Introducing Ice XV | Hypnotic Neuroscience | Rise of the Viruses

ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ OCTOBER 10, 2009

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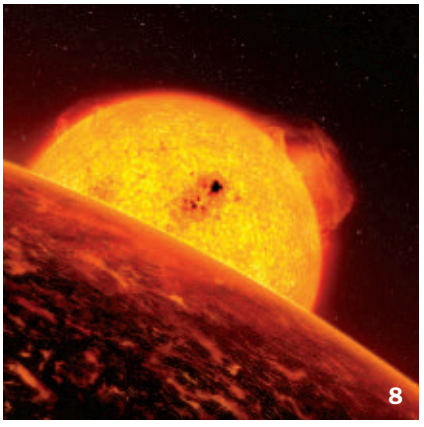

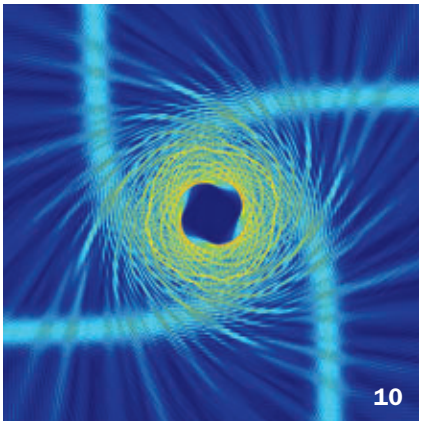

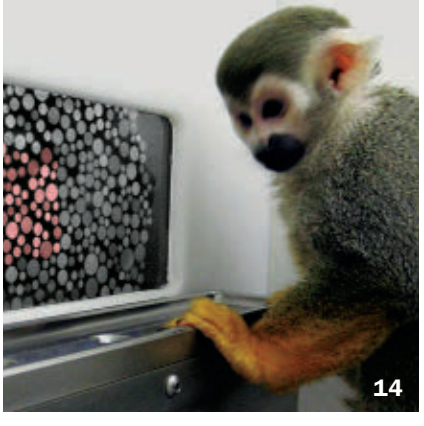

ScienceNews

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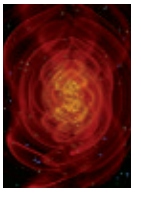

COVER Gravitational waves, shown here in a simulation of black holes merging, and other energetic signals may reveal secrets of the universe. *Illustration by C. Henze, NASA*

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FROM THE EDITOR

In science, unlike films, don't beware the stare

Stare, if you dare, into the world of research on hypnosis and the brain.

OK, that doesn't sound as thrilling as the cult horror movie *The Hypnotic Eye* (Jacques Bergerac, Allison Hayes, 1960). But some scientists are excited about studying hypnosis these days, using imaging techniques and other methods to show that hypnotic trances really do alter brain activity, as freelance writer Susan Gaidos reports in this issue (Page 26).

Such research is not just about how hypnosis works; it provides a new view into the workings of the brain itself. Most intriguingly, it allows scientists to simulate certain disorders so they can be studied without all the confusing complications of real diseases, providing cleaner clues to how brains sometimes go awry (though hopefully not as awry as the brain of the mad magician in the movie).

If you've seen the movie, you know that it's safer simply to stare out into space, which is what astronomers are doing with some sophisticated techniques of their own. And when astronomers stare, they mean business, observing the sky in all of the ordinarily invisible wavelengths of radiation that surround light in the electromagnetic spectrum. New instruments have begun or will soon begin to open these (and even some nonelectromagnetic) windows further than ever before. In the process, previously hidden details of cosmic history should be revealed, as Ron Cowen writes (Page 16).

If you prefer staring at small, small worlds instead of the whole universe, you can now see viruses, once believed to be nonliving packages of molecules too tiny to be seen with a visible-light microscope. As Rachel Ehrenberg reports (Page 22), the Goliath of viruses, known as mimivirus, is bigger than many bacteria and has opened microbiologists' eyes to the pivotal roles that viruses play in the biosphere. Recent research raises questions about whether viruses deserve to be designated as alive after all. In fact, the possible role of viruses in primordial biochemistry suggests they may hold clues to the origin of life itself.

From the secret life of viruses to the mesmerized brain to the origin of the universe, science continues to confirm the benefits of staring at nature and seeing old things in new ways. So please do dare to stare. Don't worry about movie magicians who, as the film's ominous tag line warned, had the "power that turns human flesh into helpless robots."

—Tom Siegfried, Editor in Chief

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12. Ocean Sediments Reveal 5 Million Years
13. A Bad Day in June—Death of the Dinosaurs
14. The Origin and Early History of Life
15. The History of Earth's Atmosphere
16. The Age of the Solar System
17. What Happened before the Sun Was Born?
18. Atoms Are Star Stuff—Cooking Up Carbon
19. The Lives of Big Stars—Cooking Up Big Atoms
20. Relativity—Space and Time Become Spacetime
21. (Almost) Everything Is Relative
22. Matter Vanishes; Light Speed Is Breached?
23. The Limits of Vision—13.7 Billion Years Ago
24. The First Few Minutes—Where It All Began

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Science Observation

"There is, however, a way to surmount this problem [of safe, manned travel to Mars] while reducing the cost and technical requirements, but it demands that we ask this vexing question: Why are we so interested in bringing the Mars astronauts home again? While the idea of sending astronauts aloft never to return is jarring upon first hearing, the rationale for one-way trips into space has both historical and practical roots. Colonists and pilgrims seldom set off for the New World with the expectation of a return trip.... To boldly go where no one has gone before does not require coming home again." —**LAWRENCE M. KRAUSS, DIRECTOR OF THE ORIGINS INITIATIVE AT ARIZONA STATE UNIVERSITY, IN THE AUG. 31 *NEW YORK TIMES***

Science Past | FROM THE ISSUE OF OCTOBER 10, 1959

RESERPINE TRANQUILIZES CHICKENS AND TURKEYS — Calmer birds in the hen house are predicted with the development of a tranquilizer for chickens. A new product containing reserpine, a drug used to control high blood pressure and other human ills, has been developed.... Added to the chickens' feed in very low concentrations it is said to help the chicken withstand stress. Treated chickens had a higher survival rate and produced more and higher quality eggs than did hens on a standard diet. They also are not bothered as much by crowding, social maladjustment, temperature extremes and disease. CIBA researchers claim the product is also economic because feed waste is reduced. The sedate treated chickens scratch less food out of the feeder and onto the ground. Turkeys were included in the study. The drug is said to help control ruptured aorta, a deadly affliction of turkeys.

Science Future

October 18–22
The International Diabetes Federation hosts its 20th World Congress for researchers and clinicians in Montreal. Visit www.worlddiabetescongress.org

November 11–14
National Association of Biology Teachers hosts a professional development conference in Denver. See www.nabt2009.org

November 14
Scientists and humanities scholars discuss the union of math and beauty at a roundtable forum in New York City. See philoctetes.org/Calendar

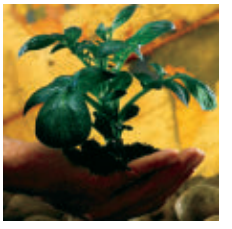
Introducing…

A new species of giant rat, about as big and furry as an opossum, turned up earlier this year during a BBC-sponsored expedition to Mount Bosavi in Papua New Guinea. Weighing some 1.5 kilograms and stretching 82 centimeters, this animal still may not be the largest in the rat-and-mouse family, says codiscoverer Kristofer Helgen of the Smithsonian Institution in Washington, D.C. Helgen and colleagues are preparing to publish the official name of the Mount Bosavi rat, which belongs to the genus of woolly rats, *Mallomys*. Helgen first met one on a rainy night. "Just like a dog, it did a body shake and sent water flying all over us from this thick fur," he says.

SN Online

www.sciencenews.org

GENES & CELLS
Genetic analysis of the microbe behind the Irish potato famine could help breed resistant plants. See "Potato famine pathogen packs unusual, sneaky genome."

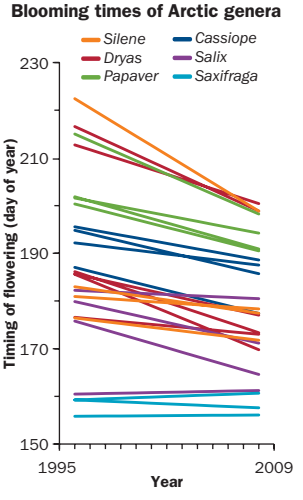


SCIENCE & THE PUBLIC
Scientists tell Congress about the possible risks of cell phone use. Read blog post "Cell phones: Precautions recommended."

MOLECULES
An electronic device sniffs toxic chemicals. See "Nose knows noxious gases."

Science Stats

Early blooms in the Arctic
Certain plants are flowering earlier in response to warming.



Multiple lines represent data from different sampling plots in Greenland
SOURCE: E. POST *ET AL./SCIENCE* 2009

CLOCKWISE FROM TOP LEFT: MIKE SANDS/CASE WESTERN RESERVE UNIVERSITY; SCOTT BAUER/ARS; K. HELGEN

“This is truly the first rocky world beyond the solar system, and we know there’s more to come.” —SARA SEAGER, PAGE 8

In the News

STORY ONE

Mental disorders more widespread than estimated

Study comes as psychiatrists reevaluate diagnostic manual

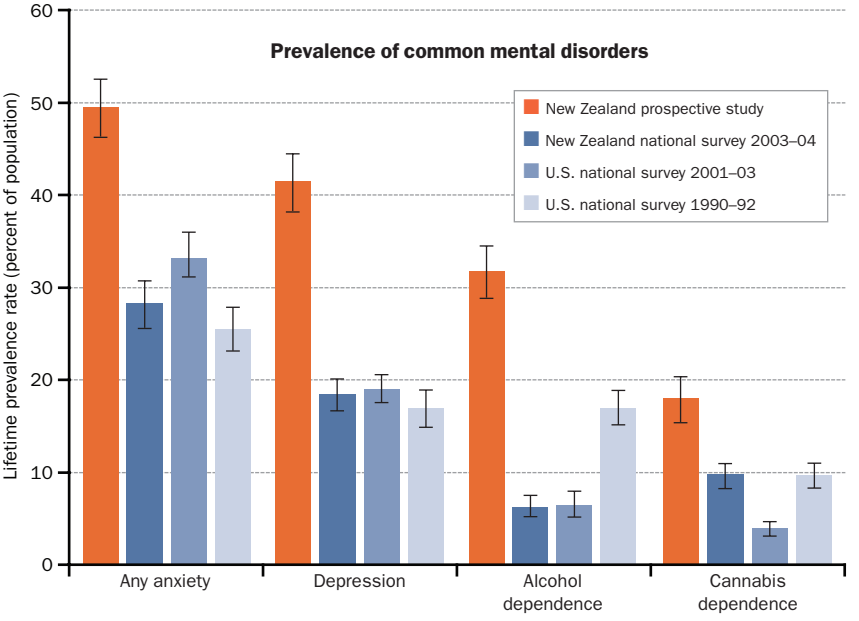
By Bruce Bower

Some mental disorders aren’t merely common—they’re the norm.

Depression, anxiety disorders, alcohol dependence and marijuana dependence affect roughly twice as many people as had been estimated previously, a new study finds. Nearly 60 percent of the population experiences at least one of these mental disorders by age 32, say study directors and psychologists Terrie Moffitt and Avshalom Caspi, both of Duke University in Durham, N.C.

That figure probably gets higher by the time people reach middle age, Moffitt suggests, as additional people develop at least one of these four ailments for the first time.

In a paper published online September 1 and in an upcoming *Psychological Medicine*, Moffitt and Caspi present results from a study of more than 1,000 New Zealanders assessed for mental disorders 11 times between ages 3 and 32. This study took a prospective approach, following people as they aged, and assessed prevalence rates based on long-term data. Moffitt’s team focused most intensively on the period from age 18 to 32, when these disorders typically first start to appear. Earlier prevalence estimates for mental disorders in the United States and New Zealand relied on self-reports and therefore adults’ ability to remember and willingness to recount their own past emotional problems.



A new prospective study (orange) finds that the prevalence of common mental disorders is twice as high as found in previous, retrospective studies (blue).

SOURCE: T. MOFFITT ET AL./PSYCHOLOGICAL MEDICINE

“Like flu, if you follow a cohort of people born in the same year, as they age almost all of them will sooner or later have a serious bout of depression, anxiety or a substance abuse problem,” Moffitt says.

It comes as no surprise that, compared with one-time survey responses, the new prospective study identified considerably more people who have had mental disorders, comments epidemiologist Ronald Kessler of Harvard Medical School. But self-report responses remain valuable, he says. Evidence indicates that individuals who report past mental disorders in surveys display an increased likelihood of developing such ailments in the future. Kessler directs ongoing U.S. surveys of mental disorders based on self-reports.

In the new study, half of the people diagnosed (using structured interviews and information from parents and teachers) had a mental disorder for a relatively short period or in a single episode. Moffitt nonetheless regards these cases as serious, since short-term symptoms often led to work problems, efforts to get mental-health care or suicide attempts.

Among 32-year-old New Zealanders, Moffitt and her colleagues find lifetime prevalence rates of 50 percent for anxiety disorders, 41 percent for depression, 32 percent for alcohol dependence and

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18 percent for marijuana dependence. Participants who developed one of these disorders tended to experience others as well, including less common ones such as eating disorders.

Self-report surveys in the United States (*SN: 6/11/05, p. 372*) and New Zealand have found lifetime prevalence rates for common mental disorders that are about half as large as those in the new investigation.

A long-term study of 1,500 North Carolina children tracked into young adulthood finds rates of mental disorders comparable to those reported by Moffitt's team, according to Duke psychologist and study director Jane Costello. Those data have yet to be published.

Researchers generally agree that self-reports underestimate lifetime prevalence rates of mental ailments. Other investigations suggest that many adults forget periods of depression, and even hospitalizations for depression, from earlier in their lives.

Still, some researchers have charged that self-report surveys inflate prevalence rates by assigning mental ailments to many people with mild symptoms of no real clinical concern.

As work intensifies to develop a new version of the diagnostic manual of mental disorders by 2012, Moffitt says the findings indicate that prevalence estimates for serious mental disorders have been too low, not too high. The upcoming manual, known as DSM-V and published by the American Psychiatric Association, will be used as the standard for classifying disorders and for insurance purposes in the United States.

