says Anders Pape Møller of the University of Paris South in Orsay. Cuckoo lineages are known to specialize in fooling different host species, including some that travel far and some that stay close to home. Now an increasing proportion of cuckoo eggs end up in the nests of long-distance migrants, Møller and his colleagues report online September 15 in *Proceedings of the Royal Society B*.

The trend is so strong, Møller says, that he wouldn't be surprised if some cuckoo lineages specializing in short-distance migrants face extinction in a matter of decades.



In a warming climate, cuckoo chicks menace a different set of victims.

Changing migration patterns are driving the shift, Møller argues. Cuckoos fly from Europe to sub-Saharan Africa for winter. By the time they return in spring, early warming has pushed year-round residents and short-distance travelers too far along in their nesting to be good targets.

"Mistiming is a worldwide trend" with climate change, says evolutionary ecologist Naomi Langmore of the Australian National University in Canberra.

In parts of Europe where spring temperatures have risen the most, cuckoos have targeted 73 species of short-distance migrants less, the new study finds. In contrast, the birds have focused more on 49 species that migrate longer distances.

FROM TOP: FRANKDREBIN/WIKIMEDIA COMMONS; CSABA MOSKAT

Body & Brain

0.43 seconds — Travel time of a 95-mph fastball

0.208 seconds — World record for fast-draw shooting

0.2 seconds — Typical button-pushing reaction time

Action games cut reaction times

Players gain an advantage in processing sensory inputs

By Bruce Bower

Don't tell that guy blasting rampaging zombies to smithereens in his favorite video game that he's getting lessons in efficient decision making. Wait until he's done to deliver this buzzkill: Playing shoot-'em-up, action-packed video games strengthens a person's ability to translate sensory information quickly into accurate decisions, say psychologist Daphne Bavelier of the University of Rochester in New York and her colleagues.

Action-game players get tutored in detecting a range of visual and acoustic evidence that supports increasingly speedy decisions with no loss of precision, the team reports in the Sept. 14 *Current Biology*. Those who have practice with quick decisions — say, killing zombies attacking from haphazard directions in a shifting, postapocalyptic landscape — pump up powers of what researchers call probabilistic inference, Bavelier proposes.

In one of several experiments, Bavelier's group tested 11 men who reported having played action video games at least five hours a week for the past year and 12 men who reported no action video game activity in that time. Participants in each group averaged 19 to 20 years of age.

Men in both groups looked at dot arrays on a computer screen and had up to two seconds to indicate with an appropriate keystroke the main direction each set of dots was moving. Arrays ranged in difficulty, with some having almost all dots moving in the same direction and others having slightly more than half the dots moving in the same direction. Action gamers responded faster than nongamers to dot arrays at all difficulty levels, while still detecting dots' direction as accurately as peers did.

Some gamers may have superior probabilistic inference skills to begin with, but Bavelier says her other findings indicate that playing action games amplifies an ability to analyze sensory information.

A growth chart for young brains

Score tracks development of neural connections over time

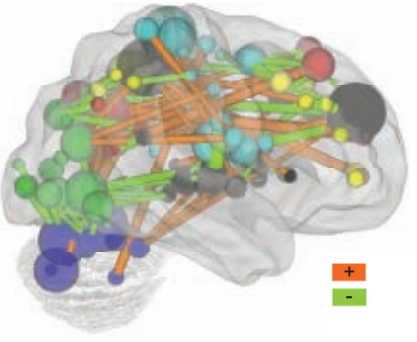
By Laura Sanders

Researchers have created a growth curve for the brain similar to the height and weight charts pediatricians use to monitor their growing patients' development.

A study in the Sept. 10 *Science* shows how a typical brain's connections evolve with age. The information could help doctors detect and treat a variety of brain disorders — many of which are marked by disordered neural connections.

Researchers led by Nico Dosenbach and Bradley Schlaggar of the Washington University School of Medicine in St. Louis constructed the brain maturity curve using data from 238 volunteers ages 7 to 30. Each subject spent about five minutes quietly resting while a magnetic resonance imaging machine recorded patterns of blood movement in more than a hundred different brain regions.

The researchers fed the information for each person into a computer, which spit out a score reflecting the subject's "brain age." This score was based on how activity in each region of the brain correlated with the activity in all the other regions. In this way, the researchers described the properties of brain connectivity for each of the 238 subjects and constructed a curve showing how this score goes up over the years.



As the brain matures, some long-range links tend to get stronger (orange), while shorter ones weaken (green).

"If you take your kid to a pediatrician, they plot their head circumference or their height or their weight on a curve," Schlaggar says. "What we've done here is made a growth curve, but in this case, each point reflects the aggregate of 200 different dimensions. We can say, 'This is the scan of somebody who has a maturity index of 0.8,' and have a pretty good idea that they are in a normal distribution for their chronological age."

The strength of connections doesn't necessarily increase as the brain matures, but the score does. One reason the score changes is that links between brain regions that are physically close to each other weaken with age, while certain long-range connections tend to strengthen.

Connections involving two particular regions — the right anterior prefrontal cortex and the precuneus — were the best predictors for overall brain maturity, the team found. The prefrontal cortex is important for sophisticated cognitive control, including regulating behavior, adapting to new tasks and planning for the future. The precuneus is known to be a major hub for relationships between separate brain regions.

The researchers don't see brain scans becoming a routine part of a pediatric checkup. "That will only happen when the cost of clinical scanning becomes similar to what it takes to measure someone's weight," Schlaggar says. "And that won't happen anytime soon."

SCIENCE/AAAS

Humans

11 percent | Proportion of U.S. drivers using a cell phone at any given daytime moment

16 percent | Proportion of U.S. traffic fatalities linked to distracted driving

Why cell phone talkers are annoying

Unpredictable 'halfalogues' distract unwilling eavesdroppers

By Bruce Bower

They're everywhere — yammering on the subway, yukking it up on sidewalks, yakking away in restaurants. It's the invasion of the cell phone–slinging, superannoying attention snatchers!

Cell phone users irritate so mightily because their background chatter forcibly yanks listeners' attention away from whatever they're doing, says psychology graduate student Lauren Emberson of Cornell University. Overhearing someone spewing intermittent exclamations into a handheld gadget lacks the predictability of hearing a two-way exchange and thus proves inherently unsettling, Emberson and her colleagues report online September 3 in *Psychological Science*.

That uncertainty makes it harder to focus on one's own task at hand, be it reading a book, contemplating a work presentation or driving a car, the team proposes.

The new results raise the possibility that drivers operate vehicles poorly not only while talking on cell phones (*SN: 3/13/10, p. 16*) but also when passengers gab on the devices. Further research will look for such an effect in people operating driving simulators.

"Drivers should be aware that one's attention is drawn away from current tasks by overhearing someone on a cell phone, at least in our attention-demanding lab tasks, and that this effect is beyond conscious control," Emberson says.

Overhearing a whole conversation does not divert listeners' attention, the investigators assert.

Their findings appear relevant to real-world behaviors, remarks psycholinguist Benjamin Bergen of the University of California, San Diego. Individuals who overhear cell phone chatter often try to guess what the unheard talker has just said or thought, contributing to distraction, he proposes.

"I bet people are often trying to fill in the blanks when they hear half of a conversation," he says.

Cell phone talkers' louder-than-usual voices may also divide others' attention, suggests psychologist David Strayer of the University of Utah in Salt Lake City.

Emberson's team had 24 college students perform two attention tasks both in silence and while hearing each of three types of speech played through headphones — two women talking to each other on cell phones in a dialogue, a woman talking on a cell phone to an unheard person in a "halfalogue" and a woman recapping a cell phone conversation in a monologue.

One attention task involved keeping a mouse-controlled cursor as close as possible to a moving dot on a computer screen. Volunteers tried to maintain focus on specific visual cues, a skill needed for driving a car, Emberson says.

The average distance participants kept the cursor from the moving dot spiked for a fraction of a second after they heard each utterance in a halfalogue. No corresponding increases appeared in any of the other conditions.

A second task required participants to remember four letters and hit a computer key as soon as possible every time one of those letters appeared on a screen, while ignoring other letters. Volunteers had to deploy attention selectively and respond quickly when necessary, much like drivers reacting to traffic signals.

Accurate identification of the specified letters declined slightly but to a statistically significant extent during halfalogues compared with the other conditions. ■

Molecules

"It's kind of like taking puzzle pieces and throwing them up in the air and them coming down assembled." —MICHAEL STRANO

Harvesting light the way plants do

Team develops a recipe for self-assembling solar cells

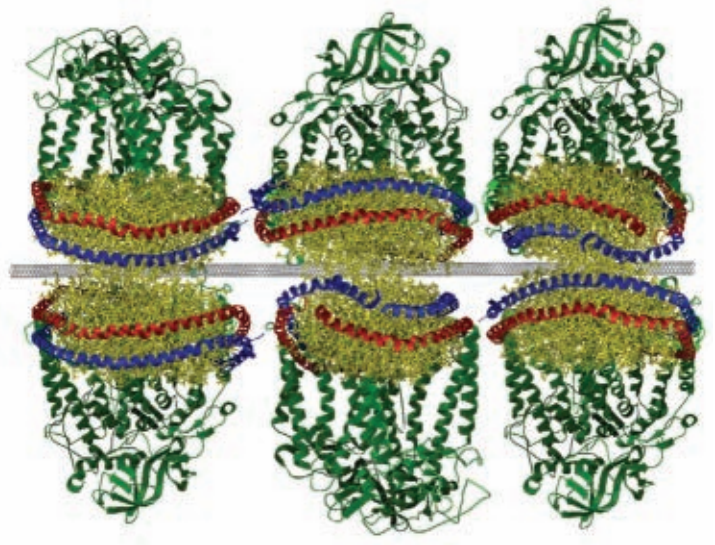
By Rachel Ehrenberg

A new technique may one day lead to solar cells that bring themselves together like a molecular flash mob and can repair damage sustained during the rough business of turning light into electricity.

