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SCIENCE NEWS

THE WEEKLY NE ZINE OF SCIENCE

ineffective juvenile justice

bad side of the galaxy

fossilized treetops

toward better measurements

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bytes and beats

THE WEEKLY NEWSMAGAZINE OF SCIENCE

SCIENCE NEWS

APRIL 21, 2007 VOL. 171, NO. 16

Features

This Week

THIS WEEK ONLINE
http://blog.sciencenews.org/

Food for Thought Certain antioxidants and magnesium, in combination, can limit the risk of noise-induced hearing loss.

MathTrek 300 years after Leonhard Euler's birth, his equation $e^{i\pi} = -1$ remains among the most elegant in mathematics.

Of Note

Departments

Cover A soloist can now practice accompanied by software representing other musicians. Researchers are teaching computers to convert scores into sound, follow a soloist's lead, and recognize beat, rhythm, melody, harmony, tempo, and other musical elements. (Dean MacAdam) Page 248

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Violent Justice

Adult system fails young offenders

State laws that send some individuals under age 18 to trial and prison as adults have achieved the opposite of what the policy's proponents intended, a new research review concludes. Transferring young people into adult systems yields substantially higher rates of later serious crimes compared with youths handled by juvenile-justice systems.

Moreover, there's no evidence that shifting some young offenders to the adult-justice system prevents or reduces violence in the general population of children and teenagers.

These findings come from the 14-member Task Force on Community Preventive Services, an independent group funded by federal and private sources. It's reviewing the effectiveness of various efforts to lessen violence committed by and against youths.

The task force reports that young offenders transferred to the adult system are later arrested for violent and other crimes 34 percent more frequently than are their peers sent to juvenile courts and facilities. The task force compared juveniles charged with comparable offenses. Its report appears in a supplement to the April *American Journal of Preventive Medicine*.

"Even given problems in the juvenile-justice system, transfer to the adult-justice system produces even worse results," says epidemiologist and task force member Robert A. Hahn of the Centers for Disease Control and Prevention in Atlanta.

Beginning around 35 years ago, increases in violent juvenile crime spurred many states to modify laws so that young people could be tried as adults for serious crimes. By 2004, 44 states and the District of Columbia permitted judges to transfer juveniles to adult-criminal courts. No national data exist on the number of juvenile offenders prosecuted as adults.

Hahn and his colleagues reviewed studies that had compared subsequent serious offenses by juveniles who had been tried and incarcerated either as juveniles or as adults. The team selected six studies that met its quality criteria. The data included youths who had originally committed serious crimes in Florida, Minnesota, Pennsylvania, Washington State, or New York. The studies' follow-up periods after prison releases ranged from 18 months to 6 years.

The researchers then identified three studies that assessed whether states' adoptions of transfer laws led to a drop in serious crimes committed by young people. These data came from Idaho, Washington State, and New York. Although transfer policies vary considerably from state to state, available evidence indicates that they are "counterproductive for reducing juvenile violence and enhancing public safety," the task force concludes.

The increase in criminal offenses among youths transferred to the adult-justice system is "a very robust empirical finding," says criminologist Jeffrey A. Fagan of Columbia University, who directed one of the studies included in the report. Individuals as young as 15 years old may end up in adult court when charged with certain offenses, such as murder or robbery, Fagan notes.

The task force report illustrates the need to restrict adult-court cases to people over age 18, with rare exceptions, remarks Michael Tonry of the University of Minnesota in Minneapolis.

Many state-run programs for juvenile offenders achieve poor results, although innovative programs can improve behavior, says Peter W. Greenwood, who heads Greenwood and Associates, a juvenile-justice consulting firm in Malibu Lake, Calif. In Florida and Pennsylvania, for instance, teams of professionals provide services and counseling to offenders' families.

It's unclear whether state lawmakers will take the new task force report to heart and restrict transfers. "The politics of crime are far behind the science of criminality," Fagan says. —B. BOWER

Forest Primeval

The oldest known trees finally gain a crown

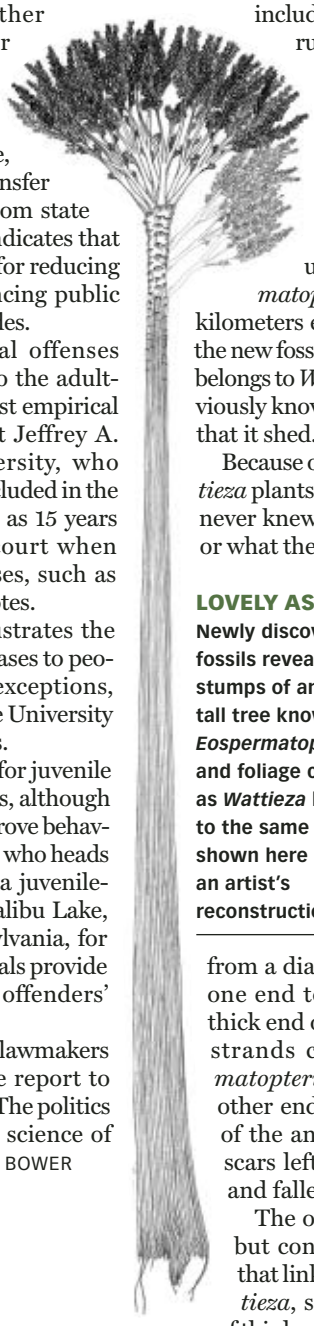
For more than a century, the world's earliest known trees were represented only by preserved stumps. Now, fossils recently unearthed in upstate New York reveal the tops of those trees.

In the early 1870s, paleontologists discovered fossilized stumps in a riverbed near Gilboa, N.Y. In the 1920s, quarrymen excavated dozens more nearby. Those 0.5-to-1.5-meter relics, preserved upright in rocks about 385 million years old, are considered to be the remains of Earth's oldest forest, says William E. Stein, a paleobotanist at Binghamton (N.Y.) University.

Distinguishing features of the species, dubbed *Eospermatopteris eriana*, include a series of fibrous strands running up and down the tree trunk. Those strands probably transported water to the upper reaches of the tree and strengthened the trunk, says Stein.

Paleontologists in 2005 discovered two fossils of upper parts of an *Eospermatopteris* tree at a site about 13 kilometers east of Gilboa. Surprisingly, the new fossils indicate that the tree's top belongs to *Wattieza*, a genus of plant previously known solely from the branches that it shed.

Because only small fragments of *Wattieza* plants had been found before, "we never knew how big these plants were or what they looked like," says Christopher M. Berry, a paleobotanist at Cardiff University in Wales. He, Stein, and their colleagues describe their new finds in the April 19 *Nature*.



LOVELY AS A TREE **Newly discovered fossils reveal that the stumps of an ancient tall tree known as *Eospermatopteris* and foliage classified as *Wattieza* belong to the same plant, shown here in an artist's reconstruction.**

F. MANNOLINI/N.Y. STATE MUSEUM

One of the new fossils is a 6-m-long section of trunk, which tapers from a diameter of 47 centimeters at one end to 13 cm at the other. The thick end of the log shows the fibrous strands characteristic of *Eospermatopteris* stumps, says Stein. The other end, presumably near the top of the ancient tree, is covered with scars left where branches had died and fallen off.

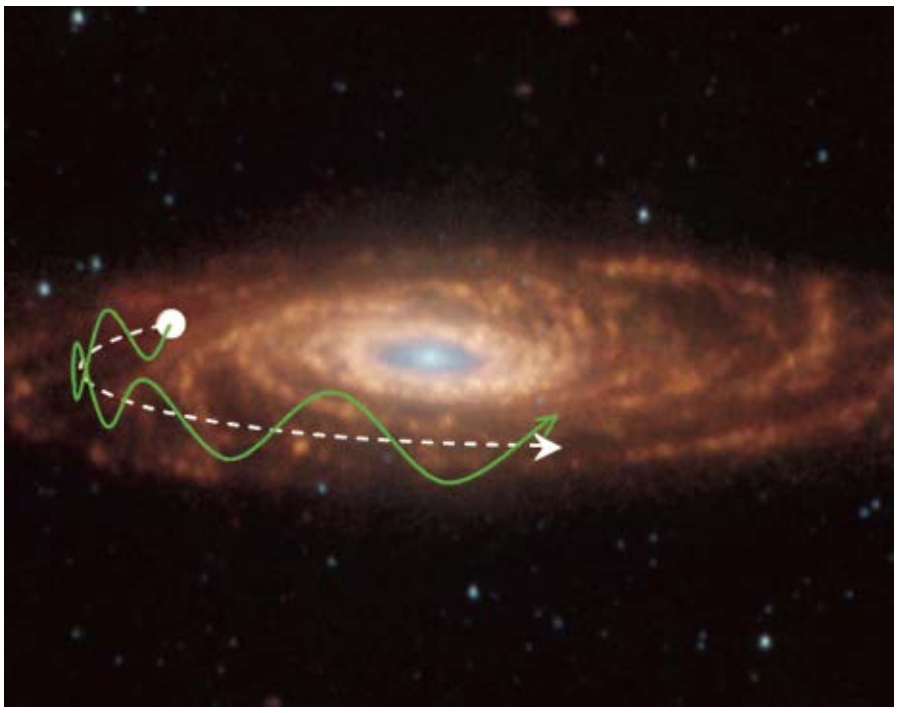
The other fossil is much shorter but contains the critical evidence that links *Eospermatopteris* to *Wattieza*, says Stein. The thicker end of this log bears scars where branches had once grown, but the crown of the plant retains branches that were alive when the tree fell. Each branch was about 1 m long and 6 cm across at its base, says Stein. Instead of having leaves, the branch just divided as it grew, and then divided again and again. The end of a mature branch looked like a bottle brush.

