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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ APRIL 25, 2009

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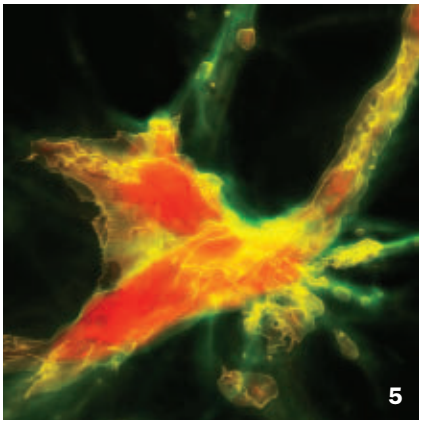

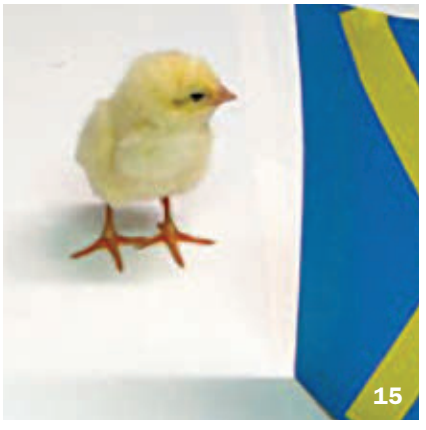

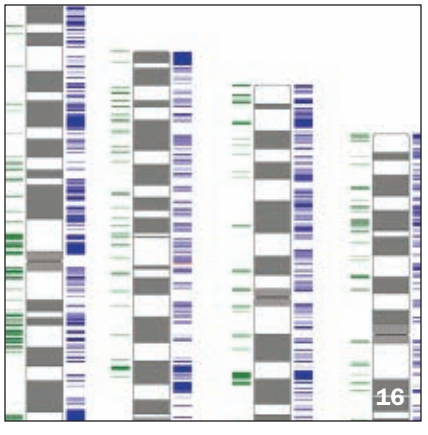

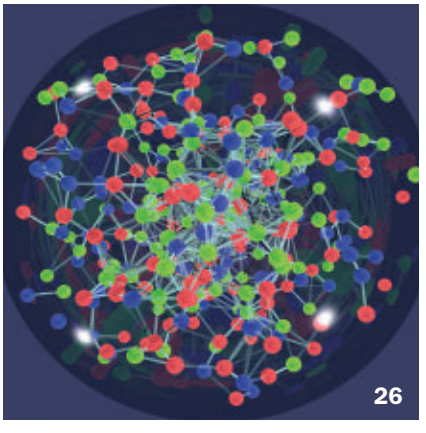

ScienceNews

In The News

Features

Essay

Departments

COVER Neuroscience taps the age-old tricks of magicians to gain insight into perception, attention and the mind. *Illustration by Lou Beach*

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FROM THE EDITOR

Neuroscience looks to magicians for big reveal

Imagine Harry Potter as a science journalist for the *Daily Prophet* and Dumbledore as editor in chief. No doubt there would be lots of stories about the genetics of herbology, the chemistry of potions, the physics of invisibility cloaks. But surely there would also be reports from the frontiers of neuroscience, exploring how magical powers depend on the inner workings of the brain and mind.

As it turns out, real-life muggle scientists are also interested in how magicians manipulate the brain. After all, ever since the days of Godric Gryffindor, magicians have been mastering methods for messing with human perception and attention. On Page 22 of this issue, *Science News* staff writer Laura Sanders explores the new partnership between the practitioners of prestidigitation and the investigators of cognitive neuroscience. It's not about spoiling everybody's fun by explaining magic with science, but rather it's a matter of magic helping scientists explain more about the mysteries of the mind.

Discovering the neural details of magical illusions is not only fascinating in itself. Knowledge of magic's mental powers could boost scientists' efforts to treat neural disorders or improve educational methods.

Such work is significant in an even larger sense, though: The magic–cognitive neuroscience connection illustrates a deeper lesson about science's importance and role in the everyday world. Science is not a domain of knowledge separate from the rest of human experience; it is rather an ever-present partner in all human endeavors.

From the composition of symphonies to baking a cake, from hitting a baseball to pulling a rabbit out of a hat, human experience provides an incredible diversity of phenomena for science to illuminate. Everything about the process of life and the workings of nature is within the purview of scientific scrutiny. But it's a mutual process; practitioners of such endeavors can learn from science, but science also makes progress by learning from the practitioners — just as Darwin consulted farmers about breeding and Einstein learned much about time from inventors hoping to patent new clockworks.

In the end, science doesn't really spoil the fun, it enhances the experiences. It's like magic.

— Tom Siegfried, Editor in Chief

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23. Predicting Natural Disasters
24. Anatomy of a Volcano—Mount St. Helens
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27. Assembling North America
28. The Sun-Driven Hydrologic Cycle
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30. Earth's Atmosphere—Air and Weather
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32. Jungles and Deserts—Feast or Famine
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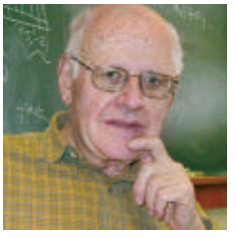
Scientific Observations



"Happily, as was made clear by two policy announcements by President Barack Obama on 9 March 2009, the break in the traditionally harmonious relationship between science and government is now ending. The first announcement, which dealt decisively with a single important and politically volatile issue, the funding of stem cell research, received the most attention. But the second, on scientific integrity, has greater breadth and at least equal significance. For as the president put it, 'promoting science isn't just about providing resources—it is also about protecting free and open inquiry … free from manipulation or coercion, and listening to what [scientists] tell us, even when it's inconvenient—especially when it's inconvenient.' "— HAROLD VARMUS (TOP), NOBEL LAUREATE AND COCHAIR OF THE PRESIDENT'S COUNCIL OF ADVISORS ON SCIENCE AND TECHNOLOGY, AND KURT GOTTFRIED (BOTTOM), PHYSICIST AND COFOUNDER OF THE UNION OF CONCERNED SCIENTISTS, WRITING IN THE MARCH 20 *SCIENCE*.

Science Past | FROM THE ISSUE OF APRIL 25, 1959

"GO-GETTER" TYPE IS HEART ATTACK CANDIDATE — The American "go-getter" type is a prime candidate for a heart attack. There appears to be a strong link between the behavior of a man with regard to his business and social activities and his chances of being a victim of a heart attack, two San Francisco specialists have suggested. Intensive studies to determine the reasons for the marked increase in coronary disease and the increased incidence of heart attacks among both younger and older men and women suggest that: A person who is full of drive toward previously selected goals; loves competition, both in work and play, and strives to "best" the other fellow; ... is a person who is likely to suffer a heart attack.

Science Future

April 28
Celebrate Save the Frogs Day. See savethefrogs.com/day

May 23
Extreme Mammals: The Biggest, Smallest, and Most Amazing Mammals of All Time opens at the American Museum of Natural History in New York City. See www.amnh.org

May 24–27
Earth and space scientists present new findings at the 2009 Joint Assembly in Toronto. Visit www.jointassembly2009.ca

SN Online

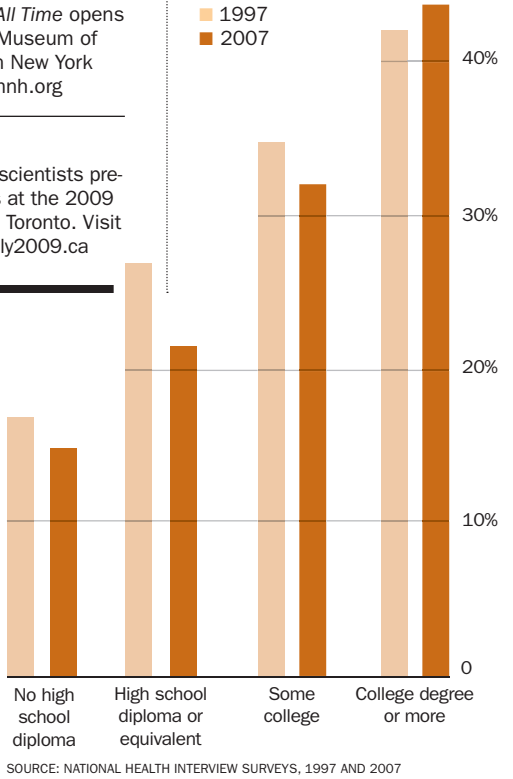
www.sciencenews.org

BODY & BRAIN
Two new studies on fruit flies show that sleep may actually sever or weaken neural connections. See "Sleep may clear the decks for next day's learning."

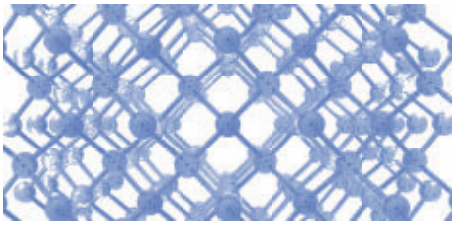
SN MULTIMEDIA
A slide show highlights some of the 600 species recently documented in a remote island forest, including this frog. See "New species in Papua New Guinea."

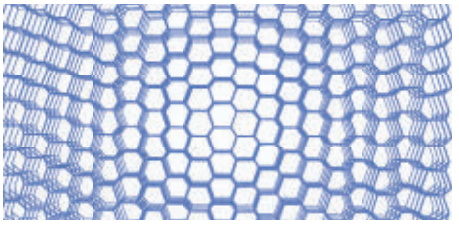
Science Stats

More schooling, more exercise
Percentage of U.S. adults 25 or older who reported regular leisure-time exercise, by education level, 1997 versus 2007



SOURCE: NATIONAL HEALTH INTERVIEW SURVEYS, 1997 AND 2007





The (-est)

Diamond is a wimp, at least compared with a form of carbon called lonsdaleite. The material bests diamond by 58 percent, making it the hardest known, according to simulations published in the Feb. 6 *Physical Review Letters*. Carbon atoms in diamond have a hexoctahedral crystal structure (top), while those in lonsdaleite have a hexagonal structure.

CLOCKWISE FROM TOP LEFT: KEITH SRAKOCIC/ASSOCIATED PRESS; CORNELL UNIVERSITY; STEVE RICHARDS; CLIVE FREEMAN/BIOSYM TECHNOLOGIES/PHOTO RESEARCHERS; ALFRED PASIEKA/PHOTO RESEARCHERS

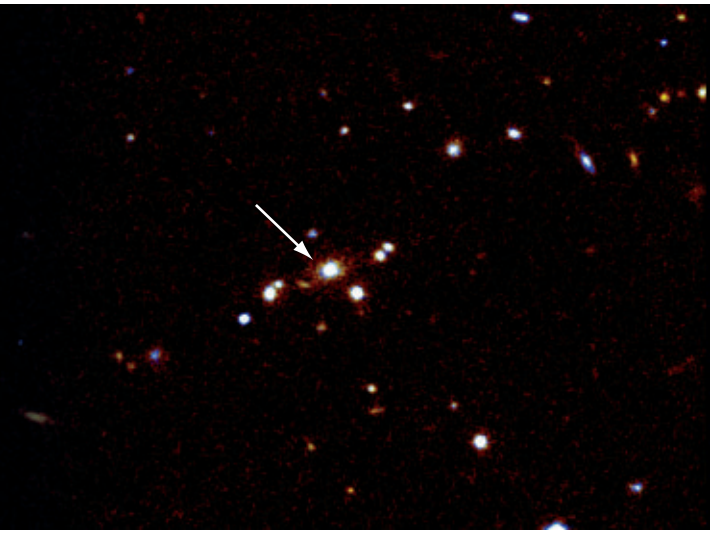
“If I can borrow a line from the diamond people, herpes is forever.” — STEVEN TRIEZENBERG, PAGE 10

In the News

STORY ONE

Heavyweights spotted in the early universe

Newfound massive galaxies may force theorists to revisit leading formation model



C. COLLINS ET AL./NATURE

This infrared image shows a remote cluster with a galaxy (arrow) about five times more massive than simulations suggest it should have been when the universe was one-third its current age.

By Ron Cowen

Peering into the center of five of the youngest known clusters of galaxies in the universe, astronomers recently found several full-grown, cigar-chomping adults among the myriad of toddlers. The remote galaxies hail from a time when the 13.7-billion-year-old cosmos was less than 5 billion years old. Yet measurements reveal that the bodies are just as massive as galaxies like the modern-day Milky Way, which took at least 10 billion years to mature.

The findings appear to call into question the leading theory of galaxy formation, known as the dark matter model, at least as it applies to the dense regions where galaxies congregate into clusters, says Chris Collins of the Liverpool John Moores University in England. He and his colleagues used the infrared Subaru telescope atop Hawaii’s Mauna Kea to observe the galaxies, and the team describes the findings in the April 2 *Nature*.

“No doubt the theorists will want to say that tweaking [the model] in very dense regions will suffice, but I think the problem could be more general than that,” Collins says.

The highly successful model holds that the gravity of a proposed, invisible material known as cold dark matter draws together gas and stars to form galaxies. Because of dark matter’s properties, the model always builds tiny, lightweight galaxies first, merging these small-fry to make bigger bodies. Indeed, simulations suggest that having formed in the young universe, the galaxies the team examined should have attained only about 20 percent of the weight actually observed.

In the dense environment of a cluster, galaxy formation is predicted to occur more quickly. Nonetheless, there doesn’t seem to have been enough time, some 4 billion to 5 billion years after the Big Bang, for the five massive galaxies to have formed by the merging of smaller galaxies, according to the model. The findings suggest that some massive galaxies formed wholesale, rather than cannibalizing their neighbors to build up stars and gas little by little.

“These observations are certainly surprising,” comments theorist Gus Evrard of the University of Michigan in Ann Arbor. Although more data and even larger-scale simulations are needed to determine whether the observations and theory are truly inconsistent, “the difference between nature’s brightest cluster galaxies and the simulated sample is quite striking,” he says.

Evrard collaborates on the Millennium Simulation, an international effort that combines the largest supercomputer simulation of the growth of dark matter ever attempted with new techniques for tracking the evolution of the visible universe. Collins’ team directly compared its observations of the five galaxies with the

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SN Today at **www.sciencenews.org**

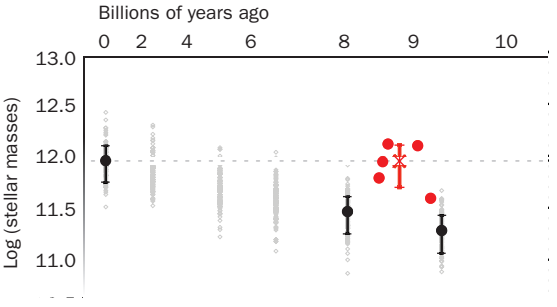
masses of galaxies predicted by this simulation at about one-third the universe's current age.

"Our result is strong evidence that, for reasons we as yet do not understand, the process of galaxy assembly at early times was much more rapid and efficient than the [dark matter model] in the simulations would have us believe," Collins says. Although the dark matter scenario for galaxy formation accurately predicts many features over a wide range of cosmic history, "it seems that in these extreme cluster environments, something else is needed."