The research lays the groundwork for cheap, self-repairing solar cells with an indefinite lifetime, a team reports September 5 in *Nature Chemistry*.

"It's a man-made version of what nature does," says nanomaterials expert Jaime Grunlan of Texas A&M University in College Station. "This really looks like groundbreaking, seminal work; I've never seen anything remotely like it."

Chemical engineer Michael Strano of MIT, Stephen Sligar and Colin Wraight of the University of Illinois at Urbana-Champaign and their colleagues began with light-harvesting reaction centers from a purple bacterium. Then the team selected some proteins and lipids for structure and carbon nanotubes to conduct the resulting electricity.



Scientists made light-harvesting complexes out of bacterial photosynthetic reaction centers (green), lipids (yellow), proteins (red, blue) and carbon nanotubes (gray bar).

M-H. HAM *ET AL./NATURE CHEMISTRY*

These ingredients were added to a water-filled dialysis bag — the kind used to filter the blood of someone whose kidneys don't work — with a membrane that only small molecules can pass through. The soupy solution also contained sodium cholate to keep all the ingredients from sticking together.

When the team filtered out the sodium cholate, the ingredients self-assembled into a unit, capturing light and generating an electric current.

The spontaneous assembly occurs thanks to the chemical properties of the ingredients and their tendency to combine in the most energetically comfortable positions. The proteins act as scaffolding, wrapping around the lipid to form a little disk with the photosynthetic reaction center perched on top. These disks line up along the carbon nanotube, which has pores that electrons from the reaction center can pass through.

"It approaches what happens in biology," Strano says, "forming a huge amount of order with the flip of a switch. It's kind of like taking puzzle pieces and throwing them up in the air and them coming down assembled."

Cockroach brains can kill bacteria

Insect extracts active against antibiotic-resistant microbes

By Rachel Ehrenberg

Cockroaches may be nasty bugs, but they could help fight even nastier ones. New research finds that the rudimentary brains of cockroaches and locusts teem with antimicrobial compounds that slay harmful *E. coli* and MRSA, the antibiotic-resistant staph bacterium. The work could lead to new compounds for fighting infectious diseases in people.

Extracts of ground-up brain and other nerve tissue from the American cockroach, *Periplaneta americana*, and desert locust, *Schistocerca gregaria*, killed more than 90 percent of a type of *E. coli* that causes meningitis and also killed methicillin-resistant staph, microbiologist Simon Lee reported September 7 at the Society for General Microbiology meeting at the University of Nottingham in England.

Lee and colleagues, all from the University of Nottingham, crushed body parts from lab cockroaches and locusts and incubated the ground-up bits for two hours with different bacteria. Leaving these mixtures overnight on petri dishes revealed that extracts from the brains of both bugs and from locust thorax nerve tissue killed nearly all of the bacteria.

Nine molecules appear to be responsible for the antimicrobial activity in locust tissue, though they have yet to be identified. The team is also still working out the details of the cockroach compounds.

Genes & Cells

"There's a great deal of disease that … we can't explain just using genetics." —MICHAEL SKINNER

Markers on DNA linked to obesity

Epigenetic tags may influence disease risk, study suggests

By Tina Hesman Saey

Chemical modifications to DNA may affect the activity of key genes involved in regulating body weight, a new study finds, raising the possibility that scientists could discover environmental factors beyond calorie intake and exercise that influence a person's size.

The study, published in the Sept. 15 *Science Translational Medicine,* is also the first to demonstrate that these chemical modifications to DNA are specific to an individual and may affect a person's risk of developing common diseases. Referred to as epigenetic, these changes don't alter the genetic information itself but the way genes are turned on and off.

Studying epigenetics may help scientists learn more about the causes of disease, says Michael Skinner of Washington State University in Pullman, who was not part of the new study. "There's a great deal of disease that is directly influenced by the environment that today we can't explain just using genetics," he says.

In the study, researchers from Johns Hopkins University in Baltimore worked with colleagues in Iceland to map a type of epigenetic change known as methylation in DNA samples taken 11 years apart from 74 Icelandic people. Methylation generally turns off nearby genes.

The team surveyed about 4.5 million spots on the genome of each person and determined how much DNA at each location carried methylation marks. The amount of methylation varied among people at 227 spots, dubbed variably methylated regions.

Of the 227 locations, 119 had the same amount of methylated DNA both times they were measured in all 74 people. Others changed over the 11-year period, presumably as nongenetic factors such as diet, age and chemical exposures varied.

To determine whether the methylation signatures found in the Icelandic people are associated with disease, the team compared each person's body mass index to the amount of methylated DNA at each spot where methylation did not change over time.

The team found four locations where more highly methylated DNA correlated with larger body mass. Obese people had more heavily methylated DNA at those regions than did people of normal weight. The four variably methylated regions are in or near genes that have previously been linked to obesity or diabetes.

One of the genes, *PRKG1,* has been shown to be involved in foraging behavior in nematodes. "You can't help but wonder whether it also sends you to the refrigerator," says Andrew Feinberg, a geneticist at Johns Hopkins who led the study.

The researchers don't know whether the epigenetic marks help cause obesity or are a side effect of weighing more. But future studies may show how genes and the environment interact to determine disease risk.

"As a concept, it's a very full road map for those researchers who want to study complex diseases that may have an epigenetic component," says neuroscientist Schahram Akbarian of the University of Massachusetts Medical School in Worcester. ■

Doing their bit by not doing their bit

Loafers can do a community good, yeast experiments show

By Tina Hesman Saey

Cheaters may not only prosper, but they can also make life better for everyone else, a study of cooperation in yeast reveals.

Published online Sept. 14 in *PLoS Biology,* the study shows that mixed communities of hardworking yeast and loafers can actually outgrow cultures in which all yeast contribute equally.

In the study, yeast cultures were grown in broth containing sucrose as a food source. To eat sucrose, yeast first have to use an enzyme called invertase to slice the sucrose molecule into more easily digestible glucose and fructose molecules.

In the wild, invertase producers live alongside yeast that don't make the enzyme and have to rely on others to cut up their food. Most models of cooperation would predict that these mixed cultures would not fare as well as communities of purely enzyme-producing yeast. But researchers found that flasks containing a mix of the two types grew faster and denser than ones containing invertase-making yeast alone.

ERIC L. MILLER

A yeast colony with a mix of freeloaders and hard workers can outgrow a colony in which individuals contribute equally.

Two of the researchers, Ivana Gudelj and Ayari Fuentes-Hernandez of Imperial College London, created a mathematical model that explains the puzzling result. Because yeast use levels of glucose, not sucrose, as a way to control how much invertase is produced, colonies of purely enzyme-producing yeast make a lot of invertase and quickly burn through their food supply, ultimately limiting growth. By taking up any extra glucose, cheater yeast limit expensive invertase production, which forces more efficient use of sucrose and steadier growth.

Life

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Native toads find ant invaders tasty

Indonesian amphibian could help control aggressive insects

By Susan Milius

After so many sad tales of invasive species overwhelming hapless natives, scientists have found a native toad in Indonesia that's fighting back.

The common Sulawesi toad turns out to be a prodigious eater of ants, even aggressive invading ones, says Thomas C. Wanger of the University of Adelaide in Australia and the University of Göttingen in Germany. On the island of Sulawesi, the *Ingerophrynus celebensis* toads readily feast on yellow crazy ants, which are colonizing the island as well as other tropical locations.

Yellow crazy ants get their name from their color and their zigzag scurrying, and they reduce the diversity of native ants and disrupt ecosystems. The invaders meet any foe aggressively, releasing noxious chemicals during battle. The Sulawesi toads eat them nonetheless, Wanger says.

During a week of high toad abundance on Sulawesi cacao plantations, test plots hopping with *I. celebensis* had as few as one-third the invasive ants found on plots where fencing kept toads out, Wanger and his colleagues report in a paper released online September 8 in *Proceedings of the Royal Society B*.

The paper could be a first in suggesting that a native toad might control populations of invasive ants, says ecologist Stacy M. Philpott of the University of Toledo in Ohio. "It is a really neat finding," she says.

The researchers speculate that the toads' taste for ants may turn out to be a boon for cacao pest control. About every three months, the toads leave their usual forest home and surge through the cacao plantations to breed in the water of neighboring rice fields.

Feasting toads may help keep ant invaders from crowding out native ants. Other researchers have shown that a rich diversity of native ants helps keep cacao pests and diseases in check.

The hunchback of central Spain

Humped dinosaur pushes back the origin of feathers

By Gwyneth Dickey

A newly described dinosaur species has a strikingly unusual hump on its back and hints of featherlike appendages on its arms. The 130-million-year-old fossil suggests that feathers evolved in more primitive dinosaurs than previously thought, researchers say.

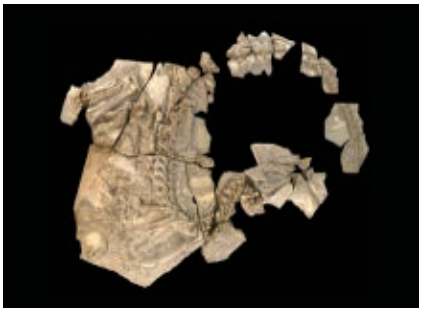
Scientists found the nearly complete skeleton of *Concavenator corcovatus*, which means "the hunchback hunter from Cuenca," at a fossil site in the Spanish province of Cuenca in 2003. The fossil was exquisitely preserved in the dense limestone, which held impressions of the dino's scales. After seven years of painstaking removal, vertebrate paleontologist Francisco Ortega of the Universidad Nacional de Educación a Distancia in Madrid and his colleagues have published the first description of the animal in the Sept. 9 *Nature*.