Higher prevalence rates can be used to support either side of a long-running dispute over psychiatric diagnoses, Moffitt notes. Some researchers see a large, unmet need for mental-health care, leading them to support definitions of certain mental disorders as serious even if they are not long-lasting. Others want to narrow DSM definitions in order to avoid labeling temporary emotional woes as mental illnesses.

It's not surprising … that the majority of people meet criteria for a mental illness at some time in their lives.
RONALD KESSLER

Jerome Wakefield, a professor of social work at New York University, calls the new report "a watershed and a fundamental challenge to the mental-health field and to DSM, just as it is in a process of revision."

In Wakefield's view, current DSM definitions encompass much "normal, often transient, human suffering," which in turn got pegged as mental disorders in Moffitt's study. Researchers have yet to establish how often temporary distress elicited by life's misfortunes gets misclassified as depression, he asserts.

Efforts underway to expand DSM-V's definition of depression "come close to pathologizing the entire population and opening the way for increases in medicating our society," Wakefield says.

Harvard's Kessler disagrees. Mental disorders, like physical ailments, range from mild to severe, he says. Accumulating national survey data indicate that "common cold equivalents" in the mental realm, such as relatively mild or brief episodes of depression and specific phobias, often precede more serious or chronic mental disorders later in life, Kessler remarks.

"It's not surprising either that 99.9 percent of the population has some sort of physical illness at some time in their lives or that the majority of people meet criteria for a mental illness at some time in their lives," Kessler says. Alarm over high lifetime prevalence rates for mental disorders largely reflects stigma attached to these conditions, in his view.

Kessler recommends that DSM-V, unlike its current version, distinguish between mild, moderate and severe forms of major depression.

Moffitt notes that treatment costs and insurance coverage also drive this debate: "How many psychiatric patients are there? Well, there are as many as America can afford to treat." ■

Back Story | HISTORY OF U.S. PSYCHIATRIC DIAGNOSIS

The Diagnostic and Statistical Manual of Mental Disorders has faced criticism, praise and a series of revisions since it was first published.

1952: DSM-I
The American Psychiatric Association released DSM-I, taking a descriptive, psychoanalytic approach to a relatively small number of mental disorders. This version of the manual had 145 pages.

1968: DSM-II
The review committee tried to improve the uniformity of psychiatric diagnoses. Also, homosexuality was removed from the list in the seventh printing of this version after a vote in 1973. "Sexual orientation disturbance," now "gender identity disorder," was added.

1980: DSM-III
DSM-III defines a larger array of mental disorders—including post-traumatic stress disorder and attention deficit disorder (with or without hyperactivity)—on the basis of lists of symptoms and features associated with the conditions.

1994: DSM-IV
A fourth manual, with more than 880 pages, came after reviews of published literature, reanalyses of data sets and field trials. It includes symptoms' impact on a person's daily life among the diagnostic criteria for many disorders. A text revision was released in 2000.

2012: DSM-V
The next DSM is in its planning and preparation phase and is expected to be released in May 2012. The process has already generated some controversy and public protest, including against the listing of "gender identity disorder."

AJT/SHUTTERSTOCK

Bob Vila endorses and recommends the famous EdenPURE® portable heater

Millions of Americans now saving up to 50% on their heating bills and raving about the "heavenly heat"

Does not get hot, cannot start a fire and will not reduce humidity or oxygen

The famous infrared portable heater, the EdenPURE®, which can cut your heating bills by up to 50%, has been greatly improved.

The new EdenPURE® GEN3 heater heats better, faster, saves more on heating bills and runs almost silent.

The EdenPURE® can pay for itself in a matter of weeks and then start putting a great deal of extra money in your pocket after that.

A major cause of residential fires in the United States is portable heaters. But the EdenPURE® cannot cause a fire. That is because the advanced infrared heating element never gets to a temperature that can ignite anything.

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Unlike other heating sources, the EdenPURE® cannot put poisonous carbon monoxide, any type of fumes or any type of harmful radiation into a room.

Q. What is the origin of this amazing heating element in the EdenPURE®?

A. This advanced heating element was discovered accidentally by a man named John Jones.

Q. What advantages does this advanced infrared heating process have over other heating source products?

A. This infrared heating process was designed around the three most important consumer benefits: economy, comfort, and safety.

In the EdenPURE® process, electricity is used to generate a type of infrared heat which, in turn, creates a very safe heat.

Q. How can a person cut their heating bill by up to 50% with the EdenPURE®?

A. The EdenPURE® will heat a room in minutes. Therefore, you can turn the heat down in your house to as low as 50 degrees, but the room you are occupying, which has the EdenPURE®, will be warm and comfortable. The EdenPURE® is portable. When you move to another room, it will quickly heat that room also. This can drastically cut heating bills, in some instances, by up to 50%.

End of interview.

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The EdenPURE® heater is now greatly improved. With no increase in price, the new EdenPURE® has been updated with the latest technology, safety, and comfort features to provide you with even greater comfort, more savings, and years of reliability. The EdenPURE® comes with a comprehensive three year warranty along with a 60-day no questions asked satisfaction guarantee – we pay the return shipping.

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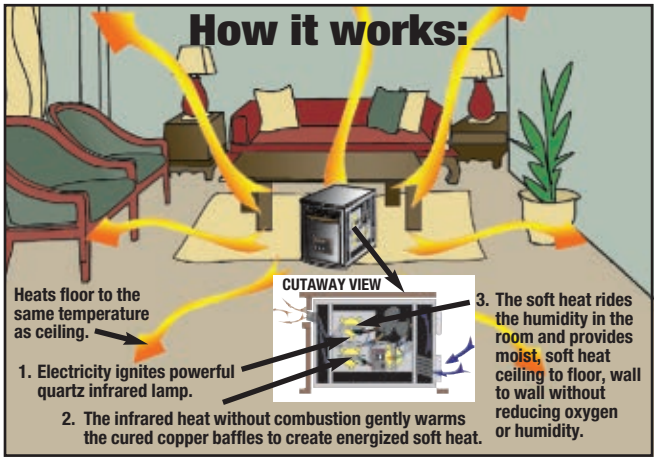
Never be cold again

Cannot start a fire; a child or animal can touch or sit on it without harm

Pictured above is Bob Vila demonstrating the famous EdenPURE® GEN3 Model 1000 heater with a family. It saves big money on your heating bill while keeping you toasty warm with "heavenly heat".

How it works:



Testimonials from a few of the millions of satisfied EdenPURE® customers

The EdenPURE® has cut my gas bill to a third of what it was last year. ***Leslie Wilson, Vancouver, WA***

The EdenPURE® really puts out the heat like a little solar furnace. It's below freezing outside and cozy warm in the rather over large living room area where I'm using it. I have already noticed a 40 to 60% drop in the cost of my heating bills. ***George B., Triangle, N.Y.***

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Atom & Cosmos

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Hubble's new finds go the distance

Galaxies discovered nearly 13.1 billion light-years from Earth

By Ron Cowen

Just days after NASA released the first cosmic dreamscapes taken by the newly refurbished Hubble Space Telescope (*SN: 9/26/09, p. 7*), three teams of astronomers have used the observatory to find what appears to be a bounty of the most distant galaxies known.

Analyses of infrared images captured in August and September with the newly installed Wide Field Camera 3 suggest there were fewer bright galaxies early in cosmic history and those galaxies formed stars at an unexpectedly low rate.

Because they do not yet have measurements of the individual wavelengths that make up the galaxies' spectra, the teams do not directly know how far away the galaxies lie. But the starlit bodies' colors suggest that about 16 reside roughly 12.9 billion light-years from Earth and another five or so sit around 13.06 billion light-years away, a record-breaking distance.

"We are looking back 13 billion years and seeing galaxies just 600 to 700 million years after the Big Bang, when the universe was like a 4-year-old," says Garth Illingworth of the University of California, Santa Cruz, a member of one of the discovery teams.

The new camera's greater sensitivity and its larger field of view have enabled scientists to rapidly find what appear to be extremely remote galaxies, says Richard Ellis of Caltech in Pasadena, a coauthor of two of four papers that the three teams recently posted at arXiv.org. "This is a golden moment," Ellis says. "All the groups independently analyzed the data with different software and broadly speaking, we're all in agreement."

The researchers find a marked downturn in the number of bright galaxies as the telescope peers farther away and thus further back in time. That decrease in the galactic population is expected from current models of galaxy formation, says Harry Ferguson of the Space Telescope Science Institute in Baltimore, who was not a member of any of the teams.

The findings "appear to show that galaxy formation is just starting at these [early times]," comments Simon White of the Max Planck Institute for Astrophysics in Garching, Germany.

Because the investigated area is tiny and because the Wide Field Camera 3 has only just begun taking pictures, it is difficult to know how representative the findings are of the rest of the universe at that time, Ferguson and Ellis caution.

Ellis notes that the new findings also hint at a puzzle. His team estimates that the distant galaxies, which are too tiny to be clearly resolved by Hubble, are making stars at a puny rate. In some cases, that rate is as low as the mass equivalent of 0.0025 suns per year. According to current models, that rate couldn't have generated enough ultraviolet starlight for a critical milestone in the evolution of the universe — the wrenching apart of neutral hydrogen atoms into their subatomic constituents.

This is not yet an astronomical crisis, Ellis says. The first stars may have produced more ultraviolet radiation than expected. Or ultraviolet light may have more easily escaped the early galaxies.

New data that may solve this and other cosmic riddles are just starting to pour in, Ellis says. "This is a very exciting time."

ESO

Rock solid planet

There may be no place like home, but a recently discovered exoplanet has some awfully familiar traits. Astronomers report that new measurements provide the first solid evidence for a rocky exoplanet, with a composition similar to that of Earth's interior. The planet (foreground in an artist's illustration) sits about 500 light-years from Earth and closely orbits its parent star, making it much too hot for life. But the diameter and newly determined mass of the body, dubbed COROT-7b when it was found in February (*SN: 2/28/09, p. 9*), indicate that the planet has a bulk composition highly similar to Earth's. The planet probably has a silicate mantle and an iron core, Didier Queloz of the Geneva Observatory in Sauverny, Switzerland, and his colleagues report in an upcoming *Astronomy & Astrophysics*. "This is truly the first rocky world beyond the solar system, and we know there's more to come," says theorist Sara Seager of MIT. "This is a day we've been waiting for, for a long time." —*Ron Cowen*

Science & Society

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Human spaceflight program needs additional $30 billion, panel finds

Augustine committee recommends two exploration plans

By Ron Cowen

NASA's program to send astronauts back to the moon and on to Mars won't get off the ground unless the federal budget for human spaceflight is ramped up by $30 billion over the next 10 years. That's one of the conclusions of a panel commissioned by President Obama to review U.S. human spaceflight activities. The White House released an executive summary of the committee's report on September 8.

Critics have charged that the initiative to send astronauts back to the moon, a plan which President George W. Bush began five years ago, has never had sufficient funding. The independent panel, headed by Norman Augustine, retired chairman and CEO of Lockheed Martin Corp., now agrees, saying that without more money human exploration can't continue in "any meaningful way."

Alan Stern, who stepped down last year as NASA's associate administrator for science, says, "The frankness of this report was refreshing."

Over the next 10 years, NASA plans to spend about $108 billion to send astronauts back to the moon by 2020. The committee says an additional $30 billion is needed over that time frame. That increase would allow one of two possible exploration programs recommended by the panel. The first would adhere to the path outlined by President Bush, to explore exclusively the moon in preparation for landing on Mars. The second possibility would be for astronauts to visit sites in space other than the moon before going to Mars.

NASA is scheduled to retire its fleet of space shuttles (Endeavor shown here in 2007) by the beginning of 2011.

The idea that we could circumnavigate Mars for an additional $30 billion is "enticing" and harks back to human spaceflight strategies first proposed in the 1990s — but for a cheaper sticker price, says Howard McCurdy, a public policy expert at American University in Washington, D.C.

Currently, NASA relies on its fleet of space shuttles to send astronauts into space. However, to save money, NASA plans to retire the fleet at the end of 2010 or the beginning of 2011. A small crew exploration vehicle is in development.

With the consultation of independent experts, the committee finds that such a crew vehicle won't be ready to take people into space for at least seven years after the shuttles are retired. That's two years more than NASA had estimated. "There has not been this long a gap in U.S. human launch capability since the U.S. human space program began," the committee notes in its summary. "The only way to significantly close the gap is to extend the life of the shuttle program" beyond 2010, the committee writes.

Reviewers prefer positive findings

Journals may be less likely to publish equivocal studies

By Janet Raloff

VANCOUVER, Canada — Peer reviewers for biomedical journals preferentially rate manuscripts with positive health outcomes as better, a new study reports.

The findings caused a buzz when presented September 11 at the International Congress on Peer Review and Biomedical Publication. If positive trials are preferentially published, explains Seth Leopold of the University of Washington Medical Center in Seattle, doctors will get a skewed impression of a therapy's value: "Novel treatments will appear more effective than they actually are."

To test whether journals give negative or equivocal findings short shrift — despite pledging not to — Leopold's team asked more than 200 trained reviewers at two orthopedic journals to rate whether manuscripts were worthy of publication. The team included a bogus manuscript in two forms. Data in the first showed better prevention of infection by one of two antibiotic regimens. In the second version, neither treatment outperformed the other but the results still would have affected patient care. The papers were identical, except for the outcomes.

Among the 55 reviewers at one journal who were asked to evaluate the positive-outcome manuscript, 98 percent recommended that the journal publish it. Only 71 percent of another 55 reviewers from the journal who got the no-difference paper rated it ready for prime time. A similar, though not statistically significant, trend emerged at the second journal.

Readers at both journals gave the positive paper's method section higher ratings, even though the other paper had identical methods. And readers of the positive paper were less likely to spot intentionally included mistakes, Leopold reported.

NASA

Matter & Energy

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Metamaterials mock the heavens

Team proposes way to study astronomical events in the lab

By Laura Sanders

Tiny materials may mimic astronomical events, including the trapping of light in black holes and the disruption of planetary orbits, a new report in the September *Nature Physics* proposes. The shape and design of the proposed materials may allow scientists to do previously impossible experiments by replicating aspects of the heavens at the laboratory bench.