The team estimates that the fossils rep-

resent trees about 8 m tall. Some of the stumps found at Gilboa had about twice the diameter of the new specimens, so the trees there were probably much taller, says Stein.

The scientists presume that each branch contained chlorophyll. But because they lacked leaves, the ancient trees' branches probably weren't efficient at collecting light, says Brigitte Meyer-Berthaud, a paleobotanist at the French National Center for Scientific Research in Montpellier.

Nevertheless, these trees—"probably the biggest on Earth at the time," Meyer-Berthaud notes—succeeded because their height enabled them to spread spores more effectively than their competition did. —S. PERKINS



COSMIC PERIL As the Milky Way (represented here by a similar galaxy) whirls around, the solar system's wobbly trajectory (green curve) periodically exposes Earth to harsh cosmic rays. The white dashed line shows the sun's motion as it would appear in the plane of the galaxy.

Northern Exposure

The inhospitable side of the galaxy?

The solar system's periodic visits to the northern side of the Milky Way expose life on Earth to extra cosmic rays that have caused catastrophic mass extinctions, two astrophysicists propose.

Biodiversity has had well-known ups and downs over the eons, with major extinctions followed by rebounds. In a 2005 study, Robert Rohde and Richard Muller of Lawrence Berkeley (Calif.) National Laboratory found that these swings were surprisingly regular, most of them taking place at intervals of about 62 million years. The researchers reached their conclusion after examining one of the most comprehensive long-term biodiversity surveys, a compilation of fossil data that charted the number of marine-life genera over the past 500 million years.

The extraordinary dinosaur kill 65 million years ago doesn't fit in the cyclic pattern, and experts widely blame it on the impact of a large asteroid.

To explain the cyclic pattern of mass extinctions, Rohde and Muller considered a phenomenon that has just about the right periodicity. As the solar system orbits around the galaxy, it swings from one side to the other of the galactic plane every 63 million years. Gravity from the rest of the galaxy's mass pulls the solar system back each time.

Perhaps when the sun is at the maximum distance from the galactic plane, Earth's biodiversity is at greatest risk, Rohde and Muller speculated. But that would put mass extinctions every 31.5 million years, not every 63 million. It wasn't clear why one side of the galaxy's plane would be more dangerous to life than the other.

Mikhail Medvedev and his colleagues of the University of Kansas in Lawrence now propose an explanation that rests on variations in the number of high-energy particles, known as cosmic rays, that strike Earth from space. They argue that because the galaxy is moving toward a large cluster of galaxies in the direction of the Virgo constellation, cosmic rays would be more abundant on the galaxy's north side—according to the view from Earth.

A particle flow similar to the solar wind emanates from the Milky Way as a whole, and as the galaxy moves, that wind runs into the tenuous medium that pervades intergalactic space. The collision creates a shock wave. The Kansas team calculates that when electrically charged particles rebound within the shock wave, they gain enough energy to turn into cosmic rays.

When a cosmic ray hits the upper layers of the atmosphere, it triggers a shower of millions of energetic electrons and other particles, some of which can penetrate to land and into the oceans. The particles have a variety of effects. For example, they may alter cloud coverage or damage DNA, with potentially fatal consequences for entire species.

"Drops in biodiversity correspond to peaks in cosmic rays," Medvedev says. However, he and his colleagues stress that they haven't identified the mechanism linking cosmic rays and extinctions.

"I was stunned when I learned that [Medvedev's team] had succeeded where we had failed" at explaining the 62-million-year cycle, Muller says.

Charles Dermer, an astrophysicist at the Naval Research Laboratory in Washington, D.C., says that the new explanation is "very tantalizing" but that it rests on Rohde and Muller's biodiversity cycles, which are not firmly established.

Medvedev and his colleagues say that the cosmic ray bombardments would also increase gamma rays from the north side of the galaxy, a prediction that new gamma-ray observatories may test in the next few years.

The researchers presented their work this week, in Jacksonville, Fla., at a meeting of the American Physical Society. The report is also due to appear in *Astrophysical Journal*. —D. CASTELVECCHI

A New Low

Lilliputian pipette releases tiniest drops

Physicists have constructed a pipette that dispenses a billionth of a trillionth of a liter, a droplet that's a thousand times as small as volumes previously achieved. The behavior of these zeptoliter-size drops challenges

MEDVEDEV/ UNIV. KANSAS

an accepted theory describing how drops crystallize as they cool, the researchers say.

To build the pipette, Eli A. Sutter and Peter W. Sutter of the Brookhaven National Laboratory in Upton, N.Y., started with a germanium nanowire. It supports an initially solid reservoir of a gold-germanium alloy. A carbon shell encapsulates the assembly, which is about 2 micrometers long.

The researchers place the pipette in a vacuum chamber within a transmission-electron microscope. To dispense liquid, they melt the reservoir of gold-germanium alloy and then focus a beam of electrons on the tip. The beam punctures the carbon shell, Peter Sutter says.

The liquid alloy oozes through the hole and slowly forms a drop up to 40 nanometers in diameter and 35 zeptoliters in volume. "It's the smallest amount of fluid that, to our knowledge, anybody has dispensed in a controlled fashion," Peter Sutter says.

A filament of liquid alloy connects the drop to the tip. Having the drop almost free of contact makes it useful for studies of crystallization, explains Peter Sutter. Typically, researchers have supported drops on another surface, which influences how they crystallize.

For their crystallization studies, the researchers slowly cooled the pipette and its drop until they were a few degrees above the liquid alloy's freezing temperature of 300°C. At this temperature, the electron microscope images show that inside the drop, the alloy remained liquid. But "what used to be a round drop all of a sudden isn't round anymore," Peter Sutter says. Areas on the drop's surface developed facets, a property associated with solids.

The facets disappeared and reappeared across the surface until the alloy reached its freezing temperature, at which point the drop solidified completely.

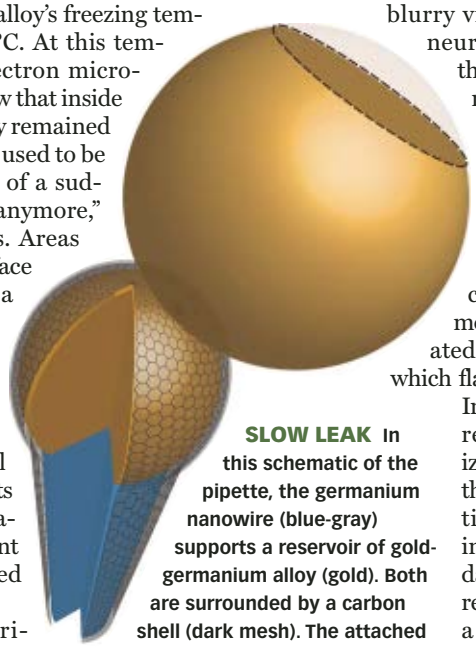
These experiments call into question the common view that crystallization in liquid drops proceeds from the inside out. "We see at the surface that solidlike behavior sets in at a temperature where the interior of the drop is still liquid," Peter Sutter says.

The observed mechanism may govern the crystallization of nanometer-size metal-alloy drops in general and possibly the freezing of other liquid drops, the researchers report online and in an upcoming *Nature Materials*.

The report combines a "very nice" technical achievement with a convincing finding, comments Uzi Landman, a physicist at the Georgia Institute of Technology in Atlanta.

"It's the first experimental proof" of this mode of crystallization, Landman says. To determine how general the effect is, "it would be nice to see more examples of different types of materials," he adds.

The Brookhaven scientists say that they have begun building pipettes that dispense different metal alloys. —A. CUNNINGHAM



E. AND P. SUTTER

SLOW LEAK In this schematic of the pipette, the germanium nanowire (blue-gray) supports a reservoir of gold-germanium alloy (gold). Both are surrounded by a carbon shell (dark mesh). The attached droplet of melted alloy shows a temporary surface facet.