***Concavenator* may have sported spiky featherlike structures on its forearms.**

Concavenator belongs to a family of dinosaurs known as Carcharodontosauria. These carnivores walked on hind legs, had three main fingers at the end of each stubby arm and ripped through flesh with razorlike teeth.

But the 20-foot-long *Concavenator* fossil sports two features that have never been seen in its family. Two of the dinosaur's vertebrae are longer than the rest, indicating that it had a triangular hump on its back. Humps are fairly common among dinos but usually span more vertebrae, as in the sail-shaped hump of *Spinosaurus*.

Concavenator also has bumps on its forearms that look a lot like quill knobs seen on the wing bones of modern birds. Quill knobs are attachment points for ligaments that support a bird's flight feathers. This could mean that *Concavenator* had featherlike structures on its arms.



The only known fossil of the dinosaur *Concavenator corcovatus* is the most complete carcharodontosaur ever found.

Signs of feathers have been found in dinosaur fossils before, but mainly in species more closely related to birds, says paleontologist Luis Chiappe, director of the Dinosaur Institute at the Natural History Museum of Los Angeles County.

"This is really pushing back, at least from the genealogical perspective, the origin of feathers," Chiappe says.

FROM LEFT: RAÚL MARTÍN; © SANTIAGO TORRALBA

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Bob Vila ranks new 2011 EdenPURE® portable heater #1 in North America

U.S. designed and engineered GEN4 uses new Sylvania heat source and EdenFLOW™ direct air technology

Accept no imitations - portable heaters and fireplaces "dry out" the air with inefficient ceramic heating elements

Bob Vila, America's Favorite Home Improvement Expert,
Canton, Ohio

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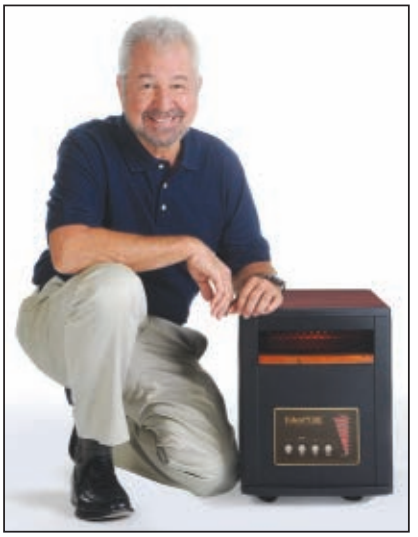

Firemen and safety professionals choose EdenPURE®. We all read about space heaters and the danger of fire. The EdenPURE® has no exposed heating elements that can cause a fire. And your pet may be just like my dog that has reserved a favorite spot near the EdenPURE®. – *Bob Vila*

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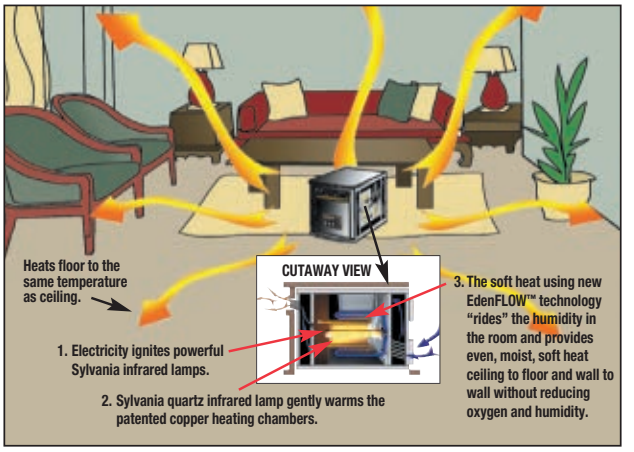

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Unnatural selection

Chemists build proteins with parts not in the typical toolkit

By Laura Beil

Amino acids are the Legos of life — tiny bricks that snap together, forming the proteins on which every function of life depends. With rare exceptions, cells choose from just 20 kinds of Legos. But this is enough for human cells to assemble the more than 1 million proteins they need to function.

A couple of decades ago, a few scientists decided that they wanted to play with more Legos. It began as an exercise in academic curiosity, a way to ask some of the Big Questions about life: Why just 20 amino acids? Why those 20? The researchers began to build artificial amino acids in the laboratory — just to see what cells would do with new construction material, and where the exploration would lead.

Today, scientists have created more than 70 of these "unnatural amino acids" and are using them to reboot the protein-making machinery of bacteria, yeast and even mammal cells — all of which seem to welcome extra choice in their protein assembly. Given the success so far, at least two U.S. biotech companies are now using unnatural amino acids to mass-produce proteins previously unknown in nature, aiming to make new drugs that may one day treat cancer, multiple sclerosis or other diseases.

RALPH VOLTZ

And drugs could be just the beginning. Artificial amino acids could take paths that no one can yet foresee, just as the inventors of nylon in the 1930s could not envision the day when their new material would lead to credit cards and water bottles, says Andrew Ellington, a biochemist at the University of Texas at Austin. "This is going to be a very powerful technology," he says. "We can recast the very chemistry of life."

The protein challenge

Chemists have been making new molecules for centuries, but mostly creating compounds that are small and easy to manipulate. Synthesizing a protein is a formidable challenge — so much so that the 1984 Nobel Prize in chemistry went to the man who mastered it.

Relatively speaking, proteins are enormous: Compared with a typical drug, a single protein could easily be 500 times larger and have mind-blowing complexity. Once constructed, a protein also has to contort itself into a unique three-dimensional shape; without this precise chemical origami, a protein is biologically useless. (The disease cystic fibrosis, for instance, occurs when just one of the body's proteins gets misshapen.)

And once created, proteins are not all that stable: A protein that gets too hot or too cold will radically change its state and function — a property that allows humans the benefits of cooking and distillation. In short, says Peter Schultz, a chemist at the Scripps Research Institute in La Jolla, Calif., "making a protein takes a lot of chemical steps."

In the 1980s, Schultz and others started brewing proteins and inserting artificially created amino acids by hand. These first proteins were painstakingly slow to make, so in the late 1990s researchers started enlisting bacteria. A bacterial cell could incorporate unnatural amino acids into its own proteins. But doing so meant overriding the cell's genetic programming. "You're actually changing the fundamental way genes are read," says Chang Liu, a chemist and fellow at the Miller Institute for Basic Research in Science at the University of California, Berkeley.

The genome, or repertoire of genetic material encoded in the DNA of each cell, contains the instruction booklet for each protein. A gene guides a cell's step-by-step protein creation, dictating which amino acid to use and where to use it. The language of DNA is spoken in chemical bases — adenine, guanine, cytosine and thymine. Each combination of three bases codes for a certain amino acid. When need arises for a protein that has to perform a certain task — say, one vital for muscle movement or breathing — the code is transcribed by RNA, DNA's sister molecule.

Artificial amino acids have rebooted the cellular machinery of bacteria, yeast and even mammal cells.

RNA transfers the code as three-letter "words" written with adenine (A), guanine (G), cytosine (C) and uracil (U), the base substituted for thymine in RNA. These four bases have 64 possible three-letter combinations. For example, UGG is the code for the amino acid tryptophan. UCC is the code for serine. So an RNA sequence of UGGUCC would mean "connect tryptophan, then serine."

Writing new genetic codes for new amino acids posed one fundamental problem: All 64 three-letter words were spoken for. So Schultz and his colleagues zeroed in on one of the few combinations that did not correspond to an amino acid — the sequence UAG. UAG is a genetic punctuation mark; as the protein factory line works its way down the RNA, reading the code, UAG means "stop, the protein is finished."

The Scripps scientists took advantage of UAG's lack of specificity, and reprogrammed the combination to correspond to one of their new amino acids. "We're not changing the DNA," Schultz says. Rather, the researchers give existing DNA new meanings.

The researchers first announced success in 1999 using the bacterium *E. coli (SN: 6/3/00, p. 360),* and in the decade since, Schultz and others have used UAG reprogramming to get artificial proteins not only out of bacteria, but also yeast and the cells of mammals. This February, in the journal *PLoS One*, Schultz's team described getting the tuberculosis bacterium to accept an unnatural amino acid, one of the first important human pathogens to do so. Being able to manipulate the proteins of the tuberculosis germ might allow researchers to better study the organism and develop new vaccines.

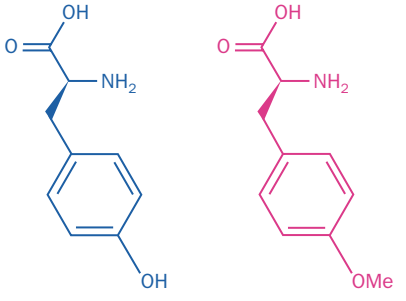
Rewiring UAG has its limits, however. For one thing, scientists can still add only one new amino acid at a time, maybe two. (In addition to UAG, two other codes signal "stop.")

