MARCH 22, 2008 PAGES 177-192 VOL. 173, NO. 12

SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

insight on aha! moments
when blood goes stale
shrimp love in lights
a botanical conundrum

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galaxy evolution

TURNS OUT, ASTROPHYSICS IS A GAS

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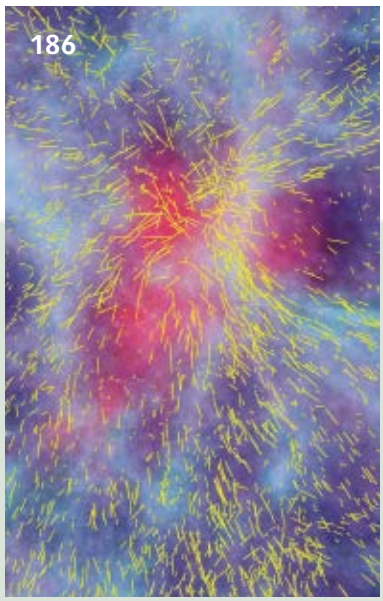

Features

This Week

Of Note

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Cover A computer simulation models how matter may accumulate into large-scale structures, the beginnings of galaxy formation. Illustrated is a patch of the cosmos 100 million light-years across. Yellow lines trace the flow and grouping of matter as it moves toward the red, or densest area, and away from the black, or least dense area. (K. Dolag and the WDS team, ESO) Page 186

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Bad Blood?

Old units might be substandard

Unsettling new evidence suggests that blood stored for more than 2 weeks might be less beneficial to recipients recovering from cardiac surgery than is fresher blood. While the study falls short of heralding a wholesale change in blood-banking practices, scientists agree that it exposes the need for a large trial to determine the optimal shelf life of stored blood. The current limit is 42 days.

Laboratory research has indicated that stored blood loses quality over time (*SN: 10/27/07, p. 269*). But previous studies of patients who received old or new blood proved inconclusive.

"No one expects blood to get a lot better during storage. It's not vintage port," says Harvey Klein, a hematologist who heads the Department of Transfusion Medicine at the National Institutes of Health in Bethesda, Md. It may be possible to show that blood cells get "run down" over time, he says, "but it's much more difficult to demonstrate that that's harmful to patients."

In the new study, researchers at the Cleveland Clinic Foundation analyzed the records of 6,002 people, average age 70, who received transfusions of red blood cells between 1998 and 2006. All were getting either heart bypass or valve surgery, or both.

Follow-up patient records revealed that those receiving blood more than 2 weeks old were more likely to have kidney failure, to need a ventilator for more than 3 days to breathe, to develop a blood disorder called sepsis, or to die within a year—compared with those getting fresher blood. The researchers excluded patients who got a mixture of newer and older blood. The report appears in the March 20 *New England Journal of Medicine*.

"This is an amazing study," says Timothy McMahon, a physician and pharmacologist at Duke University in Durham, N.C. "It's very robust and methodologically sound."

But McMahon cautions that the issue isn't settled. Scientists need to replicate these findings in a large trial that tracks patients of comparable health over months or years. Researchers would randomly assign patients to get new or older blood with neither patients nor doctors aware of which participants received the fresher blood.

Meanwhile, scientists have noticed changes in stored red blood cells that might explain the purported shortcomings of the older blood cells.

"They form long chains, like miniature doughnuts stacked on one another," says study coauthor Eugene Blackstone, a physician at the Cleveland Clinic. That makes it harder for the cells to fit through capillaries.

Stored red blood cells also lose some of their ability to alter their shape readily, McMahon says. "Often, a 6- or 8-micron red blood cell is asked to get through a 3-micron capillary," he says. "It needs to be supple to flow through properly. If a few red blood cells cannot do that, they obstruct the vessel."

STATS

14 million

Units of blood transfused in the U.S. each year.

Red blood cells deliver oxygen to tissues. But stored blood loses a chemical called 2,3-DPG (for 2,3 diphosphoglycerate) that facilitates the unloading of oxygen from hemoglobin molecules on red blood cells. While the cells begin to replenish supplies of 2,3-DPG after a transfusion, concentrations don't immediately reach the original levels, notes study coauthor Colleen Koch, an anesthesiologist at the Cleveland Clinic. —NATHAN SEPPA

Love Code

A twist of light only mantis shrimp can see

For love, some would twist the laws of physics. Short of doing that, mantis shrimp communicate with the other sex by spinning light waves, biologists find. The feat seems to be unique to this animal.

Light is made of electromagnetic waves. These are electric and magnetic fields that wiggle perpendicular to each other and to a light ray's direction. Many invertebrates have sophisticated eyes that can detect wavelengths of light invisible to humans. Some, including bees, can also distinguish linearly polarized light. That's when a light ray's electric field wiggles not in varying directions, but rather in one precise direction that forms a right angle to the ray.

Researchers now show that mantis shrimp—which actually look more like small lobsters—can tell when light is circularly, rather than linearly, polarized. That means that the electric field twists like a corkscrew as the light ray moves. The corkscrew can twist right or left—or, in biological terms, be right- or left-handed.

Roy Caldwell of the University of California, Berkeley, suspected that one species of mantis shrimp, *Odontodactylus cultrifer*, might be able to distinguish circular polarizations. Animals in this species, especially

DEPT. OF HEALTH AND HUMAN SERVICES; CALDWELL

IN A DIFFERENT LIGHT Alone in the animal kingdom, mantis shrimp may use the physics phenomenon of circularly polarized light to signal their presence to—and to see—potential mates.

adult males, are rare. But 2 years ago, thanks to a tip from a crustacean enthusiast, Caldwell obtained a 4 inch–long adult male originally from Indonesia.

The shrimp had a fin with shades of red that looked more or less intense when seen through filters for right- or left-handed circular polarization. This trait was rare enough, but not unique in the animal kingdom. Caldwell's collaborators at the University of Maryland, Baltimore County (UMBC) and the University of Queensland in Brisbane, Australia also took a closer look at the eyes of *O. cultrifer* and of two similar species to see whether the animals could distinguish between right- and left-handed polarization.

The researchers found that some of the eyes' light-sensing cells doubled up as filters, explains Tom Cronin of UMBC. The cells have microscopic structures, like bristles of a toothbrush, that slightly slow light with electric fields parallel to the bristles, but not light with fields that are perpendicular. As a result, the twist of a circularly polarized wave will be flattened into a steady, linearly polarized wiggle, which another layer of sensory cells can then detect. Depending on their arrangement, bristled cells will select right- or left-handed polarization. This parsing enables mantis shrimp to distinguish the two types of light.

Meanwhile, the team trained mantis shrimp to feed from one of a few different tubes based on the circular polarization in the tubes' reflected light. Results appear online in *Current Biology*.

Caldwell says the skill, unknown in other animals, most likely helps the shrimp find mates. "It's the most private communication system imaginable," he says. "No other animal can see it." —DAVIDE CASTELVECCHI

Finch Concerts

Female bird brain notes male attention

He knows she's listening. And now we know that she knows he knows.

Using the word "know" loosely, that's a simplified version of a new analysis of zebra finches by neuroscientists at the University of California, San Francisco.

Sarah Woolley explains that males sing a song differently when they're in front of females than when they're just twittering to themselves. Now she and Allison Doupe have found that females prefer the ladies-are-listening version. An area of the female brain associated with processing social context gets especially active during the males' formal serenades, Woolley and Doupe report in the March *PLoS Biology*.

Songbirds are among the few animals known to learn their communication skills. So studying birds could offer insights into human communication and learning.

The new research looks at directed communication, in which the sender of the message focuses on a particular audience. People talking to babies typically fall into an exaggerated lilt, and studies show that babies pay more attention to the more melodious version. Male canaries tend to add special syllables to their courtship songs when strutting in front of a female, and females prefer the embellished songs.

Zebra finch males go into concert mode too, mostly speeding up the song and keeping the pitch under tight control. "It's subtle," says Woolley, now at Columbia University.

To see if female finches reacted to differences barely perceptible to humans, Woolley broadcast the concert version through one speaker and the singing-in-the-shower version through a different speaker for five song pairs. Females between the speakers sidled back and forth and then typically perched beside the concert version. The response was strongest when a female heard her mate's concert song. Females without a mate also preferred the concert version, even when they had never encountered the singer.

SUBTLE GUY A male zebra finch changes his song when singing to females in ways that people can barely detect. But the female finch can tell the difference.

Researchers also tracked reactions in the female brains after exposure to one version of the song or the other. An increased number of cells that produce the ZINK protein showed that the caudomedial mesopallium, a brain region associated with social processing, responded to the concert version.

