JULY 22, 2006 PAGES 49-64 VOL. 170, NO. 4

SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

gauging fetal genes

building a better atomic clock

bees on the brink

migraine auras portend risks

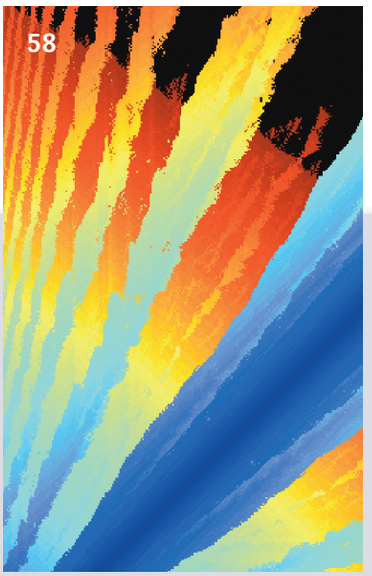
www.sciencenews.org

game theory

THE WEEKLY NEWSMAGAZINE OF SCIENCE

SCIENCE NEWS

JULY 22, 2006 VOL. 170, NO. 4



Features

This Week

Of Note

Departments

Cover Mathematics that's often used to characterize crystallization is providing new insights into simple games that don't depend on chance. These methods produce images of a game's underlying geometric structure, as shown here for a variant of Nim, a game in which players remove items from three piles until only one item is left. (A. Landsberg and E. Friedman) Page 58

Science News (ISSN 0036-8423) is published weekly on Saturday, except the last week in December, for $54.50 for 1 year or $98.00 for 2 years (foreign postage is $18.00 additional per year) by Science Service, 1719 N Street, N.W., Washington, DC 20036. Preferred periodicals postage paid at Washington, D.C., and an additional mailing office.

POSTMASTER
Send address changes to **Science News**, P.O. Box 1925, Marion, OH 43306. Change of address: Two to four weeks' notice is required—old and new addresses, including zip codes, must be provided.

EDITORIAL, BUSINESS, AND ADVERTISING OFFICES 1719 N St. N.W., Washington, D.C. 20036
202-785-2255; scinews@sciencenews.org.
LETTERS editors@sciencenews.org

SUBSCRIPTION DEPARTMENT P.O. Box 1925, Marion, OH 43306. For new subscriptions and customer service, call 1-800-552-4412.

Science News (www.sciencenews.org) is published by Science Service, a nonprofit corporation founded in 1921. The mission of Science Service is to advance the understanding and appreciation of science through publications and educational programs. Visit Science Service at www.sciserv.org.

Terrific Timekeeper

Optical atomic clock beats world standard

Physicists in Colorado say that they've refined an innovative atomic clock to be more precise than the breed of clocks that's been the best for 50 years.

The advance indicates that the reign of atomic clocks tuned to the element cesium is coming to an end, says physicist James C. Bergquist of the National Institute of Standards and Technology (NIST) in Boulder, Colo., who led the work.

To track time, a cesium clock exploits the absorption of microwaves by a cloud of cesium atoms (*SN: 9/4/04, p. 150*). In contrast, the NIST optical clock makes use of interactions between ultraviolet radiation and a single mercury ion. Ultraviolet electromagnetic waves oscillate about 100,000 times as fast as the cesium-cloud microwaves do and so provide a much finer means to measure a second.

Bergquist and his NIST coauthors describe the tweaks to their clock in the July 14 *Physical Review Letters*.

"It's a very impressive paper. It basically says that these things [optical atomic clocks] are now capable of being better than cesium [clocks]," says atomic clock specialist Patrick Gill of the National Physical Laboratory in Teddington, England.

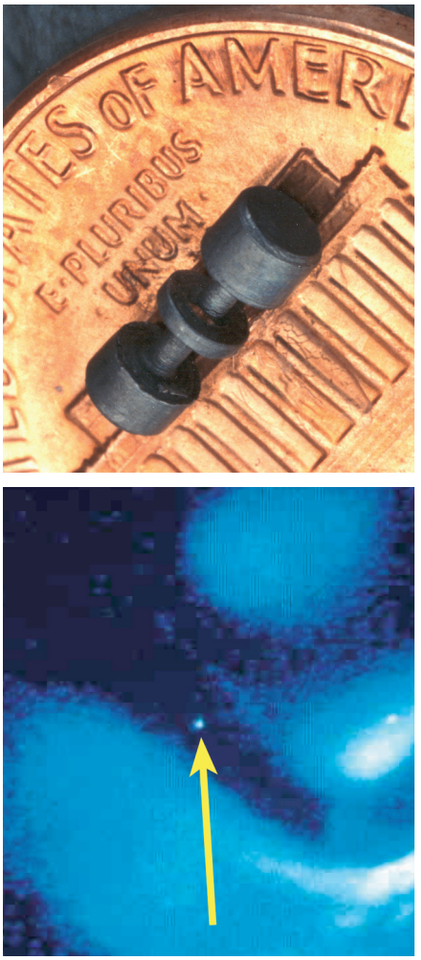
Fritz Riehle of PTB, the national-standards lab in Braunschweig, Germany, says that such superiority had already been demonstrated in a comparison of two ytterbium optical clocks at his lab. Still, the NIST results are "a breakthrough," he adds, because the mercury clock's uncertainty of measurement is so tiny.

With further improvements since they submitted their new report, the NIST researchers have made a clock that's about 10 times as precise as the world's cesium standard, Bergquist says. According to NIST figures, the cesium standard would be off by no more than 1 second in 70 million years of continuous operation.

The NIST advance could ultimately improve navigation and telecommunications systems, says Jean-Jacques Zondy of France's National Metrology Institute in La Plaine Saint Denis. Beyond that, the achievement "raises the issue of changing the definition of time," he notes.

However, a redefinition of the second, now based on a specific property of cesium, may be decades away, says Zondy. Scientists don't yet know whether some other atom will prove better than mercury in optical clocks.

The record-low uncertainty of the NIST clock opens the door to ultraprecise tests of foundations of physics, including relativity and the steadiness of the so-called fundamental constants (*SN: 5/14/05, p. 318*).



CLOCK WORKS When installed in an atomic clock, this molybdenum structure (top) traps a mercury ion (bottom, arrow) at its center. The clock uses the ion to keep time with unprecedented precision.

BERGQUIST AND D. WINELAND/NIST

At least one such test is already well under way, Bergquist says. In recent years, astrophysical data have indicated that the fine-structure constant called *alpha* has increased since the early universe. By comparing the behavior of the new mercury clock and another NIST optical clock based on aluminum, the NIST team is seeking evidence that *alpha* may be changing today. —P. WEISS

Bee Concerned

Big study: Selective pollinators are declining

A million records from insect-spotting hobbyists in Europe contain the broadest evidence so far of a decline among some of the region's pollinators and the wild plants that need them, says an international research team.

The new study shows that since the 1980s, bees have dwindled in diversity in Britain and the Netherlands, as have wild plants that are at the mercy of insects that transport pollen, says Koos Biesmeijer of the University of Leeds in England. The team's unusual study strongly supports the much-discussed worry that loss of pollinating insects will undermine local plant populations, perhaps eventually shrinking food supplies, Biesmeijer and 11 other authors contend in the July 21 *Science*.

"This is the kind of data we need," says pollination ecologist Jaboury Ghazoul of the Swiss Federal Institute of Technology in Zurich. But he wants more data before declaring a global pollination crisis, he says.

Biologists have worried for years that rising pesticide use and diminishing insect-friendly habitat are reducing pollinator populations. Most of the evidence, however, had come from declines in U.S. honeybees and European bumblebees.

Ghazoul asks, What about other species and other places? And are other insects picking up the slack? "We need to be very careful to avoid scaremongering," he says.

Britain and the Netherlands are among the few places with long-term data on insect diversity, thanks to hobbyist groups that include Britain's Bees, Wasps and Ants Recording Society. The European Union, as part of its program to assess risks to biodiversity, funded the international team's analysis of those records.

"This is the largest study to date," says Biesmeijer.

The researchers divided the two countries into 100-square-kilometer blocks and then tabulated local sightings of several hundred wild-bee species and another group of flying pollinators called hoverflies.

Bee-species diversity declined, on average, in 60 percent of the blocks, increased in a few percent, and held steady in the rest, the researchers report. The waning species tended to be bees with narrow ranges or finicky tastes in plants. Hoverflies didn't show any trend in Britain but have increased in diversity in the Netherlands.

To see what happened to the plants that the various insects service, the researchers checked extensive government records of wild-plant ranges. They omitted the majority of plants, which have several strategies for pollination. Among plants that rely primarily on insects or other animals for pollination, 70 percent had declined in range since 1980. During the same period, the wind- or water-pollinated species and those that pollinate themselves fared much better.

Ghazoul suggests that a weedy lifestyle, rather than plants' pollination tactics, could account for the success of the wind-pollinated plants. He notes that many of them thrive in disturbed landscapes.

Biesmeijer cautions that the data don't specify cause and effect, but he remains worried by declines in bee diversity. The once-rich variety of pollinators that visit select groups of flowers or have other specialized habits is giving way to a far smaller number of generalists.

The international team is currently checking for any impact of pollinator decline on European crop plants, Biesmeijer says. —S. MILIUS

WAX AND WANE A species of wild bee, *Andrena gravida*, is not as widespread in Britain and the Netherlands as it was before 1980.