How to trick nature

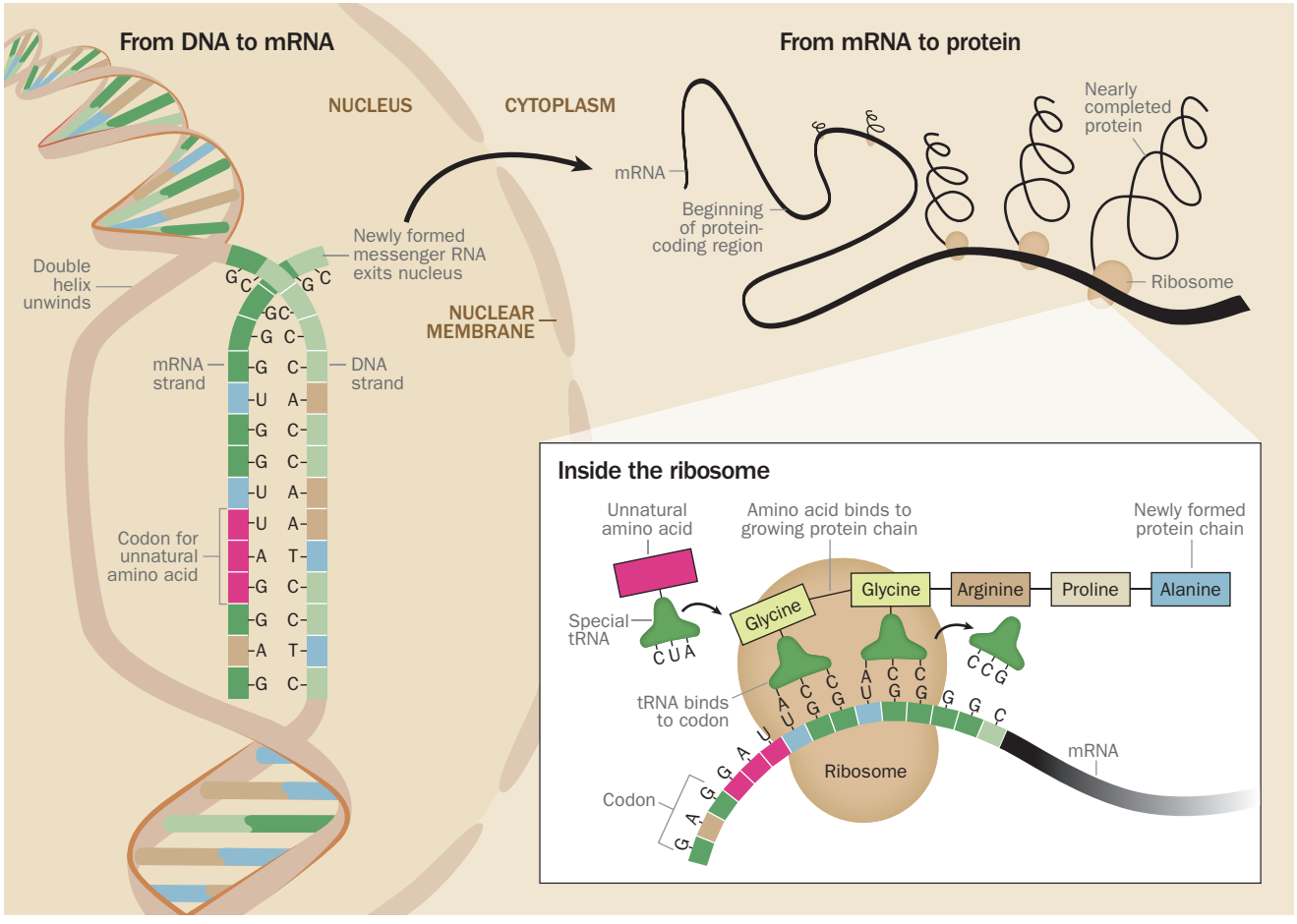
Caltech chemist David Tirrell has devised a different method to get artificial amino acids into proteins. He doesn't reprogram a cell's existing code, but substitutes an unnatural amino acid that closely resembles a natural one. "The cell thinks it's putting in what it's coding for," he says. It would be like swapping a red Lego for a green one with the same size and shape. If the red Lego isn't around, the cell will grudgingly pick up the next closest thing. This method allows a much wider use of unnatural amino acids, but also has certain drawbacks — as you might not always want a green Lego in every spot that calls for a red one.

Molecular geneticist George Church

Code tweaking Naturally occurring amino acids, such as tyrosine, can be modified to make unnatural ones, such as O-methyltyrosine.



Tyrosine **O-methyltyrosine**



Making proteins Cells make proteins—chains of amino acids—by decoding instructions stored in DNA (left). Messenger RNA copies three-letter "words" spelled out by DNA bases and then migrates outside the cell nucleus to ribosomes (inset), which assemble amino acids corresponding to the words spelled out by the code. By reprogramming one word (pink), scientists can trick the ribosome into inserting an artificial amino acid into the chain.

of Harvard University and colleagues described last year in *Nature* still another way to get around genetic programming. His method has the potential to rewrite many three-letter codes at once. Just as different words can signify the same thing—cash, bucks and moola all mean money—most amino acids use more than one code. For example, the sequences GUU, GUC, GUA and GUG all code for the amino acid valine. Church's laboratory has developed technology that can erase duplicate codes—say, GUU—and rewrite them for a custom amino acid. "We can't invent a new set of three letters," Church says, "but we can knock out the ones we want." Once the code loses its original meaning, the scientists are free to rewrite it as they choose.

Now that researchers have shown that altering the genetic code is possible, they must ask themselves whether doing so serves any purpose. After all, the current code is the product of nearly 4 billion years of trial and error. Wouldn't the best amino acids and the best proteins be left standing?

Not necessarily, Church says. For one thing, the current amino acids are the result of natural selection, but humans no longer live in a natural world. The use of unnatural amino acids might allow proteins that can function in totally man-made environments, such as oil refineries. After all, some of the odd forms of life that use a naturally occurring 21st amino acid, one-celled microorganisms belonging to the group Archaea, can exist at the extreme pressures and temperatures of hydrothermal vents on the deep ocean floor.

Many researchers are also hoping that unnatural amino acids can lead to new ways of treating disease. An artificial amino acid can provide an extra "chemical handle" on an otherwise normal molecule, says Ho Sung Cho, chief technology officer of the California biotech company Ambrx (founded in part by Schultz, who is a stockholder). If the molecule has a spot for something to dock onto, researchers can snap on whatever chemical accessory they wish. "It's like adding a USB port," Cho says.

The company is already testing proteins with extra amino acids in human clinical trials. For example, people who must take growth hormone now require daily injections of the medicine because the protein degrades quickly in the body. Ambrx has added a 21st amino acid to its clinical preparation of growth hormone, and says the modified hormone

NATIONAL INSTITUTES OF HEALTH, ADAPTED BY T. DUBÉ WITH ADVICE FROM C. LIU; DNA IMAGE: JOHNWOODCOCK/ISTOCKPHOTO

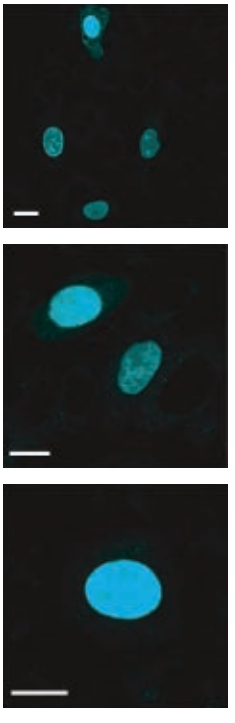
remains biologically active for days. The compound is still undergoing testing in people. But at a 2008 meeting of the International Congress of Endocrinology, Ambrx scientists reported on a study of 22 volunteers that found that an injection of the new version can remain biologically active for at least a week.

The company is working on other molecules incorporating unnatural amino acids, including some that could potentially be used to treat multiple sclerosis and diabetes. Another possible chemical attachment is a toxin hooked to an antibody, which zeroes in on a cancer cell to attack it. This method has long been attractive to cancer researchers , but natural proteins have often been too unstable to reach their target before releasing the toxin, Cho says. The hope is that an unnatural amino acid would allow the molecule to hold together longer.

Drug development

Meanwhile, the Seattle biotech firm Allozyne (founded in part by Tirrell, and using his approach), employs the amino acid substitution method to build a protein that might treat multiple sclerosis. As with the growth hormone modifications, the addition of an unnatural amino acid may help the molecule — in this case, the MS drug interferon beta — last longer in the body, says Ken Grabstein, Allozyne's chief scientific officer. The drug is in safety tests with volunteers who have multiple sclerosis, though the results have not been released.

Like all biologic drugs, those with artificial amino acids raise safety questions: Will the new protein provoke the body's immune system to attack? So far, Grabstein says, animal studies indicate that the body will accept the new drugs, but this and other questions of safety will not be answered until larger studies are underway.



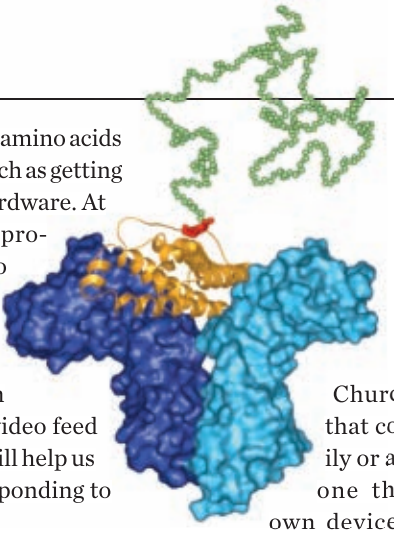
Mammalian cells with a fluorescent unnatural amino acid glow. Scale bars are 10 micrometers.

FROM TOP: AMBRX; C. LIU

Potential uses for artificial amino acids go beyond new medicines, such as getting unusual glimpses of life's hardware. At Caltech, Tirrell is flagging proteins with artificial amino acids as the molecules are made, providing the ability to see what product a cell is making at any given time. It's like having a live video feed of protein synthesis. "This will help us understand how a cell is responding to its environment," he says.