The study sheds light on what the female listener gleans from the birdsong, says Steve Nowicki, a behavioral ecologist at Duke University in Durham, N.C. "We know almost nothing about the female side of the story," he says.

The findings also caught the attention of Duke's Erich Jarvis, who first reported extra activity in part of the male zebra finch brain when singing their concerts. "The biggest story to me is that there's a lot more meaning in these songs than people had thought," he says. —SUSAN MILIUS

Long-life Link

Gut protein ties low insulin to longevity

Roundworms low on insulin tend to live longer, and a new study identifies a protein that helps explain the effect. Low insulin levels increase this protein's activity in the gut, where the protein can extend longevity by helping cells avoid damage.

Humans and other mammals have a similar group of proteins, suggesting that insulin probably affects the proteins' activity in people as well, the researchers say. The discovery could help explain why calorie-restricted diets extend life span in animals and why diabetes reduces life expectancy.

"The link with insulin is tantalizing," says study leader T. Keith Blackwell of the Joslin Diabetes Center at Harvard Medical School in Boston. However, "we'll need more research to show if this [link] has anything to do with dietary restriction or diabetes."

Scientists have known since the 1930s that yeast and many animal species live 30 to 50 percent longer when they are fed a spartan diet, containing about one-third fewer calories than normal. One frequently observed effect of this extreme diet is an improved sensitivity to insulin. This sensitivity causes the body to produce less of the hormone. At the other extreme, people with type 2 diabetes have poor insulin sensitivity, so their bodies ramp up insulin production to compensate.

Blackwell and his colleagues studied how insulin regulates a protein called SKN-1 in roundworms. This protein orchestrates a family of detoxification enzymes that protect cells by removing free radicals—vandals of the cellular world that can shorten life span. The team found that insulin decreases the activity of SKN-1, throttling down these detoxification enzymes and leaving cells less protected.

Boosting SKN-1 levels by adding extra copies of the gene for SKN-1 extended the worms' life spans by 25 to 30 percent, the researchers report in the March 21 *Cell*.

"The fact that having more SKN-1 around is sufficient to extend life span is a very important result," comments Matt Kaeberlein, a longevity researcher at the University of Washington in Seattle. "That's proof that SKN-1 is really involved in aging."

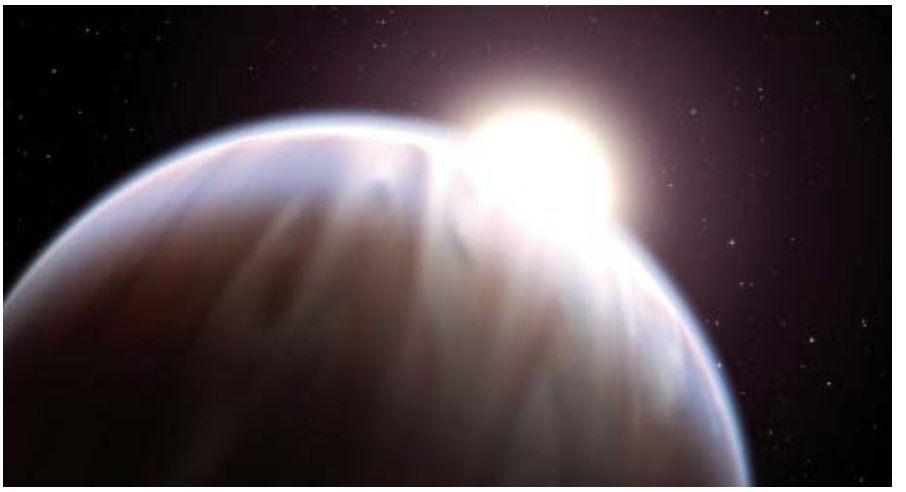
A study published last year in *Nature* did show that SKN-1 within nerve cells in roundworms' heads is essential for the

ISTOCKPHOTO

life-extending effects of calorie restriction (*SN: 6/30/07, p.414*), but the new study shows a variant of the protein in the gut influences aging in a different way—one that's controlled by insulin.

One explanation for why insulin appears to shorten an animal's life span could be that insulin requires an oxidizing chemical environment—friendly to free radicals—to do its primary function of regulating blood sugar. To disarm free radicals, the detoxification enzymes create the opposite environment, a reducing one. So the body might be trading a bit of cellular damage for the sake of improving insulin's ability to do its job, Blackwell suggests.

The mammalian versions of SKN-1 could provide new targets for researchers trying to develop drugs that extend life span, Blackwell says. —PATRICK BARRY



G. BACON/ STSCI, NASA, ESA

GASSY ORGANICS Astronomers have detected methane in the atmosphere of the hot, Jupiter-like planet circling HD 189733, depicted here in an artist's simulation.

In the Beginning

More early clues for life at home, out there

Astronomers have just moved closer to understanding how the raw ingredients for life may have arisen on Earth as well as on planets light-years beyond the solar system.

One team, using the Hubble Space Telescope, has for the first time detected an organic molecule in the atmosphere of a planet orbiting another star. Although the orb can't support life, the discovery bodes well for finding organic material on more habitable exoplanets. Another team found that space rocks delivered a bigger helping of amino acids—the building blocks of proteins—to the early Earth than previously suspected.

To learn more about the composition of an alien planet, Mark Swain of NASA's Jet Propulsion Laboratory in Pasadena, Calif., and his colleagues set their sights on a Jupiter-like body tightly orbiting the star HD 189733, which is 63 light-years from Earth. The planet, along with some 35 of the more than 270 exoplanets now known, has a special feature: As seen from Earth, it periodically passes in front of its parent star. During each of these mini-eclipses, some of the starlight filters through the planet's atmosphere and is absorbed by its atoms and molecules. The amount of starlight and the specific wavelengths absorbed reveal the composition of the planet's atmosphere.

Swain and his colleagues confirm previous suggestions that water vapor exists in the planet's atmosphere and also identify methane—the first time any carbon-bearing compound has been detected in the atmosphere of an exoplanet. The team reports the findings in the March 20 *Nature*.

"We're starting to probe the chemistry of the atmospheres of planets beyond the solar system," says Swain.

Methane is a compound that may have played a role in getting life started on the early Earth. However, the massive, searingly hot planet circling HD 189733 orbits the star at less than one-tenth Mercury's distance from the sun and therefore "cannot support life as we know it," Swain emphasizes.

Over the next few years, however, astronomers hope to record more subtle mini-eclipses, created by smaller planets dubbed superEarths, that are farther from their parent stars and lie in the zone where water might remain liquid. "The detection of methane in [those cases] would be a very big deal" and may require the power of Hubble's proposed successor, the James Webb Space Telescope, says David Charbonneau of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass.

In a study closer to home, a team led by Zita Martins of Imperial College London reports finding the highest known concentration of amino acids—between 180 and 249 parts per million—ever uncovered in ancient space rocks. The two rocks, found in Antarctica during the 1990s, belong to a rare type of meteorite called CR chondrites. This class of asteroid fragments is thought to contain the oldest and best preserved record of organic materials that have fallen to Earth.

Martins' team, including Conel Alexander of the Carnegie Institution of Washington (D.C.), determined that the amino acids were carried in the rocks before the meteorites landed on Earth, the researchers report in an upcoming *Meteoritics & Planetary Science*.

During the era known as the late heavy bombardment, from 3.8 billion to 4.5 billion years ago, comets and asteroids peppered Earth and delivered extraterrestrial organic materials, including tons of carbon each year. The new data suggest that meteorites delivered much higher abundances of amino acids to the early Earth than previously suspected. "The higher the contents of key molecules in primitive extraterrestrial materials, the more likely it is that exogenous material played a role in the origin of life," says Alexander.

"These new meteorites will get us closer to understanding the origin of the amino acids," he adds. —RON COWEN

New Recipe for Pollution Stew

Another chemical culprit adds to ozone

A chemical reaction long assumed to be unimportant in urban air quality may be a significant source of ozone, the major component of smog.

Hydroxyl (OH) radicals, among the most reactive natural chemicals in the atmosphere, help cleanse the air of some noxious pollutants. In many cases, and especially in urban environments, ozone results from that cleansing, says Amitabha Sinha, a physical chemist at the University of California, San Diego.

Previous studies suggested that the majority of the atmosphere's hydroxyl radicals are produced when ultraviolet radiation cleaves a molecule of ozone to produce a single oxygen atom, which in turn reacts with water vapor in the air. Now, lab tests by Sinha and colleagues Shuping Li and Jamie Matthews hint that reactions involving nitrogen dioxide and light may in some cases produce substantial quantities of hydroxyl radicals, and therefore more ozone.