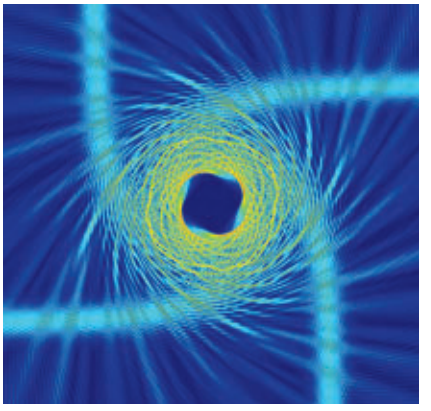
"Astrophysicists build a telescope and watch the sky, and if they're lucky, in their lives, they'll see one or two events," says study coauthor Xiang Zhang of the University of California, Berkeley and Lawrence Berkeley National Laboratory. "Now you don't have to wait 100 years to observe interesting phenomena."

Zhang and his colleagues propose to model the cosmos using a breed of man-made materials that twist and contort light and other electromagnetic waves in unusual ways. These materials, known as metamaterials, guide light in directions that normal materials can't.

The study "may give new inspiration to particle physicists and astrophysicists," says Ulf Leonhardt of the University of St. Andrews in Scotland. "If you begin to do experiments in the laboratory, it creates surprises and new perspectives."

Zhang's team suggests that a new class of metamaterials — called continuous-index photon traps — could direct light and trap it inside. Through a series of calculations, the researchers conclude that mixtures of air and the alloy gallium indium arsenide phosphide would create such a material.

"Light traveling through a metamaterial is very similar to light traveling through the universe," Zhang says. The material is not the same as space, and the trapping region is not a black hole, but Zhang says that under certain conditions, "the physics works exactly the same, so you can use one to study the other."



A proposed class of metamaterials could trap light as shown in a new model (high density waves in yellow).

In other calculations, the researchers found that with some basic tweaks in the design, the new class of metamaterials could also model chaotic systems, such as disordered planetary motions, by inducing chaos in electromagnetic waves.

Constructing these metamaterials doesn't present a major challenge, says Leonhardt. "In the not-too-distant future, we will see these kinds of things," he says.

Scientists make special snowball

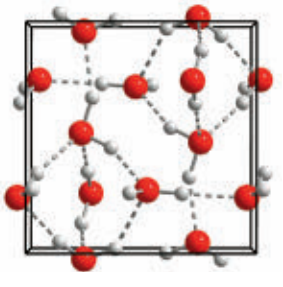
Ice XV is unstable on Earth but may exist in the cosmos

By Laura Sanders

Scientists have created the final predicted form of stable ice, called ice XV, in the lab. But don't worry — Kurt Vonnegut had nothing to do with the exotic new ice and it can't destroy civilization.

Ice types are classified by how the water molecules arrange themselves and how close they pack together. With the new discovery, researchers have identified 16 forms of ice (including two types of ice I). Most of the ice on Earth is type Ih (h for hexagonal, hence the six-sided symmetry of snowflakes). Researchers had long predicted the existence of ice XV but had never seen it before.

"We have removed the question mark from the phase diagram of water," says Christoph Salzmann of the University of Oxford in England, coauthor of a paper published online September 2 in *Physical Review Letters*. Phase diagrams map how molecules behave at various pressures and temperatures.



Ice XV (structure shown) had eluded scientists.

To create the elusive ice, Salzmann and colleagues dropped the temperature on another kind of ice, ice VI, in which water molecules are bonded willy-nilly. As the researchers lowered the temperature to 130 kelvins (around -143° Celsius) and held the pressure around one gigapascal (almost 10,000 atmospheres), disordered hydrogen bonds snapped into an ordered, tight conformation to create ice XV. In comparison, the well-known form of ice is downright fluffy.

Ice XV's stability at high pressures and low temperatures may allow it to exist somewhere out in the cosmos — maybe in deep interiors of icy planets or moons, Salzmann says. The only places on Earth with high enough pressure to sustain ice XV are also extremely hot, so ice XV can't form there, he says.

Ice IX, made fictionally famous by Vonnegut in *Cat's Cradle*, also exists only under high pressure.

FROM TOP: X. ZHANG LABORATORY/UC BERKELEY; C. SALZMANN

Earth

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Atmosphere took roller-coaster ride around time of Earth's oxygenation

Minerals hint that levels of the gas rose, dipped, rose again

By Sid Perkins

Oxygen levels in Earth's atmosphere dropped for an extended time about 1.9 billion years ago, after the atmosphere became oxygenated in what is known as the Great Oxidation Event, researchers report.

Evidence for the oxygen drop comes from minerals in banded iron formations, large iron oxide repositories that accumulated billions of years ago (*SN: 6/20/09, p. 24*). Those minerals contain trace elements that reveal environmental conditions at the time, says Don Canfield, a geobiologist at the University of Southern Denmark in Odense. In particular, he and his colleagues argue in the Sept. 10 *Nature*, stable isotopes of chromium reveal the level of oxygenation of the ancient atmosphere.

Analyses of chromium isotopes in banded iron formations that accumulated during various intervals between 3.7 billion and 550 million years ago show oxygen trends similar to those seen in previous studies. But levels unexpectedly differ during one interval, around 1.9 billion years ago. Chromium ratios in minerals deposited around that time — particularly a formation in Ontario, Canada — are similar to those in deposits that formed well before the Great Oxidation Event began about 2.5 billion years ago.

The new findings are a sign that oxygen concentrations in the atmosphere 1.9 billion years ago dropped substantially for several million years, the researchers say. The environmental circumstances behind this decline in atmospheric oxygen aren't clear, however.

Although researchers debate the exact cause and timing of the Great Oxidation Event, the evolution of photosynthetic microorganisms almost certainly was required to generate large amounts of oxygen. Scientists have long thought that after the Great Oxidation Event, atmospheric oxygen levels never dropped.

The new technique for inferring atmospheric oxygen levels works like this: When rocks bearing manganese and chromium are exposed to oxygen in the air, a series of chemical reactions releases the chromium, which makes its way to the sea via rivers. The higher the oxygen, the higher the ratio of chromium-53 to chromium-52 is in the river water. When those waters flow into an iron-rich sea where banded iron formations are accumulating, the chromium gets locked away in the formations.

"If the new findings are true," says Kurt Konhauser of the University of Alberta in Edmonton, Canada, "we'd have to reinterpret everything we know about environmental conditions" 1.9 billion years ago. Further work may determine which of the existing oxygen-inferring techniques is most accurate for this time period.

The team's data also hint that oxygen concentrations were low but on the rise for at least 300 million years before the Great Oxidation Event. That finding may reinvigorate debate about whether oxygen-making organisms evolved as early as 2.7 billion years ago, as suggested by biomarkers in Australian rocks (*SN: 11/22/08, p. 5*).

Cyclones spawn more tornadoes

Increase in hurricane size may explain extra twisters

By Sid Perkins

Hurricanes and tropical storms striking the Gulf Coast region since 1995 have spun off more twisters than those that hit during the mid-20th century, a new study suggests.

Most tropical storms and hurricanes trigger tornado outbreaks upon striking land, says Judith A. Curry of the Georgia Institute of Technology in Atlanta. A new analysis by Curry and colleagues reveals that landfalling cyclones have become more prolific tornado producers.

In the study, which appears online and in the Sept. 16 *Geophysical Research Letters*, researchers tallied tornadoes associated with hurricanes and tropical storms striking the Gulf Coast between 1920 and 2008. The team designed a computer model to fill in the gaps for years with limited data.

From 1948 to 1964, incoming cyclones triggered a median of six tornadoes, Curry says. Since 1995, landfalling Gulf Coast tropical storms or hurricanes spawned a median of 15 tornadoes.

The largest part of the boost stems from the size of landfalling storms: Cyclones hitting the Gulf Coast since 1995 were, on average, about 35 percent larger than those from 1948 to 1964. The storms may form farther out in the Atlantic and thus have more time to grow before striking land, Curry speculates.

"This study is really intriguing," says Marshall Shepherd of the University of Georgia in Athens. Using the model, scientists may be able to better predict tornado frequency and storm damage.

NASA/GSFC

In 2004, Hurricane Ivan spawned 117 tornadoes in the Gulf Coast region.

Life

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Tyrannosaurus rex's tiny ancestors

Fossil suggests peculiar features weren't limited to dino king

By Jenny Lauren Lee

A miniature version of *Tyrannosaurus rex* is throwing a bone to paleontologists interested in how the king of dinosaurs evolved.

The newly discovered species, called *Raptorex kriegsteini*, lived tens of millions of years before *T. rex* and had a large head, puny forelimbs and strong legs and jaws, researchers report online September 17 in *Science*. These features suggest that *Raptorex* was a direct ancestor of *T. rex*, the scientists say, and that smaller animals could have possessed and benefited from traits once thought particular to large predators.

"It was the common perception that the arms got smaller as the animals grew bigger," says study coauthor Paul Sereno of the University of Chicago. "No one had any idea there was something like *Raptorex* lurking around."

The findings are based on a nearly complete 125-million-year-old fossil unearthed in China. The size of the fossil suggests that an adult *T. rex* would have weighed 90 times as much as a full-grown *Raptorex*, Sereno says. But, despite its size, *Raptorex* had a body plan similar to that of *Tyrannosaurus* dinosaurs, which were the dominant predators from 90 million to 65 million years ago, during the Late Cretaceous period. In addition to a large head and tiny arms, *Raptorex* had long legs and specialized running feet, as well as large head cavities linked to a keen sense of smell, the researchers report.

Though much smaller, the skull of a new dinosaur species (foreground) shares many characteristics with a *Tyrannosaurus* skull (background).

"We see this all to our great surprise in an animal about the size of a human," Sereno says.

Other dinosaurs thought to be *T. rex*'s earliest ancestors were lankier, with long arms, small heads and a simpler foot.

Raptorex's features suggest that *Tyrannosaurus*' ancestors adapted earlier than thought to their role as runners and hunters. With strong legs, big heads and short arms, these dinosaurs became a "running set of jaws," Sereno says.

Paleontologist Thomas R. Holtz Jr. of the University of Maryland in College Park says the discovery of the dinosaur is strong proof that *Tyrannosaurus* relatives had monstrous features long before reaching six tons. However, he says, "There's still a gap of a few tens of millions of years before we pick up the classic tyrannosaurids," and it is not clear how the body plan changed during that time.

Bit of flop makes for efficient fliers

Locusts travel long distances with the help of flexible wings

By Laura Sanders

A new study may inspire aeronautical engineers to be more flexible with their designs. The bends and twists in locusts' pliant wings may make the insects' long-distance flights possible, a team reports in the Sept. 18 *Science*.

Researchers have long studied insect flight but "still don't completely understand the aerodynamics and architectures of wings," comments Tom Daniel of the University of Washington in Seattle.

The new work focused on the flight of the pestilent locust, renowned for its efficient flying style. If dragonflies are like fighter jets, then locusts are like continent-spanning 747s, says Adrian Thomas of the University of Oxford in England, coauthor of the new study. The four-winged insects can fly hundreds of miles at a time.

Thomas and colleagues used high-speed cameras to capture the details of how wings of the locust *Schistocerca gregaria* deform as they flap. (A similar motion with an extended human arm starts with the thumb pointed slightly up at the top of the flap, then the arm turns so the thumb is parallel to the ground in the middle and pointed toward the ground at the end of the downstroke, Thomas says.)

Data from the high-resolution flight images allowed the researchers to create a near-perfect mathematical model of how the flexible, twisting wings propel the insect through the air.

Next, the researchers adjusted their model to simulate stiffening the wings and, separately, to mimic straightening the wing's curved shape. When the locusts had rigid or straight wings, flight performance suffered, the team found.

Most earlier models of insect flight relied on stiff, straight wings, overlooking the important effects of flexibility and some aspects of shape, Thomas says. "Engineers like these things simple," he says. But this new study shows that wings with a little flop can actually get more lift from each flap.

"Nature's designs may be useful in creating synthetic ones," Daniel says.

P. SERENO

70 kilograms | Estimated weight of a fully grown *Raptorex kriegsteini*

6,000 kilograms | Estimated weight of a fully grown *Tyrannosaurus rex*

Ants in the pants drive birds away from choice fruit

Supercolonies of invasive insects spoil avian picnics

By Susan Milius

Dubbed "yellow crazy ants" by people, an invasive ant drives birds crazy too.

Nicknamed for their wild scurrying, the ants keep birds from eating and dispersing fruit, says ecologist Dennis O'Dowd of Monash University in Melbourne, Australia. On Christmas Island, an Australian territory in the Indian Ocean, hordes of yellow crazy ants (*Anoplolepis gracilipes*) storm onto birds landing on plants. Keeping ants off plant stems in invaded zones more than doubled the chances that a fruit would be bitten by a bird, O'Dowd and his colleagues report online September 15 in *Biology Letters*.

O'Dowd and others have been chronicling the ants' impact on the native creatures of Christmas Island since the 1980s, but this paper is the team's first to test ants' effect on fruit eating by birds.

"What never ceases to impress me is that something so small can affect vertebrates so directly," says Dennis Hansen of Stanford University, who has studied ants bedeviling geckos on the island nation of Mauritius.

On Christmas Island, yellow crazy ants have caused so many changes that O'Dowd and coauthor Peter Green of La Trobe University, also in Melbourne, have declared an "invasional meltdown" of the original ecosystem. Ants probably hitchhiked to the island sometime during the early 20th century and boomed during the 1990s. Supercolonies now cover swaths of the island in such density that ants in a feeding frenzy can clear a forest of its once-important red crabs. And ants climb onto and bother birds, too.

In ant-dense zones, O'Dowd sees birds stomp and ruffle their feathers as if maddened by crawling ants. To see if this nuisance affects the birds' feeding, coauthor Naomi Davis, now at the University of Melbourne, set out arrays of artificial fruits crafted from nontoxic modeling clay. In forests not yet invaded by ants, fake fruits showed more than twice as many peck marks as those in ant zones.

Named the yellow crazy ant because of its behavior when disturbed, this species is spreading widely in the tropics.

When Davis put an ant-trapping goo around the base of dowels holding her fake fruit in the ant zones, she found the goo's presence more than doubled the number of pecks from two native fruit-eating bird species. White-eyes and island thrushes were more willing to try the fruit when ants weren't raging over the plants.

Fruit eating could affect bird nutrition and population size and change the distribution of seeds, O'Dowd says. But, he adds, any ant-induced changes are probably complex and hard to predict.

Once highlighted mostly as a tropical phenomenon, ant invasions now menace temperate regions, says community ecologist Lori Lach of the University of Western Australia in Perth. Invaders have left seeds stranded without their native ant dispersers, lizards starving without palatable meals and flowers languishing for want of pollinating geckos, she says.

