Your Brain On Rest | Tiny Particles, Big Problems | Supernova Oddball

ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ JULY 18, 2009

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Bad BPA News

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Dirty Stars

Searching for planetary remains in white dwarfs

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— WALTER CUNNINGHAM, APOLLO-7 ASTRONAUT

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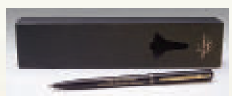

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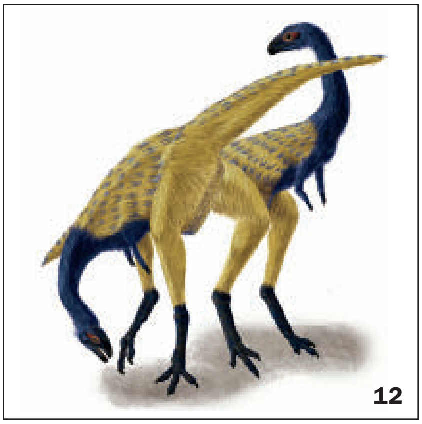

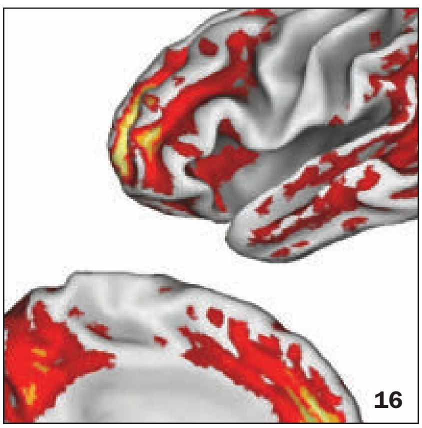

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ScienceNews

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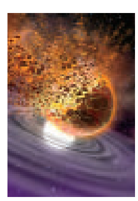
Features

Departments



COVER Scientists accuse a white dwarf of demolishing a rocky exoplanet and trapping its remains, as shown in this artist's depiction. *Illustration by Lynette Cook*

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FROM THE EDITOR

Philosophers don't know what scientists can't do

Among many scientists, philosophers are regarded with suspicion, or even disdain. It has something to do with the way that some philosophers have mistaken their love of knowledge and their power to analyze it as a path to knowledge itself. Most famously, Immanuel Kant believed that a philosopher (him) could figure out that space must of necessity observe the rules of Euclidean geometry. A few decades thereafter, mathematicians showed that other geometries were possible in principle, and ultimately Einstein figured out that space was, in fact, not Euclidean after all. Anyone who disagrees should not be allowed to use GPS devices, which would be wildly inaccurate if not corrected for the effects of Einstein's theory of general relativity.

An equally egregious philosophical faux pas came in the 19th century from the philosopher Auguste Comte, who boldly declared that he knew for sure that there was something that science could never know. "We shall never be able to study, by any method, their [stars'] chemical composition or their mineralogical structure," he wrote in *Cours de Philosophie Positive*.

About the time Comte died, though, spectroscopy began to flourish, discerning the chemical composition of the sun and other stars by identifying precise frequencies of light emitted or absorbed by particular atoms.

Such is often the way science works — by finding ways to acquire knowledge that seems at first glance inaccessible. Today a similar example is emerging in the quest to determine the composition of planets that orbit faraway stars. Space-based telescopes and other endeavors dedicated to that task are in the works. But as freelance science writer Charles Petit describes in this issue (Page 22), clues are already available from the fortuitous chemical signatures found in the white dwarf GD 362.

It seems likely, astronomers studying that star believe, that its atmosphere is polluted by the remains of one of its former planets. Deciphering the identity of the pollutants can therefore reveal what a far-off planet, too distant to study directly, was made of.

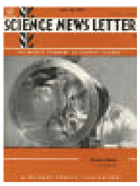
And so science seems to be succeeding in studying not only the chemical composition of a star, but also the mineralogical structure of a never-seen planet. By eating its planet, GD 362 colorfully confirms that Comte should have eaten his words.
—Tom Siegfried, Editor in Chief

Scientific Observations

"It turned out to be a great advantage to have overindulged in mathematics at an early age. [Arnold] Sommerfeld, a theoretical physicist, said math is like childhood diseases: the earlier you have them, the better." **NOBEL LAUREATE DUDLEY HERSCHBACH, AT THE EXCELLENCE IN SCIENCE AND TECHNOLOGY DISCUSSION PANEL ON MAY 12, DURING THE INTERNATIONAL SCIENCE AND ENGINEERING FAIR IN RENO, NEV.**

Science Past | FROM THE ISSUE OF JULY 18, 1959

COMPUTER COULD AID DOCTOR IN DIAGNOSING — A computer that could aid the doctor in diagnosing a disease has been suggested by two scientists.... The machine would store codes for symptoms, diseases and their relationships. Then, in those cases which are particularly hard to diagnose, such as those already in the hospital, the machine would sort out all possible afflictions for the doctor's consideration. Many doctors now believe that most of the errors in diagnosing result from omission rather than any other source. That is, the doctor sometimes simply overlooks a possibility. This machine could assure the doctor that every possibility will be dug out of the "metal brains" of the computer.



Science Future

July 20
Follow as Nature Publishing Group reconstructs the first lunar landing via Twitter. Visit twitter.com/ApolloPlus40

July 23–24
AAAS Science and Human Rights Coalition meeting to be held in Washington, D.C. See shr.aaas.org/coalition

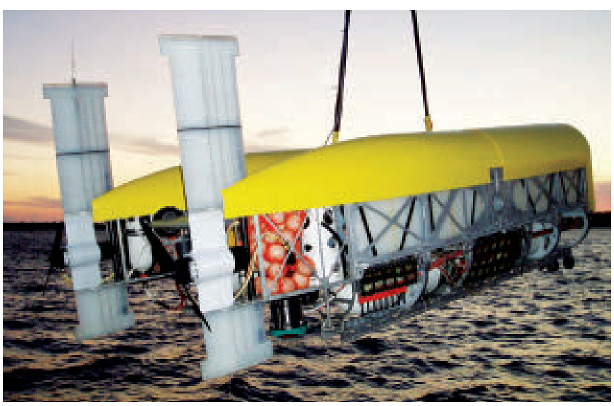
August 16–20
Chemists discuss advances at the American Chemical Society meeting in Washington, D.C. Register at www.acs.org

SN Online
www.sciencenews.org

GENES AND CELLS
Researchers link an enigmatic type of skin cell to the ability to sense light touch. See "A role for Merkels" for story and audio of cell signaling.

LIFE
Female beetles face much risk and little reward when mating with many males. Read "Beetle philandering doesn't work out for the ladies."

MOLECULES
Concrete structures deform over time due to movement of nanosized particles within the cement. See "Shifting nanoparticles cause creep."



The (-est)

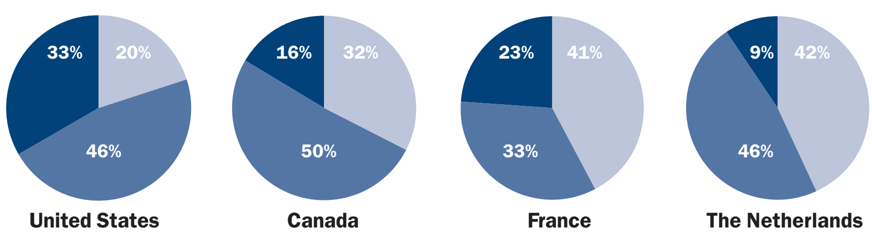
The deep-sea remotely operated vehicle *Nereus* plunged 10,902 meters to scrape seafloor in the Mariana Trench on May 31, making it the deepest-diving vehicle operating today. Researchers from Woods Hole Oceanographic Institution communicated with the robot via a fiber-optic cable designed to withstand pressures at that depth, which can reach more than 1,000 times surface pressure. The trench, located near Guam in the Pacific Ocean, is Earth's deepest known abyss. The U.S. Navy vessel *Trieste* first touched the bottom in 1960, but the trench hasn't been explored since 1998. *Nereus* (shown) shot video and collected biological and sediment samples during the record dive.

Science Stats | HEALTH CARE BLUES

Views of their respective national health care systems among adults with chronic conditions

- System needs complete overhaul
- Fundamental changes needed
- Works well but some minor changes needed

Totals do not include those undecided and nonrespondents and may not add up to 100%



SOURCE: 2008 COMMONWEALTH FUND INTERNATIONAL HEALTH POLICY SURVEY OF SICKER ADULTS

CLOCKWISE FROM TOP LEFT: SOCIETY FOR SCIENCE & THE PUBLIC; LENA RÖNN; CHRISTOPHER GRINER, WOODS HOLE OCEANOGRAPHIC INSTITUTION

“It turns out there were many ways to be a theropod.” — THOMAS R. HOLTZ JR., PAGE 12

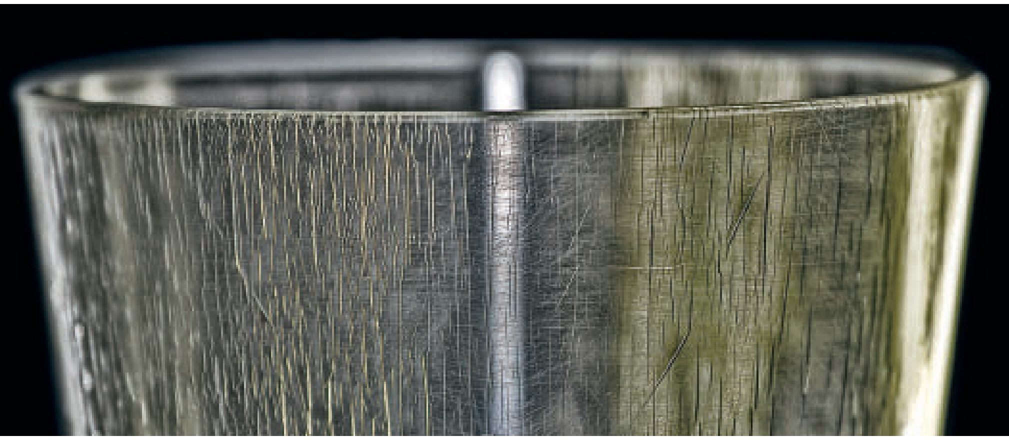
In the News

STORY ONE

Concerns over plastics chemical continue to grow

New studies of bisphenol A measure effects, exposures

By Janet Raloff



Bisphenol A can leach into foods and drinks, especially when polycarbonate cracks, as shown in the cup above.

TRAVIS PAYNE

Women may want to reconsider that popular style accessory, certain hard plastic water bottles available in fashion-coordinating colors. New animal studies link the chemical bisphenol A, which leaches from polycarbonate plastics and food can linings, with heart arrhythmias in females and permanent damage to a gene important for reproduction. Other recent research suggests that human exposure to BPA is much higher than previously thought.

In animals, fetal exposures to BPA can be especially risky, sometimes fostering brain, behavioral or reproductive problems (*SN: 9/29/07, p. 202*). Canada and some U.S. jurisdictions have voted to ban polycarbonate plastic in baby bottles for that reason. But the new heart data suggest that even adult exposures to BPA might cause harm.

In one new study, researchers treated mice with BPA during the middle of their pregnancies. All female offspring of the treated mice suffered an irreversible genetic change in one of the “master regulatory genes” of fertility, Hugh Taylor of the Yale School of Medicine reported in June in Washington, D.C., at the annual meeting of the Endocrine Society.

This gene, *HOXA10*, orchestrates the activity of “hundreds — if not thousands — of downstream genes,” Taylor says. Through the genes it controls, *HOXA10* helps synchronize the timing of uterine changes and ovulation. Without that synchrony, “you won’t get pregnancies,” he explains.

In the mice, the *HOXA10* gene lost a methyl group (a carbon bound to three hydrogen atoms), permanently altering its activity and rendering uterine tissue hypersensitive to the effects of estrogen.

That’s probably not good, Taylor says, because “many diseases we see in adults owe their origins to fetal exposures” — when genes become inappropriately modified.

In another study presented at the endocrine meeting, Scott Belcher of the University of Cincinnati and his colleagues reported that BPA boosted “proarrhythmic activity” in isolated muscle cells from mice and rats.

Arrhythmias, or heartbeat irregularities, are blamed for a higher mortality rate after heart attacks in premenopausal women compared with men, Belcher says.

During pregnancy, vulnerability to heart arrhythmias rises with higher estrogen levels. Belcher’s team found that BPA’s effect on arrhythmia risk was nearly identical to estrogen’s. In whole rat hearts exposed to BPA or estrogen, pockets of cells refused to beat in concert with others, setting up potentially life-threatening arrhythmic events. The problem escalated dramatically when the female hearts were exposed to both estrogen and BPA.

Belcher’s group traced the effect to a certain type of estrogen receptor called the beta form, which is more active (and more abundant) in women. The scientists linked this receptor’s activity to a leading cause of arrhythmias — a leak of calcium from a part of heart cells known as the sarcoplasmic reticulum.

These data suggest that at estrogen levels typically found in premenopausal women, the addition of BPA

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

could spike vulnerability to arrhythmias, Belcher says.

Although a broad host of animal studies have linked BPA to adverse health effects, comparable human data do not exist. Any human risks would also depend on how much BPA actually gets into the body.

To probe one BPA source, Karin Michels of the Harvard School of Public Health in Boston recruited 77 undergraduates to consume all their cold drinks for a week out of stainless steel bottles. The next week, the participants drank from polycarbonate alternatives. Michels' team sent students' urine samples to a lab at the Centers for Disease Control and Prevention to assay BPA levels.

Even in the first week, when drinking from steel bottles, most students showed measurable levels of BPA. Those concentrations rose by 69 percent in the second, polycarbonate week, to 2.0 micrograms per gram of creatinine, a waste product in urine, the team reports online May 12 in *Environmental Health Perspectives*.

"I went in expecting that we're so overwhelmed by BPA from other sources that this one variable would not make a difference," Michels recalls. "But it did."

Studies have indicated that food is the dominant source of BPA for most people and that any of the chemical ingested from food should peak in blood within four hours, then quickly be excreted.

Banning BPA

After Canada banned BPA from baby bottles in 2008, some U.S. states and jurisdictions moved toward passing their own legislation.

Where	Products included in ban	Legislation status
Suffolk County, N.Y.	Children's drinkware	Passed March 2009
Minnesota	Children's drinkware	Effective 2010
Chicago	Baby drink and foodware	Effective 2010
Connecticut	Children's drink and foodware	Effective 2011
California	Children's drink and foodware	Awaiting state assembly vote

However, there are growing suspicions that previous studies have underestimated how long BPA lingers in the body.