Gender Divide

Gene expression differs in males and females

There are far more biological differences between males and females than meet the naked eye. A new study suggests that the two sexes vary in the amounts of proteins produced by thousands of genes—information that could explain why some diseases strike men and women differently.

"We're certainly conscious that sex can have an effect on numerous diseases," says Thomas Drake of the University of California, Los Angeles. For example, he points out, autoimmune diseases such as lupus disproportionately strike women, whereas men are more likely to have autism and some other mental disorders.

QUOTE

"We were immediately struck by the differences in gender."
THOMAS DRAKE, University of California, Los Angeles

Ongoing studies by Drake and his colleagues are investigating the root causes of diabetes, obesity, and related metabolic diseases. To see how gender interacts with genetics to affect those diseases, Drake and his colleagues worked with 165 male and 169 female mice. Using samples of four tissues—liver, fat, muscle, and brain—the researchers measured production of the proteins encoded by each of 23,000 of the animals' genes.

"We were immediately struck by the differences in gender," Drake says. "They went way beyond what we were expecting."

The team found that in liver, fat, and muscle tissue, males and females differently expressed 55 to 72 percent of the genes studied. The brain had the smallest differences in gene expression between the sexes, occurring in only about 15 percent of the genes.

Next, the researchers looked to see whether the sex differences turned up primarily among maintenance genes, which keep up cells' general functions, or among genes that contribute to each organ's specific role. Drake says that he and his team were surprised to find that the majority of the differing genes control specific organ functions, for example, genes that metabolize drugs in the liver and those that direct energy storage in fat cells.

The researchers say in the August *Genome Research* that the mechanism behind sex differences in gene expression isn't yet clear. However, Drake notes, follow-up studies in his lab hint that sex hormones such as estrogen and testosterone control expression of many of the genes. When he and his colleagues removed mouse ovaries and testes, which produce these hormones, gender differences for many of the genes disappeared.

"This is a very nicely done study that shows the power of modern genetics," says Diane M. Robins of the University of Michigan in Ann Arbor. She points out that since mice and people share about 99 percent of their genes, future gene-expression studies could guide researchers in figuring out why men and women have different risks for some diseases. Further studies might also pinpoint the optimal doses of prescription drugs for men or women or assist researchers in crafting new, gender-specific medicines. —C. BROWNLEE

Deadly Disorder

Imagined-ugliness illness yields high suicide rate

The suicide rate among people with a psychiatric disorder that causes them to perceive themselves as ugly is higher than that among people with major depression, says a new report.

Over the course of a 4-year study, 2 of 185 patients with body dysmorphic disorder (BDD) committed suicide. That's twice the suicide rate in severely depressed people and 45 times that expected in a general population of the same age, sex, and geographic characteristics, says a research team led by Katharine Phillips of Butler Hospital in Providence, R.I., in the July *American Journal of Psychiatry*.

People with BDD form a debilitating obsession with some aspect of their appearance—nose size, scars, or body build, for example. The blemish on which they focus may be a delusion or may go unnoticed by other people. Still, patients with BDD often groom for hours a day, and some undergo cosmetic surgery only to wind up unhappy with the results.

"The core symptoms of BDD can make people feel very isolated, depressed, alone, unwanted," says Phillips. "Then, it's a small step to 'Life isn't worth living.'"

The researchers tracked BDD patients,

R. KLEUKERS/EIS, NATURALIS

age 12 and older, who either volunteered for the study or were referred by a physician. Ninety percent of the patients received psychiatric treatment at some point during the study.

Nine of the participants attempted suicide during the study, with a combined total of 30 tries, the researchers report. The rate of suicide attempts in BDD patients was higher than that expected in the general population. The rate of suicidal thoughts also greatly exceeded the norm.

In a group the same size with eating disorders, major depression, or bipolar disorder, the researchers would expect to see fewer than the two completed suicides that they report among their BDD patients.

Previous studies based on patient recollections had also shown elevated rates of suicidal thinking and attempts among BDD patients, and physician reports had suggested increased suicide completion.

The high suicide rate might come from other conditions that are likely to affect people with BDD, says Eric Hollander, chair of psychiatry at the Mount Sinai School of Medicine in New York City. Many BDD patients develop severe social anxiety disorder or depression. As a result, they often become socially isolated, incapable of working at an office, and even homebound.

Moreover, the disorder normally begins during adolescence—already a period of heightened suicide risk for some people, Hollander says.

"Some people have felt BDD is a relatively trivial disorder, and that's really not the case," he says. "This is a life-threatening illness if untreated."

About 2 percent of the population has BDD, estimates Sabine Wilhelm, director of the BDD Clinic and Research Unit at Massachusetts General Hospital in Boston. However, BDD often goes undetected, Wilhelm says, "because patients don't necessarily reveal it on their own." The link to suicides should motivate clinicians to seek out the disorder early, she says.

Phillips cautions that there's been little research on BDD patients. But she says that the high rate of suicide attempts that she reports is "very in keeping with my clinical experience." —E. JAFFE

From Mind to Matter

Data analysis challenges psychokinesis

Scientists have long considered claims that people can manipulate the physical world with their minds. Yet numerous experiments conducted over the past 35 years, in which people try to influence the output of computers that generate random sequences of 1s and 0s, have overall failed to demonstrate the existence of so-called psychokinetic effects, according to a new analysis. Some individual experiments, however, have seemed to indicate an impact.

The random-number studies were inspired by controversial mid–20th century investigations in which volunteers attempted to affect how a rolled die would land. In a typical recent experiment, a participant mentally tries to influence a computer to produce, say, more 1s than 0s over a predefined sequence. The participant receives visual cues that give constant feedback on hits and misses.

Participants shift their focus from 1 to 0 on alternating runs to account for any tendency of the digit device to produce one number slightly more often than the other.

Data collected from 380 random-number studies gleaned from journals, conference proceedings and reports, dissertations, and book chapters were analyzed by psychologist Holger Bösch of University Hospital Freiberg in Germany and his colleagues. The results appear in the July *Psychological Bulletin*.

In the majority of the random-number experiments, there are fewer than 100 participants, who try to influence sequences that total between 1,000 and 10,000 numbers, Bösch's team says. Taken together, these small-scale studies, which yield positive results more easily than large-scale investigations do, show a small but significant tendency for pre-designated 1s or 0s to appear. Typically, the effect is 1 to 2 percent above the distribution predicted by chance.

However, that effect disappears when data from three larger investigations are added to the mix, the scientists assert. Each of those studies assessed efforts to influence sequences totaling tens of millions of numbers.

The scientific literature on psychokinesis seemed to support the credibility of the effect, the investigators say. However, small studies, which are more likely than large ones to show statistically significant effects, are much more common, they note.

Large-scale studies, which rely on high-speed random-number generators and quicken the pace of volunteers' responses, seem to interfere with any psychokinetic effects, contends a group of psychokinesis researchers led by Dean Radin of the Institute of Noetic Sciences in Petaluma, Calif. Small-scale studies have yielded "a genuine psychokinetic effect," they say in the same *Psychological Bulletin*.

Psychokinesis researchers need to go beyond the statistics and explain how the mind might influence a computer, then test that prediction, say psychologists David B. Wilson of George Mason University in

LOOPE AND J. MASON

Sandy clues to ancient climate

The orientation of these dunes in north-central Nebraska provide a clue that the climate there a millennium ago was much different than it is today. The Nebraska Sand Hills have been frozen in place by vegetation for 800 to 1,000 years, says David B. Loope, a geologist at the University of Nebraska in Lincoln. The 12-to-15-meter-tall dunes, which run from west-northwest to east-southeast, couldn't have been formed by modern wind patterns, which bring plant-nurturing moisture to the region from the Gulf of Mexico in the springtime. Loope and his colleagues report in the July 21 *Science* that to build the dunes 1,000 years ago at the beginning of the so-called Medieval Warm Period, much drier spring winds must have blown in from the southwest. —S. PERKINS

Manassas, Va., and William R. Shadish of the University of California, Merced in the same journal issue. —B. BOWER

Big Headache

Auras may add risk to migraines

As if the headaches weren't enough. Women who experience migraines that are preceded by sensory irregularities face a heightened risk of heart attack, stroke, and other cardiovascular problems, a long-term study of middle-aged women shows.

Some people with migraines have sensory anomalies, called auras, which can include zigzag lines or spots of light in the visual field or grayed vision. Auras can also be characterized by tingling in the limbs and physical weakness.

To investigate potential links among migraines, strokes, and heart problems, the scientists beginning in 1992 identified 3,610 female health professionals who had had migraines during the past year. Of these, 40 percent had experienced auras. The women in the study, who were otherwise healthy and over age 45, were participating in a large trial investigating various medical conditions, says study coauthor Tobias Kurth, a neuroepidemiologist at Harvard Medical School and Brigham and Women's Hospital in Boston.

Over the next 10 years, the women who had experienced migraines with auras had twice as many strokes and heart attacks as did women in the larger trial who had no history of migraines. On the other hand, there was no significant difference in the rate of cardiovascular problems between women with aurafree migraines and the migrainefree women.

Women experiencing auras were also nearly twice as likely to have chest tightness or to need heart surgery, and they were more than twice as likely to die from a cardiovascular problem during the study, the researchers report in the July 19 *Journal of the American Medical Association*.