In the dense regions examined by Collins' team, the simulations do predict extremely rapid growth. But even in these regions, the masses of the galaxies are much heavier than the model allows.

Over the past few years, other astronomers have peered even further back in time and also found some monster galaxies among the newborns (*SN: 10/8/05, p. 235*). These heavyweights, although less massive than the ones found by Collins and his colleagues, would have had much less time to bulk up and could have put even tighter limits on models of galaxy formation. However, theorists argue that dark matter models allow a few statistical oddballs. Modelers explain away this handful of early massive galaxies as extremely rare objects that happened to be in the densest dark matter regions, Collins says.

Mismatched mass



This chart predicts how the mass of the brightest galaxy in a cluster grows with time, looking back some 9 billion years. The red points reveal five such recently discovered galaxies that are heavier than theory predicts (black points and gray lines).

In contrast, massive galaxies don't seem rare in clusters. And the rapid growth rate of galaxies in clusters is already included in the Millennium Simulation.

One reason that the dark matter model may fail to produce massive galaxies rapidly is that in high-density regions gas that is gravitationally snared by a young galaxy would be compressed quickly and heated. Hot gas, which cannot form stars, would likely loiter in the halo of the young galaxy rather than sinking toward the center to add to the system's mass.

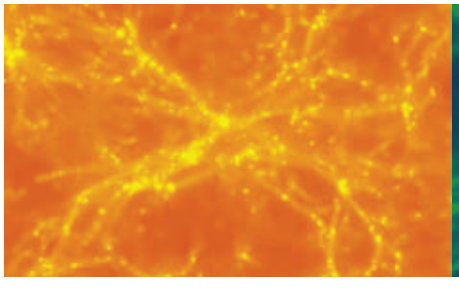
A report in the Jan. 22 *Nature* by Avishai Dekel of the Hebrew University of Jerusalem and his colleagues offers a possible solution to this cosmic conundrum (*SN: 3/22/08, p. 186*). His team's high-resolution simulations show that some gas funnels toward the center of the galaxy before the gas heats up and can therefore make stars. That would mean that galaxies could have bulked up more efficiently in the past.

"Dekel's stuff points to the underlying difficulties of forming large galaxies quickly and suggests a nice possible way out, but even here it may not be the last word," Collins says. "I think our data will stimulate more theoretical work."

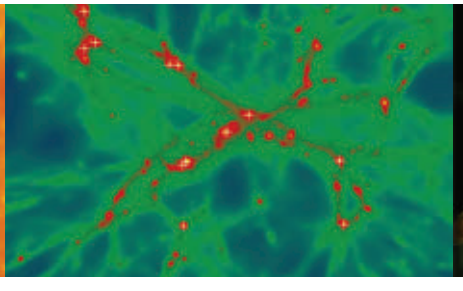
In their models, theorists could also attempt to ramp up the rate at which gas turns into stars in the brightest members of galaxy clusters, Evrard suggests. However, he cautions that it could be difficult to fatten up only the brightest members while leaving neighboring galaxies svelte. "The unintended consequence could be gigantic galaxies in today's universe that aren't seen, and they certainly would be easy to see," he says.

Speaking of the distance to the observed galaxies, Evrard says, "The observers have laid out a 10 billion light-year tightrope and challenged the theorists to balance on it. It may not be easy." ■

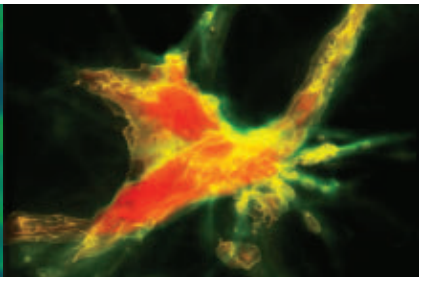
Back Story | IN LEADING THEORY, COALESCENCE BUILDS GALAXIES



1. Fluctuations in the early universe cause dark matter to collapse, forming halos. This computer simulation shows dark matter wells about 150 million years after the Big Bang. Soon after the wells form, visible matter, such as gas, will begin to fall into them.



2. As densities within those wells become high enough, stars begin to form. White crosses (within red areas) denote stars forming in halos around 220 million years after the Big Bang. As matter continues to fall in, the stars and halos coalesce.



3. Galaxies form as dark matter pulls in more stars and gas. In this simulation, the galaxy takes on a more detailed structure around 440 million years after the Big Bang. Galaxies grow and merge until jets and winds resist the buildup of matter, slowing accumulation.

FROM TOP: C. COLLINS *ET AL./NATURE*; GREIF, JOHNSON, KLESSEN, BROMM, TEXAS ADVANCED COMPUTING CENTER (ALL THREE)

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—Steven Rozensky
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The Fifth C?

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Hardness	Cuts Glass	Cuts Glass
Cut (58 facets)	Brilliant	Brilliant
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Humans

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Toddlers with autism may focus on co-occurring sounds and motions

As a result, the kids may neglect cues to social interaction

By Bruce Bower

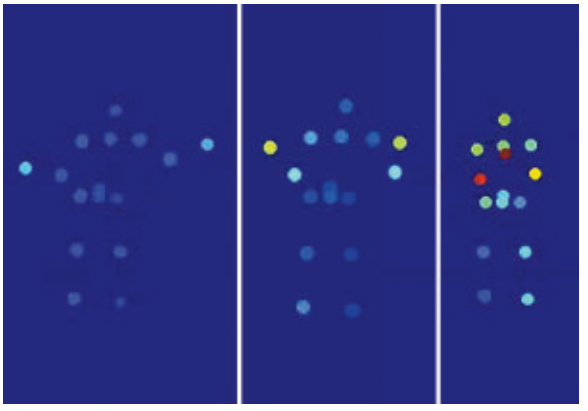
When 2-year-olds with autism look at someone's face, they may crave synchronized detection rather than social connection. Toddlers with this developmental condition track sounds and sights that occur together, such as a mother's lips moving in time with sounds coming out of her mouth, rather than social cues, such as that same mother's smile, a new study suggests.

Locked in a world of co-occurring sound and motion, youngsters with autism neglect social signals that critically contribute to mental and brain development, propose Ami Klin of Yale University's Child Study Center and his colleagues. "Our findings lead us to the rather sad hypothesis that a toddler with autism might watch a face but not necessarily experience a person, since so much of that experience involves mutual eye gaze," Klin says.

The new study, published online March 29 in *Nature*, indicates that by age 2, kids with autism pay no attention to the array of cues indicating that a body is moving. Non-autistic children do so within days of birth. Young animals in many species monitor signs of others' movements as cues to initiate social contact.

While earlier studies have suggested that children with autism often don't look at other people's eyes, it's been unclear why. Few studies have included toddlers or infants with autism because they are difficult to diagnose and study.

"For the first time, this study has pinpointed what grabs the attention of toddlers with autism spectrum disorders," Thomas Insel, director of the National Institute of Mental Health in Bethesda, Md., said in a statement.



In a new study, toddlers with autism watched an animated body playing patty-cake. The kids paid attention to audiovisual synchrony (depicted in bright colors in these shots from a video used in the study's analysis).

Klin's study employed point-light cartoons based on data from actors playing children's games. Each animation, consisting only of bright dots positioned at body joints, played normally on one side of a computer screen. On the other side, the animation played upside-down and in reverse. (Children with no developmental problems have difficulty discerning movement made by inverted figures.) An accompanying sound track played with each pair of cartoons.

> "A toddler with autism might watch a face but not necessarily experience a person."
>
> AMI KLIN
> YALE UNIVERSITY

Eye-tracking devices determined that 39 typically developing toddlers and 16 toddlers with non-autistic developmental delays preferred to look at upright animations, tracking biological motion. In contrast, 21 toddlers with autism tended to look back and forth at both upright and reversed animated figures, suggesting that these children paid no attention to whole-body movement — denying them a key to unlocking social understanding.

But toddlers with autism made an exception for a video with a cartoon that featured a game of patty-cake, where colliding dots representing two hands repeatedly produced a clapping sound. This physical synchrony existed only for the upright figure; the inverted figure played in reverse, so its motions didn't match the sound track.

An analysis of other sound-motion synchrony in the five cartoons indicated that sensory pairings frequently drew the attention of toddlers with autism.

It's too early to say for sure whether autism really involves a focus on audiovisual synchronies, since a broader mental trait could explain Klin's new findings, cautions psychologist and autism researcher Mark Strauss of the University of Pittsburgh. An intense focus on details may partly explain a tendency of kids with autism to ignore moving bodies while focusing on synchronized events (*SN: 7/7/07, p. 4*), Strauss suggests. Greater difficulty in detecting subtle eye movements versus larger mouth movements may also contribute to this pattern, he notes.

Questions remain about the extent to which kids with autism make eye contact. Klin's team reported last year that 2-year-olds with autism mainly look at people's mouths. But in another study, Strauss' group finds that 8- to 12-year-olds with autism look others in the eyes as much as their non-autistic peers.

Klin's group now plans to see whether children with autism become more social after receiving training that directs attention away from synchronized sights and sounds and toward signs of biological motion. ■

A. KLIN, D.J. LIN, P. GORRINDO, G. RAMSAY, W. JONES

Anthropology

Brain was small, but souped-up

Controversial 'hobbits' may have had complex thoughts

By Bruce Bower

In the strange and contentious world of fossil hobbits, a chimp-sized brain may boast humanlike powers. An analysis of the inner surface of an 18,000-year-old skull assigned to *Homo floresiensis*, also known as hobbits, suggests that this tiny individual possessed a brain blessed with souped-up intellectual capacities, Dean Falk of Florida State University in Tallahassee reported April 2.

As *H. floresiensis* evolved a relatively diminutive brain, the species underwent substantial neural reorganization that allowed its members to think much like people do, Falk contended. She also reported the findings online February 28 in the *Journal of Human Evolution*.

Falk compared a cast of the cranium's inner surface, or endocast, obtained from the partial hobbit skeleton LB1 with endocasts from modern humans and from other fossil skulls in the human evolutionary, or hominid, family. These casts show impressions made by various anatomical landmarks on the brain's surface."LB1 reveals that significant cortical reorganization was sustained in ape-sized brains of at least one hominid species," Falk said.

Evidence has shown that some hominid species experienced marked increases in brain size over time, but neural reorganization took center stage for others, including hobbits, she proposed. Currently, no one knows whether a large-bodied or small-bodied species gave rise to hobbits, whose fossils have been found on the Indonesian island of Flores.

Although small in size, LB1's endocast displays a humanlike shape, Falk asserted. An endocast from *Australopithecus africanus*, a roughly 3-million-year-old South African hominid species, looks similar to that of LB1, Falk said.

Yet unlike the earlier *A. africanus*, LB1 possesses a set of brain features that other researchers have implicated in complex forms of thinking done by people today, she said. These features ran from the back to the front of the brain. Traits such as expanded frontal lobes and enlarged regions devoted to integrating information from disparate areas would have supported creative and innovative thinking, in Falk's view.

No signs of disease or abnormal development appear on LB1's brain surface, she noted. Some argue that the specimen came from a modern human who had a type of growth disorder and so shouldn't be considered a separate species.

In another presentation on April 2, William Jungers of the Health Sciences Center at Stony Brook University in New York presented evidence that LB1 did not suffer from cretinism, a growth disorder attributed to it last year by one team that doubts the fossils represent a distinct species. CT scans of LB1 show no signs of dental, skull or limb conditions associated with cretinism, Jungers said. People with cretinism generally have much larger brains than that of LB1.

Hobbit-fueled controversy remains strong, though. In a meeting presentation on April 3, Robert Eckhardt of Pennsylvania State University in University Park reported that the height range within a foraging group of people now living on the hobbits' Indonesian island home overlaps with height estimates for LB1. Eckhardt and his colleagues argue that, given this finding and others, LB1 can't be its own species. ■

Chimps dig with right, left hands

Measurements from water holes suggest ape ambidexterity

By Bruce Bower

Give the chimpanzees living at Uganda's Toro-Semliki Wildlife Reserve a hand for having the mental moxie to dig water-collection holes along the edge of a river. In fact, give them two hands because the wells show no evidence of having been fashioned by either right-handers or left-handers, according to Linda Marchant of Miami University in Oxford, Ohio.

Evidence of ambidexterity in Semliki chimps counters a previous suggestion, based largely on studies of captive animals, that chimps often favor one hand over the other. If chimp handedness does exist, it may reflect an evolutionary move toward a brain organized like that of people — with one hemisphere dominating.

Chimps scoop out small holes in sandy riverbeds, leaving two piles of soil on opposite sides of each depression. During rainy times of the year, river water fills the holes and the chimps drink it. Marchant and her colleagues studied more than a hundred holes along Semliki's main river and found that all were symmetrical and likely to be produced by two hands working in concert. Each of the two soil mounds adjacent to any particular well weighed the same, she reported April 3.

Chimps may use both hands for physically demanding jobs but prefer one for tasks requiring fine movements, said Elizabeth Lonsdorf of the Lester E. Fisher Center for the Study and Conservation of Apes at Lincoln Park Zoo in Chicago.

L. MARCHANT

Chimps living in Uganda dig holes (like this one) to collect drinking water. Mounds left near the wells suggest the chimps don't have a hand preference.

Body & Brain

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Many benefits to circumcision

Operation in males fends off three common viral STDs

By Nathan Seppa

Male circumcision offers a degree of protection against genital herpes and human papillomavirus infections, scientists report in the March 26 *New England Journal of Medicine*. Previous research shows circumcision can also help protect against HIV, which means the operation can fend off the three most common viral sexually transmitted diseases — all of which are currently incurable.

The new findings, from a study of men and adolescent boys in Uganda, show that circumcision provides only partial protection against these three viruses, and the researchers caution that it should not be considered a full shield.

Nevertheless, that partial benefit could have a huge public health impact, says Anthony Fauci, director of the National Institute of Allergy and Infectious Diseases in Bethesda, Md. Herpes ulcers, for example, make a man more susceptible to HIV infection. "Circumcision not only prevents HIV outright, but also prevents [genital herpes] that is associated with an increased likelihood of acquisition of HIV," he says. In Kenya, four out of five people infected with HIV are also infected with genital herpes, says Robert Bailey of the University of Illinois at Chicago.

Meanwhile, the new study and a recent report from South Africa show that male circumcision may benefit female sexual partners, too. Compared with uncircumcised men, men who were circumcised as part of either of the clinical trials were one-third less likely to be infected with one of the dangerous types of human papillomavirus, or HPV, that can cause cervical cancer when passed on to women.

A third study team, based in Kenya, will also report findings in the coming months on circumcision's effect against STDs. Bailey, a member of the Kenya study team, could not give details but acknowledged that the upcoming results will fall in line with the newly released data.