Visual Clarity

People with MS maintain eyesight with drug

A medication prescribed to limit nerve damage caused by multiple sclerosis also seems to prevent subtle vision loss in many patients.

People with multiple sclerosis (MS) experience pain, weakness, loss of muscle control, and slurred speech as a result of inflammatory damage to the fatty sheaths that insulate nerves. More than half of people with the illness also have episodes of blurry vision caused by optic neuritis, inflammation of the nerves that carry signals from the eyes to the brain.

In 2004, the Food and Drug Administration approved the drug natalizumab (Tysabri) for MS after two clinical trials found that monthly injections alleviated some MS symptoms, which flare up during relapses. In one trial, participants received either natalizumab or a placebo. In the other trial, all the participants were taking interferon beta, a standard MS drug, and also received natalizumab or a placebo.

Natalizumab stops nerve-sheath damage by neutralizing a protein that facilitates entry of inflammatory immune cells into the central nervous system (*SN: 3/4/06, p. 131*).

The new report analyzes the data on visual acuity that were collected during the 2-year studies. In those trials, doctors monitored 2,113 patients' sight by using a standard eye chart with black letters and another chart, with pale-gray letters, that measures low-contrast vision. In both trials, natalizumab didn't affect the scores of the participants on the standard eye chart. But on the low-contrast chart, patients getting no natalizumab were more likely to show decreased acuity than were those getting the drug.

Laura J. Balcer, a neuro-ophthalmologist at the University of Pennsylvania in Philadelphia, and her colleagues report these results in the April 17 *Neurology*.

It's noteworthy that patients getting interferon beta plus natalizumab fared better than did those getting interferon beta alone, says Edmond J. FitzGibbon, a neuro-ophthalmologist at the National Eye Institute in Bethesda, Md.

Some doctors may be reluctant to prescribe natalizumab. Its label warns that the immune suppression triggered by the drug can unleash a latent virus that causes a rare nervous disorder.

The new work bolsters the value of testing for subtle vision impairments. Balcer says that many people with MS complain about their eyesight yet score 20/20 on the standard chart. However, they fare poorly on a low-contrast test.

Because low-contrast-vision impairments don't necessarily show up on a standard eye exam, "they have been underappreciated," says FitzGibbon. "You need contrast sensitivity when driving at night, in fog, or in low-light situations," he says.

For people with MS, low-contrast eye charts might offer an inexpensive yet effective tool for assessing vision, says Nicholas LaRocca of the National Multiple Sclerosis Society in New York. —N. SEPPA

Tenacious STD

Drug-resistant gonorrhea is spreading

Responding to a surge in tough-to-treat gonorrhea, the Centers for Disease Control and Prevention has stopped recommending a group of related antibiotics for the disease. Now, only one class of antibiotic—called cephalosporins—remains on the CDC's list of treatments for the second-most-common sexually transmitted disease in the United States.

"This is a bad bugs–no drugs issue," says Henry Masur, president of the Alexandria, Va.–based Infectious Diseases Society of America.

An estimated 1.4 million people in the United States contract gonorrhea each year, according to Masur's group. Left untreated, the disease can cause infertility in both men and women and can spread to the blood or joints where, in rare cases, it's fatal.

When the powerful antibiotic ciprofloxacin (Cipro) and its relatives were initially used, a single dose generally wiped out the infection. But in the 1990s, the CDC noted the emergence in Asia of ciprofloxacin-resistant gonorrhea.

This strain spread to men and women in Hawaii and California and to men elsewhere having homosexual encounters. By 2004, the CDC had stopped recommending ciprofloxacin treatment for these groups.

The bug continued spreading, and new data show that about 13 percent of gonorrhea infections across the United States are resistant to ciprofloxacin and the other fluoroquinolones.

"It isn't surprising, unfortunately," says Eileen Yee, an epidemiologist at the CDC in Atlanta. "It makes controlling [the spread of] gonorrhea difficult."

According to the CDC data, collected from sexually transmitted disease clinics, 7 percent of infections among heterosexual males are resistant. Among men who have sex with men, that figure is 38 percent. Women are not included in any of the new data, reported in the April 13 *Morbidity and Mortality Weekly Report*, which the CDC publishes.

In contrast to those data, ciprofloxacin resistance in 2001 showed up in less than 1 percent of gonorrhea infections in heterosexual men and in fewer than 2 percent of infections in men who have sex with men.

The CDC now lists just one recommended treatment for gonorrhea: injected or oral cephalosporin-class drugs. However, only an injected formulation is available for adults in the United States.

Masur joins the CDC in calling for drug companies to accelerate development of new antibiotics. But because antibiotics work in just one dose or a few doses, they're generally less profitable than drugs that patients take for months or years.

"The problem is that unless somebody guarantees them a market, no drug company wants to make a one-pill [treatment]," Masur says. "We need to find incentives for small companies or generic [manufacturers] to make this kind of drug."

A bill now in Congress would provide incentives for the research and manufacture of new antibiotics. —B. VASTAG

STATS

1.4 million

New U.S. cases of gonorrhea annually

Back to (Near) the Beginning

Galactic springtime

In their quest to capture ever-earlier moments of cosmic history, astronomers have found some of the first galaxies, a new study suggests.

The researchers used infrared and visible-light observations to compare the properties of two previously identified sets of distant objects: about 21 galaxies viewed as they appeared about 1.2 billion years after the Big Bang and 120 galaxies that are around a billion years older.

Before using the younger group to test ideas about the first stages of galaxy evolution, the astronomers needed to show that those galaxies were truly immature. Over the past few years, researchers have found several galaxies in the young universe that nevertheless have old populations of stars (*SN: 10/8/05, p. 235*).

The younger galaxies indeed show hallmarks of being in their first blush of youth, concludes Malcolm Bremer of the University of Bristol in England. Compared with the older, well-studied group, the 21 younger galaxies turned out, on average, to be smaller, have less of the elements heavier than helium, and have much less mass invested in stars. They were also making stars 10 times as rapidly. In fact, the 21 galaxies are converting gas into stars at a furious rate, each producing the equivalent of 500 new suns a year.

Most of the stars in the younger galaxies, the study found, are about one-third the age of stars in the older group.

Bremer reported his team's findings this week at the Royal Astronomical Society's annual National Astronomy Meeting in Preston, England. The group also describes its work in an upcoming *Monthly Notices of the Royal Astronomical Society*.

The report is "the first explicit demonstration I am aware of that we are seeing a step closer back toward the truly first galaxies," comments theorist Zoltan Haiman of Columbia University.

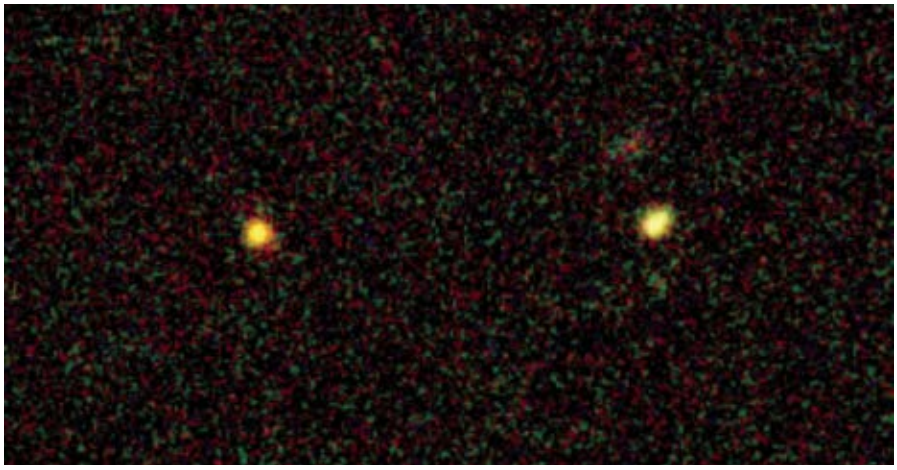
Bremer's team has captured the galaxies "at a special time," soon after star formation in those galaxies had switched on, says astronomer Richard Ellis of the California Institute of Technology in Pasadena.

The findings are in accord with the accepted model of galaxy formation, in which galaxies start out small and then grow by merging to form the massive galaxies, such as the Milky Way, seen in the universe today, say Bremer and his colleagues.

The combination of infrared observations—using NASA's Spitzer Space Telescope—and visible-light studies was critical to obtaining a complete census of the stars and stellar masses in the galaxies, notes Bremer. Visible-light observations reveal young, massive stars, while infrared detections disclose cooler, lower-mass stars.