In their experiments, the researchers zapped nitrogen dioxide, a common component of vehicle and power-plant emissions, with several wavelengths of light between 450 nanometers (violet) and 650 nm (red).

When illuminated at those wavelengths, NO_2 molecules can absorb the light's energy and remain excited for as long as 60 microseconds—long enough for them to collide with another molecule, says Sinha. Most of those collisions involve diatomic molecules of nitrogen and oxygen, gases that make up about 99 percent of the atmosphere. Occasionally, however, the extra-energetic NO_2 runs into and reacts with a molecule of water vapor, generating a hydroxyl radical.

Sinha and his colleagues' models suggest that in environments where NO_2 concentrations are 1 part per billion, light-driven chemical reactions create as many as 30,000 hydroxyl radicals each second in a cubic centimeter of air. Such reactions can produce up to 52 percent as many hydroxyl radicals as ozone-cleaving reactions do when the sun is low in the sky and much of its ultraviolet light has been filtered out by the overlying atmosphere. The team reports its findings in the March 21 *Science*.

"This throws a curve ball at what we thought about urban atmospheric chemistry," says Paul O. Wennberg, an atmospheric chemist at the California Institute of Technology in Pasadena. However, Wennberg's analyses suggest that the team's model may in some cases significantly overestimate the amount of ozone that would result from the light-driven reactions.

Production of hydroxyl radicals by excited nitrogen dioxide molecules "hasn't been included in models [of atmospheric chemistry] but certainly should be," says Luisa T. Molina, an atmospheric chemist at the Massachusetts Institute of Technology. However, she notes, in urban areas that have many sources of hydroxyl radicals, such as Mexico City, this reaction's contribution to pollution may be minimal. —SID PERKINS

Holding up

Michelangelo's David is just as buff as he was 500 years ago, when he was sculpted from marble. But the statue shows stress from holding up its weight for so long. On March 18 in Honolulu, researchers at the International Conference on Computational and Experimental Engineering and Sciences presented a new study of David's frame. Vadim Shapiro of the University of Wisconsin–Madison and Igor Tsukanov of Florida International University in Miami used new software to analyze a 3-D scan of David and confirmed that stress from gravity caused the cracks in his legs. The software requires less initial input from experts than earlier software, Shapiro says. Orthopedic surgeons could use the software to predict, say, the stress that a hip prosthesis imparts on a patient's unique anatomy. —DAVIDE CASTELVECCHI

Floral Shocker

Blooms shake roots of flowering-plant family

Imagine discovering a mammal without mammary glands or an insect with eight legs. Aquatic herbs in the genus *Hydatella* pose a similar paradox—they lack a defining developmental feature of flowering plants, raising questions about their evolution and rampant speciation during the past 135 million years.

Evolutionary biologists group together organisms that share unique traits, such as mammary glands or fur, which presumably emerged in a common ancestor. In the flowering plants—the angiosperms—these features include bearing true flowers and key events that occur during fertilization and development.

One such event is double fertilization. The plants' sperm cells each have two nuclei containing genetic material. One partakes in normal fertilization by joining with the egg cell to make an embryo. The other sperm nucleus fuses with two of mom's nuclei to make a starchy tissue called endosperm that, like a placenta, nourishes the developing plant. This second fertilization and its timing are hallmarks of angiosperm evolution. "These are the great rules of flowering plants," says botanist William Friedman of the University of Colorado at Boulder, whose new study of *Hydatella* was published online March 19 in *Nature*.

Friedman's analysis finds that *Hydatella* doesn't make proper endosperm—it provides nutritive tissue made only from mom's cells. And this starchy plant food starts developing before fertilization has even taken place.

"This is very unusual—putting down a payment irrespective of whether there is an embryo to invest in," says Friedman. The strategy is unusual for any creature but unheard of in flowering plants.

GREEN ANOMALY ***Hydatella inconspicua*, native to New Zealand, can flower under water. The tiny aquatic plant, once thought to be related to grasses, shows unusually primitive embryological development, raising new questions about the evolutionary path of the earliest flowering plants.**

SPATIAL AUTOMATION LABORATORY/UNIV. WISCONSIN–MADISON; JUSTIN GOH

Yet, a number of detailed studies of molecules, genes, and cells of angiosperms reveal that the usual traits don't necessarily hold true at the base of the flowering-plant family tree. Plants in one of the oldest surviving floral lineages, the water lily group known as the Nymphaeales, make endosperm, but mom contributes one nucleus, not two. Last year, an analysis revealed that members of the Hydatellaceae—a family that includes diminutive, grasslike water plants such as *Hydatella*—were not, in fact, highly evolved grasses, but were the Nymphaeales' closest relatives.

The standard operating procedure of angiosperms is to delay additional maternal investment in seeds until after fertilization, which prevents wasting of precious resources, says Sarah Mathews of Harvard University's Arnold Arboretum. This isn't the first odd feature found in the more ancient lineages, suggesting that the angiosperms took a while to figure out their branding strategy. Once they got going, however, they became hugely successful—today the flowering plants occur as 300,000 species and occupy every continent.

Whether making endosperm at all, and then only after fertilization, contributed to the flowering plants' astounding diversity is an open question, Mathews says. But, she says, *Hydatella* does provide a window to the past, "a picture into the variety of different experiments being tried at this stage of the game." —RACHEL EHRENBERG

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About Your Professor

Dr. Anthony A. Goodman is exactly the guide you want on this tour—he is clear but comprehensive, objective but humane, learned but light-hearted. He received his undergraduate degree from Harvard University and his Medical Doctorate from Cornell Medical College. He completed his surgical training and Chief Residency at the Harvard Surgical Service of Boston City Hospital. Dr. Goodman is a Fellow of the American College of Surgeons and a Diplomate of the American Board of Surgery. Currently, he teaches gross anatomy in the W.W.A.M.I. Medical Sciences Program at Montana State University.

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ROAD TO EUREKA!

Insight may lie at the end of a chain of neural reactions

BY BRUCE BOWER

Sudden bursts of insight that, with no warning, provide unexpected, novel solutions to thorny problems are the stuff of legend. Consider Archimedes, the great ancient Greek mathematician and scientist.

The story goes that Archimedes was stumped by a request to determine whether the king's new crown, shaped like a laurel leaf, contained solid gold or a mix of gold and silver added by a dishonest goldsmith. Archimedes couldn't follow normal procedures by melting the crown down and measuring its density as a cube. What to do?

While taking a bath one day, the scholar noticed the level of water rise as he immersed himself. A thought flashed through his mind: This effect could determine the crown's volume and after he weighed it, its density. Then, he could determine whether the crown included cheaper, less-dense metals than gold. Excited, Archimedes ran through the streets naked, shouting "Eureka!"—Greek for "I have found it!" Pedestrians who glimpsed euphoric Archimedes in his birthday suit probably thought he had lost it.

SEEING THE LIGHT — New research offers a glimpse of brain activity during problem solving.

In the past 100 years, psychologists have occasionally explored the nature of "Eureka!" experiences, sometimes called "light-bulb" or "Aha!" moments. Experimenters can't isolate and analyze great leaps of insight, like the one attributed to Archimedes. But scientists hope to untangle the mental precursors of far humbler discoveries, such as divining a new route home after encountering a traffic jam or having the solution to a word problem pop into one's head.

In recent years, insight research has entered a charged new realm. Investigators now track electrical activity in the brain linked to "Aha!" moments. Brain scanners work too slowly to track split-second neural gyrations that precede such revelations. Instead, volunteers wear nets of electrodes over their heads. These studded caps measure electrical responses that flicker and flare across the brain's surface as individuals contemplate difficult word problems.

"Using brain data, we can develop a fine-grained analysis of the insight process," says neuroscientist Mark Jung-Beeman of Northwestern University in Evanston, Ill.

Findings remain preliminary, but important themes are emerging. First, distinctive forms of electrical activity in the brain precede "Aha!" moments and may pave the way to true insights. Second, sudden mental breakthroughs depend on widening the scope of one's attention from a few obvious but unsuitable choices to an extended network of possibilities. As attention expands, diverse pieces of knowledge can be connected to a taxing problem.

This process proceeds unconsciously as a problem solver lets promising candidate solutions percolate in the mind. Eventually, a solution pops into awareness, as if it came out of nowhere.

"If Archimedes had consciously monitored his own thoughts in the bath, he never would have shouted 'Eureka!'" says neuroscientist Joydeep Bhattacharya of Goldsmiths, University of London in England.