"By 12 to 18 hours [after eating], it should be practically gone," says Richard Stahlhut of the University of Rochester Medical Center in New York. "For years that's been almost a mantra."

But when his group looked at residues excreted by 1,469 adults who had fasted before giving urine, there was still about as much BPA excreted 12 to 20 hours after a meal as just five hours after eating, the team reported in the May *Environmental Health Perspectives*.

This finding could mean there are major sources of BPA contamination other than food, Stahlhut says. More likely, he now suspects, a substantial amount of the BPA entering the body may temporarily collect in fat, then slowly empty back into blood before being excreted.

The U.S. Food and Drug Administration estimates typical daily human BPA consumption at roughly 0.1 micrograms of BPA per kilogram of body weight. But when Frederick vom Saal of the University of Missouri-Columbia and colleagues administered 4,000 times that much to 11 rhesus monkeys, BPA blood residues in the spiked monkeys ended up only one-eighth as high as seen in a German study of pregnant women, he reported at the Endocrine Society meeting.

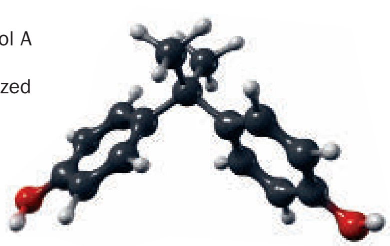
If these monkeys metabolize BPA at rates comparable to people, vom Saal says, then "humans would have to be exposed to over 1,000 micrograms per kilogram per day in order to achieve the kind of [blood] levels that are seen in multiple studies, not just the [German] one."

Based on such data, the House Committee on Energy and Commerce sent a letter on June 2 to FDA Commissioner Margaret Hamburg asking the FDA to "reconsider the Bush Administration's position that BPA is safe at current estimated exposure levels."

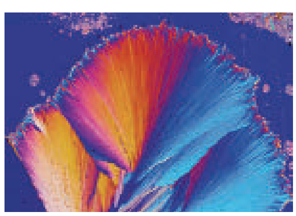
Back Story | BPA: FROM SYNTHESIS TO SUSPECT

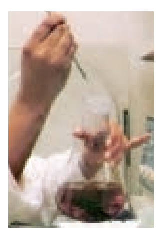
1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000

1891
Bisphenol A is first synthesized (shown)



June 13, 1936
Team reports in *Nature* that BPA can mimic estrogen (micrograph shows estradiol, a potent, naturally occurring estrogen)





June 1993
Paper shows that traces of BPA leaching from plastic labware interfere with endocrinology experiments

2003–04
Federal survey finds BPA in the urine of the entire U.S. population

Since 1993
Evidence builds that BPA can leach from food cans, polycarbonate foodware and dental sealants

FROM LEFT: DR. MARK J. WINTER/PHOTORESEARCHERS; ALFRED PASIEKA/PHOTORESEARCHERS; STANFORD UNIVERSITY; JGROUP/ISTOCKPHOTO

Atom & Cosmos

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

Team finds abundant heavy nuclei in the highest-energy cosmic rays

Iron's presence deepens puzzle about rare particles' origins

By Ron Cowen

BLOIS, France — In the genteel surroundings of the Blois chateau, home to 16th century French royalty, a controversial finding about the highest-energy cosmic rays landed with a thud. If confirmed, the new report could spark a revolution in the way astronomers think about these speedy but rare charged particles, which carry as much oomph as a big league pitcher's fastball.

Scientists have generally assumed that the most energetic cosmic rays are primarily protons. Heavier nuclei such as iron are more easily accelerated to high energies because of their greater electric charge, but heavy nuclei are also more fragile. Collisions with photons left over from the Big Bang or with intense infrared radiation from stars, for example, can easily break the nuclei into lighter particles.

"Ask anybody what are the highest-energy [cosmic ray] particles, and they'd say 'protons,'" says physics Nobel laureate James W. Cronin of the University of Chicago. But, as he announced June 22 at the Windows on the Universe meeting, researchers from the Pierre Auger Observatory in Malargüe, Argentina, have identified an abundance of iron nuclei at some of the highest energies its cosmic ray detectors can record.

From just above 10 million trillion electronvolts to three times that energy, the number of iron nuclei appears to rise steeply, with heavy nuclei ultimately dominating the cosmic ray population, Cronin reported. He and colleagues have posted these findings online at arXiv.org.

"It's a surprise," says Todor Stanev of the University of Delaware in Newark.

The data are particularly puzzling because it's unclear what the source of the iron could be, notes Pierre Sokolsky of the University of Utah in Salt Lake City. The disks of material that surround and feed supermassive black holes at the center of galaxies is a likely source for the generation of high-energy cosmic rays. But those disks consist primarily of protons and some helium, not iron.

Supernovas forge iron, and shock waves from these exploded stars could rev up the heavy nuclei to high energies. Still, "It's hard to see how you get iron when you don't have that much [of it] in the first place," Sokolsky says.

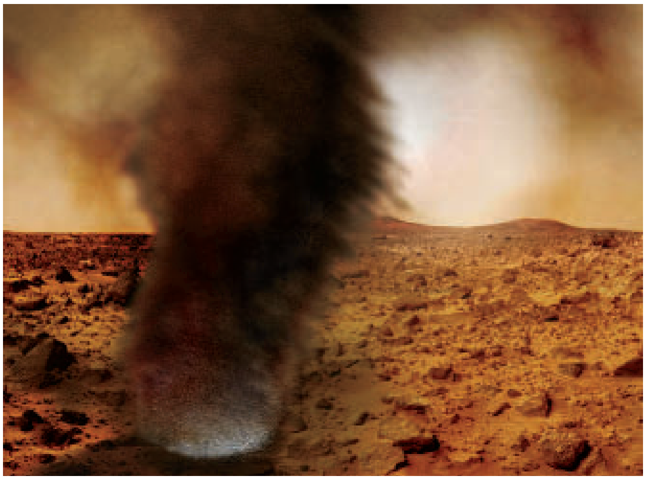
Moreover, Sokolsky reported at the meeting that an analysis of data from a cosmic ray experiment called the High Resolution Fly's Eye that operated at the U.S. Army Dugway Proving Ground in Utah until 2006 shows only protons at high energies.

Because energetic cosmic rays striking Earth's atmosphere create a cascade of other particles, astronomers can only indirectly fingerprint the rays' composition but can generally distinguish between heavy and light cosmic rays by examining the altitude at which the rays collide and create a shower of particles.

Because of its greater mass and charge, iron tends to interact with the nitrogen in Earth's atmosphere at higher altitudes than do protons. The range of altitudes at which iron nuclei break up is also narrower than it is for lighter nuclei.

Errors that make the range of altitudes appear broader are easier to generate than errors that would make the range narrower, as seen in the Auger observations, Cronin said. Stanev also says that Auger's equipment is "quite a bit better" at assessing fluctuations than Fly's Eye.

Confirming the data and determining the composition of these energetic particles is essential to figuring out their origins, Sokolsky says.



BRIAN GRIMM, NILTON RENNO/UNIV. OF MICHIGAN

Red Planet lightning

Scientists have seen the first direct evidence of lightning on Mars. They'd thought that particles rubbing against each other in dust devils could acquire a charge, the same way running on a carpet charges socks, and the charge could be released as lightning. But capturing the process had been difficult. To "see" the lightning, Christopher Ruf of the University of Michigan in Ann Arbor and colleagues looked for changes in the distribution of frequencies of light emanating from the planet. In a paper to appear in the July 16 *Geophysical Research Letters*, the team reports observing such a change during a dust storm. Instead of forks of lightning, Martian lightning bursts (artist's conception shown) would cover a wide area and glow faintly like the light in a neon tube, the researchers say. *—Jenny Lauren Lee*

34 Number of supernovas detected in 1988

260 Number of supernovas detected in 2008

Team spots odd stellar explosion

Supernova 2005E doesn't match any known classes

By Ron Cowen

Astronomers found a new type of stellar firecracker just in time for July 4.

Stars that die an explosive death generally fall into two categories: young, massive stars that collapse under their own weight and hurl their outer layers into space, and older, sunlike stars that undergo a thermonuclear explosion. But the stellar explosion recorded in January 2005 and known as SN 2005E doesn't fit either class, according to a new analysis reported online June 11 at arXiv.org.

The explosion ejected only a small amount of material — the equivalent of 0.3 solar masses — and erupted in the halo of an isolated galaxy, a region devoid of any star formation. These findings suggest that the explosion, or supernova, did not arise from the collapse of a massive star, report Hagai-Binyamin Perets and Avishay Gal-Yam of the Weizmann Institute of Science in Rehovot, Israel, and their colleagues. A massive star would have cast off much more material and would have erupted in a star-forming region. Since stellar heavyweights are so short-lived, they can't move far from their birth sites.

On the other hand, the researchers note, the explosion's dimness and the abundance of elements forged in the eruption indicate it was not a typical thermonuclear explosion. Spectra show that debris from the outburst contains five to 10 times more calcium than observed in any other known stellar explosion and probably contains an abundance of radioactive titanium-44.

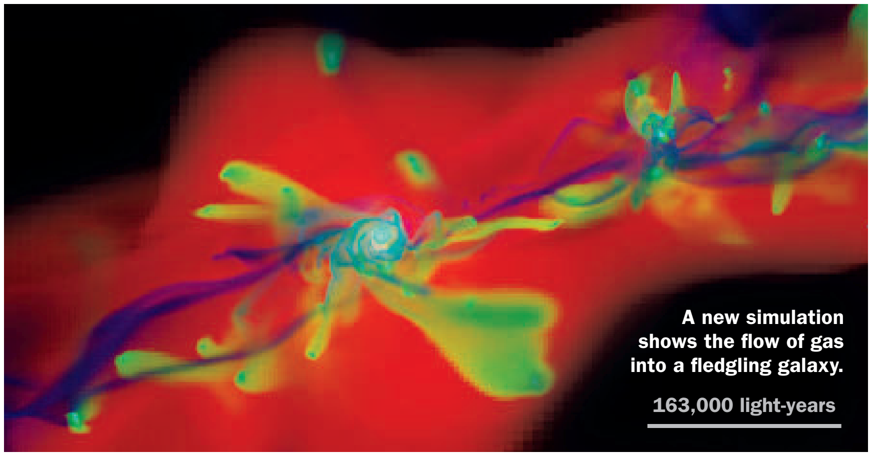
"In my experience, there are lots of strange supernovas out there … but it really does look like this one might be something different," says theorist Andrew MacFadyen of New York University.

The authors of the paper declined to be interviewed because they had submitted the report to *Nature*. In their article, they report that the erupting oddball matches a model in which a compact star called a white dwarf nabs a thick layer of helium from a companion star. The star would then undergo a thermonuclear explosion that would destroy the helium but leave the rest of the white dwarf intact. By contrast, in a common type of supernova known as a type 1a supernova, a white dwarf made up mostly of carbon and oxygen blows itself to smithereens after stealing matter from a companion.

Perets, Gal-Yam and their collaborators report that SN 2005E resembles a few other peculiar supernova, notably an explosion found last year and known as SN 2008ha.

"Both of these objects have very low luminosity, low velocity [of debris] and strong calcium lines," says Robert Kirshner of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass. Kirshner, along with some of the collaborators on the SN 2005E study, is a coauthor of a study on SN 2008ha published online June 17 in *The Astronomical Journal*.

The conclusions of both papers suggest a weak thermonuclear explosion, Kirshner says.



A new simulation shows the flow of gas into a fledgling galaxy.

B. MOORE, OSCAR AGERTZ, ROMAIN TEYSSIER/UNIV. OF ZURICH

New model bears a baby Milky Way

State-of-the-art simulation shows galaxy formation in high-res

By Ron Cowen

BLOIS, France — Like a proud papa showing off a picture of his newborn, cosmologist Ben Moore of the University of Zurich displayed an image of a galaxy that he says looks just like an infant Milky Way.

These days, with the sharp eye of Hubble and other telescopes, that may not sound like much of a feat. But the image Moore unveiled June 23 at the Windows on the Universe meeting was produced by a supercomputer and is the highest-resolution simulation ever attempted of a galaxy's assembly.

Moore and his colleagues put in all the raw ingredients and detailed interactions that are generally agreed to be essential for galaxy formation. "The complexity we find is very beautiful," Moore says. As time unfolded, the simulation, which begins shortly after the Big Bang and ends when the universe is about 2 billion years old, produced a spiral galaxy akin in mass and shape to a young Milky Way.

Body & Brain

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Gene's reported role in depression questioned by subsequent studies

Combined analysis of 14 papers fails to support connection

By Bruce Bower

The last thing depression investigators need is another dead-end research downer. Efforts to find genes that directly contribute to depression have come up empty. And a research team now concludes, after a closer inspection of accumulated research, that a gene variant initially tagged as a depression promoter when accompanied by stressful experiences actually has no such effect.

By showing that follow-up studies collectively don't support the initial study that launched this line of research, a two-part analysis debunks the proposed pathway to depression. The chances of becoming depressed rise as stressful events mount, regardless of genetic makeup, report statistical geneticist Neil Risch of the University of California, San Francisco and his colleagues.

The new analysis, published in the June 17 *Journal of the American Medical Association*, also demonstrates the difficulty of replicating reports of any gene variants that appear to work with environmental triggers to foster psychiatric disorders. Individual studies typically lack the statistical power to detect gene-by-environment interactions correctly, because most candidate genes and stressful events exert modest effects on mental ailments at best, the scientists say.

"I'm supportive of looking for gene-by-environment risk factors, but we'll need much larger samples to find interactions that can be independently replicated," Risch says. In his view, statistically rigorous studies will need tens of thousands of participants.

In 2003, scientists led by Avshalom Caspi and Terrie Moffitt, both psychologists now at Duke University in Durham, N.C., studied 847 New Zealand volunteers who had been followed since age 3. Between ages 21 and 26, those who encountered several stressful events — such as health crises, money woes and relationship breakups — and who had inherited one or two copies of a short version of the serotonin transporter gene exhibited high depression rates.

The serotonin transporter gene makes a protein that reduces transmission of serotonin, a mood-related chemical messenger in the brain. Many depression medications block the serotonin transporter gene's protein.

Caspi and Moffitt's report elicited excitement among researchers who had been unable to link any genes directly to psychiatric conditions.

> "I'm supportive of looking for gene-by-environment risk factors, but we'll need much larger samples..."
> NEIL RISCH

But the new meta-analysis directed by Risch challenges the Caspi-Moffitt findings. In the first part, Risch's team combined and reanalyzed data on 14,250 participants in 14 studies published through March 2009. A second part included unpublished data on 10,943 of the volunteers from 10 of the 14 studies. With that data, the researchers could identify any interactions between the key gene and stressful events for men and women separately. The team transformed data into a format that could be compared with the 2003 study.