ABC NATURAL HISTORY UNIT

Genes & Cells

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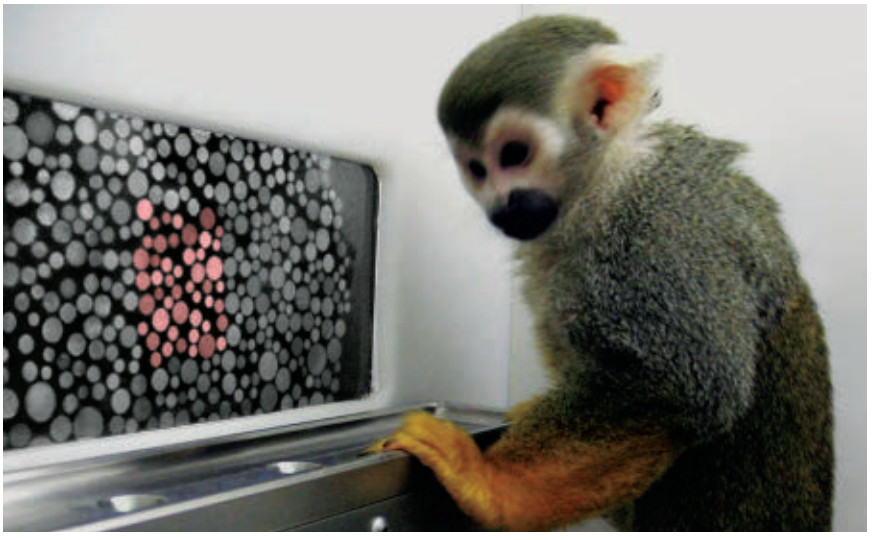
Male monkeys see in red, green with added gene

Creating color vision may not require rewiring of the brain

By Tina Hesman Saey



After gene therapy, Dalton (shown) produced proteins that detect red light. He can now distinguish red dots from a gray dotted background in a color vision test.

NEITZ LABORATORY/UNIVERSITY OF WASHINGTON

Two male squirrel monkeys now see the world in a whole new way — in full color.

Some female squirrel monkeys can see in color, but male squirrel monkeys are normally red-green color-blind because they lack pigments in the retina that detect those wavelengths of light. Now, researchers have performed gene therapy that allowed two male squirrel monkeys named Sam and Dalton to produce proteins that detect red light. As soon as the pigment was made in the monkeys' eyes, the animals discriminated between red and green spots in color vision tests, Jay Neitz of the University of Washington in Seattle and his colleagues report online September 16 in *Nature*.

The experiment wasn't supposed to work, Neitz says. People born with cataracts don't develop nerve connections that help the brain make sense of messages sent by the eye. If the defect isn't corrected early, these people remain essentially blind even if their eyes return to full function later. Because there was no reason to assume color vision was different from other types of vision, the team had assumed it would not be possible to reverse the deficit in an adult animal.

Neitz asked experts in the vision field whether they thought producing pigment in color-blind adult monkeys could give color vision. "Every single person said, 'absolutely not.'" But the researchers tried the experiment to see if the monkeys could make the pigment.

Male monkeys lacking the red photoreceptor protein were given injections of a harmless virus carrying a gene for the protein. Levels of the protein slowly rose in some retinal cells. After 20 weeks, protein production levels peaked and Neitz's team saw changes in Sam's and Dalton's performance on color vision tests.

In the tests, monkeys were shown a panel with a patch of colored dots on a background of a different color. If the monkeys pressed the area with the different colored dots, the animals got a grape juice reward. Before the gene therapy, Sam and Dalton could only discriminate yellow and blue dots. But afterward, they could consistently pick out red, green, blue and yellow dots and could tell red from green. The monkeys have maintained stable color vision for two years. The speed at which the monkeys learned new colors indicates that no brain rewiring was required for the feat.

The find may have implications for understanding color vision evolution, says Bevil Conway, a neuroscientist at Wellesley College in Massachusetts.

"Somehow the brains of these monkeys are already wired to decode these color signals," Conway says. That fact raises the possibility that "the evolution of color vision may have required just one genetic switch."

But, Conway says, there is an important disclaimer. "We have no idea if this would work in humans or that it would be a delightful experience for the people post-surgery." People who have surgery to repair sight lost in childhood often report that their new vision is confusing and disorienting, he says. Adding color could prove to be similar.

Other scientists are impressed by Neitz's achievement. "They certainly have added some color vision," says Gerald Jacobs, a neuroscientist at the University of California, Santa Barbara. "I find the measurements compelling."

Still, the monkeys' actual sensation of color remains a mystery.

"The achievement is technically amazing and conceptually very cool," says Melissa Saenz, a neuroscientist at Caltech in Pasadena. But even though the monkeys can discriminate some new wavelengths of light, that doesn't mean they perceive a new dimension of color, she says. For example, the monkeys may see red and green as different shades of yellow and blue, colors the animals already knew.

"If it doesn't involve experiencing new sensations of color, it would not dramatically change the experience of color-blind people if the treatment were applicable to humans," Saenz says. ■

Body & Brain

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Shifty eyes could signal memories that people can't consciously recall

Study finds movements linked to activity in hippocampus

By Tina Hesman Saey

Eyewitness testimony is notoriously flaky, but new research suggests that eye movements can accurately reveal what a person remembers, even if the person isn't aware of the memory.

In a memory test, participants' eye movements picked the right answer even when the participant failed to, Deborah Hannula and Charan Ranganath, both of the University of California, Davis, report in the Sept. 10 *Neuron*. The eye movements corresponded to activity in the hippocampus, a learning and memory center in the brain, suggesting that eye movements can reveal unconscious memories activated in the hippocampus.

Eye movements picked the right answer even when the participant failed to.

Hannula and Ranganath used functional MRI to track the brain activity of volunteers while the participants viewed pictures of faces paired with outdoor scenes. After presenting about 50 such pairs, the researchers showed a landscape picture followed by three faces. Participants were then asked to choose which face had previously been matched with the landscape scene.

When a landscape was shown, activity in the hippocampus increased, followed 500 to 750 milliseconds later by eye movements directed toward one of the three faces. The eyes lingered on the correct face when the hippocampus was more active. Less activity occurred when eyes dwelled on an incorrect face.

Even when participants' responses were ultimately incorrect, the hippocampus activity accurately predicted whether the eyes focused on the correct face. Even if you don't remember learning a relationship between objects, "your hippocampus and eyes might have some of that information left over," Ranganath says.

Communication between the hippocampus and the prefrontal cortex — the brain's executive control region — was reduced when volunteers made the wrong choice compared with trials in which they made the right choice. That result could mean that the hippocampus and prefrontal cortex must communicate properly for a person to remember correctly.

It's still an open question whether the volunteers were conscious of the right choice at the time their eyes lingered on the correct face, Dharshan Kumaran and Anthony Wagner, both of Stanford University, write in a commentary in the same issue of *Neuron*. The volunteers may have been immediately aware of the right choice but then second-guessed themselves. "There are undoubtedly instances in which first impressions will lead to the correct answer," Wagner says. "When we linger on the choices we sometimes get tricked."

Dopamine boost primes kidneys

Transplant patient benefits when the organ gets infusion

By Nathan Seppa

Giving dopamine infusions to brain-dead organ donors while they still have a heartbeat seems to fortify their kidneys against the rigors of transplant, a new study shows. Patients receiving a kidney from such donors are less likely to require multiple sessions of blood-cleansing dialysis immediately after the operation, researchers report in the Sept. 9 *Journal of the American Medical Association*.

Treating a donor with dopamine also seems to prevent some of the damage to kidneys that happens while the organs wait to be transplanted, the team finds.

Although dopamine is best known as a neurotransmitter, the chemical has been used in intensive care units to stabilize blood pressure in patients, says study coauthor Benito Yard of the University Clinic Mannheim in Germany. Dopamine can also quell inflammation and preserve blood vessels, which might benefit a kidney headed for transplant.

In the new study, more than 100 brain-dead organ donors received dopamine infusions while another group of donors did not. Of recipients getting dopamine-exposed kidneys, 25 percent needed multiple kidney dialysis sessions during the week after transplant. Of those getting an unexposed kidney, 35 percent needed the multiple sessions.

"This is a big deal for the recipient," Yard says. In the study, patients who needed multiple dialysis sessions in the week after surgery were more than three times as likely to have their new kidney fail within three years as were people who got no dialysis.

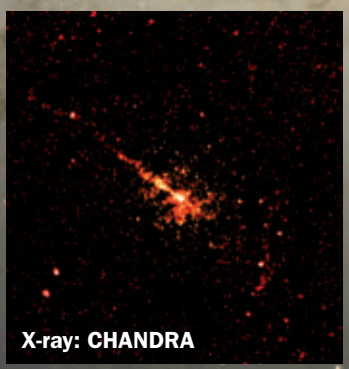
What's more, in patients receiving a kidney that had been in storage for more than 17 hours, 91 percent of dopamine-exposed kidneys were still functioning three years later compared with only 74 percent of kidneys whose donors didn't get dopamine.

The new trial is good enough to warrant the use of dopamine for kidney transplants, says Duska Dragun, a transplant nephrologist at Charité Hospital in Berlin.

Windows on the Universe

Astronomy's multiwavelength revolution paints a more complete picture of the cosmos

By Ron Cowen



Wide-spectrum portrait
The Centaurus A galaxy as seen in visible light (large image) and in an array of other wavelengths (shown with name of instrument used).

Bathed in the painterly light of late afternoon in France's Loire Valley, an old church casts an orange-tinted glow that streams through a giant, arched window on the ground floor of Blois Castle. One flight up the massive stone staircase, astronomers are convening to talk about a universe of colors — and particles — well beyond this visible tableau.

Astronomers, of course, have viewed the universe at invisible wavelengths of electromagnetic energy, ranging from radio waves to gamma rays, for decades. But a variety of new instruments are throwing wide open certain windows on the cosmos that had previously been lifted only a crack. The new views, some reported on for the first time at the Blois conference in June, promise to retouch astronomers' portraits of the heavens.

Already, the year-old Fermi Gamma-ray Space Telescope has extended the range and sensitivity with which scientists can scan the high-energy universe for violent interactions and signs of dark matter. In the infrared, NASA's Spitzer Space Telescope has given astronomers a more complete picture of galaxy and star formation, much of which happens behind a veil of dust. And new radio telescopes will soon probe the cosmic dark ages — the era just before the very first stars and galaxies illuminated the universe.

"People are now dipping into data" from a variety of telescopes that cover a panoply of wavelengths, says Richard Ellis of the California Institute of Technology in Pasadena. "The young people have this multiwavelength attitude that is revolutionizing astronomy."

Fomenting that revolution are heavenly messengers other than electromagnetic waves, such as high-speed charged particles known as ultra high-energy cosmic rays. And an even more novel window is about to open, MIT astronomer Sam Waldman noted at the meeting in Blois. Detectors around the globe are poised to record a type of energy predicted by Einstein's theory of general relativity but never before seen: the ripples in spacetime known as gravitational waves. Traveling unimpeded through reaches of the universe opaque to any form of light, these waves may offer previously unattainable views of the universe — including the merger of supermassive black holes and the earliest moments of creation.

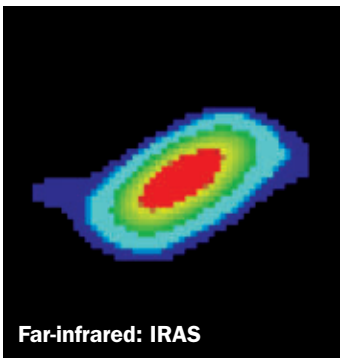
Some like it cold

But for a really cool view of the cosmos, astronomers are turning to the infrared. Although infrared space missions began in the 1980s, the Spitzer Space Telescope, launched in 2003, has proved crucial for studies of cold dust and the nature of the earliest galaxies.

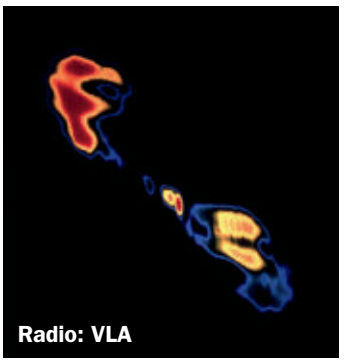
Because Spitzer has a small light-gathering mirror, only 85 centimeters in diameter, astronomers figured they would be lucky if the craft could detect galaxies as far away as 11 billion light-years. Since looking farther in space is the same as looking back in time, that distance corresponds

Near-infrared: 2MASS

Mid-infrared: Spitzer

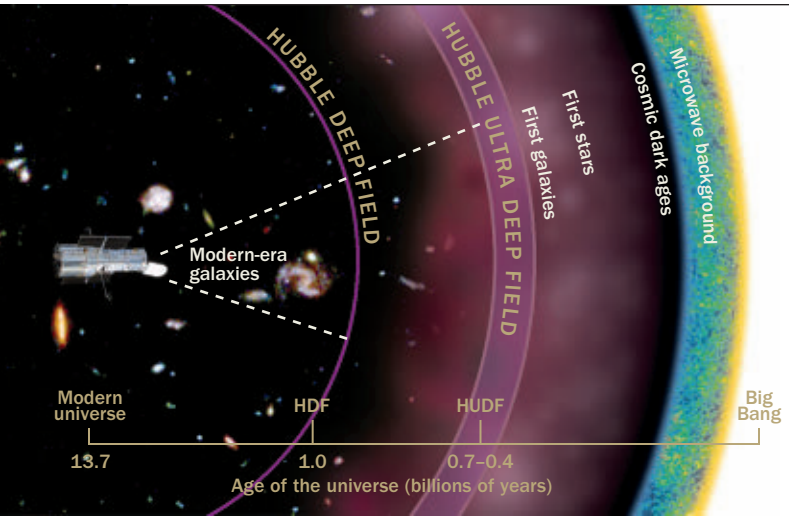


Far-infrared: IRAS



Radio: VLA

MAIN IMAGE: ESO; FROM LEFT: NASA, CXC, SAO; JPL/NASA; 2MASS; SPITZER, J. KEENE/CALTECH/JPL/NASA; IRAS; AUI, NRAO



A dim view
A map of the universe looks back in time to the cosmic dark ages, the interval between the time when radiation left over from the Big Bang streamed freely into space and when galaxies produced enough ultraviolet light to reionize the universe. Hubble, shown, cannot see that far back.

to an era when the universe was about 2.7 billion years old. To the astonishment of many astronomers, Spitzer was able to detect galaxies that were much more remote, from a time when the universe was less than a billion years old.