IMPASSE OR FAIL Bhattacharya's assertion stems from a neural study of insightful problem solving that he coauthored in the Jan. 23 *PLoS ONE*. The investigation identified the brain activity that arises during four generally accepted components of insight, which have been studied for more than 60 years.

A mental impasse occurs first. In this frustrating state, a person gets stuck on an unsuitable approach to a problem or on a few obvious but dead-end candidate solutions, can't think of anything else, and, temporarily, gives up.

Next comes restructuring, a mental transition from an intense focus on unusable concepts or information to a broader consideration of potentially relevant knowledge. Many researchers regard restructuring as the unconscious retrieval and recombination of long-term memories.

Deeper understanding follows. A more appropriate grasp of the problem and its solution, still lurking outside awareness, elicits an intuitive feel for the answer.

Finally, the correct answer leaps into consciousness without warning and triggers a feeling of "Aha!"

Bhattacharya explored these stages in 21 adults, ages 19 to 35. Each volunteer wore a cap fitted with 32 electrodes. Participants tried to solve 36 word problems, each within 45 seconds. Problems consisted of three test words, such as back, clip, and wall. Individuals had to generate a word that forms a compound word or phrase with all three test words. In this case, the word paper solves the problem, as it forms paperback, paperclip, and wallpaper.

Those who reached a mental impasse, described by the experimenters as "you feel you cannot proceed" or "you just don't know what else to think of," received a hint. Hints contained one or a few letters from the answer, such as "p_ _ _ _" or "p a _ _ r."

After providing a solution, with or without hints, participants described whether they changed their approach to the problem at some point or had otherwise experienced restructuring. They also rated the extent to which the solution appeared abruptly, like the "flashing of a light bulb."

ISTOCKPHOTO

Electrode recordings indicated that periods of mental impasse consisted of strong, low-frequency electrical activity in brain regions previously associated with a selective focus on one or a few items. This finding fits the idea that attending too closely to certain material can block efforts to find a correct solution, Bhattacharya says.

Low-frequency neural responses associated with reports of restructuring emerged roughly 1.5 seconds before participants suddenly thought of the correct word. This activity appeared at the front of the right side of the brain, an area implicated in organizing knowledge and using it to make plans. Substantially weaker activity in the same region characterized cases of restructuring that led to incorrect answers.

However, volunteers reported experiencing little or no restructuring before coming up with more than half of their insightful solutions without a hint. In many cases, those insights occurred within a few seconds of seeing a problem and may not have depended on restructuring. It's also possible that the step was unconscious and simply eluded subjects' awareness.

After receiving hints, most participants cited a keen perception of their own restructuring efforts but rarely experienced "Aha!" moments as they generated new solutions. Consciously monitoring one's own thoughts during problem solving apparently squelches the four-step insight process, Bhattacharya suggests.

"The 'Aha!' experience mainly occurs because you're minimally aware of what you're thinking as you try to solve a problem," he says.

A narrow range of high-frequency activity accompanied deeper understanding and appeared a fraction of a second before sudden insights. These responses appeared in right-brain areas involved in sorting through verbal and spatial information. At the moment of "Aha!" this high-frequency activity broke into two distinctive clusters within the same neural territory. Non-verbal tasks may activate different brain areas during insight, Bhattacharya says.

Bhattacharya's study "is striking in the degree to which it complements prior behavioral evidence for four stages of insightful problem solving," remarks psychologist Jonathan Schooler of the University of British Columbia in Vancouver.

THINKING CAP — Researchers fit a volunteer with an electrode-studded cap to measure her neural reactions during a verbal task intended to spark insight.

AKIRA SUWA/MCT /LANDOV

ANTECEDENTS OF AHA! The new study adds to findings from brain experiments jointly directed by Northwestern's Jung-Beeman and psychologist John Kounios of Drexel University in Philadelphia. However, Jung-Beeman and Kounios slice up the neural precursors of insight in their own way.

In a 2004 report, they measured electrical activity in the brain that accompanies either "Aha!" experiences or consciously generated solutions to word problems such as those used by Bhattacharya. About a third of a second before reporting sudden insights, volunteers displayed a burst of high-frequency electrical activity in a right-brain region that integrates distantly related pieces of verbal information. This response, unique to "Aha!" solutions, allowed individuals to see connections among words that previously eluded them, the researchers suggest.

A 2006 investigation moved back from the moment of insight to the brief period of mental preparation before a person views a word problem. In the 2-second span between seeing a cue that a problem was coming and seeing the problem appear on a computer screen, volunteers who generated "Aha!" solutions displayed distinctive neural responses. Activity in certain left- and right-brain areas reflected readiness to look for easily accessible words and, if no solution emerged, to broaden attention and consider a diverse array of words, according to the investigators.

Participants who solved problems through conscious deliberations exhibited preparatory brain activity that suggested a singular focus on whatever was about to appear in front of them.

The road to "Eureka!" may start even before the mental preparation period, as a person sits quietly and does nothing at all, Kounios suggests. In a recent *Neuropsychologia*, he and his coworkers report that the brains of people who later use insight to solve word problems already display "resting-state" electrical activity associated with a broadening of attention. This activity appears in right-brain areas that identify distant connections among words and verbal concepts.

In the new study, deliberative thinkers show resting-state activity associated with paying close attention to a few items. These responses primarily occur in the left brain.

It's not clear to what extent genes or previous experiences shape insight-related differences in resting state activity, Kounios notes. Twin studies suggest these brain responses remain largely stable over time, reflecting genetic influences.

"I suspect that there is a genetic set point for creative and insightful thinking that differs from one person to another," he says.

HEADING INTUIT Kounios and his colleagues see value in Bhattacharya's analysis, but they regard his findings as incomplete. In particular, Kounios contends, the London researcher failed to account for preparatory brain responses among his volunteers as they expectantly waited to see word problems.

For his part, Bhattacharya asserts that Kounios and his coworkers have yet to study distinctive elements of insightful problem solving. Neural findings that derive from volunteers' self-reports of experiencing either insight or deliberation say little about underlying mechanisms leading to either outcome, Bhattacharya holds.

Psychologist and long-time insight investigator Robert J. Sternberg of Tufts University in Medford, Mass., says recent brain studies of "Aha!" events provide intriguing new perspectives. But no experiment to date "tells us how people actually have insights, or what they can do to improve their insight skills," Sternberg says.

Bhattacharya and Kounios agree that further work needs to examine whether mental training—such as meditation or biofeedback—fosters brain activity associated with insightful problem solving.

The relationship between insight and intuition also remains largely unexplored. In 2007, a team led by neuroscientist Ruediger Ilg of the Technical University of Munich in Germany used functional magnetic resonance imaging to study brain activity in volunteers making intuitive judgments. Ilg defines intuition as an effortless evaluation of complex situations.

Volunteers viewed pairs of three-word sets, one of which had a solution word that formed a compound word or phrase with each test word. Participants frequently identified the set that had a solution word within a few seconds, though they could not name the solution word itself in that time.

These intuitive judgments activated brain areas similar to those linked to deeper understanding by Bhattacharya and to readiness for insightful problem solving by Kounios' group.

The unconscious process of intuition sometimes yields sudden, consciously experienced insights, in Ilg's view.

For now, a consensus about the neural road to "Eureka!" remains out of reach. "Insight lies at the core of human intelligence," Bhattacharya says, "but it's still uncharted territory for brain scientists." ■

FROM DARK MATTER TO LIGHT

New models of galaxy formation show the gastro in physics

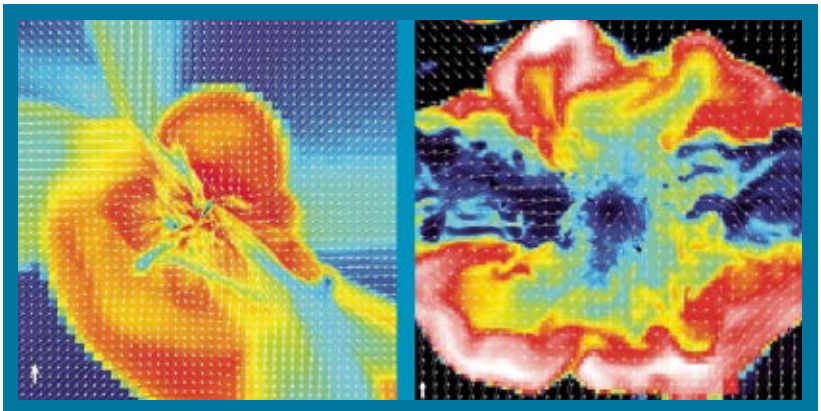
BY RON COWEN

A few years ago Avishai Dekel gave up chess in favor of mud wrestling. Dekel is a cosmologist and he isn't known to frequent strip clubs. But there are two types of cosmologists: those who study fundamentals, like the initial conditions and content of the early universe, and those who immerse themselves in the messier problem of galaxy evolution, replete with gas and stars that heat and cool, form jets, make black holes, and sometimes explode.