Astronomers haven't yet come to the end of the line in their quest for the first galaxies, cautions astronomer Garth Illingworth of the University of California, Santa Cruz. Bremer's team may be viewing those 21 galaxies bursting into life, he notes, but he and others have observed a few other galaxies that date to even earlier times and are similarly immature.

To verify the new study of the early galaxies, astronomers will need to take spectra to confirm the age estimates of the stars and to measure the abundances of chemical elements, suggests Robert Kennicutt of the University of Cambridge in England. That work may require the Hubble Space Telescope's proposed successor, the infrared James Webb Space Telescope, he notes. —R. COWEN



EARLY LIGHT These two extremely remote galaxies, imaged by the Hubble Space Telescope, are among a group recently shown to be in the first burst of star formation.

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About Your Professor

Professor Arthur T. Benjamin is Professor of Mathematics at Harvey Mudd College, where he has taught since 1989. He earned a B.S. from Carnegie Mellon University in 1983 and a Ph.D. in Mathematical Sciences from Johns Hopkins University in 1989. The Mathematical Association of America honored him with regional and national awards for distinguished teaching in 1999 and 2000 and named him the George Pólya Lecturer for 2006–08.

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Computers are learning to understand music and join the band

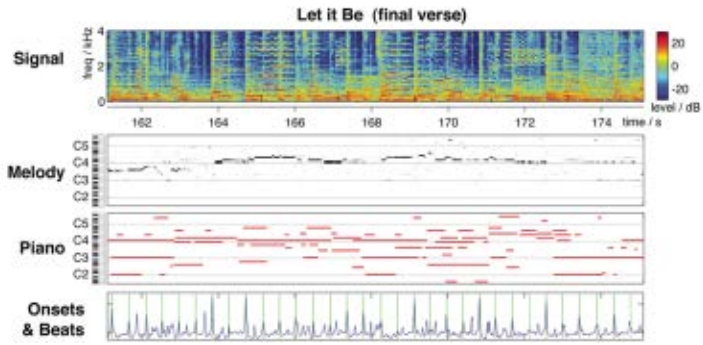
BY JULIE J. REHMEYER

Christopher Raphael begins the third movement of a Mozart oboe quartet. As his oboe sounds its second note, his three fellow musicians come in right on cue. Later, he slows down and embellishes with a trill, and the other players stay right with him. His accompanists don't complain or tire when he practices a passage over and over. And when he's done, he switches them off.

After all, his fellow musicians exist only as a recording. A software package, written by Raphael, controls their tempo and makes them respond to the soloist's cues.

Until recently, computers have had little insight into music. They've merely recorded it, stored it, and offered tools that people can use to produce or manipulate it. But now, researchers are teaching computers to recognize the basic musical elements: beat, rhythm, melody, harmony, tempo, and more. Computers with those skills are becoming musical collaborators.

"Technology is changing our sense of what music can be," Raphael says. "The effect is profound."



COMPUTING A SOUND — At top, the spectrogram for the final verse of "Let It Be" shows how the sound intensity changes over time at each frequency. A computer program detects the beats, the melody, and a piano-roll version of the full score, with horizontal stripes indicating the activation of particular notes.

LEARNING TO LISTEN With training, people can listen to a piece of music and write down the score with few mistakes. Teaching a computer to perform the same task, though, has proved remarkably difficult.

Raphael, an informatics researcher at the University of Indiana in Bloomington, compares the problem to speech recognition. "There's been a veritable army of people who've worked on speech recognition for several decades, and [the problem] still remains open," he says. "Any time you deal with real data, there is a huge amount of variation that you have to understand."

Researchers have succeeded in programming computers to transcribe limited kinds of music. For example, software can reliably identify the notes of a single melodic line played by one instrument in isolation.

The programs analyze the wavelengths of the sound. Hitting the A below middle C on a piano, for example, produces an audio wave at 220 Hertz. But it also produces weaker waves, known as overtones, at 440 Hz, 660 Hz, 880 Hz, and so on. The relative strengths of the overtones differ slightly for each instrument, which is why a piano doesn't sound like a violin. Nevertheless, the characteristic pattern of an A is similar enough across instruments that a computer can recognize it.

When several notes play simultaneously, however, as in a chord from one instrument or music from an ensemble, the audio waves from the different notes mix in ways that are hard to untangle. Echoes, noise, and imperfect recordings muddy the patterns even more.

But researchers are making progress. Every year, various transcription programs go head-to-head in a competition called MIREX (Music Information Retrieval Exchange). The researchers set their programs loose on the same pieces of music and then compare results. This September, when the competition takes place in Vienna, it will for the first time include full transcriptions of polyphonic music, in which multiple notes are playing at the same time.

Most systems slice the sound into brief segments and look for a pattern that they can recognize as a given note. After identifying this note, the programs pull its primary frequency and associated overtones out of the sound wave. Then the software repeats the process, picking out other notes in the remaining audio signal until it has accounted for the entire sound.

The results, however, aren't exact. The pattern of a particular note may be obscured by other notes that are playing at the same time. Furthermore, without information on the characteristics of the instrument producing the sound or the acoustics of the room in which it was recorded, the programmed patterns of overtones don't accurately correspond to the actual notes in the music.

As a result, when the program pulls an imperfectly modeled note out of the mix, it distorts the remaining sound, making it harder to identify the remaining notes. The more notes that are playing at once, the more those distortions pile up.

SELF-TEACHING MACHINES Music-information researchers are taking advantage of the experiences of their colleagues who study speech recognition. After some early advances in the 1970s, further improvements in speech recognition became increasingly difficult. "To take it to the next level," says Daniel Ellis of Colum-

ELLIS

bia University, "you had to do 10 times as much work each time."

By the time Ellis started working on speech recognition in 1996, researchers were trying a new approach. "To some extent, they gave up on trying to understand what speech does," Ellis says. "Instead, they collected a bunch of different examples and used statistical techniques" to identify the patterns that underlie speech.

Ellis continued that strategy when he eventually shifted his focus to the analysis of music. He built a program that uses machine-learning techniques to transcribe polyphonic piano music.

He started with a program that had no information about how music works. He then fed into his computer 92 recordings of piano music and their scores. Each recording and score had been broken into 100-millisecond bits so that the computer program could associate the sounds with the written notes. Within those selections, the computer would receive an A note, for example, in the varying contexts in which it occurred in the music. The software could then search out the statistical similarities among all the provided examples of A.

In the process, the system indirectly figured out rules of music. For example, it found that an A is often played simultaneously with an E but seldom with an A-sharp, even though the researchers themselves never programmed in that information. Ellis says that his program can take advantage of that subtle pattern and many others, including some that people may not be aware of.

When presented with a novel recording, the program labels as an A any note that shows enough statistical similarity to the As in the training sequence. In a special issue of *EURASIP Journal on Advances in Signal Processing*, an online journal, Ellis reports that his system accurately identified the notes playing in 68 percent of the novel 100-millisecond snippets that it was given. Ellis expects that when his program has analyzed more examples—ideally, many thousands more—its detection rate will improve.

He notes that the next-best system, developed by Anssi Klapuri of the Tampere University of Technology in Finland, scored only 47 percent on the test snippets. It's a traditional program that incorporates expert knowledge of music rather than machine learning.

Ellis is quick to point out, however, that this comparison isn't quite fair. Klapuri's system can recognize many kinds of music, not just piano music, so comparing the two on piano music alone gave Ellis' system an artificial advantage.

Ellis plans to enter his program in the September 2007 MIREX competition to see how it does head-to-head against more-traditional programs.

Ellis has also used the self-teaching technique to identify melodies in complex pieces of music, picking out the portion that a person might sing. After spending just a few months to develop such a system, he entered it in last year's MIREX competition and came in third out of 10 entries, with an accuracy of 61 percent. In many cases, he says, the transcribed melodies were recognizable, despite the errors.

The top performer in that competition was a more fully developed program that took a traditional approach. Devised by Karin Dressler of the Fraunhofer Institute for Digital Media Technology in Ilmenau, Germany, that program had a 71 percent accuracy rate. The results of the melody competition will appear in an upcoming issue of *IEEE Transactions on Audio, Speech and Language Processing*.

Ellis says that combining machine-learning strategies with expert knowledge of music and acoustics will ultimately offer the best performance.

FOLLOWING THE MUSIC Even as researchers continue to refine transcription methods, the work is spinning off remarkably useful tools. One advance has turned out to be especially handy: Computers can line up a score with a recording of its performance.