Meta-analyses have their own problems, though. Chief among them is the difficulty of mixing studies with different sample sizes, participant characteristics and measurements of varying quality into a mathematically meaningful concoction.

Although the new meta-analysis could not totally avoid such problems, it raises a valid concern that Caspi and Moffitt's original results have yet to be replicated, says psychiatrist Kenneth Kendler of Virginia Commonwealth University School of Medicine in Richmond.

Alleged replications have measured stressful events in a variety of ways and have usually included only male or only female volunteers, he says. Some reports have defined genetic risk as the presence of two copies of the gene variant, whereas others have required only one. A study Kendler directed found a link between the gene variant and mild stress, but Caspi and Moffitt looked at high stress.

In a joint comment, Caspi and Moffitt say the new meta-analysis underscores the need not for larger samples but for "more research of better quality" into gene-by-environment interactions.

The new meta-analysis, like meta-analyses in general, gave more mathematical weight to studies with larger samples, Caspi and Moffitt note. But in this case, larger studies — containing as many as 4,060 participants — assessed stressful life events and depression symptoms via phone or questionnaires, rather than by comprehensive interviews. "Not surprisingly, these big studies with weak measures did not find positive results, and this tilted the meta-analysis toward a null finding," the scientists say.

Also, the meta-analysis didn't include recent human and animal studies that have linked the gene variant to pronounced hormone and mental responses in stressful lab situations, they say.

Epidemiologist Myrna Weissman of Columbia University notes that the 2003 study set the methodological bar high by identifying stressful life events that occurred before rather than after first episodes of depression. Studies that have failed to replicate those findings fall short of that methodological rigor, Weissman asserts. ■

"Appendicitis is unlikely to have a magic-bullet biomarker." — ROBERT C. BARBER

Test could help determine who has appendicitis with greater accuracy

Biomarker in urine may minimize unnecessary surgeries

By Nathan Seppa

A compound detectable in urine might help doctors distinguish appendicitis from other abdominal problems and avoid needless surgery, researchers report online June 23 in the *Annals of Emergency Medicine*.

Because signs of appendicitis are difficult to assess in young children and elderly adults, surgeons unnecessarily remove a healthy appendix in 10 to 20 percent of appendectomies performed in the United States, says Alex Kentsis of Harvard Medical School and Children's Hospital Boston. True appendicitis, on the other hand, often goes untreated.

To find better biomarkers for appendicitis, Kentsis teamed with Hanno Steen and Richard Bachur — both also at Children's Hospital — and others to test for 57 compounds in the urine of 67 children being treated for suspected appendicitis.

Overall, 25 of these patients were found to have appendicitis and underwent surgery. The diagnoses resulted from physical examination, symptom assessment and tests such as CT scans, ultrasounds or other measures. Tissue analysis after surgery confirmed the original diagnoses. The other children ultimately received other diagnoses, including ovarian cysts, constipation and abdominal pain.

The compound that stood out among the children with appendicitis was leucine-rich alpha-2-glycoprotein, or LRG. Immune cells called neutrophils make LRG. "Release of LRG from neutrophils is a kind of specific feature of appendicitis," Kentsis says.

LRG is not the only compound overproduced during an attack of appendicitis. But in this analysis, it was the most reliable biomarker to show up in the urine. Together, high levels of LRG in the urine correctly identified a child who had appendicitis and low LRG levels correctly suggested no appendicitis 97 percent of the time, the researchers found.

"They may have found a biomarker that's really sensitive," says Robert C. Barber of the University of Texas Southwestern Medical Center at Dallas. "This is a very interesting finding." But, he cautions, "appendicitis is unlikely to have a magic-bullet biomarker."

Life

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Growing red hot has its downside

Culinary kick carries risks for chili peppers in the wild

By Susan Milius

MOSCOW, Idaho — Sometimes it's good to be not so hot.

Capsaicinoid compounds, which give chilies their culinary kick, have the happy effect of discouraging a seed-rotting fungus. But new work has found that this protection has a downside, says David C. Haak of the University of Washington in Seattle. Tests in wild chilies linked pungency with vulnerability to drought and to attacks by ants that devour the seeds, he reported June 14 at the Evolution 2009 meeting.

Chili heat may be an example of populations adapting to particular local circumstances, an important concept in evolutionary theory, Haak says. And the link between capsaicinoid levels and vulnerability could explain why, even within the same species, not all chilies are hot.

Though the seed-attacker *Fusarium* fungus lurks throughout the chilies' wild range, Haak and his colleagues have found that Bolivian chilies in dry spots skimp on the protective capsaicinoids. In a dry-zone population, plants yielding mouth-scorching chilies were rarer than in a population in a somewhat wetter place. And the hottest of the dry-zone plants didn't reach the heat extremes of the exceptional chilies in more moist zones.

***Capsicum chacoense* peppers (one shown) pack varying degrees of heat. New research may explain why.**

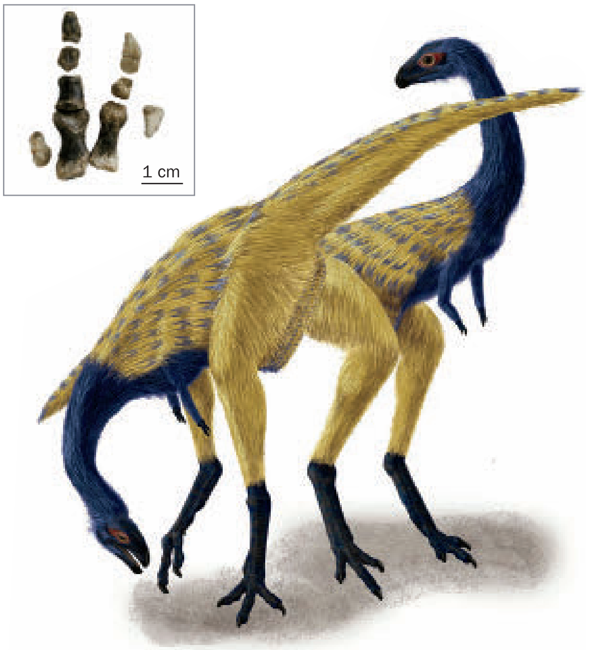
Those hot and not chilies illustrate how "adaptations that are beneficial in one environment may be costly in another — for example, pungency in a dry climate," says Emily Jacobs-Palmer of Harvard University.

To investigate whether chili heat affects susceptibility to ants, Haak and his colleagues set out little seed piles from hot, sort-of-hot and not-spicy plants. Video monitoring of the piles showed three kinds of ants settling down and snacking. More pungent seeds were the ants' favorite, Haak says. Microscopic observations showed that pungent peppers tend to have thinner spots on their seed coats than milder seeds. The ants can cut into a seed with thin spots, killing it and preventing sprouting.

Looking at another possible cost of heat, Haak and his colleagues found that plants that produced hotter chilies didn't seem to use water as efficiently as more mild plants. For a given watering regime, pungent plants weren't setting as much seed. The hotter plants grew more breathing pores, called stomata, which can allow water to escape.

Haak then crossbred hot and not-hot plants. The link between chili heat and stomata density persisted through the next two generations, supporting the team's conclusion that the two characteristics are truly tied together.

Bird in the hand



The hands of a newly discovered dinosaur species provide fresh support for the notion that birds are closely related to dinosaurs, researchers say. Many paleontologists contend that theropods — a group of bipedal dinosaurs that, with rare exception, dined on meat — didn't die out 65 million years ago with the rest of their kin. Analyses, those scientists say, show that this group gave rise to modern-day birds. But hard-core skeptics of that theory have long noted that the bone arrangement in birds' wings doesn't match that in the hands of dinosaurs, says James M. Clark of George Washington University in Washington, D.C. Now, fossils of a new theropod species, dubbed *Limusaurus inextricabilis* (shown in an artist's illustration), reveal that some theropods indeed had birdlike hand-bone arrangements (inset). *L. inextricabilis* lived in China about 159 million years ago and was probably a vegetarian, Clark and his colleagues report in the June 18 *Nature*. This theropod had a beak and stomach stones — rocks swallowed to grind vegetation and aid digestion. "It turns out there were many ways to be a theropod," says Thomas R. Holtz Jr. of the University of Maryland in College Park. — *Sid Perkins*

FROM TOP: COURTESY OF HARRY NYSTRÖM; P. SLOAN, INSET: CLARK

Humans

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Hunter-gatherers stored wild crops

Granaries in the Middle East predated plant domestication

By Bruce Bower

It apparently took a long time to get the Agricultural Revolution off the ground. Prehistoric hunter-gatherers in the Middle East cultivated the early farming life over more than a millennium, thanks largely to their proficiency at building structures to store wild cereals, a new report suggests.

An excavator works among the remains of two structures that hunter-gatherers built more than 11,000 years ago to store cultivated wild cereals in what is now Jordan.

Excavations at Dhraʿ near the Dead Sea in Jordan have uncovered remnants of four sophisticated granaries built between 11,300 and 11,175 years ago, about a millennium before domesticated plants were known to have been cultivated there, say Ian Kuijt of the University of Notre Dame in Indiana and Bill Finlayson of the Council for British Research in the Levant in Amman, Jordan.

Microscopic pieces of silica from barley husks were identified in one structure, the researchers report online June 22 in *Proceedings of the National Academy of Sciences*. The granaries were situated between oval-shaped buildings where the researchers found stone tools for grinding wild plants. Intact cereal grains have yet to be found.

Discoveries at Dhraʿ represent the oldest known clear evidence for systematic storage of wild grains, Kuijt and Finlayson report. They suggest that ancient residents of Dhraʿ and several nearby settlements sowed wild cereals in fields and stored surplus food in granaries, making it possible to establish permanent communities before farming of domesticated plants began.

“The most important implication of our findings is that fundamental social changes occurred before plant domestication, including the establishment of fairly permanent settlements, with communal labor and storage, based on cultivated wild plants,” Kuijt says.

Researchers now generally accept that people in the Middle East and Asia must have cultivated wild plants for between 1,000 and 2,000 years, with annual harvests in the fall, before domesticated species appeared, remarks Harvard University archaeologist Ofer Bar-Yosef.

“The discovery in Dhraʿ provides us with one of the earliest well-built examples” of a food-storage structure from before plants were domesticated, Bar-Yosef says.

Oldest known instruments found

Ivory, bone flutes date from 35,000 to 40,000 years ago

By Bruce Bower

The hills may be alive with the sound of music, but so were vulture bones and mammoth tusks for ancient Europeans. Researchers working at two Stone Age sites in Germany have unearthed a nearly complete flute made from a vulture’s forearm as well as sections of three mammoth-ivory flutes.

These 35,000- to 40,000-year-old finds are the oldest known musical instruments in the world, says project director Nicholas Conard of the University of Tübingen in Germany. Many researchers now consider the spaced holes in a controversial 43,000-year-old find, dubbed a Neandertal bone flute in 1995, to be the products of chewing by cave bears.

Conard and colleagues report online June 24 in *Nature* that the finds, from Hohle Fels cave, date to the time of the Aurignacian culture, when modern humans first migrated to Europe from Africa.

The age estimate appears reasonable, says April Nowell of the University of Victoria in Canada. “The finger holes on the Hohle Fels bone flute are clearly human-produced and are so different from the carnivore puncture holes on the Neandertal ‘flute,’ ” Nowell says.

Bird-bone flute found in Germany

FROM TOP: I. KUIJT, B. FINLAYSON; H. JENSEN/U. OF TÜBINGEN

Matter & Energy

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Quantum motor would run with kick

Scientists propose a way to put two ultracold atoms to work

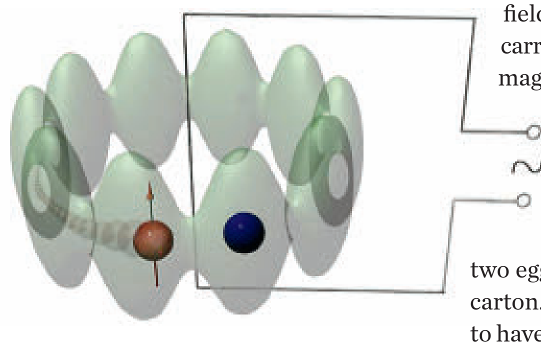
By Laura Sanders

Physicists have proposed a way to get their quantum motor running. An electric motor could be built from just two atoms held in a ring by lasers, a theoretical study published online June 8 in *Physical Review Letters* contends.

The proposal "might be hard to implement, but it has the core of a good idea," comments Ian Spielman of the Joint Quantum Institute in College Park, Md.

Electric motors, like the ones in fans, convert electric current into mechanical motion, such as spinning blades. "The idea of a quantum motor is exactly the same as a mechanical motor," says study coauthor Alexey Ponomarev of the University of Augsburg in Germany. "You have an electromagnetic force that launches it."

Because of the inherent weirdness in the quantum world, an electromagnetic force would set a quantum motor rotating counterclockwise and clockwise at the same time, resulting in no net movement. The theory put forth by Ponomarev and his Augsburg colleagues Sergey Denisov and Peter Hänggi suggests a way to get around this problem and build a quantum system with net movement, which could ultimately be harnessed to do work.



A proposed quantum motor that may one day do work would be made up of a carrier atom (brown with an arrow) and a starter atom (blue) trapped in a ring.

In the proposal, two ultracold atoms are held in a 100-micrometer-wide ring made up of confined spaces created by lasers. Researchers apply a magnetic field to the ring. One of the atoms, the carrier, is electrically charged, feels the magnetic flux and moves — but yields no net motion. An uncharged atom called the starter provides a kick to the carrier atom once the two are nestled in the same well of the laser ring, like two eggs in the same compartment of a carton. This kick causes the carrier atom to have net motion, Ponomarev says.

Next, the researchers introduced a gravity-like force into their equations to see if the motor could perform work against the force. The team found that, under certain conditions, the atoms in the motor would have net motion against the force, akin to water flowing uphill.

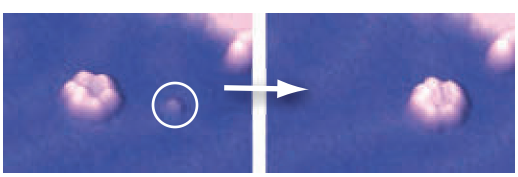
Experimentalists will have some challenges to overcome before a quantum motor can be built, Ponomarev says, and possible applications are still unclear. "How can you use it in real life? It's not so obvious," he says.

Single molecule gets geared up

Tiny version of basic machine component turns with nudge

By Laura Sanders

A snowflake-shaped molecule atop a gold sheet can turn like a gear. This most basic component of a machine could serve as a building block for complex miniature devices, researchers report in the July *Nature Materials*.