Martin Rees of the University of Cambridge in England calls the two classes of cosmologists chess players and mud wrestlers. Cosmology is "a fundamental science just as particle physics is," says Rees. "The first million years [of the universe] is described by a few parameters ... but the cosmic environment of galaxies and clusters is now messy and complex."

Now that the chess players have established those basic parameters—such as the relative amounts of invisible dark matter, even-more mysterious dark energy, and ordinary matter—more cosmologists are turning to the mud. Recent surveys of the shapes, colors, and masses of galaxies have put a new focus on the nitty-gritty of galaxy formation.

"Now that we know the cosmological parameters, it's really time to understand how galaxies form," says Dekel, of The Hebrew University, Jerusalem. To do that, "we have to trace the gas," not dark matter, because it's the gas that forms stars. "That's where the action is." The physics of gas interactions, or gastrophysics, is much more complicated than that of dark matter. Gas molecules respond to a host of forces while dark matter is simple to model because it responds predominantly to just one force: gravity. Nonetheless, says Dekel, he is a recent convert to gastrophysics.



HOT AND COLD — A depiction of gas inside a halo of dark matter when the universe was only about 1.6 billion years old (left). The infalling gas has been heated by a shock (outer circle). Only a few narrow streams can penetrate through the hot medium to build a galactic disk at the center and form stars. The bigger the halo, the more likely it is to quench star formation because of such heating. The picture is different when gas is within a dark-matter halo that is large enough to contain a cluster of galaxies (right).

A. KRAVTSOV ET AL.

GETTING COLD Through the 1980s and 1990s, Dekel spent most of his time trying to estimate the density of matter in the universe by mapping the velocities at which galaxies and matter move through the vast invisible reaches of dark matter. Although no one knows what dark matter is made of, it appears to constitute 85 percent of the mass of the universe. And simply because there's so much of it, the stuff provides the gravitational scaffolding that pulls together ordinary gas—electrons, protons, atoms, and the like—to make stars and galaxies. The behavior of dark matter has thus been considered a reliable map for the path of galaxy formation.

Every galaxy is nestled within a halo of cold dark matter, composed of exotic particles that move much slower than the speed of light. (This relatively slow pace is why this dark matter is dubbed "cold.")

The halos start out small but continually merge to grow bigger, dictating that all structure in the universe should evolve in the same way, from little to big. The growing clumps of dark matter form the backbone of a cosmic web, with clusters and superclusters of galaxies falling into place along the densest filaments, like paint onto a dark canvas. On the largest scales in the universe, dark matter accounts amazingly well for galactic structure—where and how galaxies concentrate, says Piero Madau of the University of California, Santa Cruz.

But in 2003, Dekel and others became intrigued by a finding about galaxies that dark matter alone could not explain. Astronomers have known since the 1920s that the modern-day universe consists mainly of two galaxy types—young-looking, disk-shaped spirals like the Milky Way, and elderly, football-shaped ellipticals. Ellipticals have a reddish tinge—an indication that they are old and finished forming stars long ago—while spirals have a bluish tinge, a sign of recent star formation.

A few years ago, researchers found that in the universe today, these two populations divide sharply by weight (*SN: 5/31/03, p. 341*). An analysis of the Sloan Digital Sky Survey, which has recorded about 1 million nearby galaxies of the northern sky, revealed that the "red and dead" ellipticals nearly always tip the scales at masses greater than the Milky Way, while the star-forming spirals fall below that weight. Somehow, star

birth was systematically and dramatically quenched in the big guys but proceeded unimpeded in the spiral small-fry.

The puzzle deepened in 2005 when Sandy Faber of the University of California, Santa Cruz, and her colleagues announced that they found the same galactic dichotomy when the universe was 7 billion years old, half its current age. Faber's team used a spectrometer she designed for the Keck Observatory atop Hawaii's Mauna Kea to measure the mass of distant galaxies, part of a survey of what composed the universe at 7 billion years. She reviewed the results of the survey, known as Deep-2, at the January meeting in Austin, Texas, of the American Astronomical Society.

At first glance, the dichotomy would seem to conflict with cold dark matter theory. A preponderance of "red and dead" massive galaxies early in the universe might indicate that halos can start out as giants and then break apart into smaller bodies, the opposite trend of what dark matter would produce.

Dekel and his colleagues, including Yuval Birnboim, now at the Harvard-Smithsonian Center for Astrophysics, in Cambridge, Mass., have an explanation that would fit with cold dark matter theory, but it requires combining gastrophysics with dark matter.

Gas pulled inside a dark-matter halo would normally fall into the center, where it would cool and grow dense enough to make stars. But as the universe ages, dark-matter halos merge and grow more massive, some becoming greater than about a trillion times the mass of the sun.

When a halo reaches this critical value, the stage is set for a galactic divide, according to Birnboim and Dekel. Their calculations and simulations show that the infalling gas rams into the relatively cold, stationary gas already at the halo's center. The collision creates a long-lasting shock that heats the cold gas, causing it to exert a pressure. That pressure pushes on infalling gas, hurling the material back to the halo's outskirts, where it remains like some exile in galactic Siberia, unable to coalesce and make stars. As long as the material in the central part of the halo maintains its outward pressure, the supply of fresh gas is choked off, and the galaxy can no longer make stars. Over time, the massive galaxy growing inside the halo's center, once a hotbed of star birth, becomes red and dead.

Halos that remain less massive—and which therefore beget smaller galaxies—can't forge such long-lasting shocks. Gas continues to stream unimpeded into the central region, enabling the birth of new generations of stars.

Simulations from several other groups, including those led by Dusan Keres, now at the Harvard-Smithsonian Center for Astrophysics; Darren Croton, now at the University of California, Berkeley; Richard Bower of Durham University in England; and Andrea Cattaneo, now at the University of Potsdam in Germany, have come up with similar findings.

"The idea is that big, central galaxies are quenched before [the universe is 7 billion years old] because they are in massive halos ... while smaller galaxies are quenched later, if at all, when their parent halos reach the critical mass," says Dekel.

YOUNG AND OLD — The young spiral galaxy NGC 300 (top), located about 7 million light-years from Earth, is brimming with newborn stars in this combined ultraviolet- and visible-light snapshot. In contrast, the more mature elliptical galaxy NGC 1312 (bottom), some 62 million light-years distant, is more quiescent.

NASA JPL/CALTECH, LAS CAMPAÑAS; NASA JPL/CALTECH, CTIO

A HOLE'S ROLE One remaining puzzle, notes Dekel, is how gas within the center of a massive halo can maintain, for up to 10 billion years of cosmic history, the outward pressure that keeps new gas at bay in the outer halo. He calculates that the pressure might last for only one-tenth that time. Some other source must keep star birth from turning back on.

Again delving into gastrophysics, he and other researchers point to the unusual role that black holes may play in staving off star birth in massive galaxies. Researchers now believe that every massive galaxy houses a central, heavyweight black hole, and that these gravitational monsters wield influence far beyond their immediate surroundings.

Packing the equivalent of millions to billions of suns into a volume no bigger than our solar system, black holes don't just pull matter in. Energy from the gas and stars spiraling into the hole also creates jets of matter that blast back out a million light-years from the center. In this way, a black hole could act to regulate or even switch off star formation, Dekel says.

Moreover, researchers have found that black holes at galactic centers grow in lockstep with the mass of stars in that galaxy's hub: The holes always seem to be one five-hundredth the mass of those stars (*SN: 1/22/05, p. 56*). That prescription means that the most massive galaxies house the heaviest black holes—exactly the ones that are most likely to have jets strong enough to interrupt star formation.

"What's truly amazing is how tight the correlation seems to be" between the mass of a central black hole and a surrounding galaxy, says Tim Heckman of Johns Hopkins University in Baltimore. "I don't think prior to 10 years ago you would have found one astronomer in one thousand that thought black holes had some fundamental part in the formation of galaxies. We still don't know whether a black hole dictates the formation of a galaxy or the other way around."

Dekel and Birnboim, along with Jerry Ostriker of Princeton University, recently began entertaining the idea that black holes might not be needed to explain the galactic divide after all. According to their calculations, the heat produced by gas falling into the centers of massive dark-matter halos might be enough to quench the supply of cold, star-forming gas.

EARLIER DAYS A new study goes further back in time than ever before to probe the difference between galaxy types.