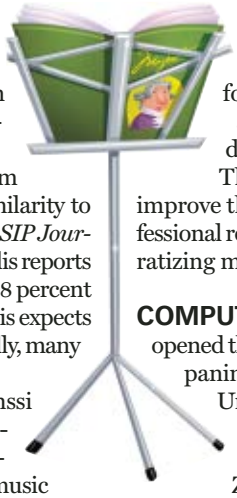
This seemingly trivial capability has many applications. Some of the simplest are programs that display supertitles at the opera at just the right moment or that automatically turn the page for musicians.

Score alignment also opens the door to programs that can correct off-kilter notes going into a microphone before they emerge from loudspeakers—a development that could transform the listener's experience at children's recitals everywhere.

Alignment software analyzes a spectrogram, which shows how the energy of sound waves changes over time across all frequencies. In most popular music, the strong drum rhythms that mark out the time appear on the spectrogram as vertical lines, which make it easy for the computer to keep track of where it is in the score. Another approach that some programs use is to recognize repeating harmonic patterns that occur in many pieces of music.

Where drumbeats or repeating harmonic patterns aren't apparent, the researchers have the computer identify the melody or employ other techniques developed for transcription. Having the score as a guide makes the task far easier than transcribing the notes from scratch.

Score-alignment programs could be used after a musician records a piece of music to do the kind of fine-tuning that's now performed painstakingly by recording studios, fixing such problems as notes that are slightly off pitch or come in late. "It'll be kind of like a spell-check for music," says Roger Dannenberg, a computer scientist at Carnegie Mellon University in Pittsburgh who is developing the technology.



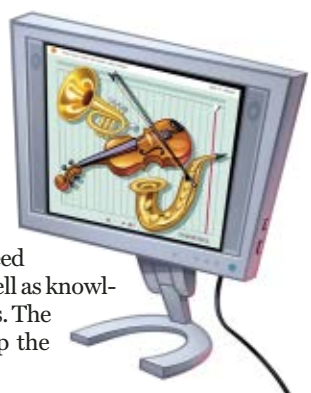
The process would make it far easier for amateurs to improve their recordings after performance in the way that professional recording studios now do. "I see what I'm doing as democratizing music-making," Dannenberg says.

COMPUTER AS MUSICIAN Score-alignment technology opened the door for Raphael to develop his computerized-accompaniment program. Mimi Zweig, a professor of music at the University of Indiana, is using the system with her violin students to give them a taste of what it's like to have 100 musicians following their every pause or trill.

Zweig is impressed with the responsiveness of the system. "After a long cadenza or a phrase where you want to take time, it's right with you," she says. "It's even better than an orchestra in some ways."

Raphael says that the soloist's freedom while using his system makes it a valuable learning tool. Few students ever experience having an orchestra accompany them. Raphael says, "It's a fundamental hole in their musical education. [Playing with an orchestra] is how people develop their ideas about musical interpretation and grow as musicians."

The first component of Raphael's program examines the sound waves produced by the soloist and lines up the performance with the score. But that's not enough, because if the program waits until the soloist plays a note before it comes in with the accompaniment, it will always be late. So, the program predicts what the soloist will do next, using information about the performance from which the accompaniment was derived and the performer's speed in the immediately preceding notes as well as knowledge gained from earlier practice sessions. The program then slows down or speeds up the recording without altering the pitch.



D MACADAM

Raphael presented the system in Boston last July at a conference of the Association for the Advancement of Artificial Intelligence.

His program requires recordings that are missing the solo parts. A company called Music Minus One, based in New York City, produces such recordings, and soloists have traditionally practiced by playing along with them. Having gotten used to his computer-accompaniment system, Raphael now scorns the use of such recordings. "You're straitjacketed, following orders from the machine," he says.

Nevertheless, he sometimes uses Music Minus One recordings for his research. But he's also developing methods to strip the soloists' parts out of high-quality recordings by top performers.

In that task, Raphael doesn't know the precise sound waves that the soloists generated, so he faces some of the difficulties that the music-transcription systems encounter. He inevitably inflicts damage when he removes the solo from a recording.

"But there's a saving grace," he says. The new soloist will be producing sound in just the frequencies that are most damaged, so it will mask the parts that sound worst.

Raphael is still refining his stripping software—"I'm like Edison in search of the right filament." But he already uses the system, which he calls "Music Plus One," to make recordings to accompany his oboe playing.

Raphael's system relies entirely on the musical sense of the soloist to drive the accompaniment. "If you have a really terrific, sophisticated live player, that's the right thing to do," he says.

But in a teaching situation, a good accompanist partly follows and partly leads, helping a beginning musician develop a more sophisticated sense of the music.

"It's a hard problem for a computer to get musicality into a performance," Raphael says.

Even without musical sense, Raphael's program is opening new musical possibilities. Jan Beran, a composer and statistician at the University of Constance in Germany, wrote several oboe solos with piano accompaniment especially for Raphael's system.

Raphael has performed the pieces with his system. He says that he doesn't think that those pieces could be played with a live accompanist.

The rhythmic interplays are so complex that performers can't handle them, he says. For example, one piece contains many sections where one musician plays 7 notes while the other plays 11. "Human players say, 'I'll play my 7, you play your 11, and let's shoot for where we come out together,'" Raphael says. "But the program can tell at any place in the middle of this complicated polyrhythm exactly where it needs to be."

> "My computer-accompaniment system could completely replace the orchestra."
>
> — ROGER DANNENBERG, CARNEGIE MELLON UNIVERSITY

With music this complicated, Raphael says, the software takes on a peculiar leadership role even though it does nothing but follow. "From the very first rehearsal, it understands the way the parts fit together and sort of teaches you this," he explains.

These developments make some musicians uneasy. Dannenberg, who wrote the earliest computer-accompaniment system, notes that the musicians' union opposes "virtual orchestras," synthesizers in the pit at musicals that replace some of the acoustic instruments.

Dannenberg says, "That's not even the stuff you should be afraid of. My computer-accompaniment technology could completely replace the orchestra."

"There's something about the social presence of live music that's going to keep it alive forever. I'm not interested in using computers to replace live musicians," Dannenberg adds. "The reason that I work with computers and music is because of all the potential that computers have to do new things that you can't do otherwise". ■

WANTED: BETTER YARDSTICKS

Measurement inadequacies threaten U.S. competitive edge

BY JANET RALOFF

Match this, Hollywood: Some physicists are gearing up to make the ultimate action flicks. Their stories will chronicle the lives and loves—from marriages through messy divorces—of individual molecules and atoms. The challenge is to distill sharp and compelling images of actors that shimmy about with blinding speed, changing place every few quadrillionths of a second.

It's difficult—but not, theoretically, impossible.

A 1,000-frame short subject debuted a few months back. Directed by David M. Fritz of Stanford University and described in the Feb. 2 *Science*, the flick portrayed 0.008 nanosecond of activity of atoms within crystalline bismuth.

Of course, such movies aren't being developed for the entertainment industry, but for science. "One of the grand goals of our research is to make a movie of a chemical reaction," Fritz explains. When two chemicals meet, a cascade of transient but important events occur before the final product emerges. Scientists need to measure the movements of atoms if they are to follow that action.

"To control reactions on the molecular scale," Fritz says, "we need to know in detail what's happening. And to do that, the ideal probe is a tool that can view atomic motion."

Fritz is among researchers pushing the frontiers of science and engineering by developing new ways to measure things. Some of the novel yardsticks may be hardly recognizable as such. One, for example, might be a means to tally protein fragments across the brain to map when genes are turned on. From the mundane to the arcane, measurement systems serve as an engine of innovation, says a Feb. 12 report issued by the National Institute of Standards and Technology (NIST) in Gaithersburg, Md.

Although U.S. industry remains a global leader in product innovation, many nations are beginning to close the gap, according to a draft of a National Academy of Sciences report. Called *Rising above the Gathering Storm*, it says that U.S. technological leadership could end—and relatively quickly—if the nation's research and development infrastructure isn't shored up substantially and soon.

Measurement tools are a pivotal part of that infrastructure, argues NIST director William Jeffrey. "To measure is to know," he says. "And knowledge, whether aimed at unraveling a fundamental law of nature or ensuring that a manufactured part will fit into its assembly, is critical to continued technical progress, to innovation, and ultimately to the economic security of the nation."

RPI

PLASTICIZED — With mostly plastic parts, a new, durable terahertz-radiation imaging system (right) is only the size and weight of a laptop computer (left). Previously developed T-ray imagers are fragile and weigh at least 100 pounds.

BIG TALLY In an attempt to identify measurement problems that could stifle innovation, NIST recently collaborated with industrial partners and others to survey the U.S. Measurement System. This amorphous network comprises all the organizations that develop or make measurement tools, set standards for things that must be measured, or identify new quantities that need measuring.

Although everyone depends on it, the measurement system is "usually unseen," the NIST report observes. Not surprisingly, it adds, any failure of the system to meet new societal and technological needs may also escape attention.