"The results are really consistent for all these areas of heart problems," which lends credibility to the study, says Richard B. Lipton, a neurologist at the Albert Einstein College of Medicine in New York City.

The researchers adjusted the data to account for smoking, hormone use, medications, weight, alcohol consumption, exercise, cholesterol, diabetes, blood pressure, menopausal status, and family history of heart disease.

Previous studies had tied migraines to stroke, with some of the strongest evidence connecting stroke risk to migraines with aura in young women. By expanding that finding to women over 45, the new study represents "the best evidence yet" of an overall stroke linkage, Lipton says.

The cause of migraines is unclear, as is the reason for the correlation between auras and cardiovascular problems. Some research suggests that a mild heart abnormality may contribute to the stroke-aura connection by shunting oxygen-poor blood to the brain (*SN: 2/19/05, p. 119*).

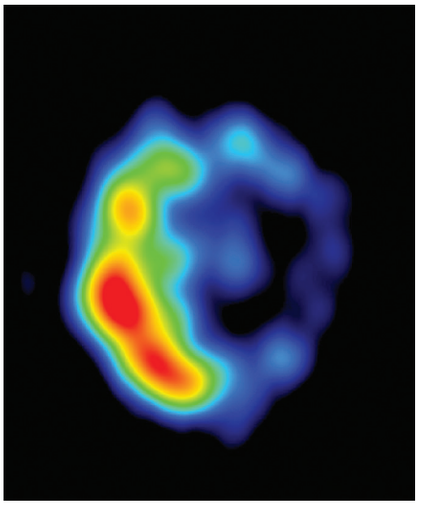
Other evidence has linked increased cardiovascular risk to a variant form of a gene that affects blood concentrations of a compound called homocysteine. A recent study found a stronger association of the variant with migraines with aura than with other migraines. —N. SEPPA

Recurrent Eruption

Explosive stellar saga

Imagine the blast of a nuclear bomb as heavy as Earth and you'll get some idea of the energy unleashed in each of the six thermonuclear explosions that have ripped off the outer layers of a dense, nearby star in the past 108 years.

During the star's most recent outburst, which occurred in February, astronomers obtained their sharpest look yet at this recurrent type of explosion, called a nova, as well as new insights into the most powerful of known stellar eruptions, the supernova.



RADIO BLAST The blast wave, seen in radio waves, from the recent eruption of the two-star system RS Ophiuchi. Red denotes brightest emission; blue the faintest.

T. O'BRIEN ET AL., NRAO, AUI, NSF

Indeed, the hyperactive star, which is part of a two-star system called RS Ophiuchi, may be teetering on the brink of going supernova and could obliterate itself in just a few hundred thousand years, suggest Jennifer Sokoloski of the Harvard-Smithsonian Center for Astrophysics and her colleagues. They base this conclusion, reported in the July 20 *Nature*, on their new estimates of the star's mass.

RS Ophiuchi consists of a compact star, called a white dwarf, and a bloated companion star, called a red giant. A strong wind emanating from the red giant dumps matter onto its smaller partner. When enough material piles up, it triggers a thermonuclear explosion on the white dwarf's surface.

On Feb. 12, Japanese astronomers reported that the star system, which last erupted in 1985, had suddenly zoomed in brightness. Within days, an armada of telescopes trained its sights on the eruption.

Astronomers found that the explosion generated a shock wave that rammed into the red giant. The shock wave exhibits many features of remnant material that's been cast from a supernova and plows into surrounding space, says Michael Bode of the Liverpool John Moores University in Birkenhead, England.

"We are seeing the same phases of evolution that one sees in a supernova remnant, but instead of taking thousands of years, here it takes months, [unfolding] right before our eyes," says Bode. He and his colleagues used the Swift satellite to measure X rays from the shock, which they describe in an upcoming *Astrophysical Journal*.

Bode and other colleagues also observed the blast with several radio telescopes. Two weeks after the eruption, the radius of the blast was already as large as that of Saturn's orbit. Over the next several months, it changed from the shape of a ring to that of a cigar. That suggests that the explosion wasn't spherical but blasted out as jets, Bode and his colleagues say in the July 20 *Nature*.

Another team found an uneven distribution of near-infrared emissions, described in an upcoming *Astrophysical Journal Letters*. That finding could have two interpretations, suggests the report's coauthor Richard Barry of NASA's Goddard Space Flight Center in Greenbelt, Md. If the star system resides at about 5,000 light-years from Earth, then the emissions reflect a mysterious, dense reservoir of material surrounding the two stars. If the system lies at only about one-third that distance, then the emission may for the first time be revealing a short-lived epoch during which the white dwarf, soon after its outburst, becomes as bloated as its red giant partner.

Either way, says Barry, the findings "could send theorists back to the blackboards." —R. COWEN

Understand the forces of the universe

with this fascinating, 12-lecture video course by a leading astronomer and professor

What forces molded the universe? Are those forces still at work, removing, changing, or adding heavenly bodies even as we gaze upward? Will humanity, and Earth itself, one day be gone? Are we alone?

In an era when science journalism is perhaps more thorough and ambitious than ever before, fascinating explorations of questions like these seem available to us almost every day—provided we have a working understanding of the scientific theories on which they're based.

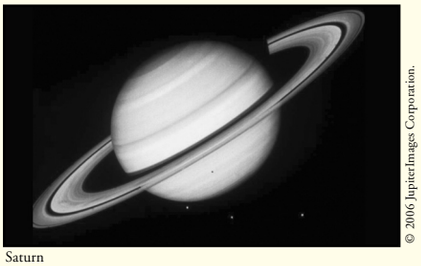
In this lecture series, the astrophysicist who directs the nation's most famous planetarium makes that understanding available to anyone. **My Favorite Universe** is a spirited and intellectually engaging journey through the cosmos and its history, from before the Big Bang to the likely ways in which Earth, and perhaps the entire universe, might end.

An Accessible Yet Awe-Inspiring Course

A natural teacher with a Ph.D. in astrophysics from Columbia University, Dr. Neil deGrasse Tyson has written prolifically for the public, including the series of essays in *Natural History* magazine on which this course is based. And though it was created for a lay audience and is readily accessible, the course is one in which science always takes precedence over drama.

It is certainly entertaining, often funny, even awe-inspiring at times, as befits the subject matter. But clear introductions to essential principles of physics abound throughout these lectures, including density, quantum theory, gravity, and even the General Theory of Relativity. And Dr. Tyson also includes forays into disciplines such as chemistry and biology as needed to explain events.

For example, Dr. Tyson begins one lecture at a point 13 billion years ago, when all space, matter, and energy in the known universe were contained in a volume less than one-trillionth the size of a pinpoint—about the size of an atom. By the time he finishes, the cosmos has been stretched, the planets and Earth formed, and 70 percent of Earth species wiped out by a gigantic asteroid—clearing the way for the evolution of humanity.



Saturn

As Dr. Tyson notes, we are made of stardust, just as the planets are. And he has created a course that explains exactly how that came to be, beginning with a grounding in the basic "machinery" of matter, forces, and energy which reveals itself throughout the universe.

The Stark and Violent Beauty of the Universe

With this basic foundation in place, explanations of cosmic events fall into place, and realities of the universe are revealed in stark and often violent beauty.

We learn how Saturn's rings were formed, and why they will eventually be lost. Why low-density conditions are necessary to produce the drama of the northern and southern auroras. How black holes are formed and can wreak havoc. Why planets are round and asteroids are not.

We explore how asteroids moving through space represent threats of extraordinary consequence to Earth. Why the seemingly infinite panorama of celestial bodies revealed by the Hubble Space Telescope's famous "Deep Field" so intrigue astronomers. Why odds seem overwhelmingly in favor of some kind of life out there.

About The Teaching Company

We review hundreds of top-rated professors from America's best colleges and universities each year. From this extraordinary group we choose only those rated highest by panels of our customers. Fewer than 10% of these world-class scholar-teachers are selected to make The Great Courses. We've been doing this since 1990, producing more than 2,000 hours of material in modern and ancient history, philosophy, literature, fine arts, the sciences, and mathematics for intelligent, engaged, adult lifelong learners. If a course is ever less than completely satisfying, you may exchange it for another or we will refund your money promptly.

Lecture Titles

1. On Being Round
2. On Being Rarefied
3. On Being Dense
4. Death by Black Hole
5. Ends of the World
6. Coming Attractions
7. Onward to the Edge
8. In Defense of the Big Bang
9. The Greatest Story Ever Told
10. Forged in the Stars
11. The Search for Planets
12. The Search for Life in the Universe

THE TEACHING COMPANY®
The Joy of Lifelong Learning Every Day™
GREAT PROFESSORS, GREAT COURSES, GREAT VALUE GUARANTEED.™

About Our Sale Price Policy

Why is the sale price for this course so much lower than its standard price? Every course we make goes on sale at least once a year. Producing large quantities of only the sale courses keeps costs down and allows us to pass the savings on to you. This approach also enables us to fill your order immediately: 99% of all orders placed by 2:00 p.m. eastern time ship that same day. Order before August 8, 2006, to receive these savings.