Using distant quasars as searchlights, a team led by Art Wolfe of the University of California, San Diego, says its search may have reached back to the era when massive galaxies were still forming stars, before the death knell sounded for these heavyweights.

During their 5-year study, Wolfe and his colleagues, including Jason Prochaska of the University of California, Santa Cruz, used spectrometers at the Keck Observatory to study star formation in 143 dense gas clouds, each pierced by radiation from a different quasar. Astronomers generally agree that these clouds, known as damped Lyman-alpha systems, are the likely predecessors of

modern-day galaxies. They reveal what those galaxies were like when the universe was only about 2 billion years old.

To assess the star-formation rate in the clouds, the team homed in on the abundance of carbon atoms stripped of a single electron. Newborn stars readily excite these carbon ions. The higher their abundance, the higher the star formation rate.

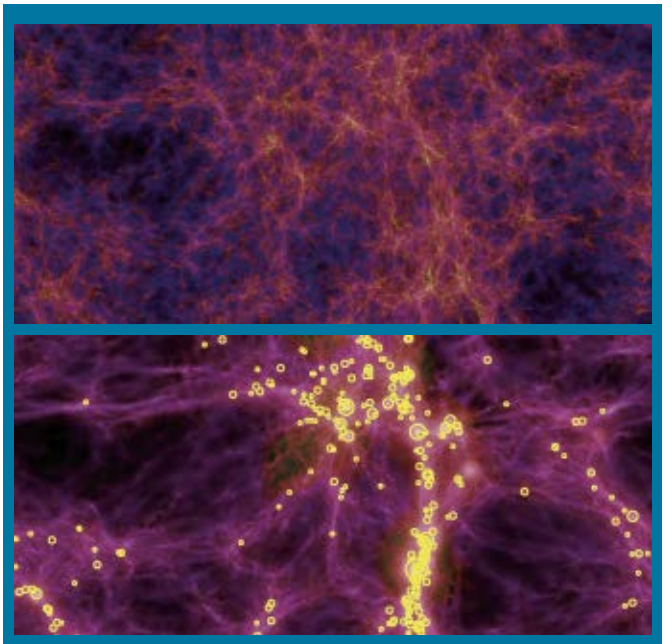
The team used spectra of another ion, silicon stripped of one electron, to indicate the masses of the dark-matter halos in which the dense clouds reside.

To the surprise of the researchers, the study revealed that star birth was highest in those clouds that lie within the heaviest dark-matter halos. Those clouds are the likely progenitors of the most massive galaxies today, the team says in an upcoming *Astrophysical Journal*.

That scenario contrasts with the current universe, "where [massive galaxies] exhibit little, if any, star formation," says Wolfe. "But that's just what the Dekel-Birnboim model predicts. That far back [in time], the high-mass galaxies are still forming stars at a high rate." Moreover, observations of distant galaxies by several researchers, including Chuck Steidel of the California Institute of Technology in Pasadena, also show that star formation once proceeded at a feverish rate in massive galaxies.

"We go back far enough to see the star-forming phase of the high-mass systems," says Wolfe. It's only later, he notes, that star birth shuts down in the high-mass systems, a victim of overheated gas and possible interference by monster black holes.

Dekel, in the meantime, says he hasn't entirely abandoned his interest in investigating the fundamental properties of the universe. It's just that the evolution of galaxies provides such a messy, and thus intriguing, canvas for testing his ideas. "I see myself as a chess player who has waded into the mud," he notes. "And that's where all the fun is." ■



WELCOME TO THE WEB — The varying density of gas is related to the evolution of structure in the universe and the formation of galaxies. Gas density is shown (increasing with brightness) along with temperature (increasing from blue to red in color). Yellow circles indicate black holes (higher masses indicated by longer diameters). The top image models the universe at about 450 million years after the Big Bang. The early universe still shows a relatively uniform structure. At about 6 billion years (bottom), the universe has many black holes and a more filamentary structure.

T. DI MATTEO ET AL.

OF NOTE

BOTANY

Attack of the skinny tomato

One gene may mark the difference in shape between round supermarket tomatoes and some of the $5-a-pound heirlooms that grace farmers markets each August. A team of botanists has pinpointed the mutation that endows varieties like Howard German, spitz, and Opalka with their elongated shapes.

Most tomatoes—including the puny wild breed from which all others descend—have just one copy of a gene called *SUN*, says Esther van der Knaap of Ohio State University in Wooster. She and a team of botanists discovered that some heirlooms have an extra copy of *SUN* lurking on chromosome 7. Adding this second copy to wild plants makes their fruit grow long and odd-shaped, while shutting off the gene rounds out oval-shaped fruit, the researchers report in the March 14 *Science*.

Van der Knaap's team is currently working out how the *SUN* gene slims down tomatoes. She says the gene might control auxin, a hormone linked to fruit growth. —EWEN CALLAWAY

NEUROSCIENCE

Alzheimer's mystery protein unmasked

A protein that forms plaques in people with Alzheimer's disease takes part in the normal process of forgetting and remembering, a new study suggests.

Scientists have long wondered why neurons make beta-amyloid, also called A-beta. This sticky protein forms the characteristic, neuron-smothering plaques of Alzheimer's disease. A-beta forms when enzymes snip a large protein called amyloid precursor protein (APP) into smaller pieces. A-beta then sticks to intact APPs, stimulating enzymes called caspases to clip APPs again.

A new study of human brain tissue suggests that the process is needed for deleting unnecessary memories to clear space on the brain's hard drive for new information.

Brains of Alzheimer's patients had four times more caspase cleavage of APP than brains of healthy older people, says Dale Bredesen of the Buck Institute for Age Research in Novato, Calif. But he and his colleagues were surprised to find that healthy young people had 10 times more cleavage than people with Alzheimer's disease.

Bredesen suggests that young brains make and dissolve memories at Ferrari speeds, but older brains gradually get slower at both remembering and forgetting. People with Alzheimer's "get stuck in reverse," dissolving memories faster than they make them, Bredesen says.

The research appeared in the March 7 issue of the *Journal of Alzheimer's Disease*. —TINA HESMAN SAEY

PARASITOLOGY

New drugs tackle difficult nematodes

Researchers have discovered what could be the first major new class of drugs in 25 years for treating animals infested with parasitic nematodes.

Three main classes of drugs have been used for decades, and nematode resistance is now widespread, says Ronald Kaminsky of the Novartis Animal Health Research Center in St. Aubin, Switzerland. A fourth drug class has so far been approved only for cats.

Nematodes, or roundworms, that infest the gut can weaken or kill their animal hosts. For example, the barber's pole worm (*Haemonchus contortus*), named for its spiraling red intestine, sucks blood fiercely enough to cause severe anemia.

Compounds called AADs, or aminoacetonitrile derivatives, kill barber's pole worms, even those resistant to current drugs, Kaminsky and an international team of colleagues report in the March 13 *Nature*.

While trying to figure out how the substances work, researchers found that *Caenorhabditis elegans*, or lab nematodes, reacted to the AADs as if dosed with a chemical known to interfere with acetylcholine receptors. Yet the reactions differed if nematodes got an old drug, which blasts a specific subset of the receptors. Therefore, the AADs might be attacking a different subset of receptors, possibly a new target for veterinary drugs.

To test this idea, researchers bred both lab nematodes and barber's pole worms to resist the AADs. Analyzing the genes that allowed the mutants to survive, the researchers saw that AADs target a type of receptor that mammal acetylcholine systems don't use. Thus an AAD drug would kill the parasitic nematodes but not the sheep, goats, or, perhaps one day, people.

"Elegant work," comments Roger Prichard of McGill University in Montreal. —SUSAN MILIUS

BAD ENDS A barber's pole worm carries a lancet (artificially colored red) for wounding a host's tissues to feed on blood.

NOVARTIS ANIMAL HEALTH

ZOOLOGY

Moths' memories

Metamorphosis completely restructures a caterpillar's wormlike body and, you would think, its brain. But caterpillars may not be so wasteful. New research shows that some of their brain cells remain intact through the supposedly annihilative process.

Scientists have long been interested in whether butterflies can remember experiences they had as caterpillars, but teasing memory from the simpler concept of familiarity is difficult, says Martha Weiss of Georgetown University in Washington, D.C.

Now Weiss and her colleagues Douglas Blackiston and Elena Casey have found a way. The team put tobacco hornworm caterpillars (*Manduca sexta*) in the stalk of a Y-shaped tube with one arm that contained a smelly, ephemeral gas. The researchers gave the caterpillars a mild electric shock when they went down the arm with the gas. Some of the caterpillars had undergone their third molt and others had completed their fifth and final molt.