Researchers pushed a snowflake-shaped molecule onto a defect in a gold sheet to form a gear. The molecule spins but can't yet transfer energy.

"This is another cog in the wheel for the development of molecular machines," says James Tour, a chemist at Rice University in Houston.

Carlos Manzano of the Institute of Materials Research and Engineering in Singapore and his colleagues built the gear out of hexa-*t*-butyl-pyrimidopentaphenylbenzene, which has a central core with six rings jutting out and is only nanometers wide. One of the six rings differs slightly from the others, allowing the team to track the molecule's rotation.

With the ultrafine tip of a scanning tunneling microscope, Manzano and his team were able to slide the molecules across a sheet of gold. But to turn the molecule into a gear, the researchers wanted to pin it firmly in place so that they could reliably rotate it.

Atom-sized impurities in the gold sheet (the exact nature of which are still mysterious) proved to be a good place to stick a molecule, Manzano says. When a molecule was centered on a tiny bump, a nudge with the scanning tunneling microscope sent the legs of the molecule gently rotating, while the center stayed stationary.

Controllable turning may eventually allow the transfer of motion between different tiny parts, opening the door for tiny machines. "What we have done here is to build and control a basic component, but at an infinitesimally smaller scale," Manzano says.

FROM TOP: IVAN PONOMAREV; MANZANO *ET AL.*/*NATURE MATERIALS* 2009

Earth

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Louisiana sinks as sea level rises

State's coast threatened by global warming, settling land

By Sid Perkins

If engineers don't divert sediment-rich waters from the Mississippi River to help replenish a sinking delta, about 10 percent of Louisiana will slip beneath the waves by the end of this century. And even if the engineers do try to abate the subsidence, the river carries only enough sediment to offset a small fraction of that loss, a new analysis suggests.

Over the past few centuries, about a quarter of the wetlands in the Mississippi River delta have been lost to the ocean, says Harry Roberts of Louisiana State University in Baton Rouge. Sea level rise and the settling of land as ancient sediments become compacted under their own weight are contributing factors. Writing online June 28 in *Nature Geoscience*, Roberts and Michael Blum — now at the ExxonMobil Upstream Research Company in Houston — describe using computer models to estimate the effect that these processes will have on the delta in the next few decades.

Tidal gauges at Grand Isle, La. — on the delta's edge, where river-dumped sediments lie about 60 meters thick — show that land there is sinking up to 8 millimeters each year, the team reports. More than 150 kilometers upstream at Baton Rouge, sediments are thinner and the land subsides up to 3 millimeters each year.

Not only is the land sinking, but the sea is also rising. Scientists on the Intergovernmental Panel on Climate Change report that since 1993, sea level has risen about 3 millimeters per year. That rate is expected to accelerate as the planet's climate warms, Roberts says. The researchers presume — conservatively — that in the year 2100 sea level will be increasing 4 millimeters per year.

Between 2000 and 2100, the team estimates, the combined effects will swamp as much as 13,500 square kilometers — about 10 percent of Louisiana's area.

Roberts and Blum "have come up with a result that we should clearly be concerned about," says Torbjörn Törnqvist of Tulane University in New Orleans.

Today, the Mississippi River carries only about 205 million tons of sediment to its delta each year, less than half the amount it transported before dams were built upstream. Typically, only 40 percent or so of a river's sediment accumulates in a delta. So, even if engineers divert sediment-laden water from the river into the marshes at the delta's head, it could save only 900 square kilometers of land from a watery fate this century, the scientists estimate.

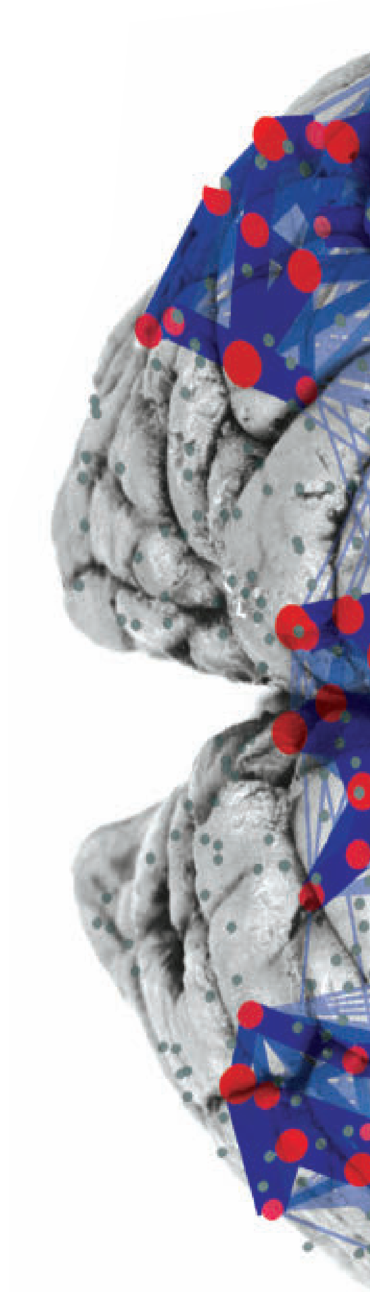
Goodbye, coast This image depicts what the Mississippi River delta may look like if land continues sinking and sea level rises 1 meter. (Grand Isle sits near today's coastline, shown in yellow.) A new model predicts that 10 percent of Louisiana will be submerged by the year 2100.

M. BLUM, H. ROBERTS

You are who you are by DEFAULT

It may be off when you're on, but the brain network behind daydreams and a sense of self is no slacker

By Tina Hesman Saey



NETWORK OVERLAY: OLAF SPORNS/INDIANA UNIV. (MODIFIED BY J. KORENBLAT); BRAIN PHOTO: OMIKRON/PHOTORESEARCHERS

You may not be riding the latest social wave on Facebook or MySpace, or tweeting your every impulse to fans on Twitter. But your brain is hooked on networking.

Vision works because different brain regions link up to connect the dots of light and color into a meaningful picture of the world. Language depends on networks of neural circuitry that make sense of the words you hear or see and that help you generate your side of the conversation. Networks of nerves control the motion of your muscles, allowing you to move smoothly and, when necessary, swiftly.

Networks are the "in" thing for brain scientists, as surely as they have been for online social butterflies.

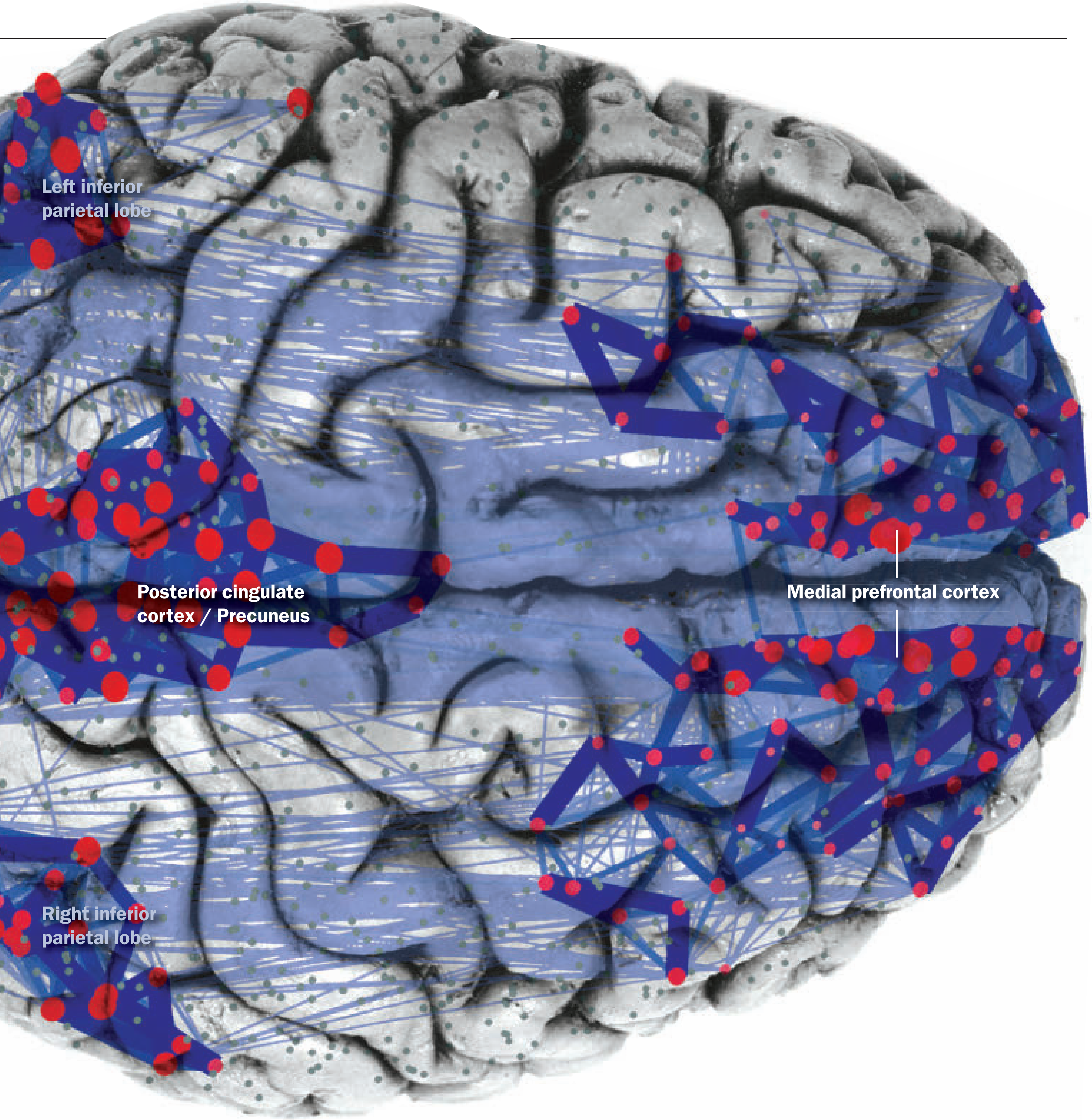
Scientists learn about the brain's networks by asking people to perform all sorts of mental acrobatics — interpreting optical illusions, solving riddles, taking tests of mental or muscular skills. But some neuroscientists think they can learn even more about the brain by asking volunteers to just lie back, close their eyes and let their minds wander.

Such unstructured journeys of the mind — be they planning tonight's dinner, thinking about that meeting at work and what your boss said afterward, debating whether to drive or fly for your next vacation, or recalling that day in your childhood when you first sat in your new tree house listening to birds chirp — turn out to offer clues about one of the most important, mysterious and well-connected networks of all. It's called the default mode network, and it's responsible for what the brain does when it is doing nothing in particular. It's the brain's core, both physically and mentally, and it's better connected to the brain's system of circuits than Kevin Bacon is to movie stars.

"I think the default mode network is the most exciting thing that has happened in cognitive neuroscience in quite some time," says Peter Fransson, a neuroscientist at the Karolinska Institute in Stockholm.

Default brain settings may lead to daydreaming and mind-wandering, but the network also conducts serious business. Neuroscientists still hotly debate the network's exact functions, however. Among its jobs may be running life simulations, providing a sense of self and maintaining crucial connections between brain cells. A few researchers doubt the network is anything special at all.

But evidence suggests that a malfunctioning default network is involved in diseases and disorders as diverse as Alzheimer's disease, autism, depression,



Wandering and wondering

The brain's default mode network — a series of connected areas that work hardest when most of the brain is at rest — is active during daydreaming and mind-wandering. The network may also be involved in imagining how certain situations play out and in giving people their sense of self and where they fit in the world. Many scientists believe the default network has two major hubs, one in the posterior cingulate cortex with the precuneus and one in the medial prefrontal cortex. The two hubs are highlighted in the image above, which shows a human brain viewed from the top and overlaid with a computer-generated map showing the most robust of the network's structural connections. Also visible in the map are the left and right inferior parietal lobes, which are among a number of other brain regions involved in the default network.

post-traumatic stress disorder, Tourette syndrome, amyotrophic lateral sclerosis, schizophrenia and attention-deficit/hyperactivity disorder.

Busy behind the scenes

Despite its laid-back name, which neuroscientist Marcus Raichle coined in a 2001 paper, the default mode network is one of the hardest-working systems in the brain. It was discovered accidentally by researchers watching the activity of brains at work on various tasks.

Neuroscientists use PET (short for positron emission tomography) and functional MRI scanners to image and gauge brain activity. To tell which areas of the brain become more active during a mental task, scientists compare brain activity during the task with activity when the person is at rest, either with eyes closed or while staring at a dot or cross. Raichle, of Washington University in St. Louis, and others saw that every time a person engaged in a mental activity such as memorizing a list of words, a collection of brain regions consistently decreased activity compared with their resting levels. Only when people recall autobiographical memories or imagine alternative situations is the network more active than it is at rest, scientists have since found. (In this context, "rest" refers to a state in which the brain is not engaged in a mental task but is still monitoring the body and the world around it.) Raichle hypothesized that the network is more active when the brain is at rest and has to dial back its activity to let people concentrate on specific tasks.

Michael Greicius, a neurologist and neuroscientist at the Stanford School of Medicine, put the resting part of Raichle's theory to the test. Greicius and his colleagues measured brain activity while volunteers had their eyes closed and thought of nothing in particular. The team used a technique called functional connectivity MRI to reveal correlations in activity in different brain areas. The group reported in 2003 that blood flow in parts of the brain implicated in the default network rises and falls like the tides — in slow but synchronized waves.

Those coordinated parts of the brain — with cumbersome names such as the medial prefrontal cortex, posterior cingulate cortex, retrosplenial cortex, precuneus, inferior parietal lobe and hippocampus — are located mostly along the crevice separating the brain's hemispheres, and on each lobe behind and above the ears. Researchers don't agree on all the components of the default network, but consensus is growing that it has two major hubs: the posterior cingulate cortex, or PCC, with the precuneus, and the medial prefrontal cortex.

Functions ascribed to those two areas may give clues to what the default network is good for. The medial prefrontal cortex is involved in imagining, thinking about yourself and "theory of mind," which encompasses the ability to figure out what others think, feel or believe and to recognize that other people have different thoughts, feelings and beliefs from you. The precuneus and PCC are involved in pulling personal memories from the brain's archives, visualizing yourself doing various activities and describing yourself.

Together, these hubs give you a sense of who you are. Their prominence in the network has led some researchers to propose that the function of the default mode is to allow you to internally explore the world and your place in it, so you can plot future actions, including contingency plans for various scenarios you might encounter.

The network that never sleeps

Some scientists quibble with the name, but Fransson says the network really is the brain's default. Peter Williamson, a psychiatrist at the University of Western Ontario in London, Canada, agrees.