Schultz hasn't abandoned the original mission that intrigued him — learning what, if anything, makes the 20 amino acids that nature provides so special. It's possible that those 20 are the optimal combination. It's also possible that those are, as the late biologist Francis Crick once described it, part of a "frozen accident" that left people with their current genetic code. Perhaps nature settled on those 20 simply because they offered the first combinations that sustained life at all, not necessarily the combinations that work best. Should other forms of life on distant planets use amino acids, the selection might look different.

Scientists know that they are experimenting with some of life's most basic elements. "Is there a reason we shouldn't have unnatural amino acids?" asks Church. "Theoretically, you could say that we could make an organism that would outcompete something in the wild." In other contexts, foreign life has entered natural environments with catastrophic consequences: Asian carp in North American waterways, European rabbits in Australia or kudzu in the American South. Exotic organisms have a history of causing native surroundings to collapse.



An experimental drug made with human growth hormone (gold) also uses an unnatural amino acid (red).

Church doesn't think that could happen easily or accidentally — for one thing, left to its own devices, an organism designed to function with an extra amino acid wouldn't survive if that extra component weren't around. Nonetheless, Church says, "we should do experiments to see what the consequences would be." He plans to undertake those in the next few months, by growing an *E. coli* that requires unnatural amino acids and mixing it with natural strains in laboratory dishes. Most likely, the strain with unnatural proteins won't survive, even if its extra amino acid is available, but Church won't know for certain until the experiment is done.

Schultz already plans to see whether life with 21 amino acids fares differently than it does with the usual 20. By next year, he hopes to be able to breed a mouse whose cells can readily use 21 amino acids in daily life. Experiments on a smaller scale have suggested that organisms with 21 amino acids can, in a kind of laboratory-simulated natural selection, develop proteins with extra functions that give them an evolutionary advantage over proteins with 20.

"The 20 amino acids are ideal for proteins that support all life," says Thomas Magliery, a biochemist at Ohio State University in Columbus. "That doesn't mean they are ideal for all possible things." Scientists have spent the past decade making sets of Legos never previously imagined. It's time now to see what these new blocks will build. ■

Explore more

- C.C. Liu and P.G. Schultz. "Adding new chemistries to the genetic code." *Annual Review of Biochemistry*. July, 2010.

Black hole silhouette

Scientists attempt to image a shadow and its tumultuous ring

By Charles Petit

Black holes are among the most bashful yet flamboyant characters on the cosmic stage. They consume matter so voraciously that the violence can ignite brilliant beacons called quasars, bright enough to outshine entire galaxies. Yet because they prevent light from escaping or even bouncing off, black holes themselves are also the ultimate unseeables.

Astronomers have now drawn up plans to gather an image of something almost as good: a black hole's silhouette. They will do it with a virtual telescope spanning the globe, electronically roping together scores of smaller instruments at observatories that usually operate independently. The new array's magnifying power will exceed that of any telescope or array made so far. Two targets await: the monster black hole believed to reside at the center of the Milky Way, home galaxy to sun and Earth, and an even more massive black hole at the core of a distant galaxy.

"If we get the first image of the silhouette of a black hole, it will be on the cover of textbooks the next year," says Avi Loeb, a member of the team pushing the idea and head of the Institute for Theory and Computation at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass.

A close collaborator of Loeb's, Avery Broderick, has been working on black holes and extreme gravitational fields since he began his studies at New York's Stony Brook University, and then at Caltech. Now at the Canadian Institute for Theoretical Astrophysics in Toronto, he sees a rare chance to add observations to a field that has been almost all theory. "It is essentially critical to show that black holes really exist," Broderick says. "We don't know that they do. It has become so common to talk about them. Their existence is the simplest assumption to make. We couldn't test it, so we internalized it as fact."

Black hole shadows would look like bull's-eyes in space. Surrounding each circle of darkness would be a thin ring of brilliant radiation — a spray of photons briefly caught in orbit around the black hole itself. Flaring farther out, distorted and warped by the light-bending nature of spacetime near a black hole, would be a billowing, billion-plus degree plasma heated by internal friction as its particles orbit and jostle at high speeds.

The plasma's shimmers and flares should carry answers to mysteries of how black holes consume such white-hot, flattened whirlpools of matter, known as accretion disks. If expectation meets reality, the plasma's source would be the disk's hot inner edge, the innermost stable circular orbit for matter. Inside that, atoms and particles fall irretrievably toward the point of no return: the black hole's actual edge, what physicists call the event horizon.

The sight should open scientists'

By studying light around a black hole, scientists may determine how fast it spins (examples from models shown).

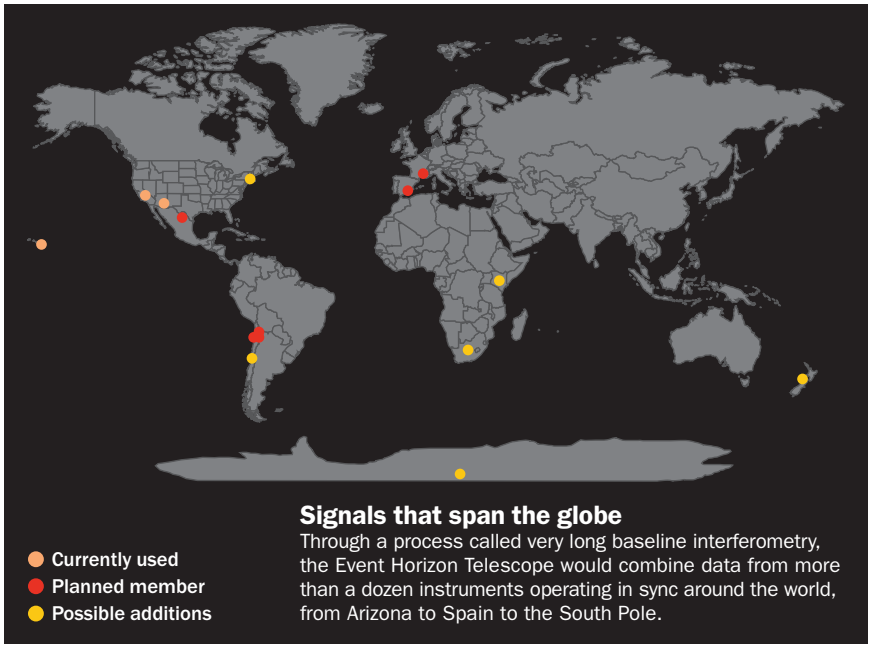
A. BRODERICK

eyes wide to long-discussed mysteries. What are the processes by which the twisting magnetic fields caught in such maelstroms manage to expel, in powerful jets, a portion of the shattered stars, planets, dust and gas drawn toward the black hole's grasp? Does a black hole even behave as theory suggests? By witnessing extreme gravity at work — from hundreds to hundreds of thousands of times stronger than gravity at Earth's surface, slowing time and warping space so that even photons can go into orbit around a black hole — humankind might see behavior that does not obey the predictions of the general theory of relativity. It would mark the first refutation of Albert Einstein's theory, and would offer guides toward more complete, truer laws of the universe.

The group has given its dream machine a name: the Event Horizon Telescope. The hope is to put it in operation some time around 2020.

"It would only cost a few tens of millions of dollars, not really so much at all," says Sheperd Doeleman of MIT's Haystack Observatory. Doeleman and 22 of his colleagues last year sent a white paper to a National Research Council committee that listed, as part of a decadal review, priorities for public astronomy funding (*SN: 9/11/10, p. 10*). Compared with the billions of dollars for space telescopes and the hundreds of millions for large conventional devices on the ground, the price is small change. In August, the Event Horizon Telescope was included by the review committee in a list of smaller but worthy projects. That is no guarantee federal agencies and Congress will actually provide any or all of its costs, but so far, so good.

This Arizona dish will operate alongside others in the Event Horizon Telescope.



Signals that span the globe
Through a process called very long baseline interferometry, the Event Horizon Telescope would combine data from more than a dozen instruments operating in sync around the world, from Arizona to Spain to the South Pole.

One scope from many

For the money, the project promises the highest resolution in the history of astronomy. It would bring distant objects into focus 5,000 times more clearly than the Hubble Space Telescope can.

Makers of telescopes have two basic ways to get a very sharp focus and thus the ability to see small details at great distance: Make the telescope wider (or the distance greater between instruments that make up the overall device) or shorten the wavelength at which it operates. Better yet, do both.

Astronomers proposing the telescope plan to use the whole Earth as a platform. And because of a fortunate break, one specific class of telescopes already spread out widely on the planet can operate at just the right wavelengths — from 0.8 to 1.3 millimeters — between the far infrared and microwave regions. This narrow window of radiation not only can provide the focusing power needed for a telescope of such size, but is also where the environs of black holes glow the brightest. Earth's mountaintops and mesas where the observatories sit are just high enough for the select wavelengths to arrive before atmospheric water vapor absorbs and distorts them.

Thus a combination of factors has practically handed astronomers the ingredients needed to examine in detail the region so close to a black hole that its shadow becomes visible. "When nature gives us so many gifts, each of them with small probability, we should accept it gratefully and try to make the best of it," Loeb says.

Doeleman and the team have already published, in *Nature* in 2008, data from a rudimentary form of the telescope array, its instruments working together in a process called VLBI, very long baseline interferometry. The work confirmed that a signal at the core of the Milky Way, dubbed Sagittarius A*, marks the site of an object that packs its 4 million suns' worth of mass in such a tiny volume that conventional physics says it must be a black hole. But there wasn't enough detail to directly confirm that the object is a black hole.

For the preliminary system, the team combined signals from a 10-meter telescope dish in the White Mountains of eastern California with the 15-meter James Clerk Maxwell Telescope on Mauna Kea in Hawaii and yet another 10-meter instrument on Arizona's Mount Graham.