SAVE $160!
OFFER GOOD UNTIL AUGUST 8, 2006

1-800-TEACH-12 (1-800-832-2412)
Fax: 703-378-3819

Special offer is available online at
www.TEACH12.com/9sn

The Great Courses®
THE TEACHING COMPANY®
4151 Lafayette Center Drive, Suite 100
Chantilly, VA 20151-1232

Priority Code 20994

Please send me **My Favorite Universe,** which consists of twelve 30-minute lectures (6 hours in all) with complete lecture outlines.

☐ **DVD $39.95** (std. price $199.95) **SAVE $160!**
plus $5 shipping, processing, and lifetime satisfaction guarantee.

☐ **Check or Money Order Enclosed**

Special price for shipping, processing, and lifetime satisfaction guarantee—this offer only.

* Non-U.S. Orders: Additional shipping charges apply. Call or visit the FAQ page at our website for details.

** Virginia residents please add 5% sales tax.

Charge my credit card:

☐ VISA ☐ MasterCard ☐ Discover/NOVUS ☐ American Express Card

ACCOUNT NUMBER EXP. DATE

SIGNATURE

NAME (PLEASE PRINT)

MAILING ADDRESS

CITY/STATE/ZIP

PHONE *(If we have questions regarding your order—required for international orders)*

☐ **FREE CATALOG.** Please send me a free copy of your current catalog (no purchase necessary).

Special offer is available online at www.TEACH12.com/9sn

Offer Good Through: August 8, 2006

BRINGING UP BABY'S DNA

Less risky techniques for assessing fetal genes

BY CHRISTEN BROWNLEE

At the age of 39, Robin Nolan of Carson City, Nev., found out that she was pregnant with her first child. The timing was perfect for her and her husband's personal and professional lives, but doctors warned Nolan that her age inflated the chance that her baby would have a congenital disease such as Down syndrome.

Three years later, Nolan has not only a perfectly normal son but also a healthy, 5-month-old daughter. Their well-being wasn't just a pleasant surprise. Like many older mothers, Nolan opted early in each pregnancy to have a procedure called amniocentesis, in which a doctor uses a thin needle to draw fluid from the sac that surrounds a fetus. Fetal cells floating in this liquid hold a developing baby's DNA and so give doctors the means to get a precise readout of genetic disorders that a fetus might have.

Both amniocentesis and another procedure called chorionic villus sampling, in which doctors pluck bits of the placenta, isolate fetal cells that can reveal many genetic problems in an unborn baby with near certainty. But both procedures come with some risk because they invade the pregnant woman's uterus. Out of every 100 women who undergo these procedures, 1 or 2 will have a miscarriage.

"I weighed the odds and thought it was more important to find out what was going on with my baby than whether I miscarried," says Nolan.

Although the gamble paid off for Nolan, this risk isn't acceptable for some women. Researchers are developing new ways to harvest babies' genes in less risky ways—for example, from fetal DNA floating in a mother's blood or from cells that have detached from the placenta and lodged in her cervix. Scientists have a few hurdles to overcome before tests based on these techniques become routine, but safely learning about their baby's health in advance could put moms and dads a significant step ahead in preparing for parenthood.

ROAMING FREE Amniocentesis and chorionic villus sampling are currently the only way doctors have for analyzing a fetus' genes, but scientists have for decades been contemplating how to replace these tests with less invasive ones. In the late 19th century, scientists found what looked like placental cells in the lungs of women who had died from preeclampsia, a condition that creates high blood pressure during pregnancy.

In the 1970s, researchers identified the vehicle that delivers these cells to the lungs. It's a pregnant woman's blood. But they found that only about two to six fetal cells, such as immature red blood cells and immune cells, circulate in every milliliter of maternal blood.

Prenatal-genetics researcher Diana W. Bianchi of Tufts University in Boston made one of the earliest attempts to harvest these cells. Using an antibody that binds to a protein found mostly on the surface of fetal cells, Bianchi and her colleagues showed in 1990 that they could pluck out a few of the precious cells floating in samples of a pregnant woman's blood. But since these cells are so rare—virtually undetectable in some women—and tricky to distinguish from a mother's own cells, Bianchi and other researchers put these circulating cells on the back burner as a new source for genetic testing.

A major advance came in 1998 when Dennis Lo, now at the Chinese University of Hong Kong, and his colleagues reported that fetal DNA circulates freely outside of cells in a pregnant woman's bloodstream. Lo notes that this genetic material seems to make its way into maternal blood when placental cells die, rupture, and spill their contents into the mother's bloodstream. Studies have since shown that about 20,000 placental cells die per minute under normal conditions. Even more DNA enters the mother's bloodstream when she or the fetus has certain health problems, such as preeclampsia or Down syndrome.

Lo notes that circulating fetal DNA sticks around for several minutes in a mother's blood, providing ample time for researchers to harvest the genetic material for prenatal tests. The tricky part, he adds, is separating the baby's DNA from maternal DNA that also floats in the bloodstream.

> "It's not inconceivable that in the future, a woman will be able to get a pregnancy test and at the same time find out if her baby has [a] disability."
>
> — BRIAN SKOTKO, HARVARD UNIVERSITY

"It's easy if the baby is a boy—then you can just use the Y-chromosome as a marker," says Lo. To make the tests usable for girls, he adds, "we need to find something else that's fetal specific."

In the Oct. 11, 2005 *Proceedings of the National Academy of Sciences*, Lo and his team reported on a novel way to differentiate a baby's DNA from its mother's. The accomplishment took advantage of a phenomenon called epigenetics, in which chemical modifiers, such as methyl groups, attach directly to DNA and regulate gene activity (*SN: 6/24/06, p. 392*).

Since epigenetic modifications can change with a person's age, Lo and his team wondered whether they could find some genes that are methylated differently in a fetus than in its mother. After searching through thousands of candidates, the researchers focused on *Maspin*, a tumor-suppressing gene that's active in the fetal cells of a placenta but not typically in a mother's cells. Lo and his colleagues found that the gene is usually methylated in a mother's blood but unmethylated in the placenta.

In subsequent tests, the researchers found that they could detect fetal DNA with unmethylated *Maspin* in all three trimesters of pregnancy. Using their new technique to reveal excessive fetal DNA in some mothers' bloodstreams, the

researchers reliably predicted which women would develop preeclampsia.

The team plans on looking for epigenetic markers that might disclose the presence of specific diseases of the fetus, such as Down syndrome. That disease is marked by three copies of chromosome 21, but the phenomenon can currently be detected only by examining whole fetal cells.

Recently, a team of scientists led by molecular biologist Sinuhe Hahn of University Hospital in Basel, Switzerland, discovered another way to reliably separate fetal DNA from maternal genetic material. The researchers made the chance discovery that circulating bits of a baby's genetic material are significantly shorter than a mother's. Though the researchers aren't sure why that is, one idea is that the high rate of turnover among placental cells might shatter long strings of DNA into strands much shorter than those of maternal origin.

In the Feb. 16, 2005 *Journal of the American Medical Association,* Hahn's team showed that separating circulating DNA on the basis of size could provide a new way to test for genetic disease in a fetus. The researchers took blood samples from 32 pregnant women carrying fetuses at high risk of beta-thalassemia, a genetic disease that causes severe anemia. The scientists separated the circulating strands into short and long strands and then tested the batch of shorter strands for four mutations known to cause the disease. Checking their findings against chorionic villus sampling, the researchers identified the mutations in the circulating fetal DNA with almost 100 percent accuracy.

Hahn and his team are currently working to expand their findings into tests for other genetic conditions.

THUMB'S UP — New techniques to harvest fetal DNA could give parents a safer readout on their unborn baby's health.

MEDISCAN/CORBIS

CELL SOLUTION Although much of the work on new prenatal tests now focuses on circulating fetal DNA, some scientists still see plenty of promise in the whole fetal cells found in maternal blood and elsewhere.

If researchers find a reliable way to isolate enough fetal cells, they could be more useful than circulating fetal DNA, says cell biologist Esther Guetta of Chaim Sheba Medical Center in Tel-Hashomer, Israel. For example, for a recessive disease such as sickle cell anemia, in which two copies of a problem gene are packed in each cell, it's difficult to distinguish whether a copy circulating in the blood belongs to the fetus or the mother. That wouldn't pose a problem if researchers had whole fetal cells to work with, Guetta notes.

"If you have the whole cell, then you know that all the fetus' DNA is compartmentalized in that cell," Guetta says. "[Cell free] DNA is important, but it won't answer all the questions."

She and other researchers have identified several different types of fetal cells, such as immature red blood cells and stem cells, that circulate along with placental cells in a mother's bloodstream. Her team is tackling the problem of fetal cells' rarity in maternal blood by developing methods to grow those cells into easy-to-test colonies in the lab.

In the March 2005 *Journal of Histochemistry and Cytochemistry*, Guetta and her colleagues showed for the first time that circulating placental cells could multiply in the lab. Starting with blood samples that held only one or two fetal cells per 20 ml of blood, the researchers placed the cells in a specially crafted mixture of nutrients and proteins to increase this number about fivefold over the course of 5 to 7 days. Guetta's team used these new cells to predict a fetus' gender with about 93 percent accuracy.

Joe Leigh Simpson of Baylor College of Medicine in Houston and his colleagues are currently investigating how to make use of another promising source of fetal cells: the mucus plug that fills a pregnant woman's cervix. Besides shedding cells into the bloodstream, the placenta deposits cells into this mucus plug, notes Simpson.