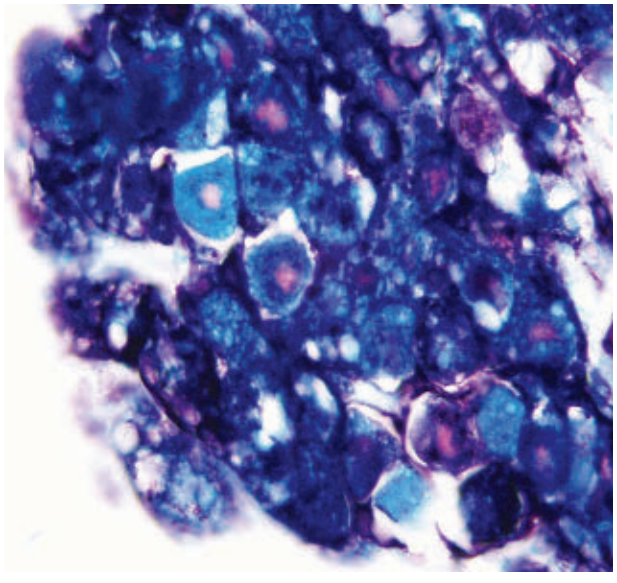
Earlier studies showed male circumcision lessened the risk of acquiring HIV by up to 60 percent (*SN: 10/29/05, p. 275*).

"I think this trio of trials is certainly a landmark in prevention, not only of HIV but of these other sexually transmitted infections," says Judith Wasserheit of the University of Washington and the Fred Hutchinson Cancer Research Center, both in Seattle. "These new data really are a game changer."

The trial in Uganda, supported by the NIAID, the Bill & Melinda Gates Foundation and others, enrolled 3,393 uncircumcised heterosexual males ranging in age from 15 to 49. None had genital herpes and all wanted to be circumcised. Half were randomly assigned to get circumcised at the start of the trial, and the others were designated to undergo the operation after a two-year wait.

After the two years, circumcised volunteers were one-fourth less likely to have genital herpes and one-third less apt to carry a type of HPV that causes cervical cancer, compared with the still-uncircumcised males. When all HPV types were assessed, circumcised volunteers were still nearly one-third less likely to carry one of the types, says study coauthor Thomas Quinn of NIAID and Johns Hopkins University in Baltimore. The study did not show protection against syphilis.

Although male circumcision surgery carries a slight risk of infection, the medical evidence showing long-term benefits is now overwhelming, Quinn says.



N. SAWTELL

The return of herpes

A single viral protein enables dormant herpes virus to wake up, suggests a study published online March 27 in *PLoS Pathogens*. The protein, called VP16, acts as the gatekeeper for viral activity, new results in mice show. Figuring out what causes the shift from an inactive to a highly infectious state is important for understanding the virus — which is carried by more than 70 percent of the global population — and stopping its reappearance, says study coauthor Nancy Sawtell of Cincinnati Children's Hospital Medical Center in Ohio. Infection with the herpes simplex virus usually triggers an acute phase that may be accompanied by a fever and cold sores. The symptoms may subside, but the virus retreats and, in people, hides in a cluster of nerve cells near each ear. Stress, sunburns and fevers can rouse the latent virus (*VP16* gene activity shown in light blue). "If I can borrow a line from the diamond people, herpes is forever," says Steven Triezenberg of the Van Andel Institute in Grand Rapids, Mich. — *Laura Sanders*

5 million Number of people infected with cholera each year | **100 thousand** Number of people who die of cholera each year

Heart cells replenish throughout life

Past nuclear testing allowed researchers to track cell birth

By Laura Sanders

By monitoring carbon 14 originally emitted from Cold War–era nuclear bomb tests, researchers have found that heart muscle cells continue to divide throughout adulthood. The low-level cell renewal may eventually be exploited to treat damaged hearts, says study coauthor Jonas Frisén of the Karolinska Institute in Stockholm.

The finding, appearing in the April 3 *Science*, contradicts the belief of many scientists that heart muscle cells present at death have been around since birth.

"The dogma has always been that cell division in the heart pretty much stops after birth," says Charles Murry of the University of Washington in Seattle, whose commentary on the new research appears in the same issue of *Science*. "In medical school, we teach that you'll die with the heart cells you're born with."

To figure out whether the cells continue to be regenerated throughout life, researchers took advantage of an inadvertent marker that has found its way into people's cells. Aboveground nuclear bomb tests during the Cold War led to skyrocketing levels of the radioactive isotope carbon 14 in the environment. After a testing ban took effect in 1963, atmospheric carbon 14 levels began to drop, giving each year since a distinctive, signature level of the isotope. Humans ingest carbon 14 through their diet, with plants incorporating it into their cells during photosynthesis.

"The carbon 14 in the atmosphere is mirrored in bodies," Frisén says.

When cells divide, they can use some of the carbon 14 to build DNA, a phenomenon that serves as a birthmark for new cells. By looking at DNA from people born before 1955, when carbon 14 levels began to spike in Sweden, researchers could see when heart cells first formed. (Cells that didn't divide after a person was born wouldn't contain carbon 14.) The team also inferred cells' birth dates by matching cells' carbon 14 levels to the annual atmospheric levels.

Frisén and his colleagues found that samples from people born before 1955 did indeed have carbon 14 in heart muscle cell DNA, indicating that the cells had been created after the person's birth.

Using DNA samples from many hearts, the researchers estimated that a 20-year-old renews about 1 percent of heart muscle cells in a year. By age 75, the rate of cell turnover slows to about 0.4 percent a year. This means that a 50-year-old has only about 55 percent of the heart muscle cells he or she was born with, while the remaining 45 percent of the cells were generated later.

NEWS BRIEFS

Immunity to cholera hindered

Intestinal parasites seem to limit a person's ability to fend off cholera, a study conducted in Bangladesh shows. The finding, which appears online March 31 in *PLoS Neglected Tropical Diseases,* might explain why vaccines against cholera have shown only spotty effectiveness and suggests that vaccination campaigns should be preceded by programs to wipe out parasites.

Blood and feces samples from 361 people hospitalized with severe cholera from 2001 to 2006 were collected and analyzed by Jason Harris of Harvard Medical School and Massachusetts General Hospital in Boston and his colleagues. They found that patients with intestinal worms had markedly poorer antibody production against the toxin made by the cholera microbe than those without the worms. These results suggest there may be a similarly weak response in people getting vaccinated, the researchers say. —*Nathan Seppa*

Prions common in yeast

Prions may be more widespread than previously thought, researchers at the Whitehead Institute for Biomedical Research in Cambridge, Mass., report in the April 3 *Cell*. Baker's yeast was previously known to have six native prion proteins, none of which appear harmful. A team led by Howard Hughes Medical Institute investigator Susan Lindquist found that 19 other proteins contain prion-forming domains—a structure that allows the protein to change its shape and function, and to spread the altered form to other proteins. One of the proteins, Mot3p, was fully characterized and found to meet all criteria for a prion. "It is logical to suggest that there are even more prions around," says Yury Chernoff of the Georgia Institute of Technology in Atlanta. —*Tina Hesman Saey*

HPV test beats Pap smear

A test for human papillomavirus infection is better than the standard Pap smear at catching cervical cancer early, researchers report. The study of women age 30 and over in India makes the case for changing screening practices, particularly in low-income countries, since the HPV test would require fewer doctor visits, a team reports in the April 2 *New England Journal of Medicine*.

"This study clearly shows that HPV screening is more sensitive to picking up precancerous lesions than the other tests," says the study's coauthor Rengaswamy Sankaranarayanan of the World Health Organization's International Agency for Research on Cancer in Lyon, France. —*Nathan Seppa*

Matter & Energy

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Scientists gain helical spin control

Guiding electrons opens door to new physics, technology

By Laura Sanders

The wild spins of electrons in a semiconductor can be tamed by guiding their collective motions into a synchronized helix, new research shows. The study, published April 2 in *Nature*, holds promise for the development of new information-carrying gadgets.

"The experiment is a fundamental discovery — a discovery with a device potential," comments Jaroslav Fabian of the University of Regensburg in Germany.

Electrons carry a quantum mechanical property called spin separate from their negative electric charge. The spin generates a magnetic field that can point in any direction. Understanding and manipulating spins is the goal of a new research area dubbed spintronics.

"This [spin] is an untapped property of the electron," says study coauthor Jake Koralek of Lawrence Berkeley National Laboratory in California.

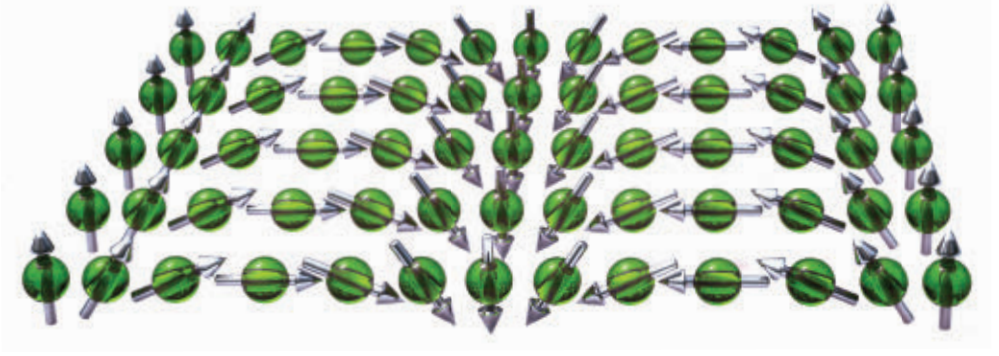
In recent years, researchers have built devices that use spins pointing up or down to encode information, much like the 1s and 0s of computing devices. But the major challenge of making spins serve as data carriers is reliability. As electrons whiz through matter, the spins occasionally flip — meaning they'd drop any information.

"The environment is typically destructive for the spins," says Fabian, who authored an accompanying commentary in the same issue of *Nature*. "Can the spins shield themselves against it? That is what the paper is about."

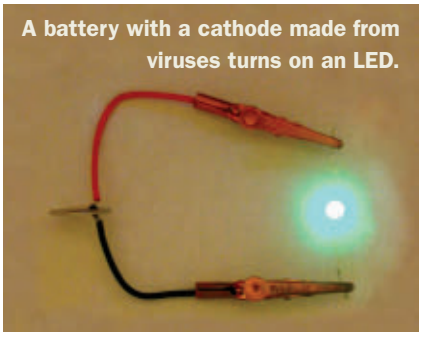
To keep spins stable, Koralek and his team created a special semiconducting material that coaxes the electrons in such a way that the directions of the magnetic fields created by their spins form a helix, which had never been observed before. The researchers set the tightness of the helix using two lasers that created alternating spin states — some up, some down.

Adjusting the experiment in accordance with two fine-tuned mathematical factors led to stability and increased the life span of the electrons' collective spins 100-fold. These two factors led to "a new type of spin conservation," Koralek says. "We can move spins around quickly, and still know exactly what each spin is."

The researchers found that electrons in the new system had stable spins for up to a nanosecond or so. And this new type of stability is relatively safe from temperature effects, marking a step toward making the technology feasible for everyday devices. "It's exciting because of this very unusual fundamental system," Koralek says. "This opens up doors for a lot of new physics." ■



The directions of the magnetic fields created by the spins of electrons in a new study form a helical shape (portion is shown) with stable spin properties.



A battery with a cathode made from viruses turns on an LED.

Viruses could power devices

New lithium-ion batteries could be more efficient

By Solmaz Barazesh

A computer virus won't help your laptop work — but a biological one could. Genetically engineered viruses could be used to build the rechargeable lithium-ion batteries that power laptops, iPods and cell phones, researchers report online April 2 in *Science*.

Angela Belcher of MIT and her colleagues used the viruses to construct the positive electrode, or cathode, of a battery. The team had already employed viruses in building the negative electrode, or anode. Once assembled, the virus batteries should perform better than traditional lithium-ion batteries, the researchers say.

Cathodes are often made of iron phosphate, which stores energy well. The team manipulated a gene of the M13 virus to make the viruses coat themselves in iron phosphate — leading to nano-sized particles of the material. Electrons move through small particles quickly, but such particles had been hard to fabricate. Tweaking a second gene made the viruses bind to carbon nanotubes. The combined result: a highly conductive cathode.

"This work is an exciting breakthrough," says battery chemist Kang Xu of the U.S. Army Research Laboratory in Adelphi, Md.

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Atom & Cosmos

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Moons are icy all the way through

Bodies likely chipped from Haumea in cataclysmic event

By Ron Cowen

You'd need a mighty tall glass to hold two space objects that researchers have now identified as ice cubes at the fringes of the solar system. The larger of the icy bodies is about the width of Ohio, the smaller about twice the length of Rhode Island. Both bodies are moons of the dwarf planet Haumea. Members of the trio were discovered in late 2004 and in 2005 and reside in the Kuiper Belt, a reservoir of objects beyond the orbit of Neptune.

Spectra taken of the larger and outermost of the two moons, dubbed Hi'iaka, had indicated that its surface, unlike most Kuiper Belt objects, is made of nearly pure crystalline water-ice. Now, new spectra taken with the Hubble Space Telescope not only confirm the composition of Hi'iaka, but for the first time also show that the surface of the smaller moon, Namaka, has the same composition. Because both moons are too small to have undergone heating and cooling that would have caused heavier elements to sink to the cores, the icy surfaces are likely to be fair representations of the moons' interiors.

"These things could be, essentially, ice cubes," says Michael Brown of the California Institute of Technology in Pasadena, a codiscover of Haumea and its moons. Brown and Caltech colleague Wesley Fraser describe the new observations online (arxiv.org/abs/0903.0860) and in the April 10 *Astrophysical Journal Letters*.

> "These things could be, essentially, ice cubes."
>
> MICHAEL BROWN
> CALTECH

The frozen findings aren't just a cosmic curiosity. Haumea, whose rapid spin is thought to have reshaped it into a squashed football, is glazed with water-ice. (The dwarf planet's interior, in contrast, is made up of much denser material.) The similarity between the surface of Haumea and its moons strongly suggests that these satellites were not Kuiper Belt residents that happened to be captured by Haumea, but were chipped off the dwarf planet as a result of a cataclysmic event. Haumea is already the only Kuiper Belt object known to be part of a collisional family—other chunks, besides the moons, are known to have been created when a large impactor, perhaps 500 kilometers in diameter, struck the once-larger dwarf planet in the distant past, Brown says.

In Hawaiian mythology, Hi'iaka and Namaka are daughters of Haumea, the goddess of fertility. The findings provide evidence that these moons are indeed offspring of the planet, Brown says.

"At face value, it looks like Haumea's collisional family and the moons are one and the same—the product of some extraordinary event" early in the history of the solar system, comments Daniel Fabrycky of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass.

In a separate study, Brown and Caltech colleague Darin Ragozzine report that, as seen from Earth, Namaka and Haumea began transiting, or passing in front of each other, a few years ago. The team posted the findings online (arxiv.org/abs/0903.4213), and the report will appear in an upcoming *Astronomical Journal*. The degree of dimming Namaka causes as it journeys across different sections of Haumea will reveal the exact shapes and sizes of the bodies, Ragozzine says.