To understand how Spitzer accomplished this feat, consider the effect that the universe's expansion has on the light emitted by distant objects. Because expansion shifts radiation emitted by distant bodies to longer, redder wavelengths, the infrared light that Spitzer records was actually emitted by distant galaxies as visible light. And visible light is primarily emitted by mature stars.

So for Spitzer to image distant, youthful galaxies, they had to be chock-full of old stars — at least 100 million years old. Spitzer had inexplicably found old stars in the young universe. The first such report appeared four years ago, and the trend continues (*SN: 4/25/09, p. 5*).

Spitzer's finding indicates that some galaxies mature in a hurry, forming stars so rapidly that even young galaxies already have aging stars. It also suggests, says Ellis, that the Hubble Space Telescope's new Wide Field Camera 3, an instrument that primarily views galaxies in visible light and short infrared wavelengths, will be able to see galaxies even farther back in space and time.

That's because the old stars seen by Spitzer when the universe was about a billion years old would have been spanking new a few hundred million years earlier. And newborn stars emit lots of ultraviolet light, which cosmic expansion shifts into the visible-light and short infrared bands that the new Hubble camera can detect.

"We're now all eagerly awaiting" new Hubble images, Ellis says. Some have since been released (*SN: 9/26/09, p. 7*).

In May, Spitzer used up its coolant, making it impossible to survey the cosmos beyond an infrared wavelength of 4.5 micrometers. (At longer infrared wavelengths, heat from the telescope interferes with observations.) However, the recently launched Herschel Space Observatory — which features a 3.5-meter–diameter mirror, the largest telescope yet flown in space — is filling in the gap. Herschel opened its eyes in June, viewing the cosmos at wavelengths from 55 to 672 micrometers, a range that includes both far-infrared and slightly longer submillimeter wavelengths. That range will allow Herschel to analyze clouds of dust and gas that mark places where stars and galaxies are born.

Tuning in to the early universe

Another group of telescopes promises to help astronomers fill a glaring gap in the cosmic photo album. Images of the cosmic microwave background, the radiation left over from the Big Bang, provide the earliest snapshots of the cosmos — from when it was only about 400,000 years old. Flash forward to the next series of images, which show what some of the first galaxies looked like when the universe was about 850 million years old. The era in between — before stars and galaxies were born — remains a mystery. It's during these cosmic dark ages that "the primordial soup evolved into the rich zoo of objects we now see on the sky," says Avi Loeb of Harvard University.

Loeb, along with Jackie Hewitt of MIT, is a member of one of three teams building arrays of radio antennas that will attempt to listen in to this dark era by recording faint emissions from atomic hydrogen. Hydrogen gas emits radiation at a radio wavelength of 21 centimeters when its atoms jump from a particular high energy state to a lower one.

At the beginning of these dark ages, explains Loeb, the universe had cooled sufficiently from its violent birth for protons and electrons to recombine into neutral hydrogen atoms. But by the end of this era, the cosmos had gone through another wrenching transition. Soon after baby galaxies and the brilliant beacons of light known as quasars emerged, they began emitting ultraviolet light, which broke hydrogen atoms back apart into their constituent protons and electrons, a process known as reionization.

The reionization of the universe didn't happen all at once, Loeb says. Instead, UV light from individual galaxies probably created small bubbles of ionized hydrogen gas — a sea of protons and electrons — around each galaxy. Each bubble grew as galaxies packed on more mass and the UV radiation they emitted intensified. As galaxies and galaxy clusters continued to enlarge, the bubbles overlapped until all the neutral hydrogen had vanished and the entire universe was reionized. (Most of the universe has remained ionized since that early epoch.)

By charting the initial distribution of neutral hydrogen gas and how quickly it ionized, astronomers hope to trace the assembly of the first galaxies. Doing so exploits the effect of cosmic expansion on radio wave signals. The expansion of the universe shifts hydrogen's 21-centimeter radio emission to longer and longer wavelengths the farther back in space — and therefore time — that the gas resides. So each wavelength of redshifted 21-centimeter radio emission

SOURCE: UC SANTA CRUZ, ADAPTED BY B. RAKOUSKAS; IMAGES: WMAP SCIENCE TEAM/NASA

corresponds to a different era in the early universe. Tuning in to each emission will therefore help astronomers map the abundance of neutral hydrogen over time and better determine when the universe, as a whole, got reionized.

Two experiments, the Murchison Widefield Array and PAPER (Precision Array to Probe Epoch of Reionization) are under construction in the radio-quiet outback of Western Australia. Hewitt says she expects Murchison to begin operation in 2011. A third experiment, the Low Frequency Array, is being built in the Netherlands.

Catching some rays

Just as radiation from hydrogen reveals part of the unseen universe, so do hydrogen atoms' energetic nuclei, or protons. Imagine a proton packing as much oomph as a major league fastball. Protons and other energetic particles making up cosmic rays pelt the Earth, bringing information about some of the most frenzied regions of the cosmos.

At the Blois meeting, though, Nobel laureate James Cronin of the University of Chicago reported a finding so surprising that he and his collaborators didn't go public with the data for two years, until they could check and recheck the results. Using the Pierre Auger Observatory, a huge array of cosmic ray detectors in Malargüe, Argentina, his team found that many of the highest-energy cosmic rays may not be protons after all, but are composed of iron and other heavy nuclei (*SN: 7/18/09, p. 8*).

The puzzling part is that the universe consists mainly of protons, and iron and other heavy nuclei account for only perhaps 1 percent of all atoms. That's true, for example, in the swirling disks of gas and dust that surround supermassive black holes, one possible source of the ultra high-energy cosmic rays. And even if some iron nuclei are revved up to high energies in these disks, another mystery remains. Heavy nuclei are relatively fragile, easily broken apart by collisions before they can reach Earth. Yet these nuclei are what Cronin and his team believe they have detected.

If iron nuclei truly constitute a significant fraction of ultra high-energy cosmic rays, astronomers may have to rethink where the particles come from and how they managed to travel intact to Earth, says Todor Stanev of the University of Delaware in Newark.

In the meantime, says Stanev, a much darker mystery has gripped cosmic ray astronomers. Some observatories, including the PAMELA spacecraft (*SN: 2/28/09, p. 16*), have recently found an unexplained excess of certain lower-energy cosmic rays — electrons and their antiparticle, positrons — in the Milky Way.

Researchers have proposed that the excess is a signpost of dark matter, the sought-after invisible particles believed to make up about 85 percent of all matter in the universe. Some types of dark matter would annihilate upon impact, creating both gamma rays and pairs of electrons and positrons, theorists say.

But a team including Stanev and Hasan Yüksel of the University of Delaware now proposes a more mundane solution. In the July 31 *Physical Review Letters*, the team suggests that the source of the electron-positron excess could be Geminga, a rapidly rotating stellar corpse known to emit gamma rays.

If the team is right about Geminga, not only would the excess cosmic rays be explained without invoking dark matter, but the finding would also mark the first time that astronomers have linked cosmic rays to any specific source in the sky. The paths of most low-energy cosmic rays — including the electrons and positrons — are so bent by the galaxy's magnetic field that their direction of origin is hopelessly lost.

Gammas galore

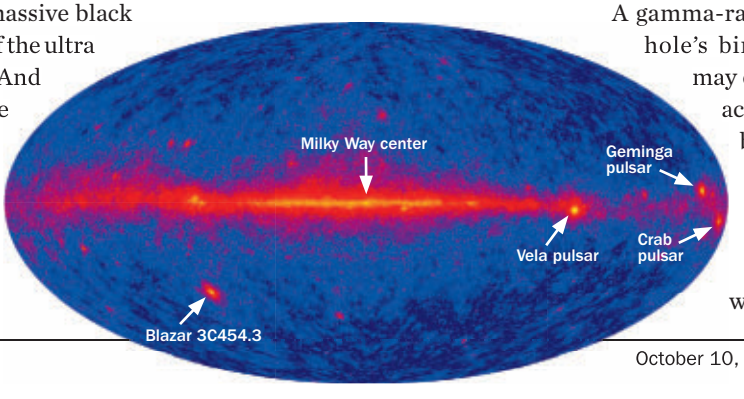
If hints of dark matter are found soon, they're likely to come from the Fermi Gamma-ray Space Telescope, Stanev says. Once every three hours, the telescope surveys the entire sky. Researchers scour the data to look for any unexplained excesses in gamma rays coming from the center of the Milky Way, where dark matter may concentrate.

The telescope will have to distinguish gamma rays produced by decaying dark matter from those generated by supernovas and hot gas around black holes. Preliminary results are expected to be announced later this fall. Already, the Fermi observatory has recorded for the first time very high-energy radiation from gamma-ray bursts, the ephemeral blasts believed to signal the collapse of massive stars into black holes (*SN: 1/17/09, p. 5*).

In April, another gamma-ray observatory called Swift found the most distant gamma-ray burst ever, a 10-second flash emanating from a region more than 13 billion light-years from Earth (*SN Online: 4/28/09*). Once a gamma-ray burst fades, it usually reveals the galaxy in which it ignited. Extremely remote bursts may therefore act like signal flares, revealing the locations of galaxies so faint and distant that no telescope would ever have found them, says Loeb. Hubble's proposed successor, the James Webb Space Telescope (scheduled for launch in 2014), may be the only telescope capable of imaging the home galaxies of such distant bursts.

New wrinkles in spacetime

A gamma-ray burst may mark a black hole's birth, but a novel detector may one day directly record the activity of these gravitational beasts. Just as a charged particle emits electromagnetic waves when it moves up and down, a massive body emits gravitational waves when it accelerates. Detecting



Gamma sky lights
A gamma-ray view of the sky as seen by the Fermi Gamma-ray Space Telescope.

FERMI, NASA

gravitational waves would offer views of black hole mergers, notes theorist Marc Kamionkowski of Caltech.

Scientists aim to detect gravitational waves by the motion they induce in free-floating masses. A typical sensor consists of an L-shaped arm with mirrored weights hanging at each end of the L and at the vertex. A passing wave compresses one arm while stretching the other. Each arm may be a kilometer long. Using lasers, researchers can now record changes in the relative arm lengths as tiny as 10 billionths the diameter of a hydrogen atom, Waldman says.

Researchers have been searching for gravitational waves for decades, but none have yet been found. Given the precision of current detectors, even this absence can be significant. Some models of the early universe, which predict a flood of gravitational waves from the Big Bang, may be ruled out by the nondetection, researchers from two gravitational-wave experiments report in the Aug. 20 *Nature*.

The Murchison Widefield Array will try to trace the reionization of the universe.

While seeing nothing does not eliminate "any dearly held theoretical prediction, it presents a watershed event," comments Kamionkowski.

Researchers are now building a new generation of experiments designed to see gravitational waves generated when two compact bodies — neutron stars or small black holes — spiral toward each other.

But the most dramatic sources of gravitational waves are likely to be recorded by detectors in space. A trio of proposed spacecraft known as LISA would detect much longer wavelength gravitational waves, such as those thought to be generated when galaxies collide and their black holes merge. LISA could also detect gravitational waves generated during the universe's explosive birth.

"One of the big triumphs in all this new territory," says Ellis, is that astronomers are teaming up to train different telescopes on the same patch of sky. Astronomers were once color-blind, restricting themselves to one wavelength or one type of particle to study the universe. Now, he says, researchers are finally transforming this black-and-white view of the cosmos into Technicolor. ■

DAVID HERNE/CURTIN INSTITUTE OF RADIO ASTRONOMY (CIRA)

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- To learn more about multiwavelength astronomy, visit http://bit.ly/6k0h9

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Enter the Viros

As evidence of the influence of viruses escalates, appreciation of these master manipulators grows • By Rachel Ehrenberg

If he were starring in a campy horror flick, Tim Rowbotham might have gasped and whispered, "It's alive!" As a microbiologist with Britain's Public Health Laboratory Service, he had isolated an unknown microorganism from an amoeba growing in a water tower in Bradford, England. Rowbotham baptized the entity "Bradford coccus." He added his new specimen to the collection of bacteria that live within amoebas and continued the search for the cause of a pneumonia outbreak plaguing the citizens of Bradford.

But Rowbotham hadn't discovered a bacterium. He had actually found a gigantic virus — one so large and possessing such a peculiar mixture of traits that it is challenging the very notion of what it means to be alive.

Viruses have long been regarded as nonliving entities. They don't have the machinery to make new viruses, nor do they have a discernible metabolism (you won't hear a virus declare "as I live and breathe," and not just because they don't have mouths). Viruses are typically thought to barely have genetic material to call their own, characterized instead as ghostly gene-thieves who prey upon and steal from real organisms. But as scientists shine the spotlight on the shadow economy of the virus world, a new vision of viruses is emerging. Rather than furtive thieves, viruses are more like commodities dealers, playing a major role in transferring genes from one organism to another. The acquisition of new genes may dramatically alter the lifestyle of the organism that gets the goods, allowing it to invade a new environment, for example, or fight off predators.

Viruses also may keep genes they've procured, and even bundle these assets together, as appears to be the case with several photosynthesis genes recently found in marine viruses. These finds hint at the vast viral contribution to the ocean's gross national product and viruses' significance in global energy production.

"Viruses are major drivers of nutrient and energy cycles on the planet," says marine virologist Curtis Suttle of the University of British Columbia in Vancouver, Canada.

This increased appreciation of the viral influence on cellular life today is reviving debate about the role viruses may have played in the planet's primordial days, scientists say. Viruses may even be at the root of the cellular tree of life, participating in the evolution of the eukaryotic nucleus.

"Viruses are and have been a main force in the evolution of life on the planet," says Jean-Michel Claverie of the Mediterranean Institute of Microbiology in Marseille, France. "They remain a leading force in the cellular world."

Of course, part of that force is virus as bad guy. From the common cold to influenza to Ebola, viruses have long been recognized as agents of illness and death. Viruses infect all domains of life — from plants and animals to protists and bacteria. In fact, viruses lurk behind many ailments blamed on bacteria. For example, the bacterium that causes diphtheria does so only when it carries a virus.