Over the past 2 years, as part of its assessment, NIST convened 15 workshops, met with more than 500 industrial leaders in 11 segments of industry, and scrutinized 164 technology road maps. The last, prepared by industry, chart the path to new products that would fulfill perceived or stated consumer wants. These road maps also identify measurement gaps that risk slowing or derailing planned products.

Altogether, NIST turned up more than 700 distinct measurement deficiencies—missing yardsticks. Then, "each of these perceived [measurement] needs was validated by going back out into the private sector—or at least to people outside NIST," notes Belinda L. Collins, director of technology services at the agency.

Most of the yardsticks that NIST identified as missing proved far more prosaic than techniques to measure the movements of dancing atoms. Nonetheless, their absence may have costly consequences.

One road map's goal, for instance, was lighter-weight but more-protective suits for firefighters. Before municipalities invest in new gear, they need concrete evidence that it will do its job, observes Shyam Sunder, NIST's acting director for building and fire research.

In this case, "methods do not currently exist" to adequately gauge how much heat firefighters' suits absorb, the report concludes. Also lacking are ways to correlate stored energy with a suit's capacity to burn skin. Firefighters can sustain burns even when their protective suits show no degradation, Sunder says.

Measurement deficiencies could cost the $270 billion U.S. semiconductor industry its competitive edge. Within 2 years, computer-chip developers expect to produce integrated circuits having fea-

tures a mere 10 nanometers across. However, there are currently no assembly-line tools that can examine features smaller than 32 nm, the NIST report found. Such tools would be needed to detect defects or contaminants in the automated manufacturing of chips.

A lack of variety in simple sensors hobbles other emerging technologies, such as the proton-exchange-membrane fuel cells (*SN: 9/7/02, p. 155*) being developed to power cars. To operate efficiently, these fuel cells need sensors to measure and control their internal humidity. However, the sensors now available were developed for applications that take place in cool, dry environments. NIST found that in the fuel cells, these sensors are "error prone when exposed to water droplets commonly found near optimum operating points."

PRICE TAGS The cost of developing a new measurement tool can be modest—or it can run to half a billion dollars.

For instance, an engineer at the Rensselaer Polytechnic Institute in Troy, N.Y., used ingenuity and about $100,000 to render the technology for terahertz-radiation (T ray) imaging more versatile. He took advantage, however, of equipment worth about $2 million.

T rays have a frequency that's a trillion cycles per second higher than that of standard microwaves but below that of infrared radiation. T rays can penetrate and measure anomalies in many dry, nonmetallic materials, such wood, glass, plastic, and carbon fibers (*SN: 8/26/95, p. 136*). Until now, however, devices that produce those rays weighed at least 100 pounds and had delicate optics.

Brian Shulkin has developed a largely plastic alternative. It's rugged, weighs just 4.5 pounds, and is the size of a laptop computer. In tests by NASA, Shulkin's prototype spotted and measured hidden flaws in the foam used to insulate the space shuttle. The system's portability is ideal for scanning massive objects such as the shuttle. Or the system could be mounted above an assembly line to scout for flaws in the silicon wafers used to make computer chips. A commercial version may debut this spring.

On the other end of the financial spectrum are massive projects from which users won't likely recoup their investments. The federal government often bankrolls such efforts. Fritz' atomic-movie camera is one example.

Its simplest ingredient is a table-top laser that excites the atoms in a bismuth crystal. The hard part of the project was producing and harnessing X-ray pulses short enough to make snapshots of the atoms' dance steps. At the 2-mile-long Stanford Linear Accelerator, Fritz' team installed a system that turns the accelerator's brief but energetic electron bursts into X-ray pulses a mere 100 femtoseconds long—short enough to snap shots of the atoms' motion.

The scientists labeled the snapshots with virtual time stamps indicating the lag from the time the X-ray pulse excited the atomic motion. They then arranged the snapshots into the appropriate sequence to create a movie of the atomic dance. Bismuth atoms move slower than many others, so the researchers plan to refine their system to follow faster dancers.

The U.S. Department of Energy is already building a free-electron X-ray laser more than a mile long at the Stanford facility. It will both excite atoms and measure their activity. This will considerably reduce the arduous computational requirements of atomic moviemaking, Fritz explains. The $400 million system is slated to begin operation in 2009.

CHALLENGES The NIST report might prove sufficient to catalyze development of many missing yardsticks—especially those with moderate development costs. However, in some cases, the technology isn't yet available to hurdle measurement barriers.

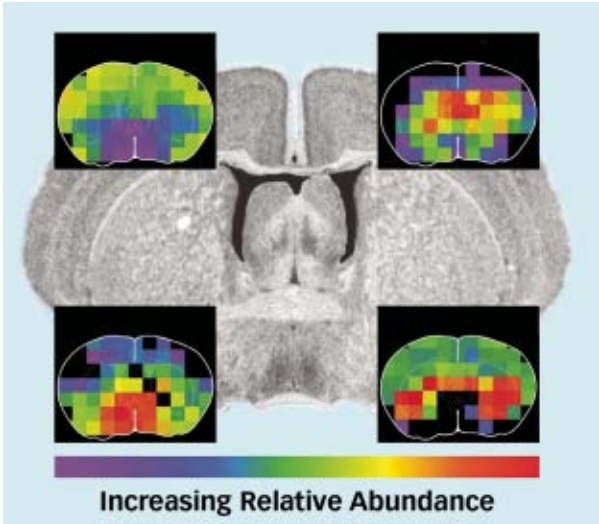
Jeffrey points out one example: proteomics.

Whereas the genome represents an organism's complete set of genes, the proteome constitutes the entire suite of proteins produced by those genes. Although all cells within an organism possess the same genes, the sets of proteins produced by gene activity differ dramatically not only from tissue to tissue but even from hour to hour.

Protein anomalies can offer clues to disease. Jeffrey notes that the National Institutes of Health has identified the absence of a means to reliably measure proteins at "very, very low concentrations" as a barrier to innovation in health care.

However, moves are afoot to begin addressing the problem. One major NIH-funded project is under way at the Energy Department's Pacific Northwest National Laboratory in Richland, Wash.

To correlate neurological disease with protein differences across the brain, scientists need a system to compare proteins from the tissues of a healthy animal against those from an animal with the disorder.



BRAIN CUBES — Each of the four corner images displays the distribution of a different protein across the brain slice shown in the background.

As a test of the concept, a team led by Richard D. Smith of the Richland lab in collaboration with Desmond Smith of the University of California, Los Angeles recently analyzed 1-millimeter cubes from brain sliced from two normal mice. Proteins in just one of the animals had been labeled with a heavy isotope.

Cube by cube, "we broke each protein into pieces—peptide fragments. It's those we measured," Richard Smith explains. In the March *Genome Research*, he and his colleagues report what they say is the first quantitative comparison of the relative abundance of proteins—many with unknown functions—from different areas across an organ. More importantly, he notes, the method tallied the proteins that were in fact being made, not merely those that could be made by the cells' genes.

The analyses took heroic processing. The team has since developed instrumentation that has speeded the process 25-fold. The next step, Richard Smith says, will be to apply the technique to tissues from normal and diseased animals—and potentially to far smaller cubes, to obtain finer spatial resolution of any protein differences.

OPTIMISTIC OUTLOOK Jeffrey argues that "the health of the U.S. measurement system is actually fairly strong." Nevertheless, the NIST report identified 723 measurement needs. "And this was by no means meant to be a complete survey," he notes.

An important question is whether the agency's findings represent unrelated deficiencies or instead many stemming from some underlying problem and so can be addressed collectively. Once NIST understands that, Jeffrey says, the United States "can begin to focus our investments" to overcome the problems.

The good news, he says, is that "all of the feedback that we've gotten from industry has been, quite literally, very positive."

Overall, Jeffrey says, through the new report and other efforts, "I think we've been making a lot of headway in educating people on the importance of measurements and standards. So, I'm very bullish." ■

ADAPTED FROM R. SMITH/PNNL

OF NOTE

BEHAVIOR

Psychotherapy aids bipolar treatment

Psychotherapy enhances emotional stability in people receiving standard medications for bipolar disorder, a new study finds.

Scientists earlier reported that only about one-quarter of bipolar patients receiving mood-stabilizing drugs get substantially better, whether or not they also take antidepressant medication (*SN: 3/31/07, p. 196*).

The same researchers, led by psychologist David Miklowitz of the University of Colorado at Boulder, have now studied 293 patients receiving medication for bipolar disorder. The team randomly assigned the participants to one of three types of psychotherapy or to a brief educational program. Patients entered treatment in the early stages of a depression episode.