"The attraction is that there are lots of cells there," he says. Having such cells harvested would be "like having a Pap smear," he adds, referring to the simple procedure that many women have once a year to check for cervical cancer and other health problems.

However, Simpson notes that several challenges must be overcome before harvesting cells from the mucus plug is practical for prenatal testing. For example, it isn't easy to extract the fetal cells from the thick, sticky mucus—researchers need to identify chemicals that dissolve this type of mucus without killing the cells. Also, since many maternal cells are mixed in with the fetal cells, researchers must come up with a way to distinguish a baby's cells from its mother's. Working with a company called Biocept in San Diego, Simpson and other researchers are testing several promising solutions to these problems.

BUNDLE OF QUESTIONS As scientists move closer to developing genetic tests that match the reliability of amniocentesis and chorionic villus sampling but lessen their potential harm to a fetus, some researchers expect that more women will choose to undergo prenatal testing. That's likely to raise the possibility that more mothers will hear that their unborn baby has a worrisome genetic condition, says Brian Skotko, a Harvard researcher who specializes in medicine and public policy.

"It's not inconceivable that in the future, a woman will be able to get a pregnancy test and at the same time find out if her baby has Down syndrome or another disability," he says. "It definitely opens a new avenue in the [obstetrics and gynecology] world with ethical and personal questions."

One of those questions that Skotko recently investigated was how doctors should tell a mother that she is carrying a child with Down syndrome, which currently affects about 350,000 people in the United States. In the January 2005 *Pediatrics* and the March 2005 *American Journal of Obstetrics and Gynecology*, Skotko published two studies that concluded that doctors often tell mothers about their baby's diagnosis in an overwhelmingly negative way, using insensitive language and focusing on the hardships and limitations that their child may face. Doctors also frequently assume that a woman carrying a child with Down syndrome will want to terminate her pregnancy.

Nowadays, that's often not the case, says Skotko. Medical advances and society's changing perceptions have greatly improved the quality of life for people with Down syndrome and many other congenital conditions—and for their parents. Nevertheless, if tests can safely spot a fetus' genetic problems, more parents will have a chance to plan for their family's future, whatever they choose.

Says Skotko: "More parents will eventually need to decide, 'Is this life valuable?' It's a tantalizing question that's a profoundly personal one." ■

CHAOTIC CHOMP

The mathematics of crystal growth sheds light on a tantalizing game

BY IVARS PETERSON

It's hard to imagine a simpler two-player game than Chomp. Start by laying out a rectangular array of cookies. The players take turns picking a cookie, each time removing the chosen cookie and all cookies above and to the right of it. Each move is like taking a square or rectangular bite out of the array. The loser is the player forced to take the poison cookie—the one in the lower left-hand corner.

Though simple, the game is both intriguing and maddeningly frustrating. Mathematicians have proved that the first player can always win. But the proof provides no hint which first moves lead to guaranteed wins. Indeed, nobody has yet come up with an efficient general strategy for succeeding at Chomp.

Winning strategies are known for only two cases. When the array is a square, the first player starts by selecting the cookie that's diagonally next to the poison cookie. This bite leaves one row and one column, with the poison cookie at the vertex. From that point on, the first player takes from one line whatever his or her opponent takes from the other. Eventually, the second player must take the poisoned piece.

When the array is two columns wide (2 by n), even if it's not a square, the first player can always win by taking the cookie at the top right so that one of the columns is one cookie shorter than the other. From then on, the first player always plays to restore this situation. The same strategy works for an array two rows high where the first move makes one row one cookie shorter than the other.

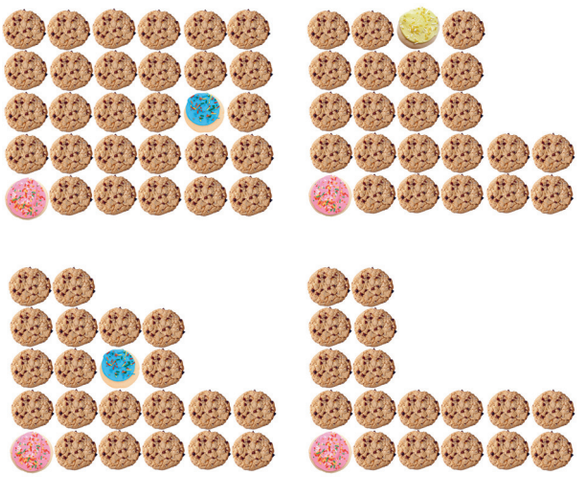
Looking beyond these simple scenarios, physicist Adam S. Landsberg of Claremont Mckenna, Pitzer, and Scripps Colleges in Claremont, Calif., and computer scientist Eric J. Friedman of Cornell University provide new evidence of Chomp's complexity. They reveal that the game has an underlying geometric structure that changes in a manner reminiscent of crystal growth.

By using mathematical tools originally developed for calculating properties of physical systems, Friedman and Landsberg show that the exact location of winning and losing cookies in Chomp varies unpredictably with small changes in the size of the initial array. Nonetheless, they make probabilistic predictions about where a winning position is most likely to be found.

Landsberg described the findings at the Dynamics Days 2006 conference on chaos and nonlinear dynamics, held earlier this year in Bethesda, Md.

"This is a fascinating breakthrough that gives lots of global insight into an otherwise [probably] intractable game," says mathematician Doron Zeilberger of Rutgers University in New Brunswick, N.J.

Moreover, such a physics-based approach opens a new line of attack for understanding games that are more complicated, Landsberg says. In economics, for example, it may provide insights into online auctions, bargaining strategies, and other gamelike situations.



TASTY BITES — Playing Chomp with 30 cookies on a 5-by-6 field, the first player selects a cookie (blue, top left) and removes a block of six cookies (top right). The second player selects one of the remaining cookies (yellow, top right) and removes a block of two cookies (bottom left). The first player responds, leaving the L-shaped array shown at bottom right. Who will be forced to take the poison cookie, which is shown in pink?

STRATEGIC STEALTH Chomp was invented in the early 1970s by mathematician and economist David Gale of the University of California, Berkeley. Recreational math columnist Martin Gardner was the first person to call it "Chomp," and the name stuck.

Chomp is an example of a combinatorial game, in which nothing is hidden from the players and no chance is involved. Chess, Go, checkers, tic-tac-toe, and dots-and-boxes also belong to this category.

However, Chomp has an important difference from chess and many other combinatorial games. In Chomp, any move that's legal at any time during a game would have been legal as an opening move.

Gale took advantage of this characteristic to prove that there's always a way that the first player can win. He argues, suppose that the first player makes a certain move. There are two possibilities. This move is going to produce either a win or a loss. If it's a losing move for the first player, the second player must have a move that sets up a win.

But no matter what corner the second player bites off, the first player could have set up the same pattern in the first move. So, there must always be a winning move for the first player. Of course, in a real game, the first player may make mistakes and consequently lose.

Gale used a computer to find the winning moves for arrays that are 3 cookies wide and up to 100 cookies long (3 by n). He

E. ROELL

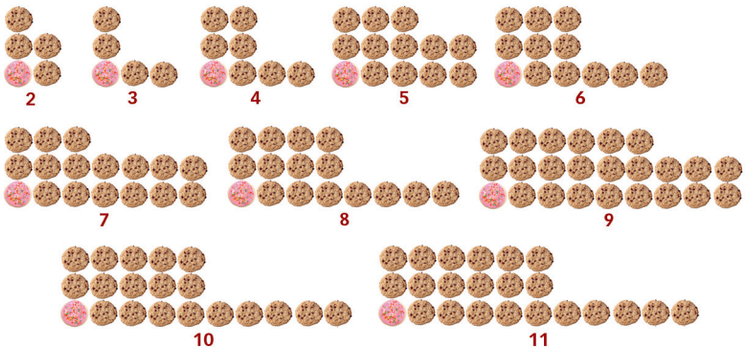
found that each of these arrays has a unique winning first move. About 58 percent of the winning moves are two-rows deep, and 42 percent are one row deep. Gale also noted that as n increases, both one-row and two-row winning moves stay the same or increase in width.

But he found one exception. The winning first move on the 3-by-88 rectangle is 2 by 36, which is one unit less than the winning 2-by-37 move on the 3-by-87 rectangle.

Such quirks led Gale to write, "Phenomena like this lead one to believe that a simple formula for the winning strategy might be quite hard to come by."

There were more broken patterns to come. Subsequent computer investigations by others, for example, showed that not every rectangle has a unique winning move. For example, 8-by-10 and 6-by-13 grids each have two winning moves.

Interestingly, Gale later learned that his game wasn't entirely his invention. Rather, it's a special case of a number game invented by mathematician Fred Schuh of the Delft Technical College in the Netherlands in 1950. In Schuh's game, two players agree on a large number, then make a list of all the divisors of the number, including the number itself but excluding 1. They then take turns crossing out a divisor and all its divisors. The person forced to take the number itself loses.



WINNING CHUNKS — These diagrams show the winning first moves in 3-by-n games for arrays up to 11 columns long.