"You don't even have to be conscious for it to be apparent," he says.

Slow yet coordinated fluctuations in activity bind the network together. The syncopations continue even while people are asleep, under anesthesia or in comas. But it is unlikely that such activity reflects ongoing conscious processing, Greicius contends. The fluctuations that move through the network are incredibly slow, he says, with one cycle every 15 to 20 seconds. Most conscious thought happens in split seconds, so it is more likely that the plodding pulses are for "subconscious synapse maintenance," he says.

Synapses are the connections between neurons where cell-to-cell communication takes place. When two neurons stop "talking" to each other, connections between them can be severed. Greicius thinks the low-level fluctuations in the network help keep the neurons in contact, sort of the brain-cell equivalent of Facebook status updates.

While it is good to stay connected, reverting to default isn't always helpful. The default mode network sometimes stirs during monotonous tasks, drawing away a person's attention. Such reactivation of the network predicted errors up to 30 seconds before a person made a mistake, Vince Calhoun of the MIND Research Network in Albuquerque and colleagues reported in 2008 in the *Proceedings of the National Academy of Sciences*. And a study published May 26 in that journal, by Kalina Christoff of the University of British Columbia in Vancouver, Canada, and colleagues, shows that not only is the default network involved in mind-wandering, it also distracts executive areas of the brain, so that people aren't even aware that their minds have wandered off task.

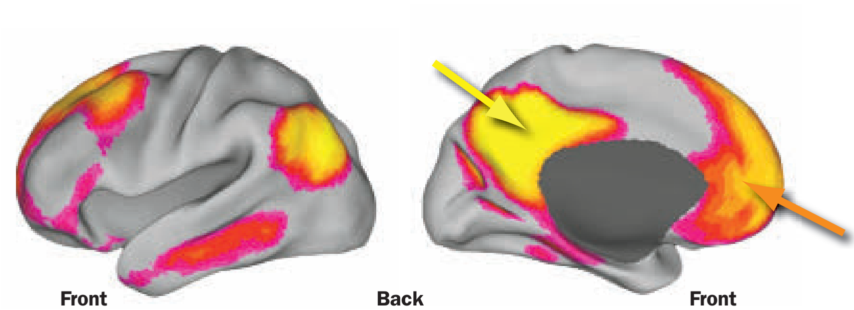
Psychiatric connections

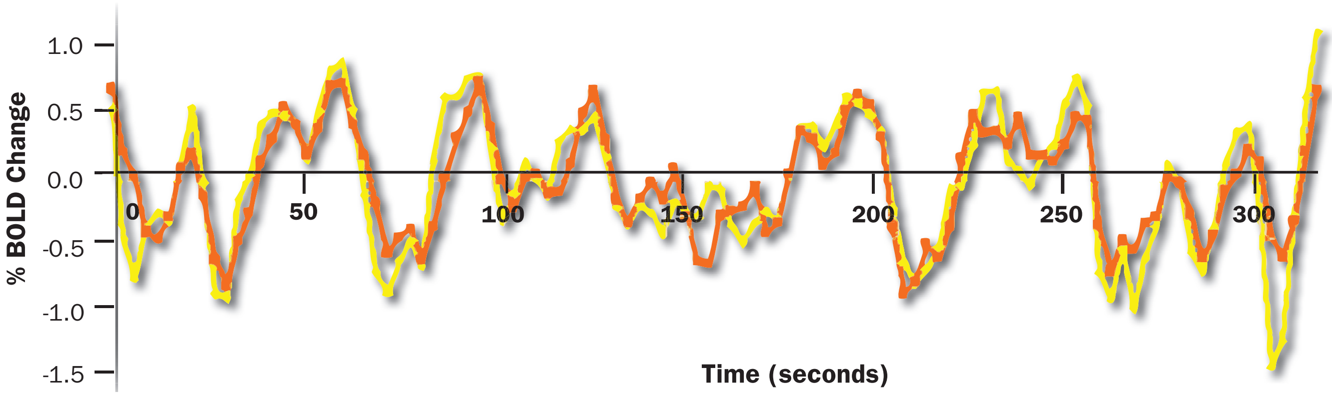
Researchers are also studying how defects in the coordination between different parts of the default network may contribute to psychiatric disorders. Calhoun, an electrical engineer at the University of New Mexico, and colleagues at other institutions studied network activity during a memory task in 115 people with schizophrenia and 130 healthy people. Some subnetworks within the default mode network had trouble disengaging in people with schizophrenia, impairing their ability to focus on the task, the team reported online May 11 in *Human Brain Mapping*.

People with schizophrenia also have faster cycles of activity in their

Network in sync

At top, fMRI images show areas of the brain that coordinate activity when people are thinking about nothing in particular. The left image shows the outside of a left-facing brain. The right image shows the inner surface of one hemisphere of a right-facing brain. Activity in the two major hubs of the default network (indicated by yellow and orange arrows) rises and falls in time with each other, as seen on a plot of those fluctuations below.





COURTESY OF M. RAICHLE

default networks during a resting state than healthy people do, Calhoun and another group of colleagues reported in the March 2007 *American Journal of Psychiatry*.

Williamson and colleagues, meanwhile, have shown that the default network's connections with other parts of the brain may be important in determining who develops PTSD after a traumatic event. People who have been traumatized can become numb and lose their sense of self, Williamson says. The researchers examined default networks in women who developed PTSD after trauma in childhood. The study found altered levels of connectivity among parts of the default network as well as between the network and other parts of the brain. The findings, published in May in the *Journal of Psychiatry & Neuroscience,* could indicate that trauma creates disturbances in the network's ability to create a sense of self.

The default network may also be the launching point for Alzheimer's disease's assault on the brain. The characteristic plaques of the disease deposit preferentially in the brain regions most associated with the network, studies have shown. And Greicius and his colleagues reported online last year in the June 2008 *PLoS Computational Biology* that activity in the default network is affected by the disease.

At least one study suggests that the default network may be vulnerable to Alzheimer's disease decades before symptoms or plaques show up. Young people who carry a genetic risk factor for the disease have more activity in the default network, particularly in the hippocampus, than young people who don't have the genetic risk, researchers from Oxford University and Imperial College in England reported in the April 28 *Proceedings of the National Academy of Sciences*. The authors say the study provides evidence for the theory that the default network's constantly high activity eventually burns it out, leaving it vulnerable to Alzheimer's disease.

Greicius says he isn't a fan of this "use it and lose it" theory. Other networks in the brain also burn a lot of energy, even at rest, but they don't fall prey to Alzheimer's disease. Instead, Alzheimer's and four other neurodegenerative diseases each target a different brain network, Greicius and colleagues including William Seeley of the University of California, San Francisco discovered. The results, published April 16 in *Neuron*, could mean that neurons that fire together die together. The researchers don't yet understand why. It could be that when a neuron dies, its silence triggers death in neighboring neurons, or neuron-killing substances might pass from one cell to another through synapses, Greicius says.

Blueprint for the brain

To understand what goes wrong with the default network to lead to psychiatric disorders, scientists need to understand how the network is built. Assembling disparate regions of the brain into a coordinated, coherent system surely is no simple task for the developing brain.

"One might imagine that the development of self might take a bit of time to sculpt," Raichle says.

Only a few studies have been done with children, so the picture of the nascent default network is about as clear as an ultrasound image is to someone other than an expectant parent. But new ways of analyzing neural connections are bringing the picture into better focus.

Fransson and his colleagues used fMRI to scan the brains of sleeping premature infants who had reached the equivalent of 40 weeks of gestation to see whether the default network is already in place when babies are first born. The researchers could not find evidence that the default mode is operational in newborns, although five other brain networks are already online, the team reported in 2007. Fransson says he is not surprised that newborns lack a network that draws on personal experience and dreams of what is to come.

"Infants cannot plan for their futures," he says. "They don't think about their pasts."

But a recent study by Weili Lin, a neuroscientist at the University of North Carolina at Chapel Hill, and colleagues shows that infants as young as 2 weeks have rudimentary, incomplete default mode networks. The study, published in the April 21 *Proceedings of the National Academy of Sciences*, tracks development of the network from shortly after birth into toddlerhood. Newborns' default networks connect six brain regions, Lin's group found.

It doesn't take long for the brain to develop a default mode, Lin showed. By age 1, babies link 13 brain regions in their default network, including 10 parts found in the adult network. In 2-year-olds, the default network is even bigger, comprising 19 regions, 13 consistent with the network in adults. But bigger networks can also be inefficient, Lin says, noting that adult default networks have been pruned of extraneous connections.

Lin and his colleagues are continuing to scan many of the children in the study as they age to track how the normal brain develops. Preliminary data from 4-year-olds indicate that extra connections are severed as the brain ages, he says.

A group of researchers at Washington University including Raichle, Steven Petersen, Bradley Schlaggar and Damien Fair (now at the Oregon Health & Science University) are piecing together the network's development from age 7 into early adulthood.

Brain connections in 7-year-olds are organized differently than in adults. Children have more short-range connections among neighboring brain regions and fewer long-range connections, particularly among the parts of the default network in the back and front, the team reported last year in the *Proceedings of the National Academy of Sciences*. As children age, the connections are rewired. Adolescents have a network structure somewhere between that of elementary-age children and adults.

"It's like different cliques of friends in childhood break up and create different cliques in adulthood," Petersen says.

Given the lack of long-range connections in children's brains, researchers were surprised to discover that kids' default networks aren't clunky. The team mapped how the brain makes connections in the network, a neuroscience version of the game to link actor Kevin Bacon to other actors in Hollywood through people with film appearances in common. Fewer steps means more efficient connections. While children's connections are structured differently, they have enough shortcuts to make information transfer in the network just as efficient as in adults, the scientists reported online May 1 in *PLoS Computational Biology*.

Once people reach adulthood, activity in the network is fairly consistent from person to person, with some slight differences between the sexes and in older versus younger people, Williamson and his colleagues wrote in a 2008 paper in *NeuroReport*.

This consistency in the network from person to person is remarkable, especially considering what its function is supposed to be. Everyone's brain is thinking different thoughts while in the default mode, Fair says, and yet all healthy brains in default mode look essentially alike.

Such fundamental issues are among the puzzles of the default network remaining to be solved.

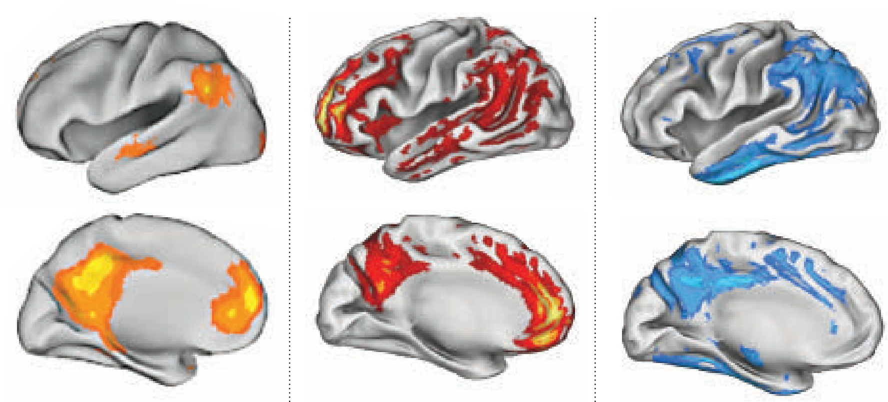
"Nobody has really figured out what it is and what it does," Williamson says. "But somebody will." ■

Explore more

- M.E. Raichle, A.Z. Snyder. "A default mode of brain function: A brief history of an evolving idea." *NeuroImage* 2007.
- R.L. Buckner *et al.* "The brain's default network: Anatomy, function, and relevance to disease." *Annals of the New York Academy of Sciences* 2008.

Alzheimer's overlaps default network

Alzheimer's disease appears to particularly affect brain areas involved in the default network. At left, two views of the brain show areas activated (orange) when a healthy person recalls personal memories. Amyloid plaques characteristic of Alzheimer's accumulate (red) and the brain atrophies (blue) in some of the same areas, as shown in scans of people with dementia (middle and right).



Default network: Autobiographical memory | **Amyloid plaques** | **Atrophy**

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The star that ate a MARS

Astronomers study white dwarf pollution for clues to extrasolar planet ingredients

By Charles Petit • Illustrations by Lynette Cook

An artist's conception shows how a superdense

For several years, UCLA astronomers have studied GD 362, a peculiarly dirty white dwarf star 165 light-years away in the constellation Hercules. Now they are pretty sure why the atmosphere of this dense, hot but slowly cooling ghost of a once much larger star is so polluted. It ate a planet.

"We probably have a destroyed world here," says Michael Jura, coleader of the UCLA team. Apparently a planet with the mass of Mars — a billion trillion metric tons or so of rock, iron, dissociated water and other ingredients — was dismembered and atomized, its remains now bobbing in the thin but dense, 10,000 kelvins atmosphere that GD 362's powerful gravity holds close around itself.

Like a specimen on the ultimate autopsy table, the supposed planet has its insides spread wide for inspection. It would thus appear to provide science its first look at the composition of an alien, rocky and roughly Earthlike planet in an exosolar planetary system. In fact, the material marring GD 362 appears to closely match what you would get by grinding up Earth, Mars or Venus, the UCLA team and collaborators report in a paper to appear in *The Astrophysical Journal*.

The report provides some of the first hard data for a nascent field of science — let's call it terrestrial exoplanetology — inching ever closer to the day when Earthlike planets might finally be visible directly to ever more powerful telescopes planned for construction on Earth and for orbit. Viewing white dwarfs with such instruments may tell astronomers whether rocky planets orbiting other stars all resemble Earth or come in diverse varieties.