NATURE

Asteroid tracked to impact

They saw 2008 TC_3 coming, and they got what was coming to them. For the first time, researchers have detected an asteroid in space, tracked its progress and collected its debris after it crashed to Earth, scientists report in the March 26 *Nature*. The debris landed in northern Sudan on October 7, 2008. Small, car-sized asteroids like 2008 TC_3 are fairly common, with a meteorite from one impacting Earth about each year. But these small bodies are usually not spotted until they enter the Earth's atmosphere. "It's like when bugs splatter on the windshield. You don't see the bug until it's too late," says study coauthor Mark Boslough of Sandia National Laboratories in Albuquerque. Comparing data from observations of the asteroid while it was in space with an analysis of its meteorite fragments on Earth (one shown) will yield new insights into asteroids, the scientists say. Following 2008 TC_3 also gave the researchers confidence that tracking devices could find and follow a larger asteroid if it were on a collision course with Earth, Boslough says. —*Solmaz Barazesh*

Genes & Cells

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40 genes aid in monarch migration

Activity differs between southbound, homebody butterflies

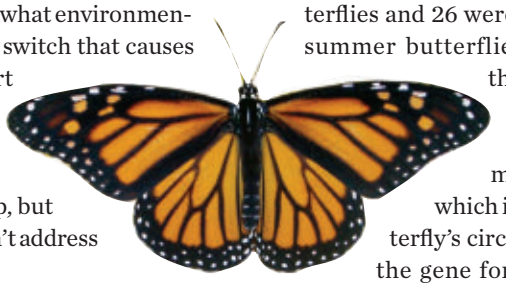
By Tina Hesman Saey

Come fall, monarch butterflies feel the need for a change in latitude. A new study shows that changes in the activity of a suite of genes in the butterflies' brains help the insects find their way to overwintering grounds in Mexico.

Steven Reppert, a neurobiologist from the University of Massachusetts Medical School in Worcester, leads a team of scientists on an ongoing mission to uncover the monarch's migratory signals. The team describes a new genetic analysis of stationary summer monarchs and fall migratory monarchs in the March 31 *BMC Biology*.

At least 40 genes are involved in keeping the monarchs Mexico-bound once they head out, Reppert and his colleagues report. The team analyzed more than 9,000 of the monarch butterfly's genes, about half of the genes in its genome.

Each fall, hundreds of millions of monarchs in the eastern United States and Canada begin flying south for the winter and forego reproduction. The butterflies navigate with internal clocks and use the sun as a compass to find their way to oyamel fir forests in central Mexico. No one knows what environmental signals flip the switch that causes butterflies to start migrating.



Some of these 40 genes may be involved in the flip, but the new study didn't address that question.

Reppert and his colleagues collected monarch butterflies in the summer and fall. As expected, stationary summer butterflies have high levels of a reproductive chemical called juvenile hormone, while migratory fall butterflies are deficient in the hormone. Summer butterflies stay near the place they hatch and reproduce, and they don't orient themselves according to the sun. The researchers gave some of the fall butterflies a chemical that mimics juvenile hormone and then placed them in a flight simulator to see whether the hormone could block navigation. But the fall butterflies still had accurate compasses, indicating that reproduction and navigation are controlled by separate systems.

Next, the scientists analyzed gene activity in summer and fall butterflies and found 40 genes showing differences. Of those, 14 were more active in fall butterflies and 26 were more active in summer butterflies. Only two of the genes had any obvious, known connection to migration—*vrille*, which is part of the butterfly's circadian clock, and the gene for tyramine beta hydroxylase, which is involved in motor behavior. The other genes are involved in metabolic processes, brain development and other processes, and the functions of 15 genes are unknown. "Nothing stood out and said, 'I'm a migration gene,'" Reppert says.

Orley "Chip" Taylor, an insect ecologist at the University of Kansas in Lawrence and director of Monarch Watch, says it is disappointing that none of the genes Reppert and his colleagues found is definitively linked to navigation. But he says, "I think they're doing exactly what needs to be done to unravel all of this."

Louse-y genome surprise

Although generally despised, the blood-sucking human body louse, *Pediculus humanus*, has gained newfound popularity among scientists for a surprising genetic feature. Instead of carrying mitochondrial DNA in a single chromosome loop, the vermin (shown) splits this DNA among many chromosomes, making the louse an anomaly in the animal world, scientists report online March 31 in *Genome Research*. Animal cells stash DNA in the nucleus, where the bulk of genetic material is packed, and in the mitochondria, specialized energy factories in the cell. The mitochondrial DNA of more than 1,200 animals has been sequenced, says study coauthor Renfu Shao of the University of Queensland in Brisbane, Australia. "With very few exceptions, all these animals have a single circular mitochondrial chromosome," Shao says. In contrast, the mitochondrial genes of the blood-sucking louse are split among 18 circular minichromosomes, the new research shows. Study coauthor Ewen Kirkness of the J. Craig Venter Institute in Rockville, Md., speculates that the multiple chromosomes may bump up genetic variation. "We see bits of genes being swapped between different circles," Kirkness says. This gene mingling may have allowed lice to quickly adapt when something new showed up on the menu: human blood. —*Laura Sanders*

FROM TOP: DAVID R. WEAVER; RICHARD WEBB, CATHERINE COVACIN

Life

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Hatchlings may add, subtract

Results point to built-in numerical understanding

By Susan Milius

Forget counting your chickens. They may do it themselves. Chicks only 3 or 4 days old manage an animal version of adding and subtracting, says Rosa Rugani of the University of Trento Center for Mind/Brain Sciences in Rovereto, Italy.

Inspired by experiments with human babies, Rugani and her colleagues worked out tests based on adding objects to and taking them away from little piles hidden behind screens. With no special math coaching, the chicks did a decent job of keeping track of object shifts representing such problems as 4 - 2 = 2 and 1 + 2 = 3, she and her colleagues report online April 1 in *Proceedings of the Royal Society B*.

"This is the first demonstration of adding and subtracting in young animals" other than humans, Rugani says. Other animals, including some primates and dogs, have demonstrated numerical powers as adults.

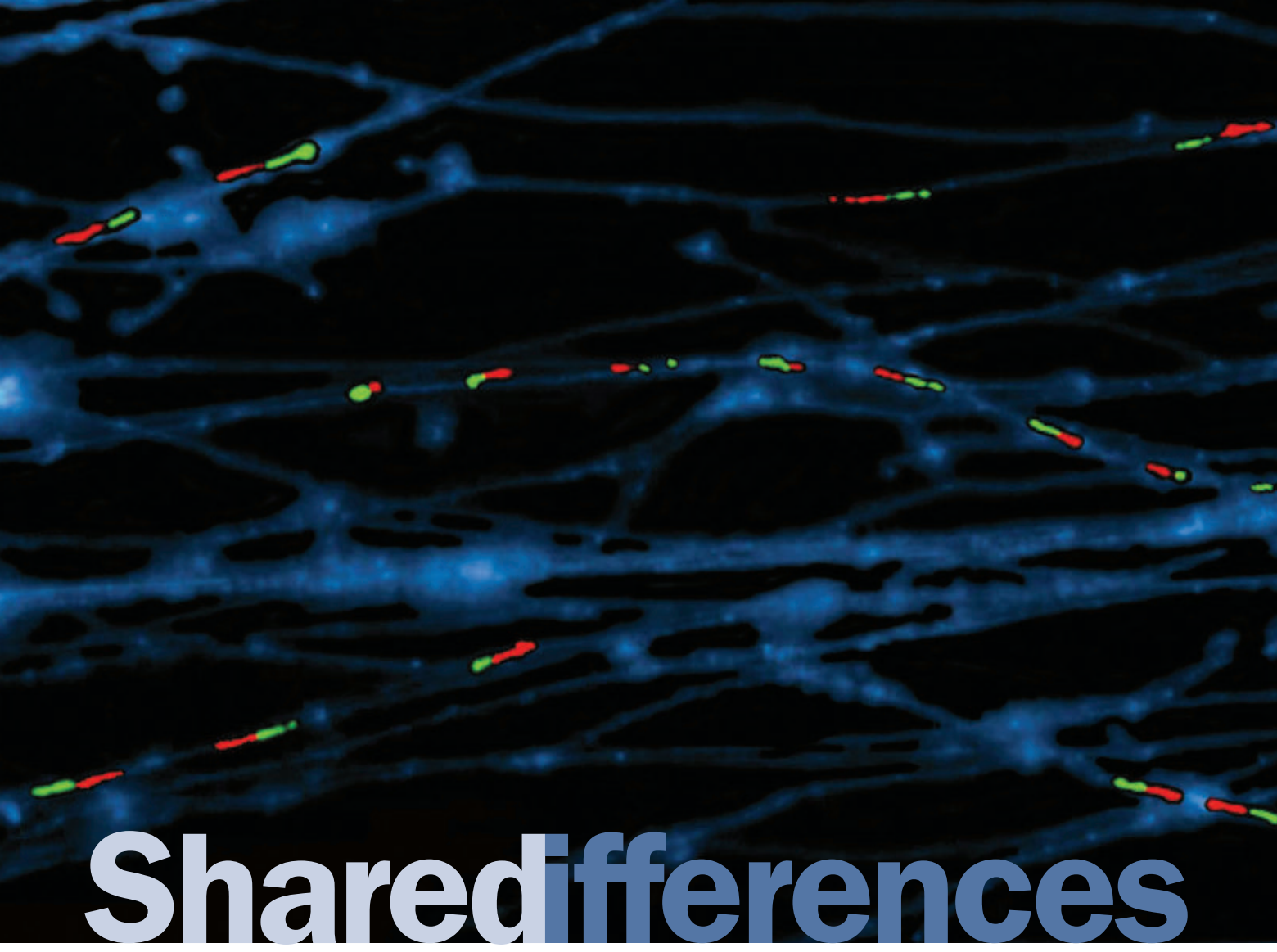
Karen Wynn of Yale University, who has reported evidence of basic numerical skills in human babies, says that the chicks haven't had a chance to learn or develop much. "This work, then, is a compelling existence proof that numerical understanding comprises a built-in system of unlearned knowledge," Wynn says.

Chicks tend to cluster, even with experimental "chicks" that are actually familiar little plastic balls. In one test, each chick watched as a researcher first hid balls behind each of two screens. Then the tester let the chick see some of the balls being moved from one screen to the other. To go to the screen with the larger number, the chick had to keep track of addition and subtraction.

R. RUGANI *ET AL.*

A chick stands amid objects and screens used as tools in a test revealing that chicks have a sense for arithmetic.

About 75 percent of the time, chicks did it right, scuttling to the screen that ended up with the most balls.



Shared differences

The architecture of our genomes is anything but basic

By Tina Hesman Saey

Whether you like it or not, you're a little different. If it makes you feel any better, so is everybody else. In fact, everybody is far more different than anybody had imagined.

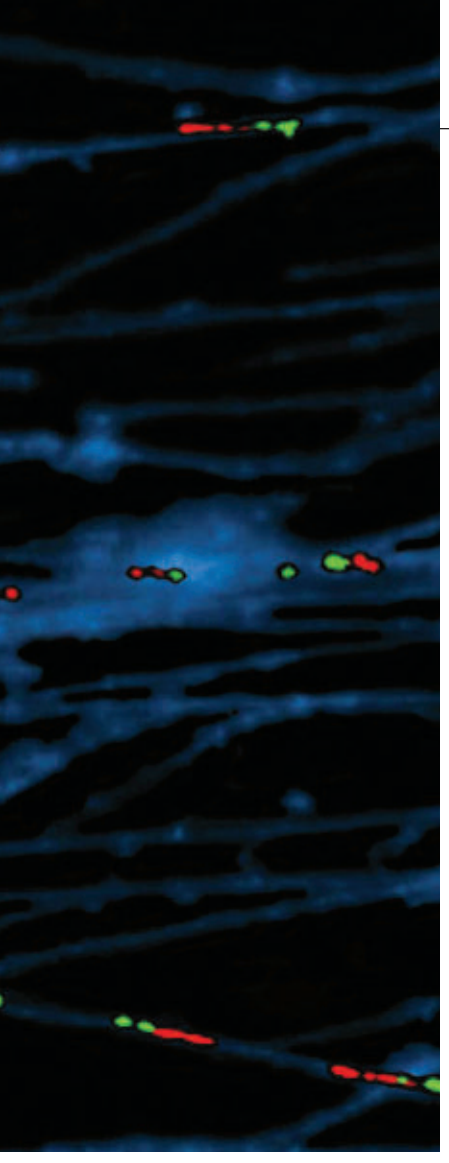
Scientists are only beginning to discover just how different humans are from each other at the genetic level and what those personal genetic attributes mean for health, history and the human evolutionary future.

It's true that people are 99.9 percent alike, if only minor spelling variations in the genetic instruction book are taken into account. In each person, about one in every 1,000 DNA bases — the chemical letters of the genetic alphabet — differs from the generic human construction and operating manual. So, on average, one person will differ from another at about 3 million of the 3 billion letters in the human genome. Researchers have recently mapped many of these single letter variations, called single nucleotide polymorphisms or SNPs, looking for variants that might play a role in complex diseases such as heart disease, diabetes and high blood pressure (*SN: 6/21/08, p. 20*).

So far, SNPs have been associated with many diseases, but SNPs can also be protective. And those little spelling differences may contain information about a person's geographic ancestry — just as whether people write *color* or *colour* is a clue about whether they hail from the United States or Great Britain.

But SNPs aren't the whole story of human-to-human distinctions. Scientists now know that a different type of variation, previously thought to be rare, is surprisingly widespread.

New research shows that the human genome has undergone extensive editing, much more sweeping than the minor letter differences or spelling variations. Entire pages may be torn from, or even stuffed into, an individual's genome. Paragraphs can be duplicated multiple times, swapped with other passages, written backward, deleted, truncated or otherwise altered in myriad ways. These differences are known collectively as structural variation, and as little as 5 percent or as much as 18 percent of the human genome may be affected.



Glowing strands of DNA from five people highlight differences among humans in the number of copies of amylase genes, which encode enzymes that break down sugars. Red and green probes bind to regions hosting the genes, and each DNA strand has a different number of the genes on the short arm of chromosome 1.

Scientists previously knew that having extra copies of an entire chromosome could lead to disorders, such as the third copy of chromosome 21 that causes Down syndrome. Research had also identified very large deletions that remove so much of a chromosome that the void can be seen under a microscope, and had revealed nips and tucks that remove single genes or parts of genes.

But until completing the Human Genome Project, an effort to map all the genes and surrounding DNA found in people, researchers had no way to detect structural changes too small to be seen under the microscope and too big to be detected by looking at individual genes.

Because these variations cover large expanses of the genome rather than single DNA bases, current estimates suggest that structural variation may encompass four times as many bases as SNPs do, meaning that people's genomes differ by an additional 0.5 percent. So any two people are really only about 99.4 percent alike.

New findings indicate that a substantial portion of otherwise healthy people are missing large chunks of their genomes, gaps that can predispose them to certain diseases. Already, structural variants, especially the type known as copy number variants, have been linked to neurological disorders such as schizophrenia and autism, to susceptibility to HIV infection, to Crohn's disease and even to tendencies in weight.

"Our work in structural variation is showing that no one is really normal," says Charles Lee, a cytogeneticist at Brigham and Women's Hospital and Harvard Medical School in Boston. Lee was among the first to discover the broad range of structural variation in the human genome.