FROM TOP: REDMAL/ISTOCKPHOTO, ADAPTED BY E. FELICIANO; DAVID A. HARVEY/STEWARD OBSERVATORY/UNIV. OF ARIZONA

The next stage, to prove the object is a black hole, will come upon glimpsing directly a ring of violent churnings around the shadow in the middle. To do so, Doeleman's team envisions as many as 100 metal dishes working together. Each resembles a giant, silvery satellite TV receiver. Some are individual units as much as 50 meters wide. Others are themselves in tight arrays of smaller receivers spread across high-altitude locales. In perfect sync they would, on different continents, turn for hours or even days to gather photons from the Milky Way's whirling heart.

Chief among the intended additions is ALMA, the Atacama Large Millimeter Array, with 64 dishes, each 12 meters across, now being deployed in the high Atacama Desert in Chile. One of the world's great new observatories, backed by an international consortium, ALMA would provide a strong signal to act as orchestra director for blending data from other, distant instruments. Also on the list are a 50-meter instrument in Mexico, a 30-meter dish in Spain, a set of six 15-meter detectors in the French Alps, additional French and German installations in the Atacama Desert, a 10-meter job at the U.S. South Pole Station, plus others. To fill in gaps, further stations may be promoted in Africa, New Zealand or even the Himalayas.

New equipment must be installed at each dish or array to handle the flood of data. Just one observation session by each station would produce one gigabyte of data per second, or roughly about 22 terabytes each day. In three years the group expects to have seven stations taking in more than 700 terabytes in a five-day campaign, almost 10 times the amount of information stored in the Library of Congress' digital holdings. With the Chilean ALMA array on line, the data requirements will explode to 6,000 terabytes per campaign.

No imaginable link from remote mountaintops permits live telemetry of such a torrent. Astronomers will physically pull eight-pack cartridges of disk drives from the data recorders. "We'll mail them," says Doeleman. "You can't beat the bandwidth of a 747 packed with hard drives." Aircraft will take the drives to Boston's Logan Airport for shipment on to the Haystack Observatory for processing.

To take the signals from multiple instruments, each changing its distance from the source as the Earth rotates, and blend those signals as though they all were hitting a single receiver will take exquisite timing. Hydrogen maser clocks at each station will place timing ticks on the disk drives with a precision that loses or gains less than a tenth of a billionth of a second per day.

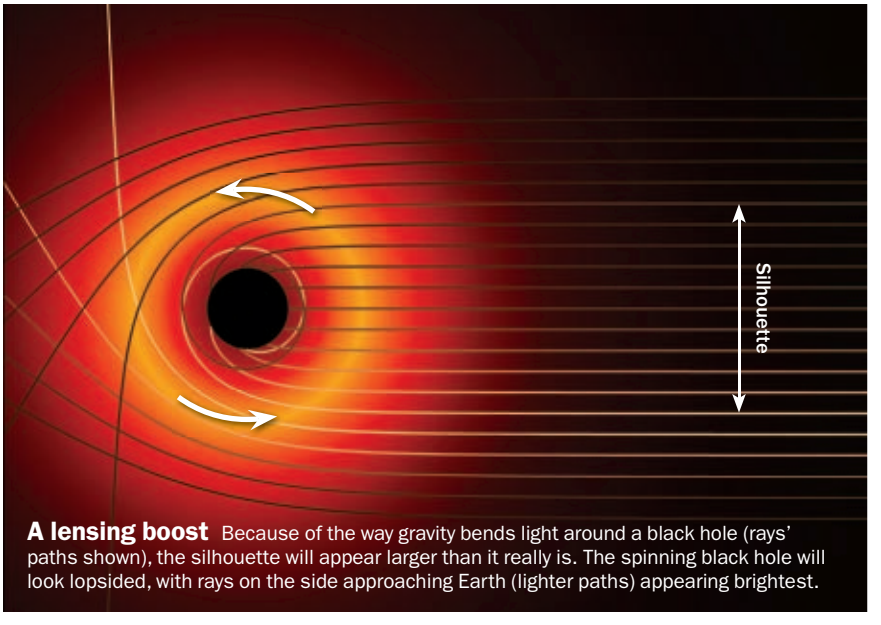
At the other end of the data stream will be the black hole itself.

The Milky Way's heart

Sgr A* (pronounced Sadge A-star) has, if theory is correct, an event horizon about 24 million kilometers in diameter — small enough to fit inside Mercury's orbit of the sun. Some 26,000 light-years away, the black hole's spot in the sky is about 20 microarcseconds across, about one part in 10 billion of a circle, or about the apparent size as seen from Earth of one of the golf balls Alan Shepard whacked and left on the moon in 1971. And the innermost stable circular orbit around the black hole, the brightly glowing edge of the accretion disk, will be about three times wider.

The focusing power of the telescope: about 20 microarcseconds. That may seem a bit coarse to make out much detail, but the telescope's designers are counting on a big break from general relativity. Light will not come out straight from Sgr A*'s accretion disk but will bend as the powerful gravity warps time and space. Thus while the black dot, the "silhouette" the telescope array will see, is real enough, astronomers don't expect much of the light from near it to reach Earth in a straight line. Most that gets here will have arisen just behind the black hole, swing wide around it, and then bend toward Earth. The result is a gravitational lens. The optical illusion will make the black hole silhouette appear more than twice as big as it actually is.

One specific payoff of seeing Sgr A*'s accretion disk should be a more precise measure of the black hole's spin, which can have profound relativistic effects on the geometry of space and the flow of time in the immediate neighborhood. Already, astronomers know that light and other radiation output from Sgr A* can vary rapidly, indicating outbursts and flares of energy release, presumably as knots of matter work their way to the interior of the accretion disk. The spin of a black hole, by twisting nearby space in a process called frame dragging, alters how closely matter can stay



A lensing boost Because of the way gravity bends light around a black hole (rays' paths shown), the silhouette will appear larger than it really is. The spinning black hole will look lopsided, with rays on the side approaching Earth (lighter paths) appearing brightest.

A. BRODERICK

in stable orbit. By revealing those orbits, the Event Horizon Telescope can tell what the black hole's spin, or angular momentum, is. With zero spin, the closest stable orbit should have a period of about half an hour — while if the black hole has its maximum permitted spin, hot spots could race around it in as few as four minutes.

Many other black holes are nearer than Sgr A*. But all are leftovers of collapsed, individual stars and are far too tiny — perhaps 30 kilometers across — for even the new telescope to see. Far beyond the Milky Way, however, a monstrous black hole seems ripe for inspection. It is in the heart of the M87 galaxy, a blob of stars more than 50 million light-years away — about 2,000 times farther than Sgr A*. M87's core ejects a powerful beam of matter and radiation, a jet that extends for thousands of light-years. It can be seen going in only one direction, like a rocket that seems to have shoved the entire black hole itself slightly away from dead center. The spectacle makes it a natural laboratory for studying the full panoply of black hole physics. A primary hope is to get a look at how some of the material and energy approaching its equator turns 90 degrees and jets out of the system's pole at near light speed.

Astronomers in the 1990s calculated from the speeds of gas clouds near M87's core that it has a mass of about 3 billion suns, 750 times that of Sgr A*. That was already enough to make it among the most massive black holes known. Then last year Karl Gebhardt of the University of Texas at Austin and a German colleague took into account the effects of unseen dark matter surrounding the galaxy. The team reported in June 2009 in Pasadena at a meeting of the American Astronomical Society that the mass of M87's core is more likely to be a whopping 6.4 billion suns, well over 1,000 times that of Sgr A*.

The event horizon diameter of the black hole in the middle of M87 would be correspondingly larger, too — perhaps twice Pluto's farthest distance from the sun. Knots of material orbiting Sgr A* are likely to circle it every hour or less. By contrast, visible changes around gigantic M87's black hole will probably take days to weeks to transpire, permitting more leisurely, detailed study.

"General relativity has passed all tests before with flying colors. But only in weak fields, like near the sun."
DIMITRIOS PSALTIS

Einstein to the test

Some scientists are already angling for time on the new instrument. Among them are astrophysicist Dimitrios Psaltis and graduate student Tim Johannsen, both of the University of Arizona in Tucson. They want to watch photons — particles of light — that go into orbit around black holes and then eventually spray away into space, scattering off material falling toward the event horizon. The exact shape of the ring of light created around the black hole's shadow should allow a check on one of the odder implications of Einstein's general theory of relativity: the no-hair theorem. And the ring's appearance may tell science that once again Einstein got it right — or not.

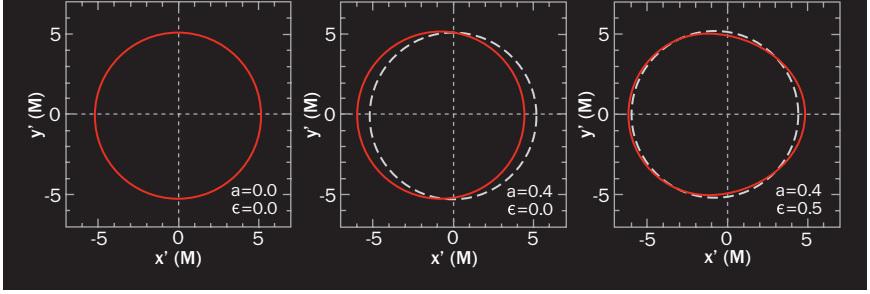
The no-hair theorem states that a black hole can be entirely described in the outside universe, no matter what has gone into it, by its mass and the accumulated angular momentum, or spin, of all it has absorbed. (Technically, it may also have electric charge, but physicists see no way for large black holes to accumulate significant net charge from galactic gas and dust.) "No hair" means nothing else, whether material or force field, sticks out beyond the event horizon. And spin and mass imply a specific distortion of space and time — in turn defining what the radius of the light ring around the black hole should be and how the ring's appearance will be distorted to outside view.