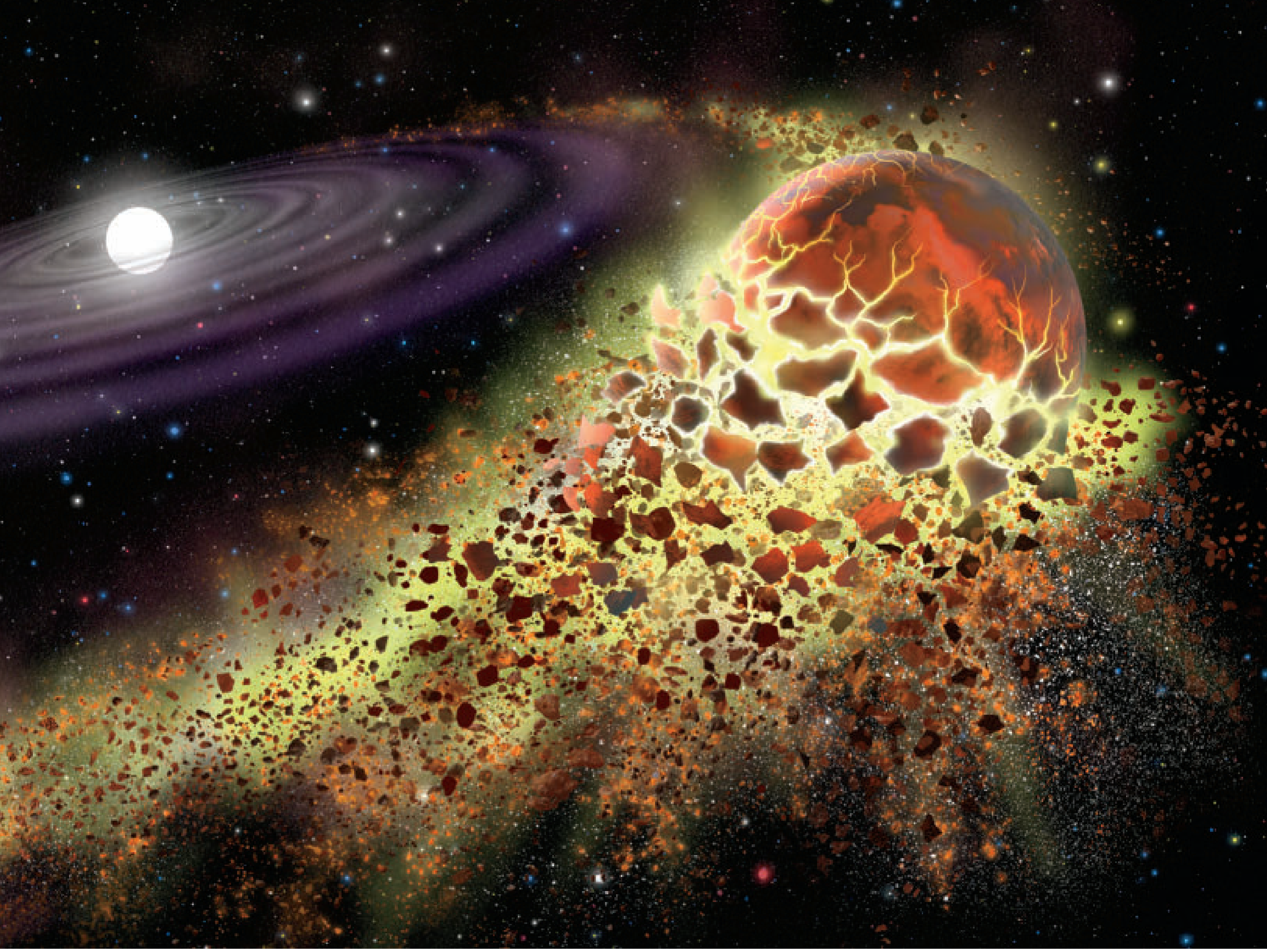
"We have a unique tool for studying extrasolar planetary composition," Jura says. "If we are clever enough, we might even know something about their structure, not just their bulk ingredients."

The UCLA team has an additional dozen or so polluted white dwarfs under study. So far, all look as though they contain similar stuff.

Like all white dwarfs, GD 362 is the steadily cooling core of a once normal-sized star, now shriveled into a sphere only about the size of the Earth with a mass nearly equal to the sun's. All white dwarfs are crushed so tightly that their atoms (mostly carbon and oxygen) lose individual identities in a soup of jostling nuclei and electrons, a condition that earns from physicists the sobriquet "degenerate matter."

But unlike most white dwarfs, GD 362 does not have a pristine, highly compressed skin of pure helium.

Jura, coleader Benjamin Zuckerman and the rest of the team have aimed some of astronomy's most powerful telescopes at the tiny star, including NASA's infrared Spitzer Space Telescope, the European Space Agency's XMM-Newton



white dwarf star might pull apart a passing planet and incorporate its matter into Saturn-like rings.

orbiting X-ray observatory, and the Keck Observatory in Hawaii. The astronomers identify not only hydrogen mixed in with the dominant helium, but also at least 17 heavier elements, including oxygen, silicon, magnesium, calcium, titanium and iron. None of those are expected in the normally immaculate outer layers of a white dwarf — its strong gravity should pull them to greater depth in a few tens of thousands of years.

For a while the astronomers thought dust was responsible, or perhaps an asteroid got too close and was shredded by GD 362's intense gravitational field. Then, with the help of German colleague Detlev Koester of Kiel University, the team reanalyzed how much water it would take to provide the extra hydrogen seen in the star, and by implication, how large a body it would take to deliver it.

The recent upgrade of the Hubble Space Telescope included a new ultraviolet spectrometer. With it, the number of elements observed in the white dwarf could grow to two dozen, Zuckerman believes. As the study expands to more white dwarfs carrying material absorbed from their former exosolar systems, the chemistry set for building planets should become generally known. And given the range of possibilities, he says, some of those planets "will be unlike that of anything known in our own solar system."

Planetary lunch

Just how a fully formed planet would be ground up to dust and ultimately consumed by a tiny white dwarf star — the previously normal star that it once circled — is a remarkable scenario.

While the details are uncertain, it goes roughly like this: Hundreds of millions to a billion years ago or so, GD 362 was born as a normal star with a mass perhaps three times the sun's. It presumably had several planets big and small. For a long time the star lived a normal life. That changed as it exhausted its core load of hydrogen fuel, burning helium instead, and generating vast amounts of oxygen and carbon as a sort of nuclear ash. It expanded enormously into a red giant, perhaps consuming some of its closer planets. The seething, bloated outer atmosphere blew away into space, taking most of the star's mass with it. Surviving planets, responding to the lower gravity, migrated farther away.

Then the star's fires, not hot enough to burn carbon and oxygen, went out.

The remains of the star's core — a fused mass of almost pure carbon and oxygen — collapsed into the white dwarf seen today. As surviving planets retreated to farther distances, their gravitational interactions produced ever-more unstable orbits. And thus, the tale goes, one of those planets, loaded with internal water but about the size of Mars, looped perilously close to the glowing ember of its former sun. It passed within perhaps half a million miles. Powerful tidal forces shredded it into a disk of debris resembling the ring system around Saturn. The disk's contents have, ever since, been filtering onto the white dwarf — perhaps as rapidly as 100 million tons per second.

A few colleagues have reservations about the details. "It is not clear that distant planets could be efficiently redirected so close to the star, or that it all would be accreted," says Philip Chang, an astrophysicist at the University of California, Berkeley. "It also could be a new planet that formed close to the white dwarf after the red giant phase," he says. "But the evidence that something like a planet has been absorbed by the white dwarf is pretty convincing."

However it happened exactly, an infrared glow near the star indicates that the process may not be done yet. If the debris has quit raining onto the star, it did so only recently on astronomical time scales.

Weird worlds

The inside-out look at an atomized planet comes as astronomers who specialize in planet formation are champing at the bit for their first looks at actual, fully intact planets in the same size and habitability category as Earth. In the meantime, a sort of academic parlor game is underway to guess how diverse and Earthlike or utterly alien rocky planets around other stars will turn out to be.

In April, for instance, when prominent scientists and thinkers met at the Origins Symposium at Arizona State University to discuss the roots of many things — the universe, life, language and consciousness — one panel confronted "How Common Are Earthlike Planets?" One thing that already should be expected, declared UCLA geochemist and cosmochemist Edward Young, is that for most alien planets "rocks are rocks." Other worlds may be too dry, too wet, too wobbly in their orbits, or too something else to be suitable for life's easy evolution, he said. But with the data on white dwarfs as evidence, he argued that in addition to likely iron cores, such planets will probably still have familiar silicate minerals such as olivine, quartz, feldspar, mica and other common ingredients of Earth's granites, schists, lavas and sandstones.

But Jade Bond, of the University of Arizona's Steward Observatory, suspecting that far more exotic worlds are awaiting discovery, argued, "Rocks are rocks, yes, but with some exceptions." She is working out the implications for planets if some budding exosolar systems grow in an environment not so different from that of the Earth's birth, but with one subtle change: What if carbon atoms outnumbered oxygen atoms?

Carbon and oxygen bond tightly to form carbon monoxide, a gas in the preplanetary nebula not substantially incorporated in solid planets. The sun and most stars are also made of relatively more oxygen, but the margin is not large. The leftover oxygens bond to silicon atoms to form the solid on which silicate minerals are based. Were the comparative abundances reversed in the disk where planets form near a sun, she said, carbon but very little oxygen would be left over for incorporation into planets. Such worlds might congeal with startlingly different mineralogy and perhaps a far different chance for evolving life — or perhaps for a distinctly different sort of life.

On such planets may be plains of graphite, cliffs of carborundum and sheets of carbide. Below them — covering an iron core — could be thick strata of pure diamond. There might even be literally dark continents washed by oceans of tar; who knows? Bond showed a schematic cross section of such a planet. She conceded that such a world would have a "giggle factor," but added, "If we ever find a planet with a global diamond layer as is pointed out here, I call dibs on it right now."

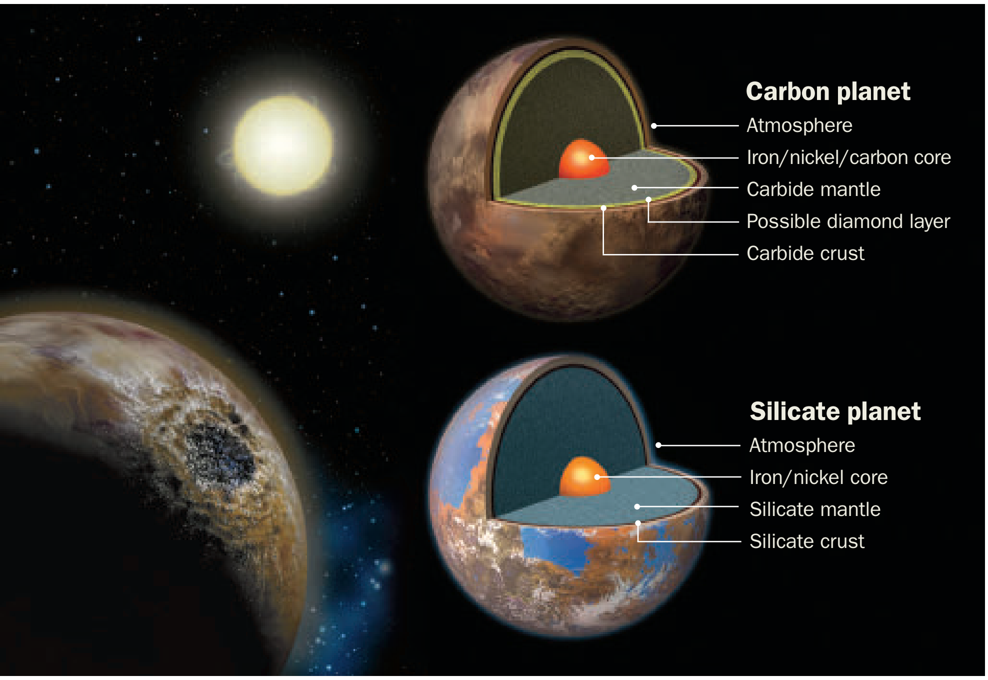
It is not a totally far-fetched idea. In the past 10 years several astronomers have imagined such things, and three years ago astronomers reported ultraviolet evidence that a carbon-rich disk orbits the star Beta Pictoris, 60 light-years away, and could spawn carbon planets. "It is easy to imagine it happening," says Eric Gaidos of the University of Hawaii. "But it is not easy to imagine it happening a lot."

Looking for little

Small planets, dead or alive, carbon or oxygen-rich, are big news. An aching hunger to find them has intensified among many astronomers since 1995. That is when a Swiss team, quickly followed by others, began detecting the gravitational influence of huge planets — many far more massive than Jupiter — circling other stars. These exoplanets are mostly bizarre places, typically seared to scorching temperatures because of their close-in orbits. The list of "hot Jupiters" and other large and uninhabitable-looking worlds now exceeds 350.

Among the smallest is COROT-7b, named for the European satellite COROT that measured its size by detecting its transit across the face of its star from a slight dimming in the star's brilliance (*SN: 2/28/09, p. 9*). COROT-7b has a radius perhaps 75 percent larger than Earth's and a mass six times greater or more. It orbits its star at such a roasting close distance that it goes around every 20 hours. Some suspect it is a former Neptune whose outer atmosphere evaporated away. That's hardly Earthlike.

NASA's newest space telescope — the Kepler satellite launched in March and just starting operation — may provide proof in coming years of how many sunlike stars have planets similar to Earth in size and orbiting at distances suitable for life of the sort biologists can easily imagine. Kepler will be able to detect them only from subtle changes in the brightness of their stars, but won't be able to



Carbon worlds

Humans are carbon-based life forms, but Earth is not a carbon-based planet. Some scientists think such planets may exist, though, in orbit around distant stars. Cutaway views show a carbon-based planet, possibly made mostly of silicon carbide, or carborundum, compared with the preponderance of oxygen-rich compounds in a silicate planet like Earth. At far left is an artist's view of a carbon-based planet covered in tar, where a meteorite impact has exposed a layer of diamond.

analyze them. Geoff Marcy, a University of California, Berkeley astronomer, is a former student of Jura's at UCLA and is now a leading pioneer in discovery of exoplanets; weird giant planets are getting old for people like him. "There is a science fiction appeal to discovery of other Earths," Marcy says. "Kepler is fantastic, we need it. But the sad news is that all the stars it is looking at are about a thousand light-years away. It will give our first accounting of small planets, but unfortunately none will be near enough to tell us much else."

Waiting in the wings at NASA is a multibillion-dollar design for a huge orbiting instrument called the Terrestrial Planet Finder, originally to have been launched this decade but now on ice due to heavy space science budget cuts. The European Space Agency's somewhat similar project, called Darwin, is also stalled by money woes.

That might change if Kepler hits paydirt.

"If we do learn that lots of stars, say 50 percent of them, have Earthlike planets, that will give a huge kick [to Congress and other nations] to pay for follow-up missions," says Victoria Meadows, a University of Washington astronomer and leader of the Virtual Planet Lab project to simulate how such planets might look.

She is involved with one spaceborne project called Epoxi that has already scored. The craft measured reflected light as a distant terrestrial planet rotated while illuminated in a crescent view by its star. The variations permitted the team to derive a crude map. "We could see the Atlantic and Pacific ocean basins!" enthused Meadows. The planet was Earth itself, as seen from several tens of millions of miles away. The exercise used sensors aboard the Deep Impact spacecraft — while it was between missions to comets — to watch Earth while manipulating the data to mimic what might be gathered by larger instruments but across many light-years of space.