Not necessarily two copies

Lee and his colleagues knew from work begun decades ago that some parts of the human genome contain multiple copies of certain genes. For example, light-sensitive opsin proteins, made in the eye and necessary for color vision, are encoded by a cluster of two to nine genes on the X chromosome. Some of the copies encode proteins that are better at sensing green light, while others are specialized for red. The number of copies of the genes affects how well people see colors, and missing certain ones can lead to color blindness.

In another example, each person has many copies of the immune system HLA genes. And blood disorders known as thalassemias arise when copies of genes that encode subunits of hemoglobin, blood's oxygen-carrying molecule, are missing.

Those examples were thought to be exceptions to the rule that each gene is inherited as two copies, one from the mother and the other from the father. No one suspected that parents routinely pass along three, four or more copies of entire parts of the genome, or sometimes fail to pass along a whole section.

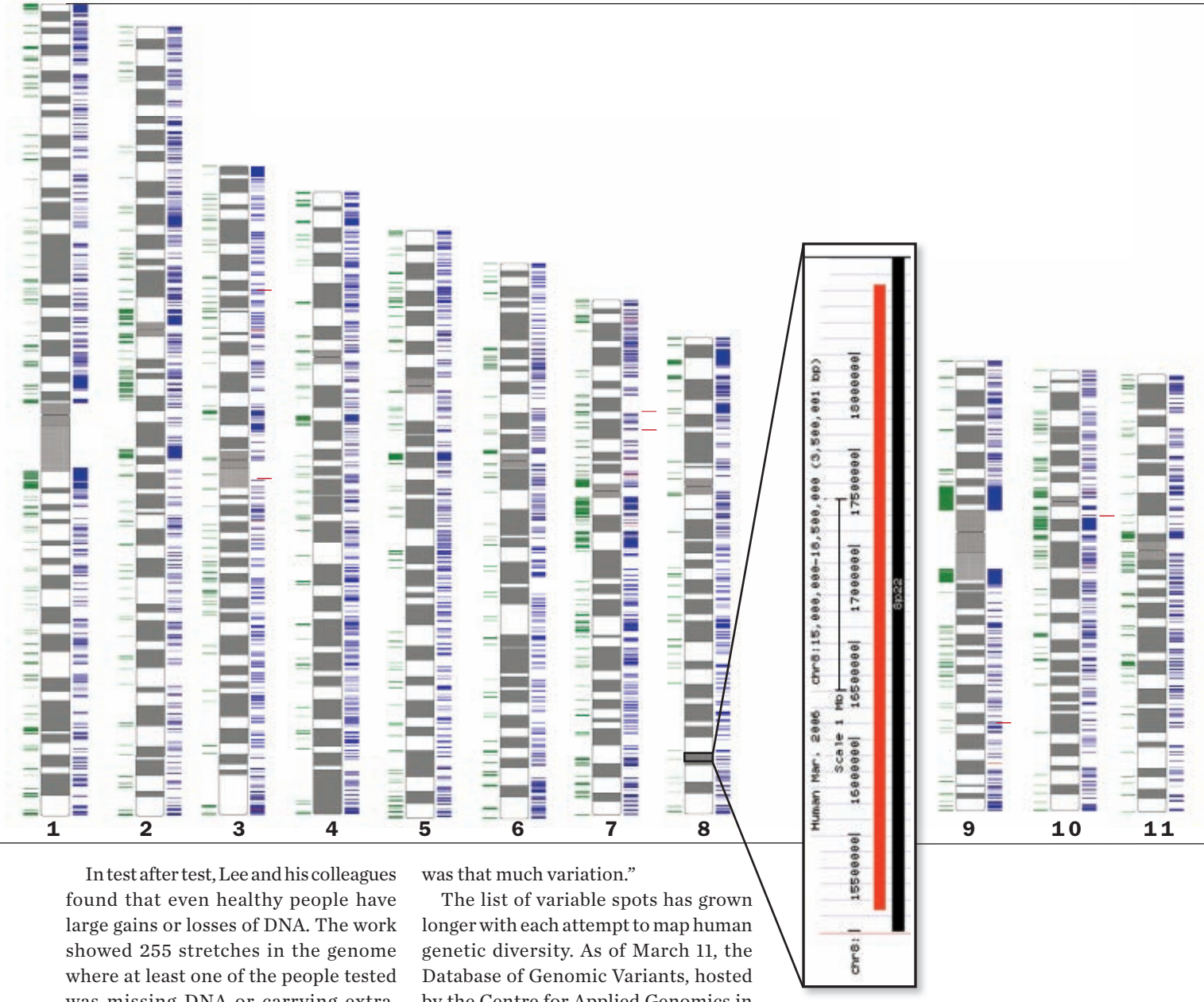
Because structural variation alters entire sections of a chromosome, the genes within those sections can be copied multiple times, inverted or deleted. As a result, the number of copies of the genes in an altered stretch can vary in many ways.

Even the Human Genome Project was affected by the assumption that most of the genome contains only a single copy of each parent's DNA, Lee contends. What the project compiled is an averaged human genome, a sequence homogenized from multiple people that represents no real person. About 66 percent is from an anonymous man of European descent. The rest is a mishmash of DNA sequences from several other people.

Left out in favor of a global template is the diversity among single letters and overall structure originally present in each of the DNA donors. Multiple copies of genes look alike or have minor differences that could be easily attributed to glitches in the decoding process. So piecing together the whole genome sequence from snippets of data ended up collapsing what should have been several gene copies into a single gene, Lee says.

He discovered structural deviation from this generic sequence while testing a method for detecting abnormalities in the genomes of tumor cells. Cancer cells are notorious for deleting, rearranging and duplicating parts of the genome. Lee wanted to map those changes by comparing the cancer genomes with the Human Genome Project consensus sequence. But first he needed to be sure that DNA samples from healthy people matched the consensus sequence.

FROM *THE AMERICAN JOURNAL OF HUMAN GENETICS*, JANUARY 2008



Uniquely schizophrenic
Large deletions from chromosome 8 could be linked to schizophrenia. In one patient, a portion of the chromosome was almost entirely missing: The black band shows the normal width of this region and the red band shows how much was missing from this person's chromosome.

In test after test, Lee and his colleagues found that even healthy people have large gains or losses of DNA. The work showed 255 stretches in the genome where at least one of the people tested was missing DNA or carrying extra, Lee's team reported in *Nature Genetics* in 2004. The same year another group independently found 221 places in the genome where copy number varies. Led by Michael Wigler of Cold Spring Harbor Laboratory in New York, the group reported in *Science* that, on average, any two people differ at 11 of those places.

The human genome had revealed an unexpectedly large variability.

"It was a major revelation," says Andrew Shelling, a geneticist at the University of Auckland in New Zealand. "Certainly when it was brought to our attention, we were staggered that there was that much variation."

The list of variable spots has grown longer with each attempt to map human genetic diversity. As of March 11, the Database of Genomic Variants, hosted by the Centre for Applied Genomics in Toronto, listed 6,558 locations in the human genome where variations may occur. Some locations have multiple variations — copy number can vary in many different ways within one person's genome or from one person to another.

The database lists 31 separate studies that document 21,178 copy number variants of DNA segments 1,000 bases or longer; 499 inversions (places where a stretch of DNA is spelled backward); and 16,729 insertions or deletions ranging in size from 100 bases to 1,000 bases. Many smaller variations may exist that current methods can't easily detect.

One recent effort to map structural variability and single letter changes in 2,500 people suggests that 65 to 80 percent of the population has copy number variants that run at least 100,000 bases long. About 5 to 10 percent of people carry copy number variants longer than 500,000 bases. Research-

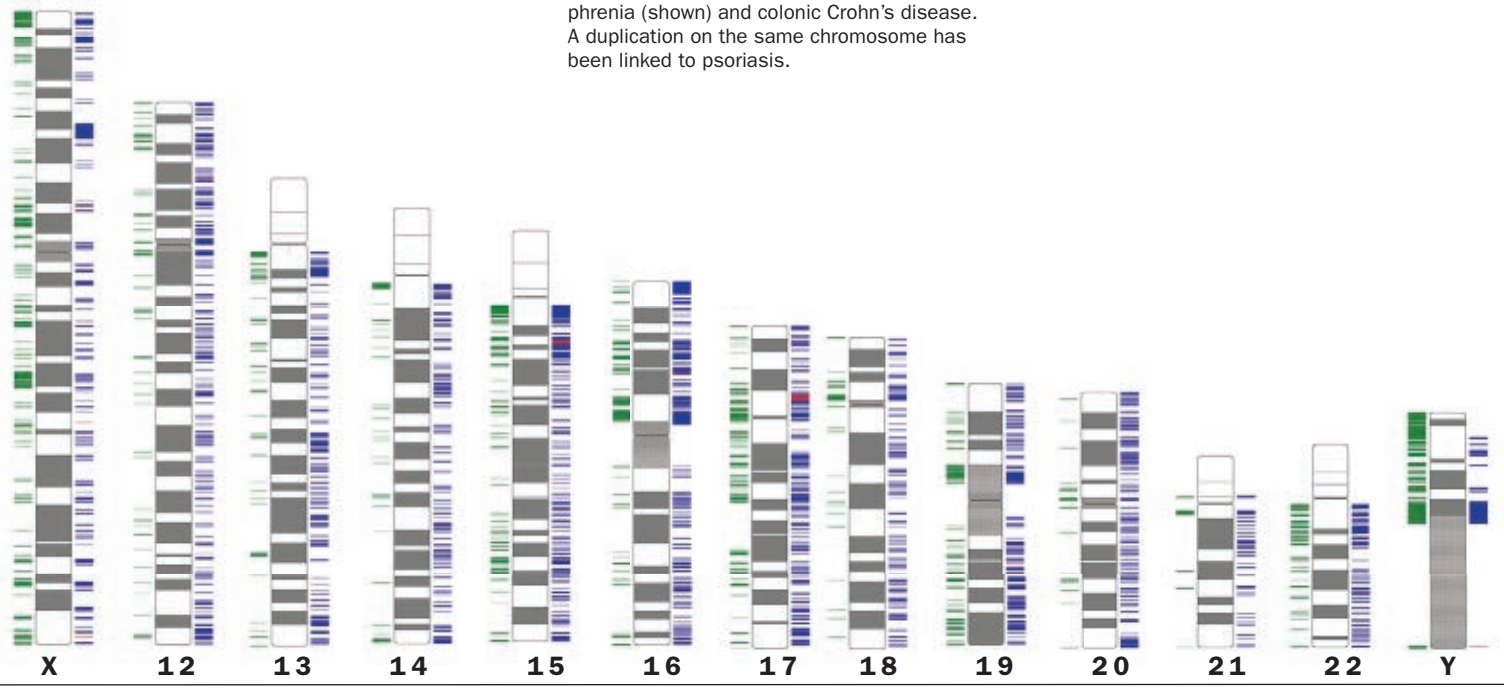
Variation in our chromosomes

A view of all the human chromosomes according to the Database of Genomic Variants reveals that people do not necessarily inherit two copies of every gene. Instead, entire sections of a chromosome (shown in blue) spanning thousands to millions of DNA bases can be duplicated, deleted or inverted, causing the number of copies of genes in those stretches to vary.

New work shows that this widespread variation within the human genome is more common than thought and is a legacy of human evolutionary history. Studies are also beginning to connect copy number variants with specific diseases. A few examples: Variation in copy number of immunity-related genes on chromosome 17 have been linked to susceptibility to HIV/AIDS. Deletions in chromosome 8 have been linked to schizophrenia (shown) and colonic Crohn's disease. A duplication on the same chromosome has been linked to psoriasis.

Key

- Reported copy number variants (Stretches where the chromosome is duplicated, deleted or inverted.)
- Duplicated segments of chromosome
- Reported end points between stretches of inverted sequences



DATABASE OF GENOMIC VARIANTS; INSET: DAVID B. GOLDSTEIN/ DUKE UNIV., MODIFIED FROM *PLOS GENETICS*, FEBRUARY 2009

ers led by Evan Eichler, a Howard Hughes Medical Institute investigator at the University of Washington in Seattle, reported in the Feb. 13 *American Journal of Human Genetics* that 1 to 2 percent of people have copy number variants, or CNVs, that are more than 1 million bases long.

"There's a real CNV burden in the population," Eichler says.

Culprits in disease

Some of these variations — and perhaps simply the volume of changes — in the genome may predispose people to diseases, other studies suggest.

A report published February 6 in the online journal *PLoS Genetics* showed that patients with schizophrenia have some of the largest variants: chromosome deletions that remove 2 million or more bases. Such megadeletions occurred only in eight of the 1,073 schizophrenia patients screened, but in none of the 2,492 healthy people in the comparison group.

Some big duplications were also found in people with schizophrenia, but healthy people had large duplications too. So researchers think that losses of large chunks of DNA, not additions, are more likely linked to schizophrenia.

The international team that conducted the study did not find evidence linking any of the common SNP variants previously implicated in schizophrenia to the disease. The results could mean that rare, harmful differences are more important in schizophrenia than are more common variations. This idea represents a change in thinking about the genetics of relatively common diseases.

Researchers have thought that common genetic variations might contribute to common diseases, such as heart disease and diabetes, when triggered by environmental factors such as poor diet, smoking and lack of exercise. This study's result indicates that, at least for schizophrenia, rare variants that remove different parts of the genome in different people might result in the same disease.

Other researchers have demonstrated that copy number variants, especially deletions, are important in autism. Last June, researchers from the University of Chicago and colleagues, writing in *Biological Psychiatry,* reported finding 51 copy number variants — including duplications as well as deletions — in 46 of the 397 people with autism in the study. Forty-one people had one variant and five people had two variants. These

variations weren't found in a healthy control group. The authors say many different variants might lead to autism, including variants that affect genes important for brain development and function, as well as variants that affect multiple other genes.

At least 14 diseases have been associated with copy number variants in the past few years, Lee says. "We're going to find a lot more out there," he predicts.

But variety is not all bad. "The vast majority of those differences will have no impact at all on the person," Shelling says. And some may even be good.

A human variety

Indeed, some variations may be tied to qualities that distinguish humans from other primates. Certainly, structural variation is part of what makes each person different from another. Varying copies of certain regions of the genome may be evolution's answer to making sure humans don't grow genetically stagnant.

"Perhaps it is a deliberate mechanism to ensure that our genome is always changing," Shelling says. "It was a bit of a shock that we could have a mechanism that would change the numbers and mess with our genomes that way."

Although humans vary at millions of bases, says Sarah Tishkoff, a geneticist at the University of Maryland in College Park, people are overall very alike.

"We still think that as a species we're still really quite similar," she says. "Any two of us are more similar than any two chimps."

Copy number variations also occur in humans' ape cousins and may be a legacy from an ancient ancestor. About 8 million to 12 million years ago, a common ancestor of humans and African great apes experienced an explosion of duplications in its genome, Eichler's group reported in the Feb. 11 *Nature* (*SN: 3/14/09, p. 14*). The large increase in the gene duplication rate continued into the common ancestor of humans and chimpanzees. Later the rate slowed again.