Psychotherapy lasted for up to 30 sessions over 9 months. One approach required family participation in boosting a patient's coping and communication skills. Another method explored distorted thinking and destructive behavior in bipolar disorder. A third technique established daily routines and addressed relationship problems.

The brief program occurred in three sessions and provided information about bipolar disorder and strategies to avoid relapses.

When assessed 1 year after the study began, two-thirds of the patients receiving any of the psychotherapies displayed good emotional health, compared with half of those who received the brief intervention. The new report appears in the April *Archives of General Psychiatry*. —B.B.

ENVIRONMENT

Increase in chemical disposals

Industrial and federal facilities in the United States released more than 4 billion pounds of chemicals into the environment in 2005, according to the latest yearly compilation of data from the Environmental Protection Agency's Toxics Release Inventory. Chemical releases had increased by 117 million pounds, or 3 percent, over the past year.

The EPA collects information on nearly 650 toxic chemicals that facilities emit into the air, release into waters, or dispose of in landfills or underground wells.

The metal-mining industry was the largest discharger of chemicals in 2005, accounting for slightly more than 1 billion pounds. This industry also claimed the largest increase from 2004, 96 million pounds. Releases from electric utilities came in a close second in 2005 and showed the second-largest increase—39 million pounds—from 2004.

The inventory also includes data on the disposal of chemicals that persist in the environment and accumulate in body tissues. In 2005, lead or lead compounds accounted for 98 percent, or 469 million pounds, of such toxic chemicals. Releases of mercury and mercury compounds added another 4.4 million pounds. —A.C.

ASTRONOMY

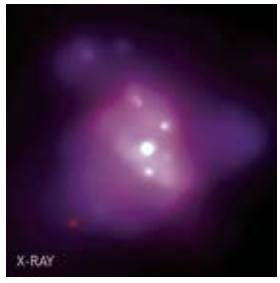
Eclipsing a black hole

A chance eclipse has enabled astronomers for the first time to measure the width of a disk of swirling, hot matter around a supermassive black hole.

The black hole lies at the center of the galaxy NGC 1365, some 60 million light-years from Earth. Scientists have proposed that gas and dust surrounding such a hole don't simply fall in but form a rotating disk. Matter dragged inward from the disk would be heated to millions of kelvins and emit X rays before disappearing into the hole.

NASA's Chandra X-ray Observatory has detected X rays from the core of NGC 1365, but the proposed disk would be too small for the craft to discern directly. For several days in April 2006, however, Chandra saw no X rays from the core. Researchers attribute the interruption to a cloud of material passing in front of the disk. From the duration of the eclipse and the inferred size of the cloud, the scientists determined that the proposed disk around this black hole must have a diameter seven times as great as the distance between Earth and the sun.

The Chandra observations also show that the eclipsing cloud lies only about a hundredth of a light-year from the black hole's event horizon—the region that marks the boundary between the hole and the rest of the universe. Existing models of the regions around supermassive black holes don't include much material at that distance, notes Guido Risaliti of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., and the Italian Institute for Astronomy in Florence. He and his colleagues report the findings in the April 20 *Astrophysical Journal Letters*. —R.C.



BLOCKING BLACKNESS
These X rays come from the supermassive black hole at the core of the spiral galaxy NGC 1365. Last year, a cloud obscured them.

CXC, NASA

NEUROSCIENCE

This is your brain on a chip

Memories form when networks of neurons learn to fire in new patterns. Biophysicists have now put that assumption to the test by inducing synchronized firings in neurons sitting on a chip.

Itay Baruchi and Eshel Ben-Jacob, two biophysicists at Tel Aviv University in Israel, extracted neurons from rat embryos and grew the nerve cells on a chip equipped with 64 electrodes to detect neuron activity. Repeatedly dropping tiny amounts of nerve-stimulating chemicals at a chosen spot, the researchers saw the same cascade of firings each time the neurons relayed signals to their neighbors. Eventually, the neurons began firing in that pattern without the chemical stimulation. The neurons had formed a memory, the researchers say.

Applying chemicals to different spots created additional memories without erasing those already formed. That contrasts with previous experiments using electrical stimuli, where new memories tended to erase old ones, Ben-Jacob says. His team's report is due to appear in *Physical Review E*.

Stefano Vassanelli of the University of Padua in Italy says that he'd like to combine Ben-Jacob's chemical-stimulation method with his own team's neuron chips, which can simultaneously detect thousands of firings through silicon transistors. —D.C.

PHYSICS

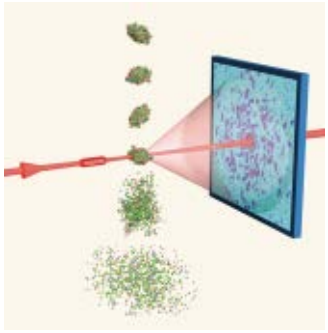
Toward imaging single biomolecules

Blowing stuff up can sometimes be good for science. A new generation of lasers is expected to image complex molecules, such as proteins, even though the molecules themselves explode in the process.

OF NOTE

Scientists can deduce a molecule's form from the way in which X rays scatter off it. This technique, called X-ray diffraction, normally requires coaxing large numbers of the molecule into crystal form. But some molecules—including many of the proteins that shuttle ions in and out of cells—are difficult or impossible to crystallize. In a few years, new machines called free-electron lasers may image single molecules with X-ray pulses that are up to 10 billion times as concentrated as the pulses that current X-ray sources can deliver.

But some scientists have worried that these machines would be too powerful for X-ray diffraction, destroying molecules before any meaningful data can be extracted.



CATCH IT WHILE YOU CAN X rays from the left scatter off molecules (multicolored clusters) and reach a detector screen in this artist's impression. Scientists can then reconstruct the molecules' structure.

Using a prototype X-ray free-electron laser in Hamburg, Germany, an international team of physicists directed the beam onto nanoscale samples of reflective material. During pulses lasting 25 millionths of a billionth of a second, or femtoseconds, the sample still reflected the laser light precisely—meaning that the deformation and ultimate explosion of the material took longer than the pulse duration.

The explosion mechanism will be different in the more energetic future machines, says Stefan Hau-Riege, of Lawrence Livermore (Calif.) National Laboratory. But the research suggests that X rays will have enough time to scatter, carrying structural information before molecules blow apart.

The results appear in the April 6 *Physical Review Letters*. —D.C.

ENVIRONMENT

On the rocks

New research explains why a cancer-causing form of chromium has been turning up in ground and surface waters far from industrial sources.

Chrome plating and dye manufacturing are among the industries that generate chromium (VI), a form that the element assumes in certain compounds. But recently, researchers have discovered the toxic agent in regions—including California and parts of Mexico and Italy—beyond the reach of industrial contamination.

In these cases, "it was obvious that [chromium (VI)] had to be coming from a natural material," says Scott Fendorf, an environmental chemist at Stanford University.

Fendorf and his coworkers focused on the mineral chromite, found in certain rocks and soils common to the Pacific coasts and other seismically active areas. Over time, chromite slowly releases chromium (III), a relatively benign form of the element.

The researchers reacted chromite with birnessite, a manganese-containing mineral that often forms in weathered rocks and soils containing chromite. In water, powders of the two solids produced chromium (VI). "Both minerals tend to be fairly insoluble, but they dissolved just enough" to react, says Fendorf.

The researchers conclude that within 100 days, chromite and birnessite could generate chromium (VI) at concentrations above the World Health Organization's limit for drinking water—which is 50 micrograms per liter. In acidic conditions, such concentrations could be reached in fewer than 10 days, the team reports in the April 17 *Proceedings of the National Academy of Sciences*.

The work indicates that certain chromite-rich regions are at high risk for natural chromium (VI) generation. "You need to watch the groundwater pretty closely in these areas," Fendorf says. —A.C.

PHYSICS

Tiny particles baffle physicists, again

An experiment on neutrinos that was meant to remove a thorn from the side of fundamental physics may instead have added a new one.

Neutrinos are some of the lightest known elementary particles and among the hardest to detect, since they rarely interact with other particles. Three types are known, each coming in both matter and antimatter forms. Neutrinos and antineutrinos are also notorious flip-floppers—one type constantly shifting into another.

A 1995 experiment at the Los Alamos (N.M.) National Laboratory first showed such oscillations in a lab setting. It also revealed a much higher rate of conversion between two types of antineutrinos than standard particle physics calculations had predicted. The simplest explanation was that in addition to direct conversions, one antineutrino could turn into another by first briefly changing into a proposed seventh type of neutrino—called sterile because it can't be detected directly.

On April 11, researchers at the Fermi National Accelerator Laboratory in Batavia, Ill., announced the results of an experiment that looked for similar anomalous conversion rates in neutrinos.