EXPERIMENTAL MATH When Zeilberger learned about Chomp, he decided that the game would be an ideal problem for illustrating the role that computers can play in mathematical research. "I found it a great case study for computer-generated, rigorous experimental mathematics," Zeilberger says. In effect, a computer is programmed to first conjecture a pattern, then prove it rigorously all by itself.

Zeilberger focused on the 3-by-n case. For a given rectangle, three numbers (x, y, z), describe the configuration of the cookies at any stage in the game, where x specifies the number of columns of height three, y specifies the number of columns of height two, and z the number with height one. Each set of three numbers represents a location in three-dimensional space, and such a position can be classified as either a winner (a player starting from that point can always force a win) or a loser.

NIBBLE NUMBERS — Suppose that the first player takes the cookies shown in yellow, and the second player takes the ones shown in blue (left). Three numbers, *x*, *y*, and *z*, characterize the new cookie configuration (right) as (2, 2, 3), where *x* specifies the number of columns of height three, *y* specifies the number of columns of height two, and *z* is the number with height one.

Computer investigations of arrays of numbers that represent winning positions for rectangles of different lengths reveal some disorder. But winning positions aren't scattered completely at random, and there are also strong hints of recurring patterns.

In 2002, Steven Byrnes, then a senior at Roxbury Latin School in West Roxbury, Mass., proved a powerful result about combinatorial games. He showed that Chomp and various other games have a common structure. He found repeating patterns for winning positions in these games, when they're looked at in the right way.

Byrnes' "approach was very useful in proving qualitative results," Zeilberger notes. He now refers to Byrnes' analysis as a significant step in making sense of these games. For this work, Byrnes was a finalist in the 2003 Intel Science Talent Search and winner of the Siemens Competition for high school students.

CRYSTAL GROWTH For the sake of simplicity, Landsberg and Friedman last year focused on three-row Chomp, as Zeilberger had done. They also employed Zeilberger's scheme for characterizing winning and losing positions by three coordinates.

By plotting points representing winning positions, the researchers visualized what was happening. For a given value of x, each plot—which they called a sheet—shows the y and z values of possible winning positions. The researchers could then see what happens to the patterns, from sheet to sheet, as x increases.

Landsberg and Friedman created visualizations of a special subset of the game's winning positions, known as instant winners. A position is considered an instant winner if nearby moves would lead to a losing position with a smaller x value.

"Once we got going, we were quite fortunate—and frankly surprised—at how rapidly the whole problem broke open, allowing us to identify a crystal-like geometric structure underlying the game," Landsberg says.

The growth of the instant-winner sheets with increasing x is similar to certain crystal-growth and aggregation processes found in physics. In each case, the structures grow through the accumulation of new points along current boundaries. Moreover, the structure on a large scale resembles the small-scale structure. In the case of Chomp, the geometry of winning positions for small values of x and winning positions for large values of x is roughly the same, after a suitable change in scale.

This geometric similarity on different scales permitted the researchers to use mathematical methods known as re-normalization techniques. These tools have been used with great success in various branches of modern physics, from statistical mechanics and particle physics to nonlinear dynamics, which is popularly known as chaos theory. With the tools, physicists calculate the properties of objects or physical systems that are geometrically similar on different scales.

"To the best of my knowledge," Landsberg says, "this nonlinear-dynamics/physics approach to combinatorial games is something of a radical departure from what the folks who work on such games normally do."

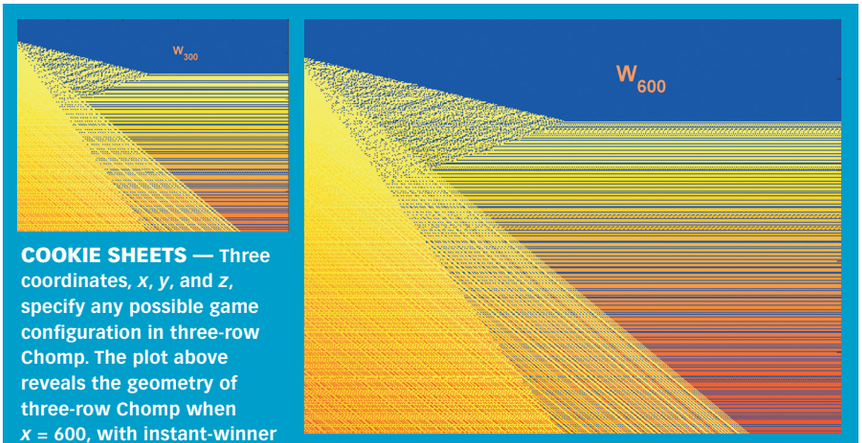
As a result of their analysis, Landsberg and Friedman provide a unified, global description of the overall structure of Chomp and related games. One immediate consequence has been to settle some conjectures concerning Chomp.

The researchers show, for example, that all 3-by-n rectangles

E. ROELL

have a unique winning position. Previously, computer searches had demonstrated that this was true only for arrays up to 130,000 columns long.

The researchers also provide a probabilistic answer to what the opening move should be in a given situation. So, given a combinatorial game's geometric structure, it may be possible to efficiently zero in on areas where winning moves are most likely to lie.



COOKIE SHEETS — Three coordinates, *x*, *y*, and *z*, specify any possible game configuration in three-row Chomp. The plot above reveals the geometry of three-row Chomp when $x = 600$, with instant-winner locations shown as blue dots throughout the graph. The instant-winner sheet for $x = 300$ (right) has a similar geometric structure.

NEW PATHWAYS Going beyond Chomp, Landsberg and Friedman conjecture that re-normalization methods can extract probabilistic information about winning any given combinatorial game, even when no simple formula or efficient algorithm appears to be available for computing winning positions.

This suggests a natural pathway toward a new class of algorithms for solving a wide range of combinatorial games. "Finding good algorithms for solving or approximating [simple combinatorial games] is a first step toward understanding the much more complex games that arise at the intersection of computer science and economics," Landsberg says.

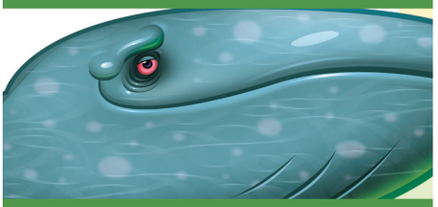
Moreover, one of the hallmarks of dynamical systems and chaos theory is the concept of sensitivity to initial conditions. In effect, one can't predict the long-term behavior of a dynamical system because of the rapid growth of small uncertainties present at a system's setup. Because combinatorial games exhibit a related behavior, it's also possible to characterize a game's sensitivity to, for example, apparently minor rule changes and to classify games on the basis of that trait. For example, Chomp gives a different geometric representation than the game Nim, where players alternately remove items from three piles (see cover).

"Our re-normalization technique for games is not a formal proof," Landsberg notes. Although re-normalization methods work astonishingly well in physics applications, they aren't mathematically rigorous.

Whether this novel, physics-based approach to combinatorial games is broadly applicable is uncertain at this stage, Landsberg says. Chomp and its variants represent just a handful of all combinatorial games.

The new results for Chomp don't even give you a foolproof strategy for winning. But they do show why it's hard to find the winning move. ■

FRIEDMAN AND LANDSBERG



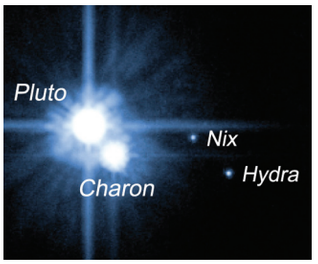
OF NOTE

PLANETARY SCIENCE

Some deadly monikers

Pluto and its large moon Charon have some company in the underworld. Two recently discovered small moons orbiting Pluto have now been officially dubbed Nix and Hydra. Nix is the mythological goddess of the night. One of Nix's offspring was Charon, who ferried the dead across the river Styx to hell. Hydra was a nine-headed, poisonous serpent that resided at the gate.

Discovered by astronomers using the Hubble Space Telescope in 2005, Nix and Hydra are about 0.02 percent as faint as Pluto and lie two to three times farther from Pluto than Charon does (*SN: 11/5/05, p. 291*). A ground-based telescope revealed Charon in 1978.



UNDERWORLDS Two recently discovered small moons of Pluto are now officially named Nix and Hydra. Pluto's large moon Charon was discovered in 1978.

The International Astronomical Union, the authority charged with naming celestial bodies, announced the Nix and Hydra designations on June 21.

Nix and Hydra may share more than their underworld names with Charon. The three moons may have a common origin, suggest William R. Ward and Robin Canup of the Southwest Research Institute in Boulder, Colo. The three moons have similar orbital features, which indicate that they all coalesced from the debris created when a large object banged into Pluto early in the history of the solar system, Ward and Canup argue in an upcoming *Science*. Their calculations suggest that Charon initially had an elongated orbit, which over time pushed Nix and Hydra into the more distant paths around Pluto that they now occupy. —R.C.

ZOOLOGY

Stilts for ants make case for pedometer

Gluing pig bristles to ant legs to lengthen their strides or trimming the insects' legs to shorten their steps distorts their judgments of distance, say researchers.

The distortions offer the first experimental evidence in any animal of a built-in odometer based on strides, says Harald Wolf of the University of Ulm in Germany.

Wolf and his colleagues studied the ant *Cataglyphis fortis* of the Sahara. Even though the landscape looks flat and featureless, foragers move this way and that until they find food and then make a more direct trip home.

