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virus linked to bee demise dune-tune dynamics overthrowing gene dogma deadly asteroid id'd

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## bad air, big city

URBAN POLLUTION'S LONG REACH

#### THE WEEKLY NEWSMAGAZINE OF SCIENCE



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**Cover** Haze smothers Mexico City in this image taken in March 2006. Data from field studies, as well as lab tests and computer simulations, suggest that megacities like this one spread their pollution problems broadly. (L.T. Molina, Massachusetts Institute of Technology) Page 152

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## SCIENCE NEWS This Week

### **Hive Scourge?** Virus linked to recent honeybee die-off

A little-known virus has been tagged as a suspect, or maybe just an opportunistic marker of disease, in the recent unexplained disappearances of honeybees.

During the past year, an estimated 23 percent of U.S. beekeeping operations saw worker bees vanish over the course of a few weeks for no obvious reason, a phenomenon dubbed colony-collapse disorder (*SN:* 7/28/07, *p.* 56).

Now, a massive genetic analysis of bees and the organisms that live in their bodies suggests a tie to Israeli acute-paralysis virus (IAPV), says Diana Cox-Foster of Pennsylvania State University in University Park. IAPV was detected in 83 percent of samples of bees from faltering colonies but in only 5 percent of samples from colonies without symptoms, she and her colleagues report online and in an upcoming issue of *Science*. Researchers in Israel first described the fatal bee virus in 2004, but until now it hadn't attracted wide attention. The lab analysis that has highlighted it, developed by Ian Lipkin of Columbia University, determines the genetic sequences of all creatures present in samples of both sick and healthy organisms. Then researchers look for DNA unique to the sick samples.

The bee analysis included two fungi that have been suspects in colony collapses. *Nosema ceranae* and *Nosema apis* occurred in 90 percent and 100 percent, respectively, of samples of sick colonies, says the Lipkin team, but also in 72 percent and 92 percent, respectively, of symptomfree colonies.

Researchers haven't yet tested whether IAPV meets the standard requirements, called Koch's postulates, that would define it as the cause of colony-collapse disorder. This test requires such steps as administering the supposed pathogen to