If the ring looks exactly as Einstein's theory says it should — almost perfectly circular when one corrects for the warping of dimensions near a black hole, and influenced only by the mass and the spin of the black hole — then general relativity will have continued its string of triumphs. If not, says Psaltis, "we will have exciting things to think about."

Asked if he really wants to disprove Einstein, he paused. "General relativity has passed all tests before with flying colors. But only in weak fields, like near the sun. At some level, everyone believes Einstein must not be correct. His theory says that inside the black hole, everything collapses to nothing, to zero. Other physical theory," he said, referring to quantum mechanics, "says this cannot be correct. Something is clearly wrong. Something must give way.

"At a black hole, the fields are like nothing anywhere else. It is the breaking point for physics as we know it." ■

Meeting expectations
The shape of the photon ring around a black hole allows a check on general relativity. The rings (red) at left and middle both fit with theory, though they belong to black holes with different spins. The photon ring at right does not fit theoretical predictions.



D. PSALTIS, T. JOHANNSEN

Explore more:

- See a special Hubble feature on black holes: http://hubblesite.org/explore_astronomy/black_holes

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BBB ACCREDITED BUSINESS

ImPerfect mimics

Reprogramming may not produce exact embryonic stem cell replicas

By Tina Hesman Saey

Pod people may look a lot like the real thing, but — as the fictional town of Santa Mira finds out in *Invasion of the Body Snatchers* — they are disastrously different. The same may be true for reprogrammed stem cells.

These cells are designed to mimic embryonic stem cells and are grown in lab dishes by researchers, not pods by aliens. But scientists now worry that reprogrammed cells, like the duplicates that invaded Santa Mira, may not be wholly satisfactory replacements.

New research suggests that important differences may separate the two kinds of cells. Such differences could impair the ability of reprogrammed cells to make other cell types, which doctors hope to use to repair diseased and damaged tissues. Other limitations of the reprogramming process could leave transplanted cells more susceptible to diseases such as cancer, some scientists fear.

Every lab has its own recipe to convert mature skin and blood cells to a reprogrammed state — and comparisons show that some of these procedures work better than others. Time and patience, one study finds, may help erase lingering differences between the superbly flexible embryonic stem cells and their lab-made substitutes.

Not like the other

Embryonic stem cells are pluripotent, meaning they can become any type of cell. But isolating stem cells destroys the embryo from which they come, raising ethical concerns and funding barriers.

In 1996, the Dickey-Wicker Amendment banned federal funding for research that harmed human embryos. President George W. Bush allowed researchers to work with a small number of existing human embryonic stem cell lines, and President Barack Obama later opened research on newly created lines, provided they were made with private money. Now a federal court is in the midst of deciding whether Obama's policy violates Dickey-Wicker.

When scientists learned that a few proteins could reprogram a skin cell into a cell that appeared indistinguishable from a stem cell (*SN: 11/24/07, p. 323*), there was great hope that the ethical considerations swirling around embryo-derived stem cells could be bypassed. Many expect that research on these new induced pluripotent stem cells, or iPS cells, might eventually lead to replacement tissue for sick and injured patients, no embryo needed.

"There's a fever to make progress and translate this into clinical applications," says bioinformaticist James Cooper of the University of California, Santa Barbara.

Teams have already made iPS cells from skin and blood cells and then coaxed those iPS cells into becoming heart muscles and brain and spinal cord neurons (along with other cell types) in the lab. Eventually, scientists would like to transplant tissues grown from these cells into the body to replace tissues damaged by heart attacks, accidents or diseases such as Alzheimer's.

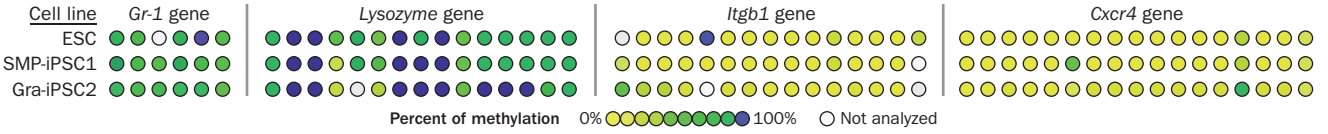
Reprogramming offers another possibility: Researchers could revert skin cells from people with a disease into iPS cells and then study the development of that disease in a petri dish.

But these hopes all bank on the premise that reprogrammed stem cells are as versatile and safe as embryonic stem cells. And niggling differences are making some scientists question that assumption.

Recent studies show that reprogrammed stem cells carry a molecular

Scientists are starting to question whether reprogrammed stem cells (colony shown) can fully forget their past.

WILL COLLINS, DEEPAK SRIVASTAVA



Ragtag tagging Chemical tags attached to DNA, called methyl groups, differ between embryonic stem cells and reprogrammed stem cells and between one lab's reprogrammed cell and another's. One study recorded varying methylation patterns on a range of genes (four shown). Colored circles represent the degree of methylation at various sites for an embryonic stem cell line (top) and two induced pluripotent stem cell lines (bottom).

memory of their former identities (*SN: 8/14/10, p. 15*). Working with mouse cells, George Daley of the Harvard Stem Cell Institute and his colleagues showed that stem cells can hold onto the past. Making blood is harder for former skin cells than for reprogrammed cells from bone marrow (where blood is made), the team found.

Daley and his colleagues reported online July 19 in *Nature* that this reluctance to switch jobs is linked to chemical tags attached to DNA. The tags — in this case methyl groups — help to shut down genes as a cell develops an identity. A heart cell, for instance, will turn off genes needed to make liver, brain and skin cells.

Reprogramming should strip away the chemical tags, like dish detergent dissolving grease, leaving the resulting stem cells wide open to take on any identity, scientists had thought. For the most part, that's true. But some residue seems to stay behind.

"Considering all the hoops that iPS cells have to go through, it's amazing that they get as close as they do," says UCLA cell biologist William Lowry. Still, his team has also found small differences between reprogrammed stem cells and embryonic stem cells — this time in the pattern of genes that are turned on and off.

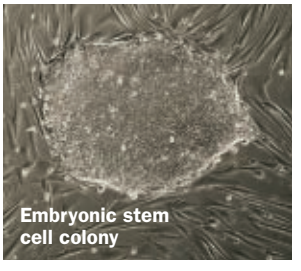
Despite the differences, there are no consistent markers that peg a cell as being an iPS or embryonic stem cell, says Richard Young, a geneticist and molecular biologist at the Whitehead Institute and MIT in Cambridge, Mass. In a study in the Aug. 6 *Cell Stem Cell*, Young and colleagues report that chemical tags on DNA-associated proteins called histones are remarkably alike between the two types of stem cells.

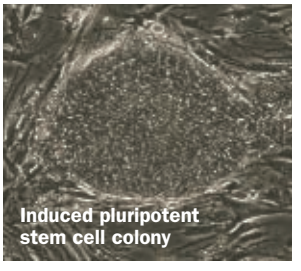
Young and others are trying to find the best way to evaluate reprogrammed stem cells to determine if they really have reverted to a pluripotent condition. "We need to know if we ever get to this fully reprogrammed embryonic stem cell state," he says.

A better recipe

Figuring out the details of why iPS and embryonic stem cells differ could help scientists reprogram cells more fully.

In another study in the Aug. 6 *Cell Stem Cell*, Lowry's team reanalyzed data from several labs and showed that some reprogramming methods are better than others at creating reverted cells that mimic embryonic stem cells.





Cooper and Aaron Newman, also from UC Santa Barbara, report in the same issue of *Cell Stem Cell* that gene activity profiles of both iPS cells and embryonic stem cells vary depending upon the lab in which they were created.

Just as one pastry chef can transform flour and butter into a flaky pie crust while another — with the same ingredients — comes up with tough dough, labs and the people who work in them may have little tricks to move stem cells in the right direction.

"You want to make the secret sauce to get the cells to do what you want them to do," Cooper says.

Perhaps scientists just need to find the right recipe to eliminate the differences. One missing ingredient may be time, according to a report in the August *Nature Biotechnology*.

Many of the differences between reprogrammed and embryonic stem cells disappear the longer the cells are grown in lab dishes, report Konrad Hochedlinger of Massachusetts General Hospital in Boston and the Harvard Stem Cell Institute and his colleagues. The reprogramming process could take several rounds of cell division to completely wipe away memories of a cell's former identity, Hochedlinger says. "It tells us that you should give the cells some time before using them for any practical purposes."

Despite efforts to fully reprogram cells, scientists don't yet know what the consequences of differences would be. One worry is that reverted skin cells clinging to former identities may make proteins that interfere with a new career. Confused identities might push transplanted cells away from their mature state, bringing them one step closer to becoming cancerous. Incomplete reversion could also make it harder to tell whether defects identified in disease studies using iPS cells are caused by a genetic problem or by proteins left over from a cell's former life.

But even if scientists can't create a perfect embryonic stem cell replica, they may make something that's close enough. "If it is safe and it does what you want it to do, maybe it doesn't matter if there are 100 genes differentially expressed," Lowry says. ■

Explore more

- Stem cell information from the National Institutes of Health: http://stemcells.nih.gov/info/basics

FROM TOP: J.M. POLO *ET AL*/*NATURE BIOTECHNOLOGY* 2010; JEANNE LORING

The Disappearing Spoon

Sam Kean

If aliens ever land on Earth, Kean writes, one of the few things humans could present that might actually be understood by the visitors is the periodic table of the elements. That observation is typical of this quirky, thoughtful and thorough book.