There is one thing that everybody in the planet-hunting business expects: surprise. They already know that a delicate balance of factors went into making the sun's family of planets, including Earth. Those details included not just the ratio of carbon and oxygen to tip the balance toward silicate rocks, but an infusion of radioactive elements from a nearby supernova or perhaps from a giant cluster of large, young stars as the sun's progenitor cloud began its contraction. The infusion of radioactivity, its signature clear in ancient meteorites, would have allowed greater heat to build up in the interiors of rocky planets as well as the minor planets and asteroids that orbit the sun beyond Neptune and Pluto.

With just slightly different starting conditions, the inner solar system could be drier than it is today, or far wetter. As it is, Venus and Mars are "Earthlike," with similar masses and orbits, yet profoundly different.

"We sometimes call Earth the water planet, but the real question is, why does Earth have so little water?" UCLA's Young said at the Origins symposium. Earth's water layer is only about two hundredths of one percent of the planet's mass — not even enough liquid to cover the mountains. "It wouldn't take much more to have a true ocean planet," Young said.

Thus Earthlike planets — really *Earth*-like — may be exceedingly rare, but only because with so many variations possible, to get two in separate systems that are the same down to fine detail would be unusual. David Stevenson, a Caltech planetary scientist, said at the Origins panel that "there will be a tremendous richness in outcomes. There will be things not like Earth — maybe carbon- rich planets, maybe super Ganymedes [a moon of Jupiter], half rock and half ice. What I think will come out from Kepler and later missions is a diversity of things different from anything that we have thought about so far. And that will be great." ■

Charles Petit is a freelance science writer in Berkeley, Calif.

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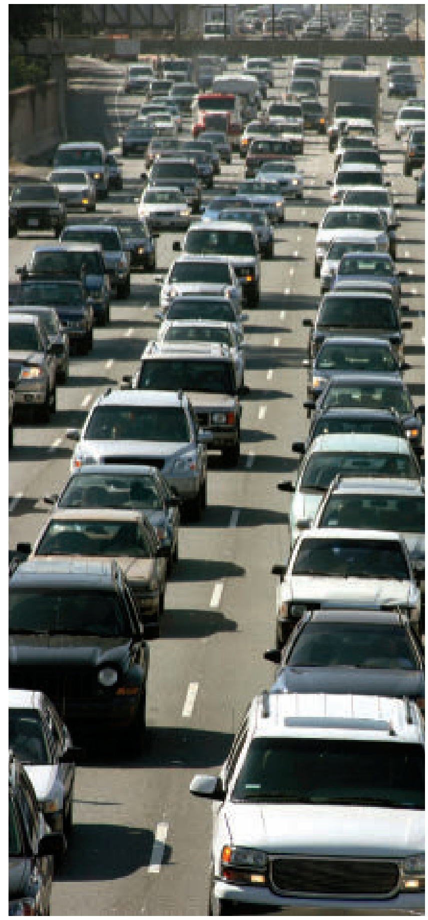
Bad Breath



Studies are homing in on which particles polluting the air are most sickening — and why

By Janet Raloff

Tasteless. Invisible to the eye. Air contaminants less than a tenth the size of a pollen grain are nevertheless dangerous.

Even on a clear, sunny day, many tens of thousands — and potentially millions — of tiny particles cloud every breath you take. Some are nearly pure carbon. But reactive metals, acids, oily hydrocarbons and other organic chemicals jacket most of these motes.

Epidemiologists have been calculating human tolls by comparing how many people die when particle numbers in the air are high against mortality figures on cleaner days. Over the past couple of decades, those data have been implicating tiny airborne particles in the deaths of huge numbers of people each year — even where concentrations of these microscopic contaminants never exceed levels permitted by U.S. law.

Based on extrapolations from such data, in China alone an estimated 1 million people die prematurely each year from the toxic inhalation of tiny airborne specks, according to Staci Simonich of Oregon State University in Corvallis and her colleagues in an upcoming *Environmental Science & Technology.*

Formally referred to as particulate matter, or just PM, these tiny particles from mostly outdoor sources and indoor tobacco smoke together "rival 'overweight and obesity' as causes of premature death," Armistead Russell of the Georgia Institute of Technology in Atlanta and Bert Brunekreef of Utrecht University in the Netherlands report in the July 1 issue of the same journal.

Airborne particles range from wind-blown dust and grit to nanoscale specks that won't darken the skies, even when 100,000 particles cloud each cubic centimeter of air. The potential impacts of these little particles also vary widely. Particles big enough to taste and feel can be an uncomfortable nuisance but don't tend to pose big health risks. Fine particles, especially those 2.5 micrometers in diameter or smaller, are another story.

Studies reported over the past few months indict such specks in contributing to or aggravating a host of conditions, from asthma and stroke to heart disease and premature aging of chromosomes.

Industrial smokestacks aren't the only villains. Several new studies finger vehicular traffic as a major driver of particulate-triggered illness.

FROM LEFT: ALOHASPIRIT/ISTOCKPHOTO; EGDIGITAL/ISTOCKPHOTO

Trafficking in heart disease

No surprise, combustion from cars and trucks is a major source of PM-2.5, also known as "fine" particles — ones 2.5 micrometers and smaller — and especially of "ultrafines," particles no more than 0.1 micrometers (100 nanometers) in diameter, notes Peter Adams of Carnegie Mellon University in Pittsburgh.

The U.S. Environmental Protection Agency regulates concentrations of PM-2.5 in the air. But by number — not mass — the vast majority of airborne particles are ultrafines. They're as yet unregulated, but not because anyone thinks they are unimportant. Studies have confirmed that they're the particles inhaled most deeply into the lungs, from which some pass directly into the blood.

The problem, notes Russell, is that ultrafines are devilishly hard to measure, which has impeded the collection of health data linking such Lilliputian specks to disease. But that's beginning to change. For instance, researchers at the University of California, Irvine and the University of Southern California in Los Angeles have just published data linking the small particles to heart disease.

The scientists measured fine particles and took a rough gauge of ultrafine pollution daily outside four California retirement communities throughout two six-week periods — first in summer, when ozone levels were high, and again in winter. Relatively novel: These scientists analyzed the particulates' composition to gauge what share came from combustion — here, largely from traffic — and from other sources.

Sixty retirement-home residents, all nonsmokers over age 70 with cardiovascular disease, submitted to weekly blood tests. Assays probed for biomarkers of inflammation, of blood platelets that had turned extra sticky and of cellular stress caused by oxidation — all factors that contribute to and aggravate artery-clogging atherosclerosis.

Although the residents spend the vast majority of their time indoors, all had exposure to traffic pollutants, notes Ralph Delfino, a UC Irvine School of Medicine epidemiologist who led the study. His group and others have shown that fine particulates seep inside homes even when doors and windows are closed.

Changes in the levels of traffic-linked particles outside the retirement homes correlated with changes in biomarkers of inflammation and oxidation in most study volunteers, Delfino and his colleagues report online April 29 in *Environmental Health Perspectives*.

The traffic–particulate matter trend didn't hold among some residents taking medicines that can reduce inflammation or platelet aggregation. These drugs made residents relatively immune to the particulates' atherosclerotic impacts.

Findings from the new study are consistent with those from a German study in 2007 that measured coronary artery calcification, a gauge of atherosclerosis, in nearly 4,500 middle-aged to elderly men and women. After controlling for other risk factors, that study showed that the closer people lived to a major road, the worse their atherosclerosis.

The new California study also showed that particle numbers climbed in winter by almost 50 percent, although the overall PM mass in air varied little. This means particles tended to be smaller in winter.

That makes sense, Delfino says, because cool air close to the ground tends to stagnate. So it takes longer for particles to mix, blow away or glom onto others. He concludes, "Air can get quite a bit more toxic [when it's cool] than at any other time of year."

Raising blood pressure

Delfino's group also collected hourly data on blood pressure from the participants. And blood pressure changes correlated better with increases in traffic-related fines and ultrafines than with similarly small particles from other sources.

At the Experimental Biology meeting in New Orleans in April, Robert D. Brook of the University of Michigan Medical School in Ann Arbor also reported that blood pressure spikes as airborne particulates increase. His group recruited 50 nonsmokers from Ann Arbor to come into a lab for two-hour sessions where the participants breathed either pristine air or local air concentrated to contain 150 micrograms of PM-2.5 pollution per cubic meter. That dirtied air was comparable with levels of pollution that sometimes occur in Detroit, Brook explains, and was only about half as bad as what residents of Beijing, Cairo or Delhi regularly encounter.

Taking measure of particulate matter

Pollutant particles tiny enough to be inhaled deeply into the lungs, typically PM-2.5 and smaller, can't be seen with the naked eye but collectively can contribute to hazy skies. The particles can grow in size as they collide and stick to others or become jacketed with other airborne chemicals. Smaller particles can ride air currents for days to weeks, traveling far — until washed out by rains.

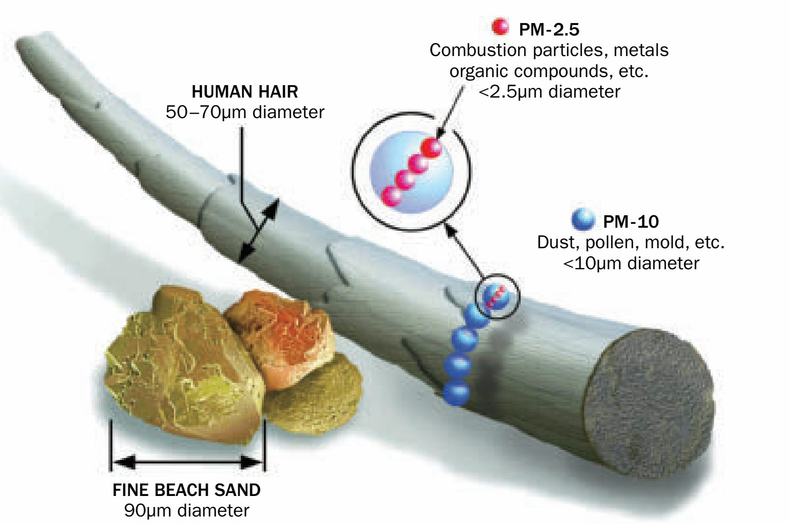


IMAGE COURTESY EPA OFFICE OF RESEARCH AND DEVELOPMENT, MODIFIED BY A. NANDY


SDOMINICK/ISTOCKPHOTO

Urban air often hosts up to 10,000 particles per cubic centimeter. But, a team from Carnegie Mellon University found, on some apparently pristine days in Pittsburgh (above), the air may hold up to 150,000 particles/cm³. Unseen, the ultrasmall particles may form spontaneously on sunny days under certain conditions.

During this brief exposure, diastolic blood pressure in volunteers inhaling the dirty air climbed an average of 4 to 5 millimeters of mercury. Blood pressure remained at background levels in the recruits who breathed clean air.

Brook also reported on two longer-term studies at the April meeting. One followed 350 people from three Detroit neighborhoods, correlating blood pressure over a five-day span with local readings of outdoor PM-2.5. In contrast with the lab studies, it was systolic blood pressure that altered in lockstep with the pollution.

Variations in particulate levels generally appeared to trigger changes in blood pressure of 4 to 8 millimeters of mercury. But in an area directly downwind of a power plant, some people experienced bigger, and potentially more dangerous, pressure fluxes, Brook reported — "as much as a 30 mm blood pressure increase for every 10 μg/m³ increase in PM-2.5."

Stroke of bad luck

Particulate pollution appears to foster other types of vascular disease as well, such as ischemic stroke, the type caused by the blockage of an artery.

Gregory Wellenius of the Harvard School of Public Health in Boston reported at the Experimental Biology meeting on an analysis of 9,000 patients at regional stroke centers in Ontario, Canada. "We didn't find any association between ambient air pollution — specifically the PM-2.5 — and risk of ischemic stroke," he said. Until, that is, his team separated out patients with diabetes, one-quarter of the total group.

"When we looked just at the diabetics," he said, "there was a very strong effect — a 10 percent increase in risk of being hospitalized for ischemic stroke for every 10 μg/m³ increase [in PM-2.5]." Overall, the data showed, particulate pollution "tended to be about 10 percent higher on the two days before the diabetics were hospitalized" than earlier or after their symptoms set in.

These findings fit with data that his colleagues published four years ago showing that particulate matter pollution impairs the ability of diabetics' blood vessels to relax appropriately — a sign of cardiovascular disease. Wellenius says the new diabetes-PM correlation may also explain why earlier studies, which looked at largely healthy people, missed stroke's link to particulate pollution.

Traffic's choke hold

Another reason why reports inconsistently link particulates with some ills may stem from the fact that monitoring stations report PM data on the basis of mass and size, not composition. Yet there is considerable variability in what these tiny specks are made of, which tends to reflect their source and whether they've morphed during their travels.

To investigate whether PM pollution aggravates childhood asthma, Yale University epidemiologist Janneane Gent and colleagues analyzed PM-2.5 data collected in New Haven, Conn. Then they calculated the likely share of the tiny motes that came from particular sources, based on the ratio of metals and other elements that serve as characteristic markers of the most likely contributors: tailpipe exhaust, road dust, biomass burning, sea spray and power plant (and home heating) emissions.

Mothers of the 149 children recruited for the study kept a yearlong daily log of the kids' symptoms and any need for asthma medicines. When the researchers correlated the daily particle pollution against these logs, "we didn't find any association between overall PM-2.5 and health," Gent notes. But when the team stratified these fines by apparent source, she says, "we found that for every additional 5 μg/m³ mass from motor vehicles or road dust, you see an increase in the [risk] of respiratory symptoms or inhaler use."

Pollution aggravated some symptoms more than others, they report in an upcoming *Environmental Health Perspectives*. For each 5 μg/m³ increase in mass, Gent says, "we see that a child typically had a 10 percent increased risk of wheezing" — in addition to a 3 percent increased risk of persistent cough and a 12 percent increased risk of shortness of breath.

Flipping genetic switches

Some researchers are probing for pollution-induced genetic changes that may underlie symptoms of particulate-linked disease.

At the Experimental Biology meeting, Jesus Araujo described his team's research into how airborne particulates promote atherosclerosis. Previously, Araujo, who directs environmental cardiology at the University of California, Los Angeles' Geffen School of Medicine, and his colleagues showed that constituents of certain tiny particles "can synergize" with plaque-fostering elements of low-density lipoprotein cholesterol, or "bad cholesterol." The combination turned on genes that foster vascular inflammation, a driver of atherosclerosis.

In test tube studies, tiny particulates dramatically boosted the activity of some 1,600 of the 9,000 genes surveyed. Follow-up work showed mice "exposed to ultrafine particles had an up-regulation of those same genes," Araujo said.