Past research revealed that the ants judge direction by sun position and light polarization. As long ago as 1904, theorists proposed that ants measure distance by their own strides.

In Tunisia, Wolf and his colleagues tested this idea for the first time. They trained ants to trot along a 10-meter-long runway between a nest and a feeder. Once ants were familiar with the route, the researchers caught some at the feeder and modified the length of their legs. Researchers then put the test ants on a different runway parallel to the training course. The ants resumed their normal behavior, quickly accepting a crumb and heading in the direction of home.

Those with shortened strides underestimated the distance, starting to look for the nest when they had traveled only 6 m instead of the usual 10 m. Ants on pig-bristle stilts, however, scurried some 15 m before looking for the nest.

After a day or two on the new legs though, the ants could gauge the distance correctly, as if they'd reset their odometers, researchers report in the June 30 *Science*. —S.M.

BEHAVIOR

Why people punish

Many people say that they believe in punishing criminals only to deter further offenses, but a study of people's decisions as mock jurors overwhelmingly suggests that they would punish lawbreakers for the purpose of retribution.

"What's fascinating is that people don't seem to know why they punish," says Kevin Carlsmith of Colgate University in Hamilton, N.Y. Scientists call the main categories of punishment utilitarian, for deterring crime, and retributive, for making a criminal suffer.

Few previous studies have explored what motivates punishments, and those studies simply asked people why they favored a sentence. Carlsmith's three-part study, which appears in the July *Journal of Experimental Social Psychology*, evaluates the type of information people consider when deciding on a punishment.

In the first test, 132 subjects imagined themselves as jurors and ranked crime-related information in order of its relevance to a sentence. They consistently ranked retributive information, such as criminal intent, higher than utilitarian information, such as a criminal's record.

In a second test, 42 subjects received nine pieces of information relating to a crime and selected which was most useful in determining a sentence. Ninety-seven percent of subjects chose a piece of retributive information.

A final test revealed that 35 subjects who based their sentences on retributive information were substantially more confident that the punishment they had selected was correct than were subjects who based their sentences on utilitarian information.

Previous research had shown that when asked for the justification behind criminal punishment, people generally split their responses between utility and retribution. Asking someone why he or she would impose punishment is a flawed method because people often don't know what's behind their decisions, says John Darley of Princeton University. —E.J.

BOTANY

Orchid bends around to insert pollen

Researchers studying an orchid in a parched, windless habitat have discovered a new twist on self-pollination.

Other flowers pollinate themselves, but none has been reported to do so as acrobatically as the flowers of *Holcoglossum amesianum*. The orchid grows on trees in the forests of Yunnan, China. It blooms during the dry season, from February through April, says LaiQiang Huang of Tsinghua University in Shenzhen, China. While observing 10 orchid populations over three flowering seasons, Huang and colleagues never saw an insect visit a bloom. It wasn't a windy place, either, Huang says.

Nevertheless, the flowers manage quite well, the researchers report in the June 22 *Nature*. All the flower's sexual organs sit on a single protrusion from the bloom. The researchers observed that when the blossom matures, a little cap drops off the protrusion, revealing two pollen-covered organs that look like orange lollipops. Each

A. STERN ET AL., NASA, ESA

OF NOTE

slowly twists as it grows until its end pushes into a little pocket on the protrusion's underside, where the female organ, or stigma, lies. —S.M.

GENETICS

Mammoths: Blondes and brunettes?

The wool of woolly mammoths may have come in at least two shades, according to new genetic research.

Scientists have dug up several of the Pleistocene-era beasts in recent years, and a few well-preserved specimens have yielded remains of the animals' distinctive hairy coats. However, scientists weren't sure whether the color variations they've seen represent mammoths' true hues, notes evolutionary biologist Michael Hofreiter of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany.

"No one knew whether differences in hair color came from genetic differences between animals or from storage in the soil for 10,000 years," says Hofreiter.

To investigate, he and his colleagues examined a gene called *mc1r*, isolated from the leg bone of a 43,000-year-old mammoth. A similar gene controls color in a variety of other animals, including people, mice, and chickens.

The researchers found distinct differences between the two copies of *mc1r* present in each mammoth-bone cell, suggesting that the gene existed in at least two forms with varying activity.

Previous research had shown that less active versions of *mc1r* are responsible for lighter hair color in mice and people. The less active gene variant probably led to lighter shades of woolly mammoths as well, the team reports in the July 7 *Science*. —C.B.

BIOMEDICINE

Ingredient might prevent sexually transmitted disease

A seaweed derivative that's commonly added to baby food, lubricants, and other consumer products as a thickening agent can inhibit the virus that causes cervical cancer and genital warts.

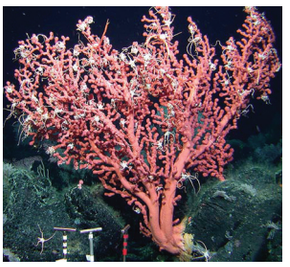
About 20 million Americans are infected with the human papillomavirus (HPV). Although people can reduce their chances of acquiring HPV by using condoms (*SN: 6/24/06, p. 387*) or receiving a new vaccine (*SN: 10/15/05, p. 243*), scientists have long sought a chemical that could be a topical HPV microbicide.

While studying chemicals that affect HPV's penetration of cells, Christopher Buck and his colleagues at the National Cancer Institute in Bethesda, Md., realized that the seaweed derivative carrageenan has a molecular structure that might block the virus.

Sure enough, when the researchers mixed carrageenan and HPV with human cells in a test tube, individual viruses couldn't get inside the cells. No other microbicides known to inhibit HPV infection worked as well at carrageenan's effective dose, says study co-author John Schiller, also of the National Cancer Institute.

Since carrageenan is a common ingredient in a variety of consumer products, including some sex lubricants, the researchers tried the same test with lubricants containing carrageenan and those without it. Only the carrageenan-containing lubricants inhibited HPV particles from entering cells, the researchers report in the July *PLoS Pathogens*.

Though carrageenan-containing products prevent HPV infection in the lab, Schiller notes that it's too early to say whether they do so in people. "Until we do clinical trials, we don't want people modifying their behavior based on false ideas of how carrageenan can protect them," he says. —C.B.



SEA TREE Growing several meters high, hot-pink soft corals can host living ornaments, such as brittle stars, in their branches.

ENVIRONMENT

Alaskan coral beds get new protection

Huge tracts of delicate coral gardens and soft-coral forests off the coast of Alaska will be permanently protected from fishing gear that targets groundfish and shellfish by scraping the seafloor.

Most of the affected sites have never been disturbed by this gear. The National Oceanic and Atmospheric Administration (NOAA) on June 28 announced its new rule to preserve that situation, which will take effect July 28. The rules don't address nets or long-line fishing practices that don't disturb the sea bottom.

The largest area to be protected, off the Aleutian Islands, covers 279,000 square nautical miles, an expanse the size of Texas and Colorado combined. Some sites were chosen to protect rockfish habitats. Others protect dense thickets of red tree corals or the unusual communities that have developed around seamounts.

NOAA's new rule is "a big deal," says Elliott A. Norse, president of the Marine Conservation Biology Institute in Bellevue, Wash. Not only does it conserve "a colossal area," he says, but "more importantly, it establishes the principle that bottom trawling is a really severe threat to slow-growing seafloor ecosystems." Trawling particularly damages deep-sea corals and sponges, he says (*SN: 10/26/96, p. 268; 8/7/04, p. 88*). He notes the new rule also establishes that "we shouldn't let trawling expand into new areas." Indeed, he explains, "the pass of a trawl that does the most devastation to fragile seafloor ecosystems is not the hundredth or even the thousandth—it's the first." —J.R.

EARTH SCIENCE

Global warming heats up nursery of hurricanes

A record number of tropical storms and hurricanes formed in the North Atlantic last year (*SN: 12/24 & 31/05, p. 406*). One factor driving this unprecedented activity was the unusually warm waters there, and global warming was largely to blame, says Kevin E. Trenberth, an atmospheric scientist at the National Center for Atmospheric Research in Boulder, Colo.

Between June and October 2005, the average sea-surface temperature in the region between Africa and the Caribbean where such storms typically form was 0.92°C above the average recorded there between 1901 and 1970. That 70-year period predates a recent surge in temperatures worldwide, report Trenberth and Dennis J. Shea, also of the center.

By analyzing oceanographic data gathered around the world, Trenberth and Shea estimate that less than 0.1°C of last year's North Atlantic temperature anomaly resulted from long-term variations in a regional climate cycle called the Atlantic Multidecadal Oscillation. About 0.2°C stems from the aftereffects of an El Niño.

About 0.45°C comes from climate changes that boosted sea-surface temperatures worldwide. The remainder of the anomalous warmth, around 0.2°C, reflects normal year-to-year variation in weather, Trenberth and Shea report in the June 28 *Geophysical Research Letters*. —S.P.