Remembered by many as a daunting chart looming over a teacher's shoulder and typically "less than frickin' helpful" on exams, the periodic table is actually a map, writes Kean, a science journalist. It is a map on which geography is destiny, a map of rivalries and antagonisms, a map that — accompanied by a guide like Kean — can take you through space and time.

From the Big Bang to ancient Greece to Nazi Germany and Gandhi's India, Kean highlights the prominent roles of various chemical elements throughout history. He also reveals their personalities: Gold is aloof, carbon promiscuous and nitrogen an intriguing combination of "plentitude, ineptitude, and importance."

While a map is an excellent metaphor, Kean doesn't guide the reader region by region across the table. Instead, chapters deal with periods in history, such as the Cold War, or a particular theme, such as art or money. These broader ideas reveal how truly elemental the elements are and explain why this chemistry book appeals to nonchemists.

If your most recent glance at the periodic table was in a classroom long ago, have no fear, this book is threaded with plots more often found in love stories or thrillers than in chemistry books, and Kean's enthusiasm and wit carry the reader through spells of heavy lifting.

Even hard-core chemists will undoubtedly learn something new. So might aliens, Kean notes: If they ever glimpse the periodic table, perhaps they'll even "whistle (or whatever) in real admiration." — *Rachel Ehrenberg*

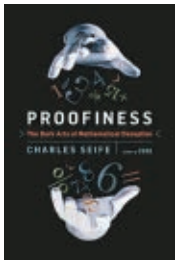
Little, Brown and Co., 2010, 391 p., $24.99.

Proofiness: The Dark Arts of Mathematical Deception

Charles Seife

The 2000 U.S. presidential election should have been decided by a coin flip.

Or so argues Seife, a mathematician-turned-journalist who tackles some of society's biggest math problems in his new book. The race between George W. Bush and Al Gore was, mathematically speaking, too close to call. So, Seife suggests, instead of counting chads, the contested state of Florida should have relied on an age-old procedure for breaking a tie: drawing lots.



Seife is somewhat obsessed with the flaws in the country's electoral system, but he makes an eloquent case that all citizens should be so concerned. What he dubs "proofiness" — the manipulation of mathematics for untrue ends — permeates modern culture.

He gives plenty of examples. One flawed study suggests that women who have had an abortion have a 30 percent increased risk of breast cancer. Another argues that tobacco is a gateway to harder drug use. Statisticians can spend all day eviscerating the math behind these studies, but proofiness nonetheless trickles deep into social policy.

Even mathphobes will appreciate Seife's clear explanations of why polls are so flawed and how risks are routinely exaggerated to justify a particular decision. Seife is trying to do the admirable and the impossible — educate the public so people can understand when they are being manipulated by bogus numbers. If only those doing the manipulation would believe that the public is too smart to be duped. — *Alexandra Witze*

Viking, 2010, 295 p., $25.95.

Much Ado About (Practically) Nothing: A History of the Noble Gases

David E. Fisher

Delve deep into the far right of the periodic table with a chemist who appreciates noble gases' many uses. *Oxford Univ. Press, 2010, 264 p., $24.95.*

How to Mellify a Corpse

Vicki León

Eighty-eight tales tell of science and superstition in the ancient world (including Alexander the Great's mellification, or embalming in honey). *Walker, 2010, 308 p., $17.*

2030: Technology That Will Change the World

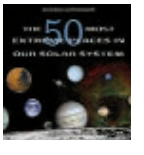
Rutger van Santen, Djan Khoe and Bram Vermeer

A survey of science and engineering breakthroughs that may lead to technological leaps. *Oxford Univ. Press, 2010, 295 p., $29.95.*

Spider Silk

Leslie Brunetta and Catherine L. Craig

Arachnid evolution is woven into this history of one of the strongest natural materials. *Yale Univ. Press, 2010, 229 p., $30.*



The 50 Most Extreme Places in Our Solar System

David Baker and Todd Ratcliff

Tour Earth's hottest, coldest, stormiest and stinkiest neighbors, plus the solar system's weirdest phenomena. *Harvard Univ. Press, 2010, 290 p., $27.95.*

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Musical bonding

In the article "Birth of the beat" (*SN: 8/14/10, p. 18*), Sandra Trehub says that music's evolutionary origins remain unknown. Evolution is the sum of many acts of natural selection, so the question is, what survival advantage did music provide? The mother teaching her infant musical skills wouldn't be so prevalent if survival of musical genes wasn't an advantage.

This was an excellent set of articles. Please keep up the good work, as you have over the 40 years that I've been reading *Science News*.

Bill Hawkins, Bloomington, Minn.

"Birth of the beat" is a fascinating article and supports some of my own beliefs about the importance of music to humans. However, I didn't see the word "father" anywhere in the article! I know I had extensive musical interactions with my infant daughters, both vocally and instrumentally. Have the researchers let their innate bias lead them to ignore half the parenting population?

Rylan Luke, Cupertino, Calif.

Communicative musicality researchers assume that caretakers of either sex can interact musically with babies. Moms are studied because women provide the bulk of active infant care, even if dads get more involved these days. —Bruce Bower

I find the conclusions reached in "Birth of the beat" most unconvincing. Before one studies "music" it is essential to know precisely what music is. This is made difficult by the extremely close connection between music and ordinary speech. Pitch, pulse, rhythm, tempo, volume, dynamics and timbre do not constitute music. They are simply abstracted components of music and, more important, they are components of speech as well. Thus what Stephen Malloch, Colwyn Trevarthen and others may be studying is not so much music as precursors of speech, that is, speech without words. Indeed, one might suggest that music is wordless speech in which the designative content of words is replaced by the emotionally evocative content of organized sound, resulting in a potent form of communication unencumbered by specific meaning.

Furthermore, in the reported experiments, the musical components are served up with too many social cues. Infant responsiveness may be more to the personal interaction than to the "music" itself. In order to study music as such, one should eschew studies involving mother-child relationships and rely on music or musical fragments performed on instruments and presented through recordings.

Stephen E. Silver, Santa Fe, N.M.

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Satyandra Gupta

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We, robot: What real-life machines can and can't do

As director of the Maryland Robotics Center, Satyandra Gupta oversees 25 faculty members working on all things robotic: snake-inspired robots, robotic swarms, minirobots for medicine and robots for exploring extreme environments on land, under the sea and in outer space. In September the Center hosted its first Robotics Day; afterward, Gupta talked robots with Science News *writer Rachel Ehrenberg.*

How do robots influence our lives today?

There are certain scenarios, such as manufacturing — making cars, making airplanes — where people are replacing human labor with robotic devices and the rationale is usually that it is less expensive, quality is consistent, that kind of thing. Then there are certain applications where very few humans can do the task because the skills required are so high.... Surgery would be an example. Let's imagine that there's a very hard-to-perform surgery that very few humans can do. Now if a robot can be trained or even teleoperated by these surgeons, then you would be able to get that performance from that robot.

A third scenario is where humans can do it but it is so dangerous that it doesn't make sense.... Disaster relief, mining — if people get trapped and you want to send somebody in, the situation is often dangerous and rescue efforts can get delayed quite a bit. Another category is in space applications. Sending people to Mars to do explorations, it's just not feasible. You don't have any alternative except to send a robotic vehicle there. Or if you are going to send something to a planet far, far away and it takes, say 10 years to get there and 10 years to get back, it's just not realistic to think about deploying humans.

Also, for example, with prosthetics, these are tasks where no human can be the replacement. If somebody lost a limb and you need to give them an artificial limb, then there's no competition, no human substitute for that, for the capability needed by that person. Similarly when you are looking at a very small airplane doing surveillance, you don't have an option of a human doing that surveillance because, in order for a human to be sitting in there and flying it, the size has to be bigger than a certain threshold. But if you have a very small plane which can do the surveillance for you, then you have all kinds of advantages and maneuverability. So there the robot is not a substitute for the human; the robot gives you brand new capabilities.

A lot of us teach ourselves how to reason, how to think, how to analyze new information.... This has been very difficult for robots to be able to do.

Is it important to have thinking robots?

I think the goal has been to make the robot intelligent.... The idea being that you should be able to give the robot a goal, a mission, and the robot should be able to take actions based on the mission and whatever information becomes available. So that's what people would like, as opposed to programming a robot at a very, very low level that specifies move this way, move that way.

Isn't it hard to mimic what was created by billions of years of evolution?

Yes, at both levels. Mimicking evolution in the physical manifestation is hard. What tends to happen is natural systems have lots of little joints, lots of little muscles which pull and tug and make the motion. And if you start introducing that many joints and that many motors in a synthetic thing, your cost goes up exponentially as complexity keeps growing. At the same time, the reliability goes down. If any single joint fails, your whole thing is going to fail. So that makes it very hard to mimic nature.

On the brain side of things, it is also very, very hard. A lot of us teach ourselves how to reason, how to think, how to analyze new information and make sense of it. This has been very difficult for robots to be able to do. So people will try to program different contexts and different scenarios for what a robot should do, but that way of doing it is simply not scalable. You don't have enough time and manpower to code up all the possible scenarios that a robot would encounter and what it should be doing. People have made very small steps toward reasoning and learning, but in general robots do not yet know how to learn.

Will we ever have to worry about evil robots?

I'm not too worried about that, but I am really worried about the virus part of it. All of us have computers, and there are some people that are intent on infecting our computers with viruses. So in that way, you will have a bad or evil robot. Not that it *thought* and then became bad or evil, but it will be evil because somebody wrote a virus and infected its brain.

Think about it this way: People introduce a virus that can clean out your hard disk, right? Imagine if somebody wrote a virus on a robot and it started punching a hole in the wall.... Because a computer isn't just running the robot's brain. It has a bunch of limbs sticking out, and you can do a lot of damage with those limbs. ■

JOHN CONSOLI/UNIV. OF MARYLAND

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