The researchers had assumed that neutrinos and antineutrinos would oscillate the same way. In the energy range explored in the previous experiment, the Fermilab results showed no anomaly in their conversion rate. Either the Los Alamos results were wrong, or they must be explained without the sterile neutrino.

However, the new experiment found anomalous conversion rates at lower energies.

"We firmly stand behind the [Los Alamos] data," says Bill Louis, who was a lead researcher in that experiment and is also in the new one. Solutions of the dilemma that don't rest on sterile neutrinos range from a new and unforeseen difference in the behavior of matter and antimatter to the existence of additional dimensions of space. —D.C.

PLANETARY SCIENCE

Little Enceladus disturbs Saturn's magnetic field

Like a mouse reining in an elephant, Saturn's tiny moon Enceladus is acting as a brake on the giant planet's magnetic field, researchers assert in an upcoming *Science*. Don Gurnett of the University of Iowa in Iowa City and his colleagues trace the effect to water vapor and ice particles shot from geysers at Enceladus' south pole.

Bombarded by radiation, the ejected material acquires an electric charge and is captured by the magnetic field girdling Saturn. The particles' total mass exerts a drag on the field, causing its rotation to lag slightly behind that of the planet. Bursts of radio waves emitted once by the magnetic field during each rotation show the same slowdown, detectors on the Cassini spacecraft have revealed.

The drag induced by little Enceladus is not only surprising but also poses a challenge for planetary scientists trying to discern Saturn's rate of rotation, says Gurnett. Saturn's high-altitude clouds prevent direct observation of the planet's spin, but scientists had assumed that the radio wave bursts were constant and would indicate the planet's rotational speed. The drift in timing, however, shows that the signals don't trace the planet's unvarying rotation. —R.C.

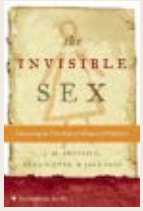
LAWRENCE LIVERMORE NATIONAL LABORATORY

Books

A selection of new and notable books of scientific interest

THE INVISIBLE SEX: Uncovering the True Roles of Women in Prehistory

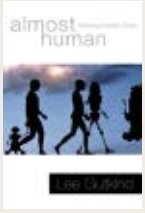
J.M. ADOVASIO, OLGA SOFFER, AND JAKE PAGE



Folklore, as well as museum dioramas, have traditionally portrayed prehistoric men as aggressive warriors and women as passive bystanders. Much of this view came as the result of male dominance in the field of archaeology, according to this book. Here, archaeologists reconsider that view by presenting accounts of women's contributions in the advance of human culture. One of the problems facing researchers interested in women's roles in prehistoric culture is that artifacts such as fabric, nets, and baskets that may have been created by women aren't as persistent as stone or bone tools that might have been the realm of men. Nevertheless, evidence indicates that women played crucial roles in development of language and social life, the authors assert. They ponder theories that arise from the new field of ancient genetics, such as that modern Europeans descended from just seven women. ***Smithsonian, 2007, 302 p., b&w images, hardcover, $26.95.***

ALMOST HUMAN: Making Robots Think

LEE GUTKIND

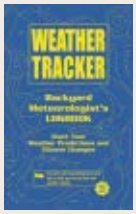


At Carnegie Mellon University, enthusiastic engineers and software designers are creating robots that may someday aid or even replace people in various capacities. Gutkind spent 6 years observing these researchers and their creations, which include devices as seeming frivolous as robot dogs scooting around in the RoboCup soccer competition and as serious as machines in a Defense Department program to create driverless vehicles. Gutkind, editor of the journal *Creative Nonfiction,* also accompanied the roboticists to one of the most barren places on Earth, Chile's Atacama Desert. In this Marslike environment, a Carnegie Mellon team put the robot Zoë through its paces for NASA. The machine or one like it may someday search for life on the Red Planet and elsewhere. ***W.W. Norton, 2006, 284 p., hardcover, $25.95.***

WEATHER TRACKER: Backyard Meteorologist's Logbook

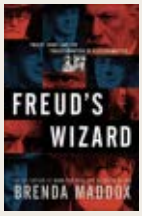
LESLIE ALAN HORVITZ

The closest that many people come to studying weather is flipping on the news for the latest forecast. On the other hand, increasing attention to climate change and bizarre weather patterns has brought more people than ever to an appreciation of meteorology. Horvitz, a science writer, here outlines the basic elements of weather. He reviews the forces that determine seasons, defines and describes jet streams, explains warm and cold fronts, and outlines what is known about ongoing climate change. Next, he explains weather forecasting, including how modern meteorology employs supercomputers, professional weather stations, and satellites. However, he also maintains that weather can still be studied, and even forecast, by people using low-tech, homemade weather stations. Finally, the book lists resources for amateur meteorologists and offers a blank logbook for daily weather observations. ***Barron's, 2007, 224 p., b&w illus., paperback, $16.99.***



FREUD'S WIZARD: Ernest Jones and the Transformation of Psychoanalysis

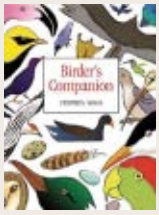
BRENDA MADDOX



Today, Sigmund Freud's psychoanalytic concepts of ego, repressed memories, and developmental stages are familiar to most people. Maddox contends, however, that Freud and his work might have sunk into obscurity were it not for the efforts of Ernest Jones, an eccentric but devoted translator of Freud's writings. Maddox, a biographer of figures such as D.H. Lawrence and William Butler Yeats, details Jones' colorful life. Mired in suspicions of child abuse and philandering, Jones seemed destined to remain an unremarkable, second-rate physician until he read Freud's writings. He immediately became a psychoanalytical devotee and Freud's personal champion. He went from England to Toronto to spread Freud's ideas, which were met with controversy for their sexual nature. With Freud's on again, off-again support, Jones set about translating the German's texts, introducing the English-speaking world to psychoanalysis, and accumulating followers for the approach. Furthermore, Maddox credits Jones with saving Freud's life by getting him and his family out of Nazi-occupied Vienna before World War II. ***Da Capo Press, 2007, 354 p., b&w plates, hardcover, $26.00.***

THE BIRDER'S COMPANION

STEPHEN MOSS



Birding can be a pastime enjoyed simply because it puts people in touch with nature, bird by bird. Moss, author of several books on birds, wants to push bird-watchers to the next level with this information-packed guide. Presented in a question-and-answer format, the guide provides facts about bird evolution, mating, behavior, physiology, flight, communication, and other topics. Moss answers questions about bird diets, extinction, nests, and cages. Each chapter also includes sidebars that highlight facts such as that the sooty tern can fly for up to 7 years without touching down on land, that eagles can kill prey as large as a small antelope, and that the world's oldest-known wild bird lived to age 60. Accented with black-and-white illustrations, this guide is intended for amateur bird enthusiasts. ***Firefly, 2007, 208 p., b&w illus., paperback, $16.95.***

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LETTERS

How the West isn't one

The author of "Why So Dry? Ocean temperatures alone don't explain droughts" (*SN: 2/10/07, p. 84*), seems to feel, like most other writers do, that "the western United States" properly covers all geographical bases. Believe me, the Pacific Northwest is anything but dry. One other point about geography: Weather phenomena, and other stuff, occurring in the Dakotas, Nebraska, Oklahoma, Texas, or Kansas are not happening in the 11 westernmost states.

MATT ANDREWS, SEATTLE, WASH.

The word on worms

I enjoyed reading in "What's Going on Down There?" (*SN: 2/17/07, p. 107*) about the marine census that's been taking place, but I was waiting for some mention of the organisms' parasites. Granted, worms are not glamour-pusses, but they are fascinating creatures. If we want a complete survey, they must be included.

ANN GARDNER, LINCOLN, NEB.

Net gains

"Net Heads: Huge numbers of brain cells may navigate small worlds" (*SN: 2/17/07, p. 104*) points out that vital intrinsic neural activities may in part stem from a person's random thoughts and daydreams, or from neural efforts to balance the opposing signals of cells simultaneously trying to jack up and cool down brain activity, or could occur during an internal process of generating predictions about upcoming environmental demands and how to respond to them. These findings corroborate some of the basic principles important for the development of psychoanalytic theory: the utility of conceptualizing functional divisions of the mind and the importance of a person's inner world. Freud maintained that the organizing principle in the nervous system was based on functional groupings rather than topographical relationships.

LEON HOFFMAN,
THE NEW YORK PSYCHOANALYTIC INSTITUTE AND SOCIETY, NEW YORK, N.Y.

Many parallels could be drawn between this perspective on the brain and the World Wide Web. The active nodes, the chaos, and the long-distance and short-distance connections can be compared to servers, terminals, Web sites, and the Web chaos that results in packet traffic being delivered simultaneously to millions of different locations. Each person has his or her own internal Internet.

DAN DELL, SANTA CLARITA, CALIF.

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