Scientists have long been well acquainted with the nefarious activities of these viruses of doom, but now a more productive view of death by virus is emerging. Viruses don't just kill plants and animals — they kill the organisms at the bottom of the food chain, deaths that have dramatic implications. "If you take viruses out of seawater, counterintuitively, things stop growing," Suttle says. In death, victims of viruses release nutrients. "Their killing feeds the world."

White cliffs of death

Viruses are the most numerous entities of the oceans; a thimbleful of seawater contains millions of virus particles. Stretched end to end, the estimated 10^{30} viruses in the oceans would reach farther than the nearest 60 galaxies, Suttle notes. These viruses infect creatures from krill to whales, sometimes with worrisome effects, as with the one that spurs tumor development in green sea turtles. Viruses also infect phytoplankton — the microorganisms that include algae and photosynthesizing bacteria. These tiny critters are the major force behind the ocean's nutrient and energy cycles and make up about 90 percent of the oceans' biomass. Viruses kill an estimated 20 percent of

OPPOSITE, FROM LEFT: PHOTO BY NEON JA, COLORED BY RICHARD BARTZ/WIKIMEDIA COMMONS; NASA

phere

Bloom and bust
Viruses prey on marine floaters known as coccolithophores, which are characterized by their calcium carbonate plates. Two such victims, *Gephyrocapsa oceanica* (left) and *Emiliania huxleyi* are notable for their "blooms" (satellite image, above), population bursts that change the color of the seas and influence global temperatures by increasing the amount of light reflected off the planet. Killed by viruses, the victims' cells fall apart, releasing nutrients and sequestering carbon in the oceans.

this biomass every day. (Fortunately, phytoplankton are avid propagators and replenish themselves quickly.)

In the long term, this death on the high seas can shape the land, as it did with coccolithophores, single-celled marine floaters known for their calcium carbonate skeletons. Those skeletons eventually became the layers of rock known as the chalk group, outcrops laid down in the Cretaceous.

"The white cliffs of Dover are 100 percent the cytoskeleton of those animals," says Claverie. "Those animals were killed by viruses."

Oceans teem with coccolithophores; their "blooms" turn the seas a milky blue and then quickly dissipate—a boom-and-bust cycle now linked to marine viruses. Not only do these deaths influence the makeup of the marine microbial community, but they also affect geochemical cycling. As these dead phytoplankton sink in the seas, they sequester an estimated 3 metric gigatons of carbon each year. Viruses' phytoplankton massacres can also profoundly affect the world's climate. Death and injury of some phytoplankton enhances production of dimethylsulfide, an oceanic gas that is the main natural source of sulfur in the air. A series of reactions transforms dimethylsulfide into airborne particulates that seed cloud formation and affect global storm cycles.

Even when they aren't killing things, viruses are a force to be reckoned with. Viruses apparently manage much of the gene-trading between bacteria, for exam-

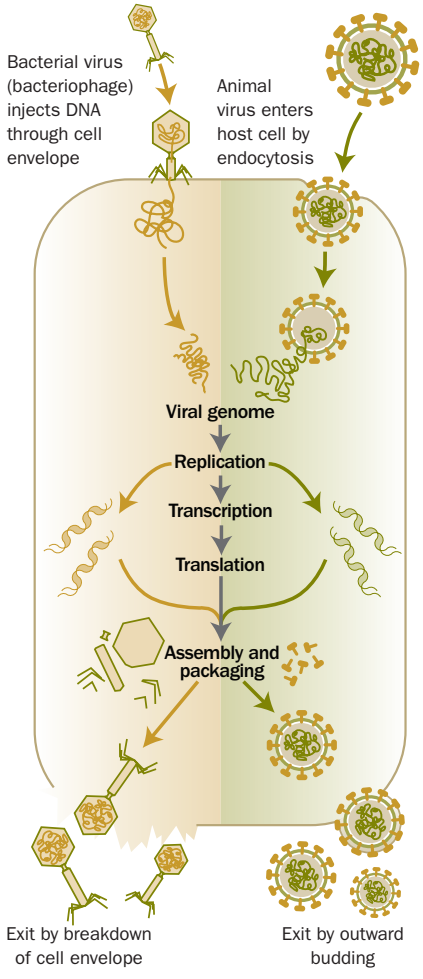
ple. Such "horizontal gene transfer" is a recognized mechanism for passing antibiotic-resistance genes among bacterial species. And there's increasing evidence that viruses may broker such exchanges across the kingdoms of life, as may be the case with the solar-powered sea slug.

The emerald-green sea slug *Elysia chlorotica* gets its hue and photosynthesizing skills from grazing on the algae *Vaucheria litorea*. Upon digestion, the algae's light-harvesting factories — the chloroplasts — are sequestered in specialized cells in the slug's gut (there's even a name for this chloroplast theft: kleptoplasty). Photosynthesis continues, providing enough energy to sustain a slug for months without eating. Yet the chloroplast genome doesn't contain all the necessary genes to make the light-harvesting factories run; genes from the algae's nucleus are also required.

Puzzled about how the slugs maintain their solar power, scientists searched their nuclear DNA and found an algal photosynthesis gene, the team reported in 2008 in the *Proceedings of the National Academy of Sciences*. That find adds to evidence of three other algae genes in the slug's DNA. It appears that slugs today are born with algae genes that support photosynthesis, but still need to scarf some chloroplasts.

Intriguingly, scientists have also detected viruslike particles in the stolen chloroplasts and in the nuclei of the slug. While direct evidence remains elusive, the slugs may have originally acquired those photosynthesis genes via a virus.

50 copies, please Viruses, not much more than genetic material wrapped in a protein coat, need a host to reproduce: most bacteria-infecting viruses, or phages, inject just genetic material into a host cell. In animal hosts, the whole virus usually enters. Both hijack host machinery to make new viruses.



Gene wheeler-dealers

Viruses also may have introduced a DNA-repair gene into the octocorals, which include the organ-pipe coral and sea fans. Clues to this transaction come from relatives of one of the most spectacular viruses known today — the supersized beastie from the water tower in England. Now known as mimivirus, it's more than 4,000 times the mass of the common cold virus. After its discovery, analyses of DNA from ocean samples revealed an abundance of mimivirus relatives. That search also led to the discovery of a version of *MutS*, a DNA-repair gene known from bacteria but never before seen in viruses.

So far, mimivirus's marine relatives all seem to have this version of *MutS*. An octocoral ancestor may have acquired the gene from a marine mimivirus, sometime after the octocoral lineage split from that of the true corals, Claverie and colleagues reported in July in the *Journal of Invertebrate Pathology*.

In addition to acting as gene brokers, viruses appear to keep some of what they've garnered for themselves. Seven genes, part of a set needed for photosynthesis, were recently found in the genomes of viruses that infect marine cyanobacteria. These genes encode directions for making photosystem I, a protein complex that nabs electrons from proteins upstream in the photosynthesis chain. In a cyanobacterium, these genes are separated by good-sized chunks of DNA. But in viruses, the genes appear to have been packaged into a cassette, with two of the bacterial genes fused into one, scientists from the Technion-Israel Institute of Technology and other institutions reported online August 26 in *Nature*.

Because the genes are separated in the cyanobacterium but next to each other in the viral DNA, they probably represent multiple acquisitions, says Matthew Sullivan of the University of Arizona in Tucson. And the viral version of photosystem I might be able to nab more electrons than the algae version, and thus photosynthesize more efficiently.

"The virus definitely seems to have its own agenda," says Shannon Williamson, director of environmental virology at the J. Craig Venter Institute in San Diego. Examples of coordinated gene collection by viruses are increasing, she notes. "It's much more common than we anticipated, and we're starting to see there really is no restriction on the types of genes they can acquire."

As sampling of the oceans continues, similar instances of gene wheeling and dealing will probably emerge. The hunt for the viral photosystem I genes began with the scientists combing the database of DNA collected in the Global Ocean Sampling Expedition, which has so far done extensive collecting in waters from French Polynesia to Antarctica. The 2009–2010 expedition, now underway, includes visits to the Mediterranean and Black seas. Since these bodies of water are relatively isolated, they may harbor especially odd viruses.

Sullivan is part of a second virus-seeking mission, dubbed project OViD (ocean virus diversity), which began a three-year seafaring trip on September 4 to study the planet's ocean ecosystems.

Scientists are pretty jazzed about these explorations of ocean microbial diversity. Yet viruses may be even more prevalent in soils than in the sea, Williamson says. She is working on

A. NANDY, SOURCE: LEHNINGER, NELSON AND COX, *PRINCIPLES OF BIOCHEMISTRY*, 2ND EDITION, 1993

a project to compare the diversity of viruses in agricultural and nonfarmed land. "Pretty much anywhere you look you are going to find viruses," she says.

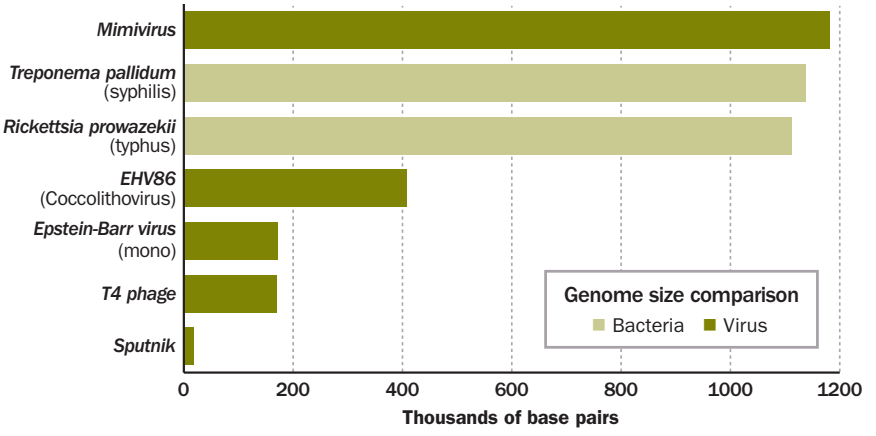
That includes freshwater locales, such as the water tower where mimivirus was discovered in 1992. It took a decade for scientists to realize that "Bradford coccus" wasn't a bacterium, says Didier Raoult of CNRS in Marseille. Raoult had no luck trying to digest the critter's cell wall and decided to image the thing with a scanning electron microscope. To his surprise, the "bacterium" looked like an iridovirus — icosahedral viruses that infect some insects, fish and frogs. But it was enormous.

Viruses aren't supposed to be visible under a light microscope; they are typically far too small. But mimivirus ("mimi" for mimicking microbe) isn't just big for a virus, it's bigger than some bacteria. Analyses of its DNA, cataloged in 2004, revealed that it also has more genetic material than some bacteria and certainly more than any other previously seen virus. The mimivirus genome contains genes for more than 900 proteins. (In contrast, T4 — which, pre-mimi, was considered a large virus — has about 77 genes.) Some of the mimivirus genes appear to be involved in processes thought to be conducted only by cellular creatures — the virus's hosts — such as translating messenger RNA into proteins. All in all, mimivirus seriously unsettled the world of virus research.

"I think the discovery really messed up the heads of a lot of people," says Eugene Koonin of the National Institutes of Health in Bethesda, Md.

Mimvirus has proved startling on another front: It's big enough that other viruses infect it. In September 2008 in *Nature,* scientists including Raoult and Koonin reported a new strain of mimivirus. Dubbed mamavirus, it is slightly larger than mimi and was also isolated from an amoeba. The mamavirus was infected with a smaller virus that the scientists called Sputnik. There was some speculation that Sputnik might just be coinfecting the amoeba, but a new analysis by Claverie and Chantal Abergel, to appear in the *Annual Review of Genetics,* reports that Sputnik is truly infecting mamavirus and cares little about the larger amoeba universe.

My genome's bigger than yours Mimivirus startled the world with a genome of nearly 1.2 million DNA base pairs, larger than the genomes of bacteria such as rickettsia. The *E. coli*–infecting T4 phage has a mere 168,903 base pairs, while *E. coli* itself has more than 4 million. The DNA in a human mitochondrion (one of a cell's energy factories) contains 16,569 base pairs.



Putting viruses in their place

Discoveries of such bacteria-dwarfing viruses have revived an old debate about what it means to be alive and where viruses fit in the big evolutionary picture. More than 80 percent of mimi's genes have no resemblance to cellular genes, suggesting that it isn't an errant gene thief gone wild. This is true of much of the viral genetic material out there, Suttle says. "It's like discovering unknown life-forms."

No one gene is found in all viruses, but a small pool of genes, dubbed "hallmark genes" by Koonin, are found in many viruses. Because viruses infect all kinds of life and can be made of all forms of genetic material (DNA or RNA, either single- or double-stranded), Koonin argues that viruses may have predated cellular life. A sort of "previrus being" perhaps formed in the nooks of a hydrothermal vent, he speculates. Some scientists have even argued that viruses were involved in the origin of the nucleus. A fundamental split in the tree of life divides organisms with a nucleus — their DNA is sequestered from the cell's cytoplasm in a protective membrane — from organisms without a nucleus. Eukaryotes, which include yeast, plants and people, have nuclei. Creatures without nuclei comprise a messy mixture of microorganisms, such as bacteria — and viruses, if they are included in the tree of life at all.

"Fundamentally, what is a nucleus?" asks Claverie. "Its goal in the cell is to replicate its own DNA using machinery outside of itself, in the cytoplasm. That's what a virus does."

Data don't really support the nucleus-as-virus notion, says evolutionary biologist Anthony Poole of Stockholm University in Sweden. Studies suggest that the nucleus emerged from a cell folding into itself. But Poole still finds the virus idea interesting.

"Speculation in this field is quite important," he says. "It can be nonsense, but it can lead to new ideas you can test and then we can progress a little bit."

The role of viruses in the history of life — and whether viruses should be considered alive — was debated in a flurry of correspondence in the August *Nature Reviews Microbiology.* (Scientists including Koonin, Claverie and Raoult weighed in.) While the philosophical "life" question will probably remain unanswered, Raoult says, research clearly shows that viruses are a vital force, no matter how they are labeled. "Words are just to communicate," he says. "They don't reveal the truth." ■

Explore more

- The Institute for Molecular Virology website: www.virology.wisc.edu

A. NANDY

The Mesmerized Mind

Scientists are unveiling how the brain works when hypnotized

By Susan Gaidos • Illustration by Lou Beach

Mention hypnosis, and the image that springs to mind is a caped magician swinging a pocket watch, seducing otherwise sensible people into barking like dogs.