When the critters emerged as adult sphinx moths, 77 percent of those that were shocked following the fifth molt remembered their aversion to the smelly gas, the team reports in the March 5 *PLoS ONE*. Caterpillars shocked just after their third molt did not remember, suggesting that postmetamorphic memories are created in brain regions that develop later in metamorphosis.

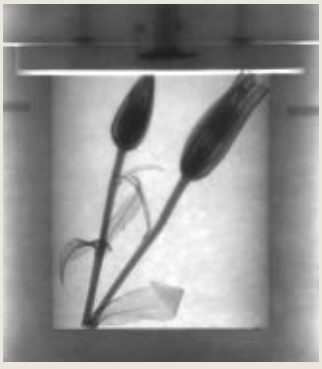
Solitary insects like caterpillars may have more use for memory than social insects like wasps or ants because there's no division of labor in the species, says Weiss. Unlike with bees, no scout is going to do a dance showing the butterfly where to find good food. A female butterfly needs to recognize a host plant for egg-laying, a nectar-bearing plant for feeding, and a safe spot for roosting. "I call it my single-working-mother hypothesis," Weiss says. —RACHEL EHRENBERG

NUCLEAR PHYSICS

Neutron vision

A new technology for measuring neutrons might help detect smuggled radioactive materials.

A common type of neutron detector uses a container filled with helium-3, a light isotope that readily reacts with neutrons. When a neutron from a sample of uranium, for example, hits a helium-3 nucleus, a reaction ensues. The helium nucleus breaks and produces one hydrogen nucleus (a proton) and an atom of hydrogen's radioactive isotope, tritium. Usually, these particles are highly energetic and ionize matter. In the presence of a voltage, the ionization produces a small spark, and the reaction is detected.



BEAT SUPERMAN A neutron beam imaged these Asian lilies inside a lead cask, where X rays cannot reach. Neutrons could be used to detect radioactive materials in cargo.

Now Charles Clark of the National Institute of Standards and Technology in Gaithersburg, Md., and his collaborators have developed an alternative technique. It promises to detect neutrons over a range of intensities at least 100 times greater than the old method. The new detector simply looks for photons produced when tritium's single electron falls back into a lower-energy state.

A better neutron detector could help prevent nuclear or dirty-bomb terrorism, Clark says. Radioactive materials such as uranium and plutonium emit neutrons, and these are harder to shield than other forms of radiation. Neutrons coming out of a cargo container could then betray the stuff's presence. —DAVIDE CASTELVECCHI

MATERIALS SCIENCE

A sticky issue

Old decals die hard. Try removing one from a wall by pulling its side, and usually only a small wedge will come off. The same tends to happen with pieces of adhesive tape. Unless the glue is weak or the tape is strong and doesn't break, the removal takes patience.

"Why is it so frustrating?" says Benoît Roman of the National Center for Scientific Research in Paris. Now Roman and his collaborators have found the answer.

The researchers tried pulling tape off surfaces using a machine that also measured the forces involved. Every time they began pulling a strip of tape off, the strip's edges tended to close up toward each other, forming a wedge (and making it impossible to pull the tape off in one clean sweep). For a given kind of tape and a given rate of pulling, the wedge's angle was always the same, regardless of the width of the initial strip.

Some hypothesizing helped the team understand why the wedge forms. When tape is pulled, the researchers reasoned, a sharp bend forms right at the edge where the tape is coming off the surface. Where the material bends or folds, it stores energy, much like a compressed spring. The wider the fold, the more energy it stores. During pulling, the bend will try to minimize its stored energy by becoming narrower. As it narrows, it releases energy, and that energy tears the material.

The team noticed that faster pulling or stronger glue led to sharper bend angles. The sharper the bend, the harder it was to pull the tape off—more energy went into tearing and smaller bits of tape came off. Slower pulling essentially softened the glue. "If you pull fast, the adhesion is higher," Roman says.

So slower is better. Still, Roman adds: "There's no way out. Tape will always be difficult to tear [off]." —D.C.

BEHAVIOR

People move like predators

Every morning is the same: You get up, shower, and eat breakfast, and you're ready to go. On a hunt.

If hunting is not in your daily routine, it might as well be, or so it could seem to someone tracking your movements. A new study based on data from cell phone use shows that people's daily roaming mirrors familiar patterns—universal statistical laws that researchers have observed before in the movements of certain carnivores looking for prey.

Albert-László Barabási and Marta González of Northeastern University in Boston and their collaborators sifted through 6 months' worth of text messages and call records for 100,000 users, provided by cell phone companies. By tracking which cell phone towers users were connecting to at any given time, the data allowed researchers to map individuals' movements throughout the day, as long as they went far enough to enter another tower's service area.

González says that a better understanding of human mobility might help improve urban planning and model how infectious diseases spread.

Some of the conclusions were hardly shocking. For example, most people commute, some farther than others, and a few people travel a lot, while others don't travel at all.

But, seeking statistical patterns, the researchers measured the distances between consecutive calls and calculated which distances were traversed with higher probability. Predictably, shorter trips happened more frequently than longer ones, but anomalously long "jumps" took place relatively often, following a statistical law called a Lévy distribution.

Researchers have observed Lévy motion in other animals including, most recently, in several species of marine predators, as described in the Feb. 28 *Nature*. Occasional longer trips into new areas, the thinking goes, increase the chances of finding food.

While some people in the study were much more mobile than others, the less mobile ones had similar behavior, just on a smaller scale. "Each trajectory is statistically identical," which is surprising, Barabási says. "I would have expected that people who travel a lot would have significantly different patterns."

Dirk Brockmann of Northwestern University in Evanston, Ill., says the new study is unprecedented in the richness of its data. Humans, he says, must be following some strategy that leads to a Lévy distribution, but what the strategy is remains a mystery. "Why is there a mathematical law?" he says. "There still is no plausible explanation."

On the other hand, H. Eugene Stanley of Boston University says the similarity between humans and other animals is not surprising. After all, he says, the same instinct that pushes a predator to try new territory in search for food could also inspire people to venture into a new neighborhood hoping to get a new job or to discover a good bar. It's a jungle out there. —D.C.

DANIEL HUSSEY/NIST

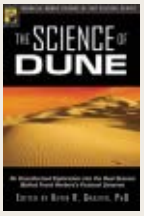
Books

A selection of new and notable books of scientific interest

THE SCIENCE OF DUNE: An Unauthorized Exploration into the Real Science behind Frank Herbert's Fictional Universe

KEVIN R. GRAZIER, ED.

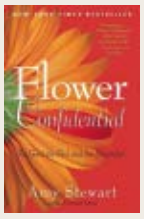
Enormous sandworms traverse the desert in Frank Herbert's 1965 science fiction classic, *Dune*. In the novel's appendices, Herbert provided some details about these worms but left out much of their (fictitious) physiology. Here, science writer Sibylle Hechtel, one of the contributors to this book, speculates about how, and if, these giant sandworms might have been able to survive and reproduce. She wrestles with a problematic contrast between the size of sandworms (averaging 200 meters long) and the great speeds at which they skimmed across shifting sands. Additional chapters by scientists and science writers speculate on the biological, physical, and chemical feasibility of Herbert's "Duniverse." They consider such topics as the engineering of moisture-retaining "stillsuits," the biochemistry of precious and addictive "spice," and whether humans could truly evolve without selection pressures, as Herbert imagined. ***BenBella Books, 2008, 232 p., paperback, $17.95.***



FLOWER CONFIDENTIAL: The Good, the Bad, and the Beautiful

AMY STEWART

The delicate roses delivered by a loved one might have been bred in a laboratory, grown in a factory-like greenhouse, packed into a box, and shipped great distances before reaching you. Is it then any wonder that after a night on the mantle those lovely blooms begin to droop? Stewart sensed something was wrong during a visit to the San Francisco flower market because the air was free of fragrance. Having been bred for color, size, and durability, the flowers lost their scent, she writes. As with other businesses, the U.S. flower trade has largely moved overseas, where costs are lower. In researching the story, Stewart interviewed growers in Ecuador, the Netherlands, and California. A journalist and award-winning nonfiction author, Stewart knows how to tell an engaging investigative tale. ***Algonquin Books, 2008, 306 p., paperback, $13.95.***