Those duplications may have established a genome architecture that predisposes humans to changes in copy number even today, Eichler suggests.

In the Feb. 13 *American Journal of Human Genetics*, Eichler's group describes hot spots for copy number variation, sites located in or next to duplicated regions of the genome. The locations hint that such variations arise when chromosomes line up to swap genetic information during recombination. Recombination occurs when chromosomes are paired before separation during the production of egg or sperm cells. But sometimes existing gene duplications can cause the chromosomes to misalign, and that misalignment leads to further duplications or deletions. Last year in *Nature*, Eichler and his colleagues reported comparisons of individual human genomes suggesting that misalignment and unequal swapping during recombination create nearly half of copy number variants.

> "It was a bit of a shock that we could have a mechanism that would ... mess with our genomes that way."
>
> ANDREW SHELLING
> UNIVERSITY OF AUCKLAND

Damage to DNA may lead to structural changes too. Toxins and other stressors sometimes break chromosomes. The process that repairs broken chromosomes may add or subtract DNA or mistakenly relocate a bit of one chromosome on to another.

Still other copy number variants may arise when DNA replication is stalled. And mobile bits of DNA — commonly called jumping genes — do their share of shaping the genome, too.

Most methods of detecting structural variation have not identified the precise location of the end points of the variants, information that is needed to determine the mechanism that created the variant, says Steven McCarroll, a geneticist at the Broad Institute in Cambridge, Mass., and the Harvard Medical School in Boston.

Scientists do know that most of the copy number variants in the general population are old. In a study published last October in *Nature Genetics*, McCarroll and his colleagues found that over 90 percent of the copy number differences among people in the study are due to the usual suspects, variants that are quite common. Only 8 percent of the variants identified in the study were rare, found in a single family or individual. And only 10 rare variants of the 1,320 analyzed were found in a child but not the parents, indicating a new change.

New mutations are more common in sporadic cases of disease than in cases where the patient has a family history of the disease, McCarroll says. But researchers still don't know whether rare or common variants are more likely to be associated with disease.

About 1 to 2 percent of autism and schizophrenia cases have been associated with rare structural variants, but no common variations have been found to explain inheritance of those disorders, McCarroll says.

In contrast, some cases of Crohn's disease — an inflammatory bowel disorder — have been linked to a common variant that deletes defensins, genes involved in protecting against invading bacteria. And an international consortium reported January 4 in *Nature Genetics* that body mass index is linked to a common structural variant: a deletion covering a stretch of DNA more than 45,000 bases long and containing an important gene called *NEGR1*, which is associated with obesity. No rare structural variants have been linked to either Crohn's disease or body mass, McCarroll says.

Despite what specific genetic additions and subtractions may contribute to such diseases, environmental factors may be just as important in determining who gets sick, says Shelling.

"You are not predestined by your genes," Shelling says. "If you've got a gene that protects you from having cancer, it doesn't mean you should smoke. If you've got a gene that makes you slim, you still shouldn't eat a McDonald's every night." ■

Explore more

- Charles Lee lab: www.chromosome.bwh.harvard.edu

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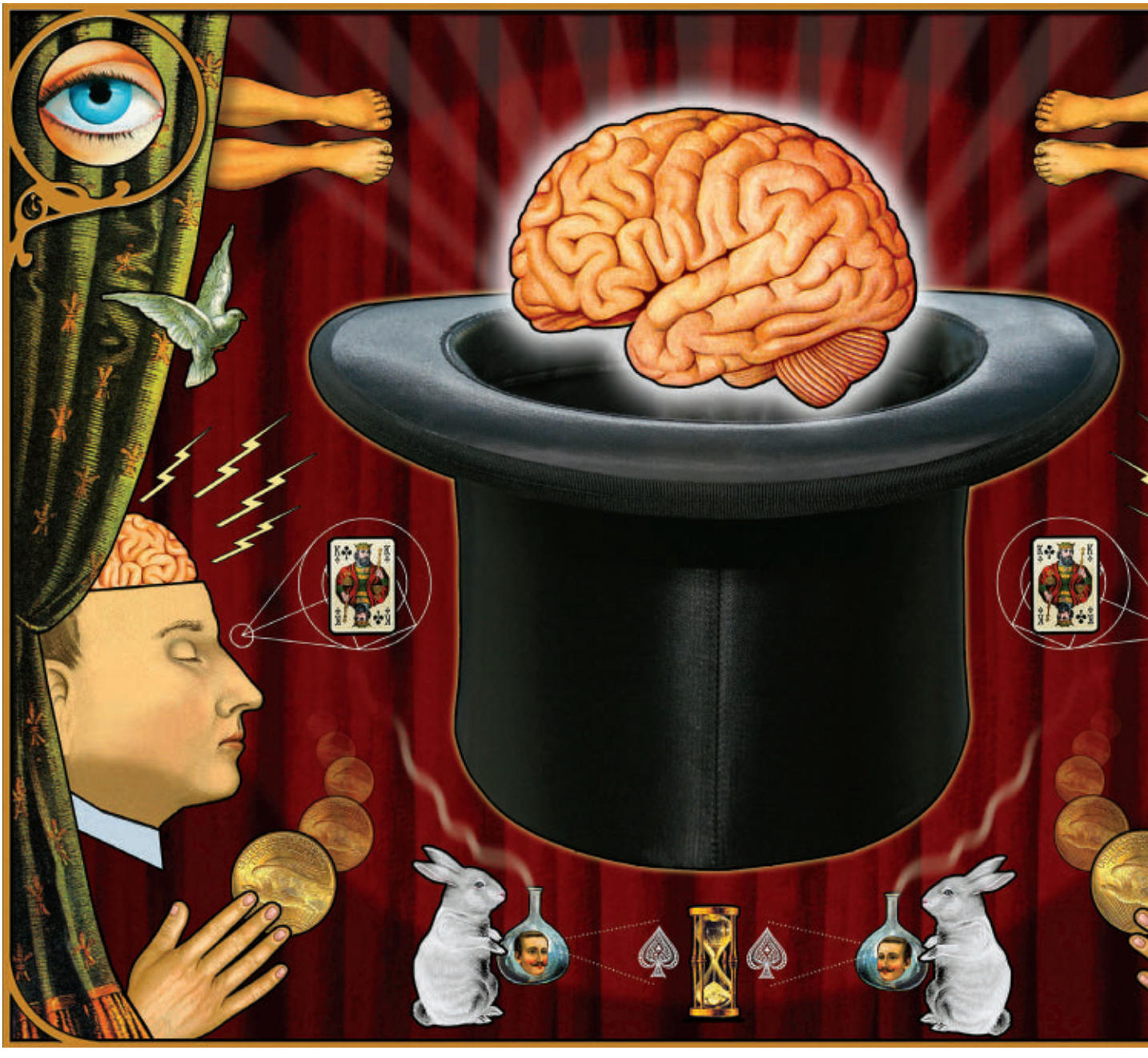
It's not magic, it's neuroscience

By Laura Sanders • Illustration by Lou Beach



elio!

As the curtain lifts at Harrah's in Las Vegas, magician Mac King walks out on stage in a tacky plaid suit and belts out a goofy "Howdy! I'm Mac King!" He then starts bending minds with more finesse and precision than a Jedi knight.

King convinces spectators that he can hook a fish out of thin air, eat it and then spit it back out — intact — into a wine glass. Such skill in manipulating people's perceptions has earned magicians a new group of spellbound fans: Scientists seeking to learn how the eyes and brain perceive — or don't perceive — reality.

Magicians' intuitions about human cognition have been passed down, along with their methods for entertaining, for thousands of years.

"We as scientists have a lot to learn from the art world," says Susana Martinez-Conde, of the Barrow Neurological Institute in Phoenix, who studies the neuroscience of visual systems. "If we had been paying attention to magic early on, cognitive neuroscience may have come around much faster."

In an article published in November 2008 in *Nature Reviews Neuroscience*, Martinez-Conde and other neuroscientists teamed up with famous magicians to argue that magic can be a powerful tool for probing how the human mind sees the world. Using cutting-edge methods to study how the brain and visual systems control perception, scientists are starting to figure out what magicians have known for ages — how your brain can play tricks on you.

"The interest for magic has been there for a long time," says Gustav Kuhn, a neuroscientist at Durham University in England and former performing magician. "What is new is that we have all these techniques to get a better idea of the inner workings of these principles."

These new techniques promise to give scientists front-row seats to magic's action in the brain and may yield insight into the very basis of consciousness itself.

"We do this because we want to know how the human brain works," says Stephen Macknik, a colleague of Martinez-Conde at the institute. "That's a fundamental question."

A recent brain imaging study by Kuhn and his colleagues, for example, revealed which regions of the brain are active when people watch a magician do something impossible, such as make a coin disappear. Another group's work in monkeys suggests that two separate kinds of brain cells are critical to visual attention. One group of cells enhances focus on what a person is paying attention to, and the other actively represses interest in everything else. A magician's real trick, then, may lie in coaxing the suppressing brain cells so that a spectator ignores the performer's actions precisely when and where required.

Other research asks whether individuals have different abilities to spot the critical moment in a magic trick, or if magicians are taking advantage of something intrinsic in every human brain.

Using magic to understand attention and consciousness could have applications in education — imagine a teacher directing students' attention in the same powerful way a magician does. And figuring out the workings of the brain might have medical uses, such as helping people who have attention impairments.

"We want to take these principles to the clinic," Martinez-Conde says. People with autism, attention-deficit/hyperactivity disorder and traumatic brain injuries have trouble focusing on just one thing. Figuring out how magicians mold the mind may ultimately lead to powerful new therapies that could shape and reshape the brain.

Imaging the impossible

In a lighthearted, (un)scientific report that appeared in the *British Medical Journal* in 2007, researchers from the University of Oxford proposed that magical abilities may be heritable. Evidence, the researchers argued, comes from the complex patterns of gene inheritance seen among young wizards and witches at Hogwarts School of Witchcraft and Wizardry (comprehensively recorded by author J.K. Rowling in her fictional series, which is also the source of this article's title).

Harry Potter may have inherited magical genes, but real-life magicians are not so lucky. Instead, they must rely on quick fingers and misdirection to sneak past spectators' perceptive brains. Kuhn and his colleagues are tracking down exactly what happens in the incredulous brain as it witnesses an impossible act, what the researchers call the "neurobiology of disbelief."

In particular, Kuhn is studying how people understand cause and effect relationships. Everyone knows that coins disappear because someone moves them, not because a magician waves his hand over them — and certainly not because Harry Potter mutters a spell.

"What magic is doing is producing disbelief and a sense of wonder," Kuhn says, "and that's what we are studying."

Kuhn and his collaborators performed brain scans while subjects watched videos of real magicians performing tricks that Harry Potter could do in his sleep, including coins that disappear (*evanesco!*), cigarettes that are torn and miraculously put back together (*reparo!*) and levitating napkins (*wingardium leviosa!*). Volunteers in a control group watched videos in which no magic happened (the cigarette remained torn), or in which something surprising, but not magical, took place (the magician used the cigarette to comb his hair). Including the surprise condition allows researchers to separate the effects of witnessing a magic trick from those of the unexpected. Although magic is often unexpected, the reverse isn't always true, Kuhn says. A car crashing into your living room may be surprising, but not magical.

In terms of brain activity patterns, watching a magic trick was clearly different from watching a surprising event. Researchers saw a "striking" level of activity solely in the left hemisphere only when participants watched a magic trick, Kuhn says. Such a clear hemisphere separation is unusual, he adds, and may represent the brain's attempt to reconcile the conflict between what is witnessed and what is thought possible. The two brain regions activated in the left hemisphere — the dorsolateral prefrontal cortex and the anterior cingulate cortex — are thought to be important for both detecting and resolving these types of conflicts.

Such studies provide a glimpse of the tasks in the brain that ultimately shape a person's view of the world. "If we are to truly understand [cognition]," says Martinez-Conde, "we must understand the neural circuitry."

Masters of suppression

New studies on individual nerve cells in the brains of monkeys reveal something that seasoned magicians know well. When it comes to attention, what goes unnoticed is as important as what is noticed. But exactly how the brain attends to one thing and ignores another has been mysterious.

Jose-Manuel Alonso of the SUNY State College of Optometry in New York City thinks that the answer may lie in brain cells that actively suppress information deemed irrelevant by the brain. These cells are just as important, if not more so, than cells that enhance attention on a particular thing, says Alonso. "And that is a very new idea.... When you focus your attention very hard at a certain point to detect something, two things happen: Your attention to that thing increases, and your attention to everything else decreases."

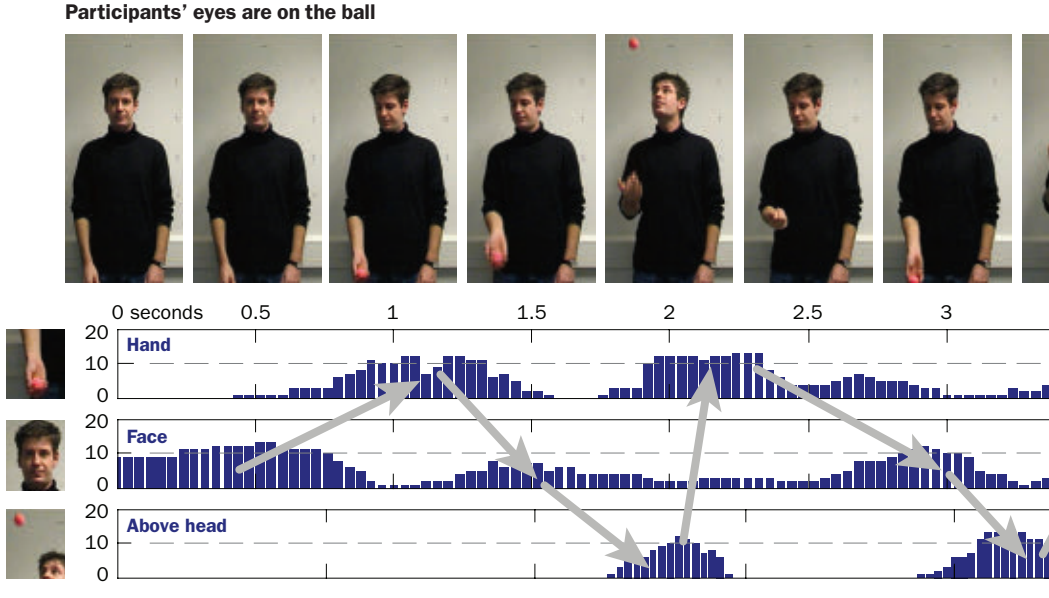
Alonso and his colleagues recently identified a select group of brain cells in monkeys that cause the brain to "freeze the world" by blocking out all irrelevant signals and allowing the brain to focus on one paramount task. Counter to what others had predicted, the team found that the brain cells that enhance attention are distinct from those that suppress attention. Published in the August 2008 *Nature Neuroscience*, the study showed that these brain cells can't switch jobs depending on where the focus is — a finding Alonso calls "a total surprise."