Books

A selection of new and notable books of scientific interest

A MIND OF ITS OWN: How Your Brain Distorts and Deceives

CORDELIA FINE

The human brain has the amazing capacity to simultaneously perform multiple tasks of perception, emotion, and reasoning, making it the most powerful computational tool in existence. Fine, a psychologist, nevertheless examines a side of our brains that few people focus on or are consciously aware of: the side that distorts reality. Our brains do that, Fine explains, to protect our egos from unpleasant truths or to maintain a sense of control and continuity in an otherwise unpredictable world. Citing the latest psychological research but writing in an informal style, she shows readers how greatly emotions, whether or not we are aware of them, can affect our decision making. The author also reveals the great lengths to which a person's mind will go to protect his or her sense of self-esteem or belief in a just world. Fine probes what separates everyday delusions, such as the experience of déjà vu or fleeting hallucinations, from the delusions of madness. She explains why people find it easy to believe what they're told and difficult to doubt it and why brains are so susceptible to the power of suggestion. ***Norton, 2006, 243 p., hardcover, $24.95.***

OGALLALA BLUE: Water and Life of the High Plains

WILLIAM ASHWORTH

Beneath the sprawling, flat midsection of this country lies an underground aquifer, called the Ogallala that's large enough to fill Lake Erie nine times over. This water is what makes possible the area's crops of corn, cotton, wheat, and sorghum. However, Ashworth notes, the store of water is rapidly shrinking. People are pumping water from the Ogallala three times as fast as rain, runoff, and snowmelt can replace it. Five trillion gallons of water are pumped from the Ogallala aquifer annually, and if that resource ever dries up, more than $20 billion worth of food and fiber would be quickly lost from the world market. Ashworth chronicles the history of the aquifer and people's increasingly sophisticated methods of tapping it. The author also details various efforts under way, planned, and proposed for helping natural processes recharge the aquifer. ***Norton, 2006, 330 p., hardcover, $26.95.***

BIG COAL: The Dirty Secret behind America's Energy Future

JEFF GOODELL

In support of a homegrown energy source that might lessen this country's reliance on Middle East oil, some politicians have recently touted coal. The Department of Energy estimates that the United States has 270 billion tons of recoverable coal, enough to power U.S. homes, offices, and factories for 250 years. However, Goodell reveals in this book why coal may not be the answer to our energy woes, especially in light of the century-long toll coal has already taken on the environment and people's health. He begins with the inherent danger in coal mining to the people who work underground, as evidenced by several recent tragedies. He details how coal-burning furnaces contribute to air pollution, producing almost 40 percent of the greenhouse gas carbon dioxide that is released into U.S. air by all sources. People living near power and manufacturing plants operating such furnaces are plagued by health problems. Overall, Goodell attempts to remove what he claims is a veil of denial about the effects of coal as an energy source. ***Houghton Mifflin, 2006, 324 p., hardcover, $25.95.***

WHEN A GENE MAKES YOU SMELL LIKE A FISH: And Other Tales about the Genes in Your Body

LISA SEACHRIST CHIU

Trimethylaminuria, otherwise known as fish odor syndrome, is a devastating condition whose origin, until recently, remained mysterious. Sufferers emit a foul smell that no amount of hygiene can remove. The disease's mystery was solved when scientists discovered that mutations in a gene known as *FMO3* prevent the body from breaking down a smelly substance found in foods high in protein. The discovery, a direct result of scientists' success in sequencing the human genome, could be the first step to curing this unusual and embarrassing disease, writes journalist Seachrist Chiu. She highlights other unique conditions with recently discovered genetic origins, such as a type of cerebral palsy found disproportionately among the Amish and a condition that makes certain animals and people abnormally sensitive to the sun (and that may account for the madness of King George III). These conditions can be attributed to the workings, or malfunctions, of specific genes. Seachrist Chiu focuses not only on odd genetic effects, but also the many less-dramatic traits attributable to genes. Examples include right- or left-handedness, male-pattern baldness, and whether or not we can stomach milk. In telling these stories, the author explains how genetic information controls human traits. ***Oxford, 2006, 219 p., b&w illus., hardcover, $27.00.***

MANY WORLDS IN ONE: The Search for Other Universes

ALEX VILENKIN

Cosmologists have amazing stories to tell about the beginning of the cosmos. Most people are somewhat familiar with the Big Bang, the theory that the universe emerged from a great eruption of matter and energy 14 billion years ago. In this fascinating book, Vilenkin, a professor of physics at Tufts University, outlines some of the more recent cosmological ideas that may be harder for the layperson to accept. He introduces readers to the notion of repulsive gravity and inflation and the idea that these processes will make the universe expand forever. He also outlines a theory that suggests an infinite number of histories exactly identical to our own, populated by duplicates of ourselves who are scattered throughout the universe. ***Farrar, Straus, and Giroux, 2006, 235 p., b&w illus., hardcover, $24.00.***

HOW TO ORDER Visit *http://www.sciencenews.org/pages/books.asp* to order these books or others. A click on the link under a book will transfer you to Barnes & Noble's Internet bookstore. Sales generated through these links contribute to Science Service's programs to build interest in and understanding of science.

LETTERS

First, count all the lawyers

The study in "Legal Debate: Assumptions on medical malpractice called into question" (*SN: 5/13/06, p. 291*) fails to address the more disturbing issue: Most of the insurance money (apparently) goes to lawyers (both sides), and very little to those injured.

PETER WILSON, SIMI VALLEY, CALIF.

The numbers in the story pose a question. First, one reads that "about 85 percent of [1,452] cases were settled out of court, and plaintiffs lost four-fifths of those that did go to trial." This means that about 175 cases went to court and failed. Two paragraphs later, we learn that "236 plaintiffs who did suffer an injury from medical error received no compensation." The question: Did 61 cases settle out of court for no compensation?

FRED RAMSEY, CORVALLIS, ORE.

According to the study, plaintiffs' attorneys typically received a standard contingency fee of 35 percent of the indemnity (insurance) payment, if one was made. And it's true that 236 plaintiffs who suffered real injury traceable to medical error received no compensation. Of those, 170 plaintiffs lost in court and 66 just dropped their case at some point, the researchers say. —N. SEPPA

Aye for an eye

Regarding the "new humanmade version of an insect's compound eye" ("Rounding out an insect-eye view," *SN: 5/20/06, p. 318*), it has been obvious for many years that such structures need not be exceptionally small and need not be extremely like ommatidia to behave like ommatidia. Triads of small light sensors can be arrayed in large, wide, and slightly concave or convex panels and hardwired into networks capable of not only sensing but also of tracking motion—in color. Many practical advantages accrue from the fact that such panels do not resemble "eyes" and are therefore ignored by subjects who would be aware of cameras. I find the suggestion that such devices are extremely high tech and difficult to make somewhat disingenuous.

DAVID C. OSHEL, CEDAR RAPIDS, IOWA

SEND COMMUNICATIONS TO:
Editor, Science News
1719 N Street, N.W., Washington, D.C. 20036
or editors@sciencenews.org
All letters subject to editing.

From the company that first introduced noise reducing headphones.

The next step.

NEW Bose® QuietComfort® 3 Acoustic Noise Cancelling® Headphones

Now you have a choice. We began researching noise reduction technology 28 years ago. Since then, we've been leading the industry in advancing the category we created.

New QuietComfort® 3 headphones represent the latest achievement. They rest on your ears rather than surrounding them. And while they are smaller than our highly acclaimed QuietComfort 2 headphones, there is no compromise in noise reduction, sound quality or comfortable fit. So now you have a choice: QC™2 headphones for around-ear use, and new QC3 headphones if you prefer a smaller, on-ear alternative.

QC2 headphones (left). New QC3 headphones (right).

The challenge of reducing size. Studies show that many people prefer on-ear headphones. But with conventional technology, smaller earcups compromise performance. So we launched a research project to explore something we were not sure was even possible – overcoming the performance limitations of smaller size and on-ear design.

The result is our new QC3 headphones. For the first time, you have the option of on-ear headphones that match the noise reduction and audio quality benefits of our award-winning QC2 headphones.

FOR
TRAVEL
WORK
HOME

Hear the difference Bose technology makes. You will notice a dramatic decrease in engine roar on a plane. The cabin becomes more peaceful. Connect your CD player, MP3 player, or listen to the in-flight movie. You'll hear detail you may have never experienced while flying.

But use them at home or at the office, too. Although the noise reduction will be more subtle, you should notice distractions fading softly into the background. No headphones will eliminate all noise, but patented Bose® noise reduction and audio technologies, working together, can make any listening experience more enjoyable.

Try them for 30 days at no risk. Choose new QC3 headphones for an on-ear fit, or QC2 headphones for an around-ear design. Both come with our 30-day Excitement Guarantee. Take advantage of **12 easy payments,** with no interest charges from Bose.* And ask about our optional Cell Connect cable for use with select music-enabled mobile phones. QuietComfort headphones. Engineered exclusively by Bose, the most respected name in sound.

FREE shipping with your order.

Fold-flat design for easy storage.

To order or learn more about Bose headphones:

1-800-901-0256, ext. Q4901

QC3.bose.com

BOSE®
Better sound through research®

*Bose payment plan available on orders of $299-$1500 paid by major credit card. Additional financing offers may be available for select products. See website for details. Down payment is 1/12 the product price plus applicable tax and shipping charges. Then, your credit card will be billed for 11 equal monthly installments with 0% APR and no interest charges from Bose. Credit card rules and interest may apply. U.S. residents only. Limit one active financing program per customer. Financing and free shipping offer not to be combined with other offers or applied to previous purchases, and subject to change without notice. Risk free refers to 30-day trial only and does not include return shipping. Delivery is subject to product availability.