More recently, Araujo's team exposed genetically engineered mice for 75 hours to clean air or to air enriched with Los Angeles particulates. The animals' engineered predisposition to atherosclerosis serves to model early stages of this disease in people. Animals getting the dirty air were exposed over five weeks to either fines or to ultrafine particles.

"Those exposed to the fine particles exhibited about a 25 percent increase in lesions — aortic atherosclerotic plaque — over mice breathing clean air," Araujo says. Mice getting only the ultrafines, a size fraction that tends to contain at least twice the amount of polycyclic aromatic hydrocarbons present in PM-2.5 particles, developed a 50 percent increase in plaques.

Moreover, Araujo observes, "animals exposed to the ultrafine particles developed evidence that their plasma high-density lipoprotein cholesterol, or 'good cholesterol,' lost its ability to protect against oxidation and inflammation." His group recently showed that the inability of this HDL cholesterol to protect correlates strongly with buildup of arterial plaque. So this HDL, which appears to become pro-inflammatory, is no longer "good cholesterol," he concludes.

Since ultrafine particles constitute the majority of fines, much of the plaque-fostering impact of fine particulates may trace back to the ultrafines, Araujo says. In his region, traffic is a major source of those ultrafines.

Traffic also appears to prematurely age the body's genetic material. Andrea Baccarelli of the University of Milan and his colleagues compared DNA in white blood cells from 77 people who regularly stand in the roads directing traffic with that from 57 office workers. Outdoor workers assigned to high-traffic streets had significantly shorter protective caps on the tips of their chromosomes than did any of the other recruits.

> "Size and chemistry are both important.... Traffic probably has a greater health impact on a per-mass basis than do other [particulate matter] sources."
>
> ARMISTEAD RUSSELL

These caps, known as telomeres, tend to shorten each time cells divide. As such, telomere length serves as a rough gauge of biological aging. After accounting for the individuals' ages, Baccarelli says, blood cells of workers who regularly had high daily exposures to combustion exhaust "looked 10 years older" than the cells should. Eventually, when telomeres become too short, a chromosome's genetic material can start to degrade. Baccarelli's team reported its findings in San Diego in May at the American Thoracic Society annual meeting.

On the job exposure

At the same meeting, the team also reported a link between exposure to fine particles and epigenetic changes to DNA — either the addition or removal of methyl groups (a carbon bonded to three hydrogen atoms). Such changes inactivated two cancer-suppressor genes and altered the activity of other genes throughout the body in ways that Baccarelli notes have been linked with "higher incidence and mortality from cardiovascular disease."

Among foundry workers at a steel plant in northern Italy, an increasing incidence of switched-off tumor suppressor genes accumulated during the week, when PM exposures were high, then fell over the weekend, presumably as repair mechanisms caught up. "This signifies," Baccarelli says, "that after only three days of work, these men experience changes in the regulation of their genes."

Although such changes appeared reversible, his group witnessed a similarly inappropriate methylation of inflammation-provoking genes that didn't recover over a weekend, suggesting cardiovascular impacts could be longer lasting.

Another persistent change that didn't recover after a weekend away from work: The blood cells of foundry workers with high workplace PM exposures had mitochondria with extra copies of their genomes. In these energy powerhouses, the development of additional copies of DNA tends to reflect genetic damage, Baccarelli says, as the mitochondria attempt to compensate for oxidative stress.

It was hard to tease out which size particles were most toxic, he says, because as the number of small particulates rises or falls in the foundry air, so too does the number of even smaller particles. But particulates enriched with metals, especially cadmium and chromium, did correlate with high levels of epigenetic damage in the workers, Baccarelli reported.

When it comes to particulate toxicity, "there's no question: Size and chemistry are both important," Russell says. And studies do suggest "that traffic probably has a greater health impact on a per-mass basis than do other [PM] sources."

That said, Russell argues that science hasn't presented a clear enough picture to help policy makers know how best to improve regulations. At issue: Should the emphasis remain on regulating solely by size and quantity of particles — perhaps finally tackling ultrafines? Or by size *and* chemistry? Or maybe even by pollution sources, such as traffic?

"To settle this," Russell says, "we're going to need far more of these epidemiology and toxicity studies." ■

Explore more

- Visit the U.S. Environmental Protection Agency's particulate matter home page at www.epa.gov/particles

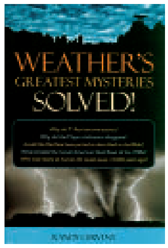
Weather's Greatest Mysteries Solved!

Randy Cerveny

There's no escaping the weather: It affects all people nearly every day of their lives. And climate — long-term trends in temperature, precipitation and other aspects of weather — influences everything from agriculture to the health and vitality of civilization itself.

In this book, climatologist Randy Cerveny provides an insider's perspective on how storms, droughts and even asteroids may have altered the course of history. For instance, was it a fluke that Columbus crossed the Atlantic in 1492 without encountering a hurricane even though his voyage began in late summer, typically the height of today's hurricane season?

Cerveny tackles this question and others in fascinating chapters, many with Nancy Drew–like titles. In each vignette, Cerveny details how scientists have used clues — oxygen isotopes locked in ice cores in Greenland, tree rings in Arizona — to solve the puzzles. "The mystery of the Mayan megadrought" explores how an extended dry spell during the eighth and ninth centuries may have triggered the demise of one of the world's great civilizations. "The mystery of the Pacific hot tub" describes scientists' efforts to decipher how a warming of sea-surface temperatures in the mid-Pacific, called El Niño, influences temperatures and storm paths around the planet.



Through spellbinding tales set in the distant past and not-so-distant future, Cerveny reveals how major trends in weather and climate have shaped world events. Among his most important points: Climate does change, and civilizations can be profoundly influenced — often detrimentally so — in the process. *— Sid Perkins*

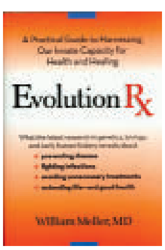
Prometheus Books, 2009, 328 p., $26.98.

Evolution R_x: A Practical Guide to Harnessing Our Innate Capacity for Health and Healing

William Meller

Meller is a modern physician with an eye on the Stone Age. His book offers practical medical and health advice with evolutionary justifications that range from plausible to fanciful.

Meller accepts the premises of evolutionary psychology, a controversial school of thought grounded in the assumption that our bodies and brains evolved to handle Stone Age conditions. Though he sometimes strains to connect illnesses, diet and behavior to their presumed prehistoric roots, he nonetheless provides sensible guidance on preventing disease and promoting health.



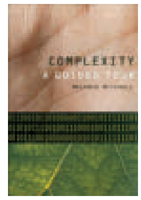
Much evidence suggests that Stone Age people ate foods rich in protein and fats, not carbohydrates, for example. Citing this work, Meller recommends a diet tilted toward meat, fish and vegetables.

Because Stone Age people lived in far-flung bands, the spread of bacteria and viruses was dampened. Today vaccinations, including flu shots, prove invaluable to prevent disease transmission, he says. But Meller advises readers not to rely on over-the-counter cold remedies, noting they contain no ingredients to shorten the infection.

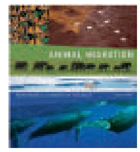
Some of Meller's claims are questionable. In a chapter offering advice about relationships and sex, he asserts that Stone Age women preferred mating with bald guys — because signs of maturity were sexy in a world where the weak died young. That sounds like male-pattern wishful thinking.

Still, this book, which includes contributions from *Science News* biomedical writer Nathan Seppa, contains prudent suggestions for healthy living in the Information Age. *— Bruce Bower*

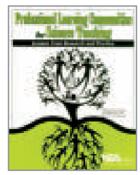
Perigee, 2009, 309 p., $24.95.



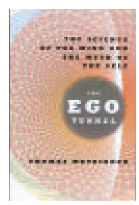
Complexity: A Guided Tour
Melanie Mitchell
A scientist surveys the field and explores how complexity emerges from simple interactions in a variety of systems. *Oxford Univ., 2009, 349 p., $29.95.*



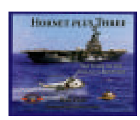
Animal Migration: Remarkable Journeys in the Wild
Ben Hoare
A collection of color photos, maps and drawings depicts animals' treks across the planet. *Univ. of California, 2009, 176 p., $34.95.*



Professional Learning Communities for Science Teaching: Lessons from Research and Practice
Susan Mundry and Katherine E. Stiles, eds.
Examples of educators creating collaborative networks to develop their skills, and how students can benefit. *National Science Teachers Association Press, 2009, 161 p., $22.95.*



The Ego Tunnel: The Science of the Mind and the Myth of the Self
Thomas Metzinger
A philosopher argues that your idea of self is all in your head. *Basic Books, 2009, 288 p., $27.50.*



Hornet Plus Three: The Story of the Apollo 11 Recovery
Bob Fish
After men first landed on the moon, they still had to get back to Earth — a surprisingly complicated feat. *Creative Minds Press, 2009, 232 p., $29.95.*

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On honeybees and jury duty

Reading "Swarm Savvy" (*SN: 5/9/09, p. 16*), I was struck by how closely the honeybee decision-making process resembled the internal dynamics of a jury I once was on. The "obvious" jury decision, in my not-very-humble opinion, was guilty to a lesser charge of non-aggravated battery, but I was surprised by how many moms and nurses wanted to acquit the defendant immediately — and how offended they were by my obstinate refusal to back down. The final result, when it came, was indeed guilty to the lesser charge, but by then I had been worn down and was doubting my own decision. It was not an easy afternoon, and the end came only when everyone had allowed [like the honeybees in the article] "their enthusiasm to decay." The end came abruptly, in fact, and correctly in my opinion.

I wonder if the jury system has not been deliberately designed to facilitate this behavior. But if so, by whom? Are 12 jurors an optimum number because 12 is so easily divided by four or three or two? I wonder if the law distinguishes gradations in offenses, not because criminals are sometimes "less guilty" or "more guilty," but because juries cannot reach a decision if their only options are guilty or not guilty. Has common law reached preeminence precisely because it is an optimum, highly evolved decision-making process?

David C. Oshel, Cedar Rapids, Iowa

Monkey business

The June 6 Science Past (*SN: 6/6/09, p. 4*) says that on May 28, 1959, two monkeys were shot into space and successfully retrieved for the first time. Wrong! You are off by 10 years. Immediately after the war, Wernher von Braun brought several V-2 rockets to a proving ground in White Sands, N.M. My good friend, flight surgeon Dr. David G. Simons, designed a seat in the nose cone of a V-2 rocket to fit a monkey attached to instruments that measured blood pressure, pulse and respirations. In 1949, he shot a monkey into space and recovered the animal in good health. That same year, Dr. Simons spent 12 hours at the edge of space in a balloon. He proved that cosmic radiation was not [acutely] hazardous.

Paul H. Ripple, Lancaster, Pa.

While we can't verify Ripple's assertion that the monkey sent to space in 1949 was retrieved unharmed, his letter certainly counts as a first: A request for a correction in an article that originally ran 50 years ago. —Editors

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

Paul Fendley

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

Five problems in physics without the definite article

In a 2006 book that garnered much press for its silly attacks on string theory, author and physicist Lee Smolin provides a list of "The Five Great Problems in Theoretical Physics." There are many offensive things about this list, starting with the use of the definite article in the title, which implies that people not working on these problems (the majority of theoretical physicists) are working on less-than-great problems. But to me the most offensive thing is that only one of the five problems, I believe, could eventually be resolved by experiment.

Most physicists don't consider a phenomenon to be understood until there are both repeatable experiments displaying it and a quantitative theoretical description. The only physics problems without both aspects are those unrelated to experiment. We have a name for such problems: mathematics.

The book's list, however, did inspire me to come up with my own list. Here are my "Five Great Problems in Theoretical Physics," without the definite article:

1. Explain the dark matter and energy in the universe

This problem is the one of Smolin's five that stands a shot at being resolved in my lifetime. It's actually two related problems. Astronomers have observed that the gravity we theoretically understand does not describe how galaxies rotate — unless there's a lot of matter out there that we don't see. This is known as dark matter. Similarly, at staggeringly long-distance scales, astronomers observe that light is overall not bent, even though gravity does indeed bend light. The only way this is consistent with Newton and Einstein is for the universe to possess a precise energy density. Dark energy is our name for this extra energy. For both dark matter and energy, we need to figure out what this stuff is or we need to figure out how to extend the work of Newton and Einstein.

2. Explain high-temperature superconductivity

Even ignoring possible real-world applications, superconductivity is one of the coolest (literally and figuratively) phenomena in quantum physics. It's hard not to be impressed with experiments that let current flow for years without a battery. We understand theoretically what characterizes a superconductor: Electrons of opposite momentum form an unusual quantum state of zero energy called a Cooper pair. But this long happened only at excruciatingly low temperatures, hard to achieve outside a lab. Thus the physics version of mass hysteria occurred in the late 1980s when materials that superconduct at high temperatures were found. "High" here is still pretty cold but is above the temperature of liquid nitrogen, which means it's easy to get that cold. For the high-temperature superconductors, we theorists are embarrassed to admit that after more than 20 years, we still aren't sure how these Cooper pairs form.

In physics, understanding requires both experiments and a quantitative theoretical description.

3. Explain the "Higgs" phenomenon in the standard model

Billions (in any currency unit) have been spent to build the Large Hadron Collider, a gigantic accelerator in Switzerland and France. Explanations for why usually start with "we're trying to understand what gives particles mass." According to the successful standard model describing quantum physics at the shortest observable distances, at even shorter distances (or higher energies) there's a symmetry that requires particles to be effectively massless. Since we know particles do have mass, something must break this symmetry. The simplest candidate is a particle called the Higgs boson, which may or may not exist. The LHC is built to go to short enough distances to find it, or find whatever else breaks this symmetry. Theorists are hoping for the latter — it would be much more interesting.

4. Figure out how to make a quantum computer

There are many simple-to-state problems unsolvable by even the fastest computers. For example, encryption on the Web relies on computers' inability to factor very large numbers into prime numbers. A radical proposal to solve this and other computationally intractable problems is to build a quantum computer, where each bit obeys the laws of quantum mechanics. A quantum bit is very hard to build and manipulate, so current quantum computers have only a handful of bits. Building a suitable quantum computer sounds like an experimental problem. But we're currently so far from our goals that brilliant new ideas from theorists and experimentalists will be required to further advance this field.

5. Say nice things about your own work without slamming others

Your list will probably be different from mine. Diverse priorities in any science are a strength — the study of one problem often helps solve another. The theory of the Higgs phenomenon, for instance, was first understood in a completely different context: superconductivity. ■

Paul Fendley is a theoretical physicist at the University of Virginia.