The work also shows that as a task gets more difficult, both the enhancement of essential information and suppression of nonessential information intensify. As a monkey tried to detect quicker, more subtle changes in the color of an object, both types of cells grew more active.

To make tricks work, magicians may be exploiting this property of the brain, Alonso says. Magicians can "attract your attention with something very powerful, and create a huge suppression in regions to make you blind." In the magic world, "the more interest [magicians] manage to draw, the stronger the suppression that they will get," he says. It's the perfect cover for a trick.

Fooling the brain

Magician and neuroscientist Gustav Kuhn performs the vanishing ball trick in these video stills. On the third "throw" (beginning at 4 seconds), Kuhn secretly palms the ball. In his study, 68 percent of spectators (who wore equipment to track their eye movements) reported watching the ball the entire time and seeing it vanish at its zenith. But a different story emerges from eye-tracking data showing where study participants actually looked. During the first two throws, most participants looked at Kuhn's face, then his hand, then above his head — tracking the ball's path (bars indicate the number of participants who looked at each spot). But during the fake throw, most never looked above Kuhn's head, where the ball supposedly vanished. Instead, they gazed at Kuhn's face or his hand. The eyes knew the ball didn't leave the hand, even though the brain thought otherwise.



G. KUHN, M.F. LAND/*CURRENT BIOLOGY* 2006

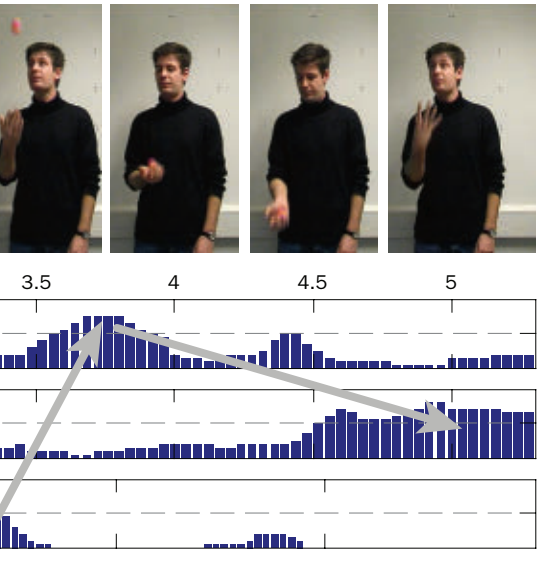
Looking but not seeing

Magicians often rely on misdirection — getting the audience to look to the wrong place while the performer pockets the dove or switches a live fish for a fake. By carefully controlling the audience's gaze and using gestures to draw focus away from the trick, a magician can force spectators to look away, too.

Macknik explains a classic trick called the French Drop to illustrate this point. A magician holds a coin in the left hand and pretends to pass the coin to the right hand, which remains empty. "What's critical is that the magician looks at the empty hand. He pays riveted attention to the hand that is empty," Macknik says. The audience takes its cue from the magician and focuses attention on the right hand, believing it to hold the coin.

Controlling where spectators move their eyes takes skill. Perhaps more impressive, though, is controlling spectators' minds. Several experiments have now shown that people can stare directly at something and not see it.

For a study published in *Current Biology* in 2006, Kuhn and his colleagues tracked where people gazed as they watched a magician throw a ball into the air several times. On the last throw, the magician only pretended to toss the ball. Still, spectators claimed to have seen the ball launch and then miraculously disappear in midair. But here's the trick: In most cases, subjects kept their eyes on the magician's face or on the ball, which never left his hand. Only when the ball was actually at the top part of the screen did participants look there. Yet the brain perceived the ball in the air, overriding the actual visual information: The brains, not the eyes, were fooled.



Understanding how magicians carry off tricks by manipulating perception begs the question of whether their success depends on some people being less perceptive. (And, alternatively, of whether there really are tough crowds.) Researchers trying to answer that question get only one shot: Once the ball in the magician's hand is pointed out, it's impossible to miss. "The tough part with studying inattentional blindness, and with magic, is that you can only do it once," says Daniel Simons of the University of Illinois at Urbana-Champaign.

Simons and his colleagues found a way around this problem by first measuring how perceptive people are. Then the team asked whether more perceptive people succumb less easily to inattentional blindness, which is when a person doesn't perceive something because the mind, not the eyes, wanders. In a paper in the April *Psychonomic Bulletin & Review*, the researchers report that people who are very good at paying attention had no advantage in performing a visual task that required noticing something unexpected. Task difficulty was what mattered. Few participants could spot a more subtle change, while most could spot an easy one. The results suggest that magicians may be tapping in to some universal property of the human brain.

"We're good at focusing attention," says Simons. "It's what the visual system was built to do." Inattentional blindness, he says, is a by-product, a necessary consequence, of our visual system allowing us to focus intently on a scene.

Magical experiments

Magicians have perfected their tricks over the millennia. So the techniques magicians use on stage, says Macknik, are "exceptionally robust," which, in neuroscientists' lingo is very high praise for a strong effect. "Cognitive neuroscience's experiments are really crappy compared to magicians'," he says. In his experience, subjects often guess what the experiment is about, which ruins the experiment.

There's another reason the tricks up magicians' sleeves may prove more powerful than anything dreamed up in a lab. Many classic visual attention experiments completely ignore social context, something known to affect attention and perception and long exploited by magicians.

Martinez-Conde and Macknik plan to study the effects of one aspect of social context — laughter — on attention. Magicians like Mac King have the audience in stitches throughout a performance. Martinez-Conde says one of her collaborators, magician John Thompson, told her that when the audience is laughing, time stops, giving the magician a golden opportunity to act unnoticed.

Understanding how emotional states can affect perception and attention may lead to more effective ways to treat people who have attention problems.

"Scientifically, that can tell us a lot about the interaction between emotion and attention, of both the normally functioning brain and what happens in a diseased state," says Martinez-Conde.

Channeling attention within different settings — such as a hospital rehabilitation unit or a classroom of unruly fifth graders — is one lofty aim of this new marriage between magicians and neuroscientists. "Here we can take methods from magicians," Macknik says, and find new ways to treat people who have brain trauma, Alzheimer's disease and attention-deficit/hyperactivity disorder. "We don't know how it's going to work because no one's ever done it before."

He expects that the study of consciousness and the mind will benefit enormously from teaming up with magicians. "We're just at the beginning," Macknik says. "It's been very gratifying so far, but it's only going to get better." ■

Explore more

- Visit Gustav Kuhn's website: www.scienceofmagic.org

Strings link the ultracold with the superhot

Perfect liquids suggest theory's math mirrors something real

By Tom Siegfried

Shadows live in a simple world. They glide effortlessly across any sort of surface, oblivious to the higher dimension of space in which 3-D bodies move, collide and sometimes block the paths of rays of light.

Shadows have no idea how important that third dimension is, and how objects in it endow those very shadows with their quasi-physical existence. Indeed, the laws of shadow physics all depend on the third dimension's presence. And just as the clueless inhabitants of the shadow world require an extra dimension to explain how they exist and interact, reality for humans may also depend on an invisible dimension or dimensions unknown.

Physicists, in fact, have long pondered possible higher dimensions beyond the familiar four — three of space and one of time — that describe ordinary experience. Such extra dimensions have emerged as essential features in a sophisticated mathematical pastime known as superstring theory. Believed by some theorists to be the ultimate building blocks of all physical reality, superstrings are supposedly inaccessible to experimental study. If they exist, they would be far too small to detect directly — enlarging a superstring to the size of an amoeba would be the equivalent of making an ant as big as the visible universe. Similarly, the extra dimensions that strings require would probably be far too small to detect by available methods.

So string theory has long remained in the physics version of *The Twilight Zone*, disconnected from the ordinary world of sight and sound. But now the extra-dimensional math has begun to audition for Reality TV. For the first time, superstring theorists can point to a place where their formulas help other physicists understand something they can see in their experiments.

One such experiment generates matter in its most fiery form — simulating the temperatures of the Big Bang itself. Another probes matter most frigid — atoms vastly colder than even the depths of outer space. At both extremes, matter behaves surprisingly like a liquid, contrary to all expectations. More surprising still, explaining this behavior apparently requires an extra dimension of space, something that superstring theory conveniently provides. And so the scientists who study hot matter, cold matter and string matter have found themselves sharing common ground in an extra-dimensional world.

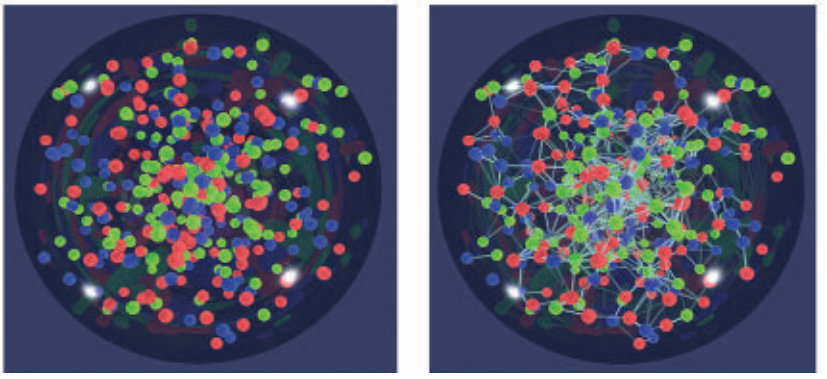
"It surprised the heck out of us two years ago when we started realizing that this was the case," says physicist Peter Steinberg of Brookhaven National Laboratory on Long Island, N.Y. "It's a once-in-a-generation convergence of scientific communities. None of us really saw this coming."

Cosmic soup

Steinberg and other scientists discussed the new developments recently in Chicago at the annual meeting of the American Association for the Advancement of Science. Speakers at a session there described the surprising confluence of different physics fields as a sort of perfect storm, with the eye centered on the esoteric idea of a "perfect liquid."

Liquids are usually the Goldilocks state of matter, the not-too-hot, not-too-cold, cohesive yet shapeless assemblages of molecules that exist only in a relatively narrow range of temperatures. Colder, and matter typically becomes solid — rigid and crystalline. Hotter, and matter turns gaseous, with molecules flying about freely and occasionally colliding. Hotter still, and a gas should become plasma, with electrons torn from atoms to form an electromagnetic mélange of charged particles, a gas with flash.

When the universe was very young, and still superhot from the aftermath of the Big Bang, plasma should have been the only state of matter around. And that's what scientists at Brookhaven expected to see when they smashed gold ions together at 99.99 percent of the speed of light using a machine called RHIC (for Relativistic Heavy Ion Collider). RHIC physicists thought the ion collisions would melt the gold's protons and neutrons into a hot plasma of quarks and gluons at a temperature of a trillion kelvins, replicating



Researchers colliding gold particles at Brookhaven National Laboratory found stronger interactions among quarks and gluons (force lines shown in the simulation at right) than had been expected (left). The matter is now being described as a nearly "perfect liquid."

conditions similar to those a microsecond after the birth of the universe. But instead of a gaslike plasma, the physicists reported in 2005, RHIC served up a hot quark soup, behaving more like a liquid than a plasma or gas.

"It's given us a certain amount of consternation about what to call this stuff," says Barbara Jacak of the RHIC team. "It certainly shows liquidlike properties."

An ordinary plasma's electrically charged particles should block the path of light, for example, just as a thick fog dampens the beams of a car's headlights. But light passes right through RHIC's quark-gluon soup, says Jacak. And free-flying quarks would easily be able to zip through the rarefied molecules of a gas, like a bowling ball scattering any pins in its way. But even the heaviest quarks get stuck in the soup.

"That is really astounding," Jacak says. "It's as if these bowling pins stopped the big giant bowling ball, and the only way they could do that is if they are somehow tied together with strings."

Soon after the RHIC experiments, string theorists realized that *their* strings might be tying the bowling pins together, explaining the odd liquidlike behavior of the quark-gluon plasma. That was a spectacular realization in itself. But around the same time, another branch of physics found itself dipping into a perfect liquid, this time made from cold lithium atoms.

Very cool

In 2002, physicists at Duke University first created what they called a stable, strongly interacting gas of cold atoms, using the isotope lithium-6. Using laser beams to confine and cool the lithium atoms, researchers produced an atomic cloud with a temperature lower than a tenth of a millionth kelvins — barely above absolute zero.

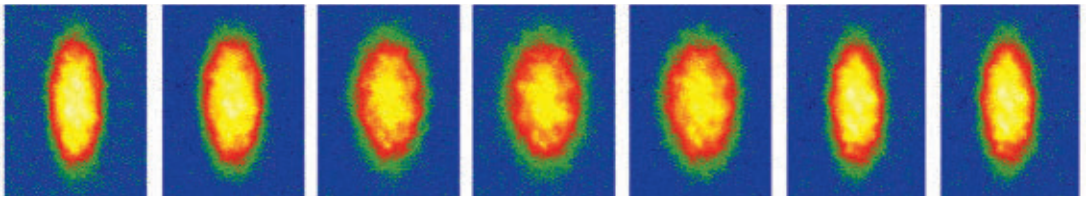
Curiously, when researchers released the cigar-shaped cloud from its laser prison, it expanded at its sides, but not at the tips. Such an odd "elliptical flow" also described the expanding cloud of quarks and gluons produced at RHIC.

"It's quite remarkable that we have such different systems, yet we have this common behavior," says Duke's John E. Thomas, who also spoke at the Chicago meeting.

Such similar flow seemed especially surprising given the wide disparity of the two systems, with a temperature difference of 19 orders of magnitude separating them. In both cases, the flow seemed to signal the features of a liquid — and a liquid with extremely low resistance to flow. Both cases constituted what physicists call a "strongly coupled" system, in which the particles exhibit collective behavior.

Strongly coupled systems are like a baseball stadium with a big crowd, where the fans can perform the wave, rather than a poorly attended game with the crowd so "weakly coupled" that nobody else notices if one fan stands up. In strongly coupled systems, string theory–based calculations

A strongly interacting ultracold gas created by Duke University researchers expands and contracts at its sides but not its tips (as shown by the series of snapshots). The atoms exhibit collective behavior, so the gas behaves like a nearly "perfect liquid."



FROM TOP: BROOKHAVEN NATIONAL LABORATORY; A TURLAPOV *ET AL.*, SPRINGER SBM

suggest, there is a limit to how low the resistance to flow, or viscosity, can go. A liquid with that lowest possible viscosity earns the label "perfect," and both the hot RHIC soup and the cold lithium cloud turn out to be nearly as close to perfect as possible.

This formula for perfection is actually a ratio of viscosity to entropy — a measure of disorder that depends on the system's temperature. For a perfect liquid, the viscosity-entropy ratio is a very small number (about 0.08 in units derived from certain fundamental constants). For ordinary water, the ratio is 380 times higher than that theoretical minimum; liquid helium's ratio is only 0.7, still about nine times higher than perfection. But both RHIC's soup and the lithium atoms approach the theoretical limit even more closely. Cold lithium's ratio is less than 0.5, and the quark-gluon soup is in the neighborhood of 0.2.