But hypnosis is more than a stage show act. For years, psychologists have used it to help patients calm preflight jitters, get a good night's sleep or chuck a cigarette habit. Hypnosis even has uses in mainstream medicine for reducing the side effects of cancer treatments and helping patients cope with pain. Some physicians routinely employ hypnosis as an adjunct to mainstream anesthesia to help block pain during surgery or childbirth.

Most recently, hypnosis has advanced from stage and clinic into the laboratory. It is now used as a research tool to temporarily create hallucinations, compulsions, delusions and certain types of seizures in the lab so that these phenomena can be investigated in detail.

Such studies may lead to more effective treatments for a number of psychiatric and neurological disorders, assert psychologists Peter W. Halligan and David Oakley in the June issue of *Trends in Cognitive Sciences*.

Other scientists, intrigued by the many

practical uses of hypnosis, are striving to figure out how it works. Using the latest neuroimaging tools, these scientists are getting a look at what goes on in the hypnotized brain. The findings are mesmerizing.

When hypnotized people act on a hypnotic suggestion, they really do see, hear and feel differently, such research shows. When they're told to see colors, for example, the color-processing parts of their brains light up — despite the absence of any real color in view. When they are told to envision color objects in black and white, these color-processing areas are less active. Other imaging studies show that hypnotically induced pain activates the same brain areas as "real" pain.

Still, questions remain, says Halligan, of Cardiff University in Wales, who has studied hypnosis for more than a decade. Scientists have yet to discover how hypnosis produces physiological changes. And some scientists question whether such changes are confined to hypnosis. Perhaps the patterns of brain activity seen during hypnosis can occur during everyday experiences when people are fully absorbed in an activity, some researchers say.

The real question, says Halligan, is whether hypnosis is a specific brain state that differs from any other.

"In other words, is there some sort of neural correlate, or biological marker, within the brain during a hypnotic trance?" he asks.

The answer so far, emerging from studies done during the past few years, is maybe. New research at the University of Geneva suggests that hypnosis alters neural activity by rerouting some of the usual connections between brain regions. Such neurological detours don't happen when subjects merely imagine a scenario.

Changing your mind

Hypnosis got its start as a "miracle cure" in 1774 when physician Franz Mesmer found a way, using ethereal music played on a glass harmonica, to induce a hypnotic trance in patients suffering from various unexplained medical problems. Though eventually discredited as a healer, Mesmer demonstrated that the mind could be manipulated by suggestion to produce an effect in the body. So powerful is this effect that the practice was resurrected in the 19th century, before the discovery of ether, to block pain during major surgeries.

In this mysterious state of mind, the brain is "quiet," focused and superattentive. People sometimes report feeling disconnected from their surroundings and lost in thought. During hypnosis, subjects are more open than usual to suggestions and have the ability to focus intensely on a specific thought, feeling or sensation.

Over the past few years, scientists have begun gathering evidence that hypnosis can indeed measurably change how the brain works.

Most adults, about two-thirds, are hypnotizable to some degree, though some people experience the effects of hypnosis more intensely than others do, says David Spiegel, a psychiatrist at Stanford University School of Medicine who uses hypnosis in his medical practice. Ten to 15 percent of adults are "highly hypnotizable," he says, meaning they can experience dramatic changes in perception with hypnosis.

A person's ability to become hypnotized is unrelated to intelligence, compliancy or gullibility, but may be linked to an ability to become deeply absorbed in activities such as reading, listening to music or daydreaming. People who find themselves engrossed in a best seller even while the television is blaring, or swept away by a movie and losing track of time, are likely to be quite hypnotizable.

During hypnosis, the hypnotherapist tries to direct thoughts, feelings and behavior by instructing a person to concentrate on particular images or ideas. A typical session starts with some sort of induction procedure that helps the subject relax — say, counting down from 20 to one or mentally descending a set of stairs.

To produce a specific behavior or thought, the hypnotherapist will make suggestions targeted toward the goal. To reduce the pain of a medical procedure, for example, a hypnotherapist might invoke an image of pain being turned down like the volume on a radio.

Over the years, rigorously controlled studies have shown that hypnosis can also control blood pressure and even make warts go away. But because very few studies have attempted to find out how it works, some scientists are still skeptical of its power.

Critics suggest hypnosis is nothing more than play-acting, with subjects trying to please the hypnotist. That skepticism has driven some researchers to take a hard look at what happens in the brain during hypnosis. Over the past few years, scientists have begun gathering evidence that hypnosis can indeed measurably change how the brain works.

In 2005, scientists at Weill Medical College of Cornell University in New York City used functional MRI to show how hypnotic suggestions can override "automatic" processes in the brain. When shown the names of colors printed in different colors of ink — for example, the word *red* printed in blue — subjects were instructed to name the ink color while ignoring the word.

Though this task may sound easy, it's often difficult for people who can read because the tendency is to automatically read the word instead of naming the color. When told under hypnosis that the words would appear as gibberish, highly hypnotizable subjects were able to perform the task faster, and with fewer errors, than subjects who were less hypnotizable and therefore less likely to respond to suggestion.

The fMRI results were also striking. Highly hypnotizable participants showed less activity in a brain area called the anterior cingulate cortex, which is active when people are trying to sort out conflicting information from different sources, such as contradictory word

names and colors. The study was published in the *Proceedings of the National Academy of Sciences*.

Going deeper

Scientists agree that there is a pattern or "orchestra" of brain activity during hypnosis. Halligan and his colleagues are working to figure out what this particular pattern might be, and which — if any — brain region serves as conductor. As part of a collaboration with psychiatrist Quinton Deeley of King's College London, the researchers are looking at how patterns of brain activity in the induction phase — the countdown — prepare the brain for suggestions.

Preliminary findings suggest that hypnosis boosts activity in the brain's prefrontal cortex — a region responsible for various executive functions such as decision making and regulating attention — while suppressing activity in other brain regions.

Still, researchers are stumped to explain how these changes in brain patterns work to make hypnotized people feel and see things differently. Recent theories, discussed in the article in *Trends* by Halligan and Oakley, of University College London, propose that hypnotic suggestions may inhibit or disconnect certain mental processes from the brain's executive control systems.

Until recently, such hypotheses had remained untested. But in the June 25 issue of *Neuron*, Yann Cojan of the University of Geneva and colleagues report a direct test.

The researchers put 18 subjects in a brain scanner, instructing them to push a button using one hand or the other. Each trial began with a cue indicating which hand to prepare for movement. After a brief interval, an image of a hand would turn green — signaling to press the button — or red, a command to inhibit any motion. Twelve subjects did half of the trials while hypnotized, with the suggestion that their left hand was "paralyzed," and the other half in a normal, unhypnotized state. Six subjects did trials without hypnosis under instructions to pretend their left hand was paralyzed.

When volunteers used their right hands, the motor cortex linked up with brain regions that control body movement to carry out the task.

But fMRI scans showed changes in several brain areas when hypnotic paralysis prevented subjects from responding to the "go" signal with their left hands. Under hypnosis, neurons in the brain's motor cortex fired up as usual to prepare for the task. But when instructed to use the left, or "paralyzed" hand, the motor cortex failed to send signals to motor execution regions. Instead, it directed its signals to another brain region, the precuneus.

The precuneus is a sort of center for self-consciousness. If you've ever pictured yourself falling flat on your face in the middle of an important event, that's your precuneus working overtime. Its function is to help retrieve memories and images of yourself from the brain's archives and help to visualize movements.

By rerouting motor signals to the precuneus, hypnosis appeared to decouple the typical relationship between brain areas that generate the signals for hand movement and the areas that carry out such movements. Subjects who were not hypnotized and were asked to fake paralysis showed no such disconnect between these regions.

Because the precuneus is involved in mental imagery and self-awareness, Cojan says, hypnosis appeared to enhance the brain's self-monitoring processes to allow images generated by suggestion — "your hand is heavy and cannot move" — to guide behavior.

By linking to the precuneus, "the motor cortex is connected to the *idea* that it cannot move the left hand," Cojan says. "So even if you try to move, it will neglect to send signals to the motor execution areas."

Because the motor cortex fired up as usual to prepare for the task, the findings suggest that mental images created through hypnotic suggestions work by redirecting normal brain functions rather than actively suppressing them, he adds.

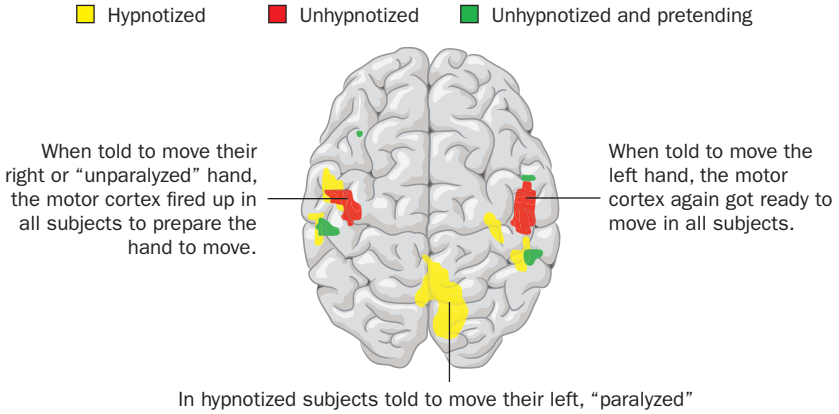
Generating piece of mind

Using insights gleaned from the brain scans of subjects paralyzed under hypnosis, Cojan conducted a follow-up study to see whether something like hypnosis happens in the brains of patients during hysterical paralysis. In such instances, patients become paralyzed even though the condition can't be traced to any physical or neurological brain damage.

An fMRI study of patients with hysterical hand paralysis did not find the heightened precuneus activity that is seen in hypnosis, Cojan's group reported

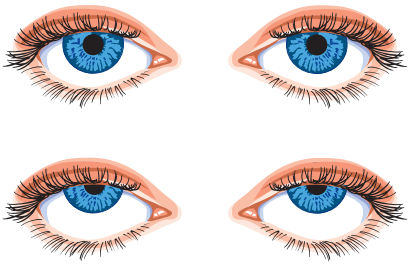
Your brain on hypnosis

Studies show hypnosis reroutes brain signals. Hypnotized people who are told that their left hand is paralyzed show brain patterns (yellow) that differ from those who aren't hypnotized (red) and from those who aren't hypnotized but are told to pretend their left hand is paralyzed (green).



In hypnotized subjects told to move their left, "paralyzed" hand, the motor cortex routed signals to the precuneus, an area involved in mental imagery and memory about oneself. Pretenders (green) did not use the precuneus.

Y. COJAN *ET AL./NEURON* 2009



Some researchers and hypnotists use a simple eye-roll test to get an idea of how hypnotizable people are. If more white, or sclera, shows when a person looks up (bottom), he or she is more likely to be susceptible to hypnosis.

T. DUBÉ, ADAPTED FROM POWERLINES/ISTOCKPHOTO

in the September *NeuroImage*.

Previously, it had been suggested that hysterical paralysis was "a kind of self-hypnosis," Cojan says. "Our findings show that's not the case."

Halligan points to the recent paralysis studies as examples of how hypnosis can be used to further studies on the nature of hypnosis and to provide insights on a variety of real-life syndromes and disorders.

In 2000, he and Oakley began looking at ways to use hypnosis to simulate psychosomatic conditions, such as hysterical paralysis or hysterical blindness, in the lab. By creating virtual patients through hypnosis, scientists might be able to better understand the basis for such disorders by comparing patients' brains with hypnotized brains, the researchers reckoned.

Deeley, who treats psychiatric patients at his private practice in London, says using hypnosis also allows him to track brain processes involved in other kinds of disorders that would not ordinarily be possible to study with brain imaging.

In an ongoing series of experiments, he and his colleagues are using hypnosis to study conditions in which patients sense a "lack of control" over their movements or behavior. Such perceptual experiences may be reported by people who experience nonepileptic seizures or who suffer delusions caused by schizophrenia.

By making some targeted suggestions — "Your left hand is now shaking at your side" or "Your right leg is twitching" — the scientists can model a particular symptom in a consistent and controlled way, Deeley says.

"You can't have somebody having a full-blown seizure within an MRI scanner," he says. "It's not safe because they're moving fast, and you wouldn't get any useful information. But if you actually restrict an involuntary movement to a particular limb or a hand, it is possible to create a partial model of these involuntary movements."

Another advantage of hypnosis is that it allows researchers to untangle the many components that make up a complex disorder, such as schizophrenia. In such cases, patients may feel not only that they're losing control, but also that their actions or behavior are guided by an outside force or agent, such as the CIA.

Scientists then have the problem of sorting out whether a change in brain activity is associated with the physical experience of a movement or whether it is tied to the delusional beliefs behind the movement.

"In such cases, you've got two processes going on associated with complex change in brain activity, and you just can't unpack them in terms of working out what's associated with what," Deeley says.

Experimental manipulations using hypnosis could provide a window into a wide range of disorders, he says, and could help explain other types of altered states, such as meditation.

Halligan agrees, noting that hypnosis could be used to simulate various disorders commonly associated with brain injury, such as visual impairment. In a recent study, he used hypnotic suggestions to replicate conditions described by injured soldiers who are still capable of detecting motion in certain visual fields but are unable to make out any distinguishing features of the moving object.

"That's not to say that the same psychological consequences of pathology seen in patients are somehow replicated in hypnosis," Halligan says. "But using hypnosis to simulate a specific condition for imaging may tell us which brain systems are involved." This information may then feed back into the development of new treatments and rehabilitation tools, he says.

Such advancements, however, hinge on learning more about the underlying processes involved in hypnosis itself. Current efforts may help scientists differentiate between the brain structures that play a role in hypnosis and those that are involved in the tasks subjects are asked to perform.

"These are still early days," Halligan says, noting that it has yet to be seen how well hypnotically simulated disorders will actually match the conditions they're intended to mimic. Still, he says, hypnosis provides a way to "test and probe."

Best of all, no pocket watches are involved. ■

Susan Gaidos is a freelance science writer based in Maine.

Explore more

- Explore the science behind hypnosis at the Hypnosis and Suggestion website: www.hypnosisandsuggestion.org

Connected: The Surprising Power of Social Networks and How They Shape Our Lives

Nicholas A. Christakis and James H. Fowler

Double bacon cheeseburgers, milk shakes and your mother's best friend's brother can all make you fat. In *Connected*, social networking researchers Christakis and Fowler explain such effects by reviewing research into the ways even strangers may impact how you live, love and, yes, gain weight.