TROUT ARE MADE OF TREES

APRIL PULLEY SAYRE AND KATE ENDLE

Elementary school children will be intrigued by this lavishly illustrated and vibrant telling of the trout's life history. Most young readers won't be able to easily sound out or recognize all the words that make up this fish biography, so this is a book to read to them. How nutrients in leaves move up the food chain to nourish big fish is painlessly explained. As youngsters pore over colorful drawings that include bacteria, algae, caddis flies, and shrimp, their narrator offers sound effects to explain the depicted predation: "Swim and snap! Fins flick. Rush. Zap! They eat dragonflies." The book's title comes from its ecological message, which is simply stated: "Trout are made of trees. So are the bears and the people who catch the trout and eat them." Parents or teachers can learn more with the book's primer on the trout's life cycle and can gain green tips on how to become "a stream hero" by fostering the environmental stewardship of local waterways. ***Charlesbridge, 2008, 34 p., color illus., hardcover, $15.95.***

THE PRESIDENTIAL ELECTION GAME

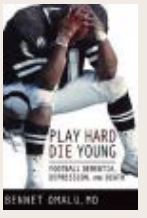
STEVEN J. BRAMS

Game theory and decision theory are enormously useful in explaining presidential elections and politics in general, according to Brams, a professor of politics at New York University. This book updates one by the same title first published 30 years ago, when "game theory was barely a blip on the radar screens of political scientists," Brams notes. Today, he says, the game theory models that he developed to study presidential primaries, conventions, general elections, and related topics have never been more applicable. Be forewarned: The book contains equations and mathematical ideas presented in less-than-breezy prose. But it also posits an explanation for how these mathematical concepts might account for the Supreme Court's ruling on the Nixon White House tapes. Brams also describes how better insights into decision making could inform the reform of U.S. election procedures in ways that might increase voter turnout, "reinforce the legitimacy of election outcomes," and help centrist candidates without denying voters a chance to vote for those with more extreme views. ***A.K. Peters, 2008, 224 p., paperback, $29.00.***

PLAY HARD, DIE YOUNG: Football Dementia, Depression, and Death

BENNET OMALU

One concussion per game—that's the average for a typical season of the National Football League. In this book, neuropathologist Omalu makes the case that "gridiron dementia" is a real condition. It could explain why former NFL players are up to five times as likely as their fans to have depression and why some end up homeless, Omalu suggests. His autopsies of deceased NFL players revealed brain damage consistent with repeated blows. Interviews with NFL players add perspective. One player is quoted as saying he had lost count of his on-field concussions after suffering 15 of them. "There may be a threshold for the number or severity of concussions each football player's brain cells may tolerate," Omalu writes. This sad tale documents suicide, drug abuse, and a list of symptoms attributable to gridiron dementia that include headaches, insomnia, memory loss, hyperactivity, violence, suicidal thoughts, and general deterioration of cognitive and social function. ***Neo-Forenxis Books, 2008, 161 p., paperback, $15.95.***



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LETTERS

The price of water

In reference to the article "Going Down" (*SN: 2/23/08, p. 115*), scarcity requires society to allocate. Usually markets do a better job than law at allocating efficiently and fairly. Lake Mead could remain full to the brim regardless of pending climate change. The quoted "demand" for 16.6 km^3 of Lake Mead water in Southern California and Arizona is not some fixed biological imperative but an artifact of absurdly low water prices. At these low prices, people take 20-minute showers, hose off their driveways, use 5 or more gallons of water to flush their toilets, top off their swimming pools, flood or sprinkler irrigate their lawns, etc. Raise the price, and these uses disappear voluntarily. At the right price, Lake Mead remains full.

KENDRICK MILLER, APTOS, CALIF.

Beneficial bacteria

The article "Swell, a Pain Lesson" (*SN: 2/16/08, p. 101*), by Tina Hesman Saey, offers a mechanism to explain the hygiene hypothesis featured prominently in past issues of *Science News*. If exposure to microbes has a beneficial effect on the immune response of mice, it may also help humans as well. The relatively antiseptic environments that many Western children experience today as compared to the past may explain the skyrocketing incidence of diseases like asthma.

SIMCHA POLLACK, QUEENS, N.Y.

It is true that the hygiene hypothesis—that modern cleanliness throws our immune systems out of balance because of less exposure to microbes early in life—has been used to explain rising asthma and allergy rates. However, it doesn't apply to the recent study, which focused on intestinal bacteria. There is little reason to think that people have fewer bacteria in their intestines now than they did in the past. —TINA HESMAN SAEY

Correction *The article "Rotten Remedy" (*SN: 3/8/08, p. 152*) misidentified scientist Mark Roth of the Fred Hutchinson Cancer Research Center in Seattle as David Roth.*

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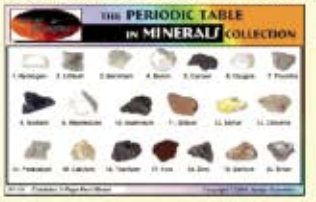
The Periodic Table in Minerals



The Periodic Table in Minerals Collection - This study collection demonstrates a new way to actually understand the elements of the Periodic Table as colorful mineral samples that contain the individual elements! 20 samples are presented in a 5 inch by 7.5 inch snap-close plastic display case, and each set includes a detailed information sheet. **Order #JPT-135, Cost: $35.00; 2 for $60; 6 for $165**

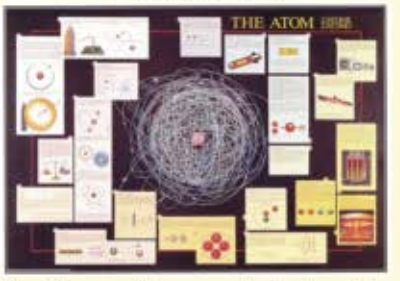
"The Tree of Life on Earth" poster offers a vivid, up-to-date overview of the modern classification of living things. The central image of a tree, with its labeled limbs and branches, represents the relationships among all the major groups of organisms on Earth. This visual presentation is reinforced verbally in an outline at the bottom of the poster, which gives descriptions and interesting facts about the 236 taxonomic groups shown in the tree.An indispensable guide to the unity and diversity of life. Size: 26" X 38", Laminated; Comes with 8 ½"X 11" 2-sided information sheet with questions and answers. **Order #JPT-1288, Cost: $24.95; 2 for $45**

The BIG Moon Rock / Earth Rock Collection!

The Moon rocks collected from the lunar surface during the Apollo missions are priceless, and are NOT available to the public for actual hands-on study. The Moon Rock / Earth Rock Collection was created by bringing together a set of Earth rocks that match the Moon rocks closely in mineral content and structure. These specimens are representative of the samples brought to Earth by the Apollo astronauts. Some of the samples are rare, and four glass vials contain carefully created analogs for lunar dust, lunar soils, and lunar volcanic glass. This set is HIGHLY recommended for collectors, and for use in museum displays and educational outreach programs. **Order #JPT-3521, Cost: $185.00**

Meteorite Impact Craters on the Earth poster - is a NEW full-size, fully revised color poster that provides a great introduction to impact science. This poster features a table with all new information about the size, location, types of materials found and features of 177 verified craters discovered on Earth (copyright 2008) Comes with an 11" X 17" In-color information sheet. **Order #JPT-7901, Cost: $24.95**

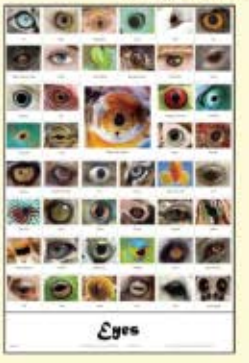
The Atom Poster



The Atom poster is an encyclopedic view of the atom from fusion to isotopes, from theory to application. The Atom poster is great for the young scientist or adults that have always wanted to learn what the atom is all about! Laminated Size: 38.5" X 26.75" **Order #JPT-2982-21, Cost: $15.85; 2 for $30**

CSI: Crime Scene Identification Poster-
This colorful Crime Scene Investigation poster contains 12 pictures and one large illustration on this popular and interesting science. The subjects of the pictures are: the forensic C.S.I. investigation kit; keeping the crime scene uncontaminated; photographing a murder scene; arson evidence; methods of investigation; 7 things to remember while doing a crime scene investigation and more! Size: 27"W X 38"L; Laminated **Order # JPT-6541; Cost: $24.95; 2 for $40**

Medicinal Herbs Poster - "Great for any classroom, laboratory, greenhouse, kitchen or study!" Size: 24" X 36" Laminated; **Order #JPT-1683, Cost: $19.95**



Eyes poster - 45 images of all different types of eyes. Do you know what the eye of the eagle, owl, red-eyed frog, macaw, turtle and balloonfish look like? **Size: 26" W X 36"L, laminated Order #JPT-4443, Cost: $21.95**; Order #JPT-1011, 2 for $38; Black metallic frame: Order #JPT: 4442, Cost: $75; Walnut frame: Order #JPT-6319, Cost $110 ***Great for schools, doctors offices, and anyone that loves biology!***

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