Not only does string theory predict the perfect liquid limit for the viscosity-entropy ratio, string math also offers an explanation for how the cold and hot worlds can be so similar. Both systems can be described as something like a shadow world sitting in a higher dimension. Strongly coupled particles are linked by ripples traveling through the extra dimension, says Steinberg, of Brookhaven.

String math describing such ripples stems from an idea called the holographic principle, used by string theorists to describe certain kinds of black holes. A black hole's entropy depends on its surface area — as though all the information in its three-dimensional interior is stored on its two-dimensional surface. (The "holographic" label is an allusion to ordinary holograms, where 3-D images are coated on a 2-D surface, like an emblem on a credit card.) The holographic principle has value because in some cases the math for a complex 3-D system (neglecting time) can be too hard to solve, but the equivalent 4-D math provides simpler equations to describe the same phenomena.

"The point is that we have two different kinds of systems capturing the same kind of physics," says string theorist Clifford Johnson of the University of Southern California in Los Angeles. "String theory provides us with a dictionary that translates between these two systems."

One of the two systems is a realm of four spatial dimensions where the string math describes gravity and quantum theory; the other is the 3-D world of quarks and gluons. Usually the math for describing each of these systems looks very different. But string theory's extra dimension allows the math to be transformed in ways that show the two systems to actually be equivalent — in technical terms, the systems are "dual" to each other.

"The bottom line is we can exploit all this, because we can use ... easy computations in the gravity system to compute hard-to-compute things in the dual system," Johnson said at the Chicago meeting.

> **"The point is that we have two different kinds of systems capturing the same kind of physics.... String theory provides us with a dictionary that translates between these two systems."**
>
> CLIFFORD JOHNSON
> UNIVERSITY OF SOUTHERN CALIFORNIA

So just as shadow physics is hard to explain without knowing about objects in the third dimension, quark physics makes more sense using the 4-D math. Quarks can be viewed, for instance, as the endpoints of strings that vibrate in an extra dimension, and that explains how they can be so strongly coupled. Precisely the same math can then also describe the collective behavior of the cold lithium atoms. As Johnson points out, viscosity is all about how neighboring pieces of a fluid communicate with each other. With an extra dimension, that communication can take place as disturbances in the higher dimensional space, explaining the perfect liquid behavior.

Strings strike back

In recent years it has become popular to criticize string theory as out of touch with reality. Popular books have been written by scientists, some prominent and others not so prominent, arguing that string theory makes no predictions that experiment can test, that its fundamental objects can't be observed, that physicists have wasted their time on an enterprise that isn't even scientific to begin with.

Such arguments leave an impression of utter unfamiliarity with the history of science. In times past, the same kinds of aspersions were cast against quarks, neutrinos, even the very existence of atoms. Superstrings are in good company. And string theory's limit on how low viscosity can go now seems to have established that string math does indeed mirror something real in nature. "This may well be the first prediction from string theory to be validated by experiment," Steinberg writes in a recent paper (arxiv.org/abs/0903.1474).

Superstrings' success with perfect liquids does not, of course, establish that the whole theory is the correct description of the universe. Much work remains to figure out how much of reality string theory actually captures beyond the realm of perfect liquids. But the usefulness of superstring math in these instances argues strongly that those equations capture something true. Establishing that truth for certain will still not be easy.

It's not surprising, of course, that such groundbreaking science should be difficult and controversial. Advances in physics today are naturally much tougher to achieve than they used to be — because the problems remaining to be solved are precisely those that have resisted solution for so long.

"A new truth always has to contend with many difficulties," the German physicist Max Planck said decades ago. "If it were not so, it would have been discovered much sooner."

Explore more

- View slides from the AAAS session "Quest for the Perfect Liquid" at www.bnl.gov/aaas09/perfectliquid.asp

An Orchard Invisible: A Natural History of Seeds

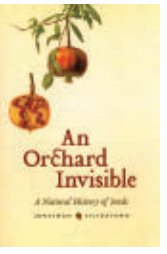
Jonathan Silvertown

A single coco-de-mer, the largest known seed, can weigh 23 kilograms, as much as an airline passenger's checked luggage, writes Jonathan Silvertown, an ecologist at the Open University in Milton Keynes, England.

What drove the coco-de-mer palm to such extreme nuttiness is just one of the evolutionary puzzles Silvertown discusses in *An Orchard Invisible*. The book tours the marvels of plant seeds, standing out among others on the subject by emphasizing how the weird and the wonderful have evolved.

Since the coco-de-mer can't float, extra provisions for sustaining the plant embryo during dispersal by sea didn't drive the gigantism. Instead, an ancient climate shift ignited a fight for height, Silvertown explains. Most other tree trunks grow out as they grow up, ensuring stability. But palms can't thicken their trunks throughout life. To soar as a structurally sound adult, a palm has to thicken as a youth, and bigger well-provisioned seeds offered a fast start in the race for fat trunks.

Silvertown covers not only seeds but also the quirky plant sex that makes them. Anyone inclined to dismiss wind pollination as the boring alternative to bees and flowers needs to read his account of ginkgo tree procreation. It starts with female parts dangling a liquid droplet from a pore and then drawing the drop back, along with pollen snagged from the breeze. The male structures eventually produce sperm with thousands of whipping hairs to power them forward.

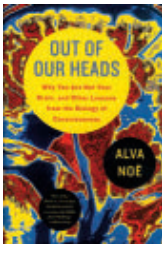


Plants can make seeds without sex, so Silvertown reviews the pros and cons of sexuality. Asexuality has its success stories: Japanese knotweed plants in Britain, continental Europe and the United States are all clones of a single plant. But overall, Silvertown concludes, sex is winning. —*Susan Milius*
Univ. of Chicago, 2009, 224 p., $25.

Out of Our Heads: Why You Are Not Your Brain, and Other Lessons from the Biology of Consciousness

Alva Noë

Alva Noë wants to knock the brain off its scientific pedestal, where it reigns as maestro of mind and king of consciousness. In his new book, the University of California, Berkeley philosopher offers an often thought-provoking explanation of why neuroscientists won't make headway in understanding conscious experience until they drop their brain-centric attitudes.

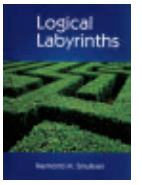


Noë rejects the traditional assumption that consciousness depends on the brain compiling sensory information to create its own internal pictures of the world—pictures bearing a tenuous relationship with what's really out there. Consciousness doesn't happen in the brain, like digestion happens in the gut, Noë argues. The brain is an equal player with the body and the environment. Interactions among all three allow an individual to understand the world and accomplish goals—from making a cup of coffee to designing a business plan for a coffee company.

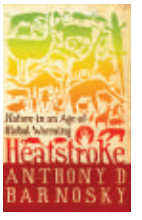
This is not a new idea. Noë notes that fields such as philosophy, artificial intelligence and developmental psychology already take seriously the possibility that consciousness depends on actions taken and goals sought in context.

Marshaling recent findings, Noë outlines why his approach best explains how vision works, how people learn to speak native languages and why individuals experience various illusions of self-perception. His book may not change many neuroscientists' minds, but it will likely get them thinking. —*Bruce Bower*
Hill and Wang, 2009, 214 p., $25.

Why Sh*t Happens: The Science of a Really Bad Day
Peter J. Bentley
Science explains life's daily mishaps and offers ways to fight back. *Rodale, 2009, 308 p., $16.95.*



Logical Labyrinths
Raymond M. Smullyan
Analogies and a fantasy setting bridge the author's earlier puzzle books and technical writings to teach readers about logic. *AK Peters, 2009, 327 p., $49.*



Heatstroke: Nature in an Age of Global Warming
Anthony D. Barnosky
Rising temperatures could irrevocably alter creatures and their habitats, great and small. *Shearwater, 2009, 288 p., $26.95.*

Birth Day: A Pediatrician Explores the Science, the History, and the Wonder of Childbirth
Mark Sloan
What is known—and what isn't known—about the first day of a child's life. *Ballantine Books, 2009, 370 p., $25.*

The Unwell Brain: Understanding the Psychobiology of Mental Health
F. Scott Kraly
Dysfunctional moods and behavior have chemical roots. *W.W. Norton & Co., 2009, 224 p., $18.95.*

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Why good looks look good

The article "It's written all over your face" (*SN: 1/17/09, p. 24*) made me recall another article (a couple of years ago, I think!) describing the work of researchers investigating an apparent human, obsessive need to identify patterns in our environment. The scientists studied stockbrokers with and without a specific type of brain injury. The results led the researchers to conjecture that this obsession is hardwired into our brains at a very basic, primitive level. Their thinking was that perhaps our precognitive ancestors developed this obsession as a way of locating others of their species in the chaotic wilderness. Campsites, etc., brought an orderliness and organization to the wild, so if you observed a pattern, others like you might be nearby.

I wonder if the authors of the face studies have considered the possibility that the preference for symmetry in the human face has nothing at all to do with selecting the best mate (conferring some sort of genetic advantage, such as a better immune system), but rather, it just satisfies this deep-seated need to find a pattern. With this anxiety thus removed, we become more comfortable with the symmetric face, setting off that cascade of chemicals associated with finding something attractive. From there we then begin to observe other traits that lead us to selecting an ideal mate. If the face is not symmetrical, perhaps we all begin to subconsciously obsess with trying to fix it and focus too much on the unique features, making us feel uncomfortable.

Thanks for many thought-provoking, accessible articles.

Neal Cox, Lake Oswego, Ore.

Psychologist Anthony Little of the University of Stirling responds: "The question is interesting and in fact echoes many previous researchers' beliefs about symmetry. Older theories suggested we prefer symmetry because the human visual system is itself symmetric and so symmetric images are easier to process, or because there is redundant information in symmetric images, making them easier to process (similar to what the reader suggests as finding a pattern). However, one of my own studies neatly demonstrates that this reason can't explain face symmetry preferences: Symmetry is preferred in upright faces and not in inverted faces. Such upside-down images contain the same pattern to be found, and yet they aren't preferred. This isn't direct evidence for the mate-choice view but suggests there is something special about symmetry preferences that is specific to upright faces and not to symmetric patterns in general."

Regarding "It's written all over your face," OK, here's the thing: We don't choose mates based on attractiveness (otherwise I'd still be single). We choose someone to partner with us. If we are needy, we seek caregivers; if we are familiar with addicts, we choose one (or more). Mutual interests, resemblances to first caregivers/parents/teachers, common life experiences, goals and outlooks all weigh in. This article could have been titled simply, "Measuring beauty." Still, good material, and thanks for the pictorial examples — I'm a visual learner.

O. Daniel Miller, Portland, Ore.

Dolphin reader

"Dolphins wield tools of the sea" (*SN: 1/3/09, p. 13*) reminded me of a 2001 book called *To Touch a Wild Dolphin* by Rachel Smolker. She, my nephew Andrew Richards and others observed and reported on the dolphin-sponge behavior in Shark Bay in Western Australia. I highly recommend the book.

L.C. Thompson, Phoenix, Ariz.

Send communications to:
Editor, Science News
1719 N Street, NW
Washington, D.C. 20036
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Alice S. Huang

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Science needs ace communicators and politicians

In February, Alice Huang became president-elect of the American Association for the Advancement of Science. The renowned virologist began her career at Harvard in 1971, eventually becoming director of the laboratories of infectious diseases at Children's Hospital Boston. After a stint at New York University, she moved to the California Institute of Technology in 1997 when her husband, Nobel laureate David Baltimore, became its president. She is now a senior faculty associate in biology at Caltech. In March, Huang spoke with senior editor Janet Raloff about the need to make science accessible to the public and policy makers.

You've said researchers need to be willing to popularize science. Like Carl Sagan did?

Absolutely. In fact, in the early 1980s, [physicist] Leon Lederman and I tried hard to get a prime time TV drama that would focus on science — to show the process of science, its ability to solve problems and that scientists are, well, human. It never got off the ground, but I'm glad to see that several shows with scientists or mathematicians in them have since become quite popular.

Haven't scientists taken flak for popularizing science?

Sometimes. There's a certain elitism among scientists who feel that a popularizer is not as good a scientist as he or she could be. But that's just snobbishness.

We are at a time when many decisions involving science will have to be made by lawmakers — or even voters at the ballot box. So it's important for people to understand the issues. And that's where we, as scientists, can help.

Unfortunately, there isn't much consideration given to training scientists to communicate, except with other scientists. And much of that is in jargon, which can make what we say hard even for scientists in other fields to understand.

We held a National Science Foundation–supported program one summer where we invited some of the best communicators from various fields of science. And what was amazing is that physicists had a totally different concept than biologists of what a cell was. We were using the same words but in ways that had very different meanings. So imagine how nonscientists must get confused when we throw these terms out and expect that people will know what we mean.

But probably the most difficult concept to get across to nonscientists is that we look at data and then use probabilities to judge those data. The public wants an absolute black-and-white answer. We may look at something that is 80 percent likely as being good enough to base decisions on.

We'd like absolute answers, but we realize that sometimes decisions must be made with partial data or some uncertainties.

We'd like absolute answers, but we realize that sometimes decisions must be made with partial data or some uncertainties. And ... as we collect more data, what we thought of as truth might change.

If we can be patient and explain this to nonscientists — how we are seeking truth with the best tools available — they are less likely to be negative or skeptical of our conclusions.

You've said scientists should step up to the plate and become "politically active." Do you mean lobbying?

It could mean going up to Capitol Hill and engaging congressional staffers and lawmakers — explaining certain needs that scientists have as well as the international competitiveness of certain aspects of science and their relevance to national policy. And here I'm thinking of some of the bigger projects, such as the large telescopes, the physics community's colliders and the space station.

Sometimes you'll want to ... lobby. At other times, it's important ... to give carefully considered, unbiased opinions and options that policy makers can use in their decision making. We just need to make it clear which role we are playing.

I also wish more scientists would become politicians. Especially now, because there seems to be a big welcome mat in this administration.

I've frequently been struck by how in many developing countries the leadership contains the intellectual elite: physicists, economists and medical scientists.

In my own family, I had an uncle, K.T. Li, who was a physicist studying under Ernest Rutherford at Cambridge in England during the late '30s, when Japan and China were at war. He left [the] lab to go to Germany to study radar because he realized that was something China would one day need to defend itself.

But later, he ... became minister of economic affairs. In doing this, he gave up a very promising career in science, but helped Taiwan's national economy get on its feet and become an important economic force in the Far East.

Personally, I support every Ph.D. scientist who is running for office — Democrats and Republicans — because I believe that, as in the sciences, advances in our social structure come from a diversity of inputs and ideas. ■

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Just plug it in and hear what you've been missing. With the Bose Wave® music system, there are no stacks of components. No tangle of wires. No dials to adjust. Advanced Bose technologies inside this small system work together to fill the room with the acclaimed performance that has made Bose the most respected name in sound. Audio writer Wayne Thompson of the *Oregonian* calls it "one-of-a-kind" and "my choice for product of the year." You enjoy clear, realistic sound that you may have only thought possible from a much larger, more complicated stereo. In fact, *Forbes FYI* reports that "you'll think you're listening to a…sound system that costs five times more."

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