Social networking studies often rely on high-powered computers that model complex relationships. But in describing how such networks form and how moods and health practices can spread among members, the authors avoid technical language and jargon.

Some of the conclusions sound like common sense: People have less influence over others who are a few times removed than over intimate counterparts. And people with the most connections tend to have the greatest impact on group behavior. Other conclusions were counterintuitive: Health behaviors of a distant, same-sex friend can have a greater influence than those of an intimate, opposite-sex spouse.

Of course, showing how likely you are to gain weight once your mother's best friend's brother packs on some pounds doesn't explain what causes the mutual ballooning. Perhaps his weight gain made a bigger waistline more acceptable in your social circuit. Or maybe he likes to take everyone out for burgers and shakes. The authors acknowledge the difficulties in untangling cause and effect in social influences.

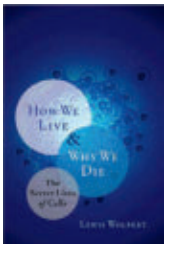
Connected argues convincingly that it's not enough to understand how individuals behave. The book details examples of how individual behaviors affect other members of a social network. In short, you are your brother's keeper. And your mother's best friend's brother's keeper, too. —*Rachel Zelkowitz*

Little, Brown and Co., 2009, 320 p., $25.99.

How We Live and Why We Die: The Secret Lives of Cells

Lewis Wolpert

You don't hear many scientists describe themselves as cell biologists anymore — geneticist or molecular biologist seems to be preferred. But cells are still more than the sum of their parts. By taking an all-inclusive look at human cells, Wolpert offers a portrait of their seemingly chaotic workings — how cells use checkpoints, backup systems and clever defenses to keep people alive. He also addresses how cells, and bodies, eventually expire.

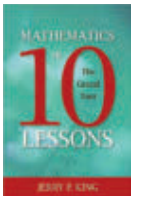


Wolpert delves into the details of DNA and other genetic material, contrasting complicated networks (each human cell houses about 30,000 genes) with simpler ones (the German measles virus has just three genes). Genes serve as blueprints for assembling proteins, which Wolpert rightfully dubs the "wizard machines" of cells. He describes how free-floating proteins bump into thousands of molecules in a cell every second before finally attaching to a specific site on a specific molecule.

But the book goes beyond this basic look at cells to describe the specific roles that different kinds of cells play in body processes. Wolpert takes a magnifying glass to reproduction, immunity and nerve development, for example. Turning to the negative side, he explores the aberrant cell growth known as cancer.

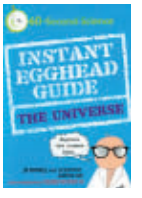
Throughout, Wolpert uses straightforward language and helpful imagery. He likens the genetic language of a cell to Morse code. And to illuminate cell division, or mitosis, he describes tying a string around a balloon and pulling to constrict it into two. As such, the book doesn't read like a textbook, but it could certainly serve as one. —*Nathan Seppa*

W.W. Norton & Co., 2009, 240 p., $24.95.

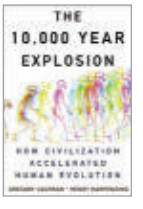


Mathematics in 10 Lessons: The Grand Tour
Jerry P. King
A few fundamental principles and an aesthetic awareness underlie all math, King shows. *Prometheus, 2009, 394 p., $18.95.*

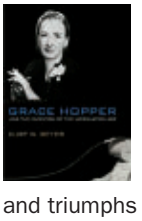
Green Intelligence: Creating Environments that Protect Human Health
John Wargo
Pollution's past effects could inform today's environmental policy. *Yale Univ. Press, 2009, 400 p., $32.50.*



Instant Egghead Guide: The Universe
J.R. Minkel and Scientific American
Bite-sized knowledge on subatomic particles, supernovas, time dilation and more. *St. Martin's Griffin, 2009, 221 p., $14.99.*



The 10,000 Year Explosion: How Civilization Accelerated Human Evolution
Gregory Cochran and Henry Harpending
Genetic changes reveal how culture has shaped recent human evolution, the authors argue. *Basic Books, 2009, 288 p., $27.*



Grace Hopper and the Invention of the Information Age
Kurt W. Beyer
This biography explores the trials and triumphs of one of computer programming's few female pioneers. *MIT Press, 2009, 389 p., $27.95.*

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Richard A. Bradley

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Looking for a change on climate policy in Copenhagen

In December, climate scientists, policy makers and other representatives of 192 nations will convene at the United Nations Climate Change Conference in Copenhagen. In advance of that meeting, Science News *earth sciences writer Sid Perkins spoke with Richard A. Bradley, head of the Energy Efficiency and Environment Division of the International Energy Agency in Paris. An intergovernmental organization that counts 28 industrialized nations as members, the IEA analyzes and facilitates global energy policy.*

What is the purpose of December's United Nations meeting?

The Kyoto Protocol, which prescribes greenhouse gas emission targets for nations that have signed and implemented the agreement, has a commitment period from 2008 to 2012. Copenhagen is to be the concluding negotiation for what will happen after the current agreement expires. While some parties want to simply extend the Kyoto Protocol with new emission commitments, others, like the United States, look for a somewhat different framework.

How can negotiators come up with an agreement that's equitable as well as effective for the developing and developed world, and for future generations?

We don't know the answer to that question because climate change is an unprecedented problem and we have limited experience dealing with a problem of such global scope. The Montreal Protocol of 1987, which dealt with regulating emissions of ozone-depleting substances, affected only a relatively small portion of national economies, whereas greenhouse gases emerge from all sectors.

Certainly, I think it's the case that any agreement forged in Copenhagen will not be the complete package. There will be subsequent negotiation, both within nations and among them, to provide specific details about how the agreement will be implemented. It's in those details that equity among various interests, whether they be different countries or different economic sectors, will in fact be worked out.

Coal is one of the cheapest and most abundant fossil fuels, yet it is also one of the dirtiest. How can people wean themselves from coal?

It's hard to imagine how we would transition over the next 40 to 50 years to fuels that don't generate carbon dioxide emissions and still maintain active economic growth rates without the use of coal. We at the International Energy Agency think that it is essential that carbon capture and sequestration (CCS) techniques work. CCS separates the act of fuel consumption from the act of releasing carbon dioxide into the atmosphere. Frankly, I don't think there's a way around this: There's going to have to be a continued use of fossil fuels, but the climate system can't live with the emissions. That's the reality.

There's going to have to be a continued use of fossil fuels, but the climate system can't live with the emissions. That's the reality.

What effect do you think the current economic slowdown will have on trends in greenhouse gas emissions and on international agreements?

From the evidence we see, emissions are going to be down globally. And depending on how rapidly the world climbs out of the current recession, that may be the case for several years. The recession might have the effect, basically, of buying some time to meet lower emission concentration targets.

Many governments have responded to the economic realities of the recession with stimulus packages, and an important piece of many of those packages — particularly in the United States, China and Europe — has been investments in cleaner energy technologies. So, as economies grow out of the recession, greenhouse gas emissions might rise more slowly than they would have otherwise.

How important will new technologies be in helping nations meet their targets for reducing emissions?

While a lot can be done with technologies that are currently available, the reality is that meeting even a 450-part-per-million target concentration for carbon dioxide would be difficult to achieve without new technologies, particularly carbon capture and sequestration.

Why is it important to reach a new climate agreement this year?

There's a certain amount of inertia in the energy-producing infrastructure: Power plants and other greenhouse gas emitters typically have long lives and therefore take quite a while to reach the end of their useful lifetime and be phased out.

A new climate agreement will send signals to the private sector as soon as possible. The sooner that occurs, the sooner we're likely to see the effects of policy and keep open the possibility of stabilizing concentrations of carbon dioxide in the atmosphere at 450 parts per million or below. ■

INTERNATIONAL ENERGY AGENCY

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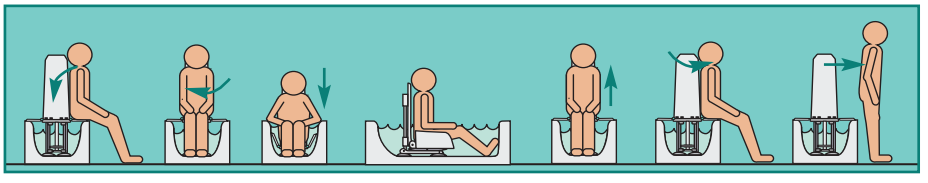

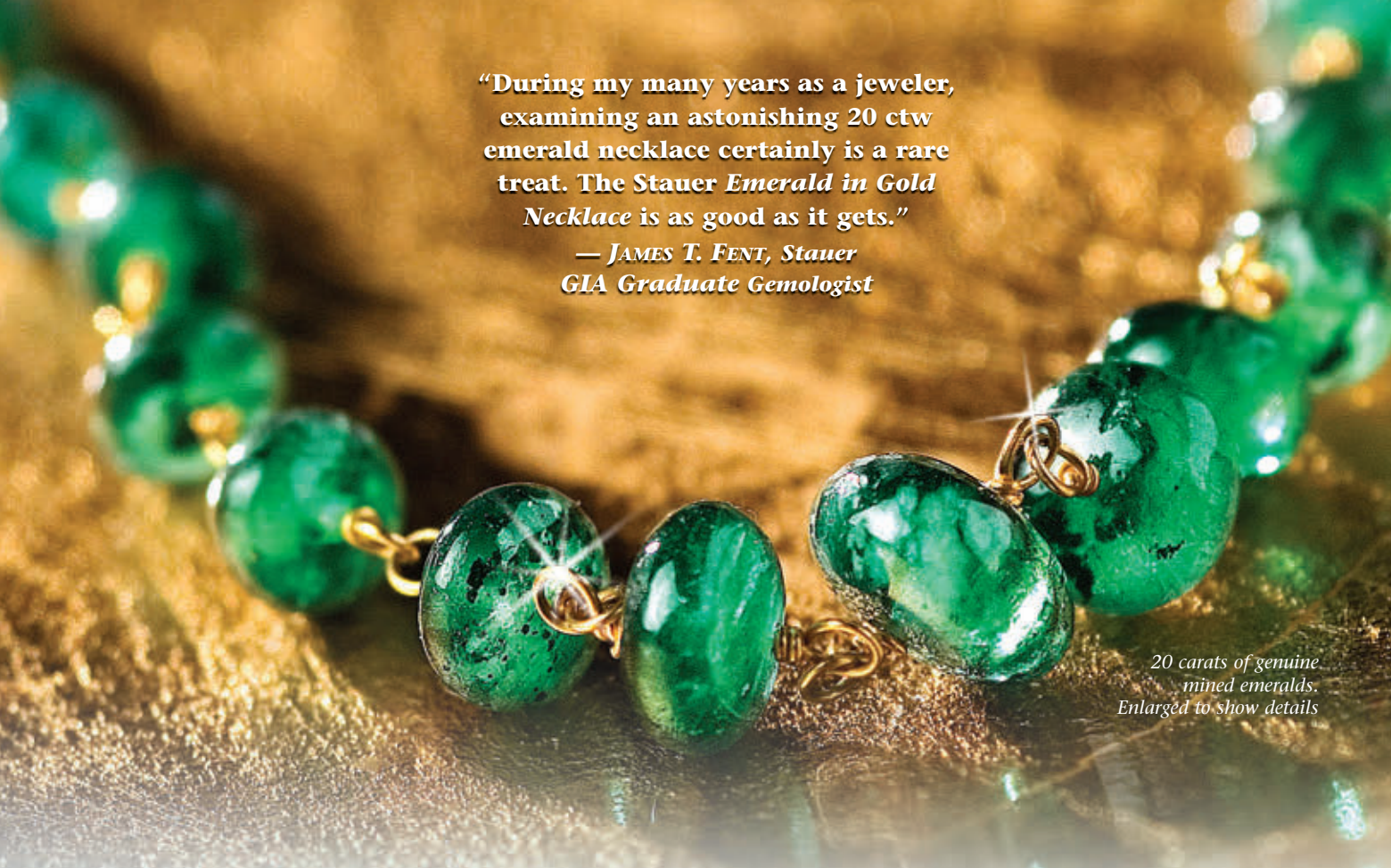

The Curse of the Perfect Gift

20 carats of polished natural emeralds linked with 14K gold for under $200!

It happened on our last trip to South America. After visiting the "Lost City" of Machu Picchu in Peru, we ventured through the mountains and down the Amazon into Brazil. In an old village we met a merchant with an impressive collection of spectacular, iridescent emeralds. Each gem was tumbled smooth and glistened like a perfect rain forest dew drop. But the price was so unbelievable, I was sure our interpreter had made a mistake.

But there was no mistake. And after returning home, I had 20 carats of these exquisite emeralds strung up in 14k gold and wrapped as a gift for my wife's birthday. That's when my trouble began. She loved it. Absolutely adored it. In fact, she rarely goes anywhere without the necklace and has basked in compliments from total strangers for months now.

So what's the problem? I'm never going to find an emerald deal this good again. In giving her such a perfect gift, I've made it impossible to top myself.

To make matters worse, my wife's become obsessed with emeralds. She can't stop sharing stories about how Cleopatra cherished the green gem above all others and how emeralds were worshiped by the Incas and Mayans and prized by Spanish conquistadors and Indian maharajahs. She's even buying into ancient beliefs that emeralds bring intelligence, well-being and good luck to anyone who wears them. I don't have the heart to tell her that I'm never going to find another deal this lucky.

Complete your collection with the 5 ctw Emerald in 14K Gold Earrings.

Our elegant *Emeralds in 14K Gold Necklace* features 20 carats of smooth, round emerald beads, hand-wired together with delicate 14K gold links. Each bead is unique in both size and color, ranging from transparent to translucent. The 18" necklace fastens with a spring ring clasp. If you are not thrilled at this rare find, send it back within 30 days for a full refund of the purchase price. But remember, we have only found enough emeralds to make a small limited number of necklaces and earrings at this low price.

JEWELRY SPECS:
- 20 ctw of polished natural emeralds
- Linked with 14K gold
- Necklace is 18" in length
- Earrings are 1 ½" in length
- Individual color may vary.

Emeralds in 14K Gold Necklace
(20 ctw) MSRP ~~$1,110~~
Your price **$199** +s&h

Emeralds in 14K Gold Earrings
(5 ctw) MSRP ~~$820~~
Your price **$175** +s&h

Call now to take advantage of this limited offer.

1-800-333-2045

Promotional Code EGN216-01
Please mention this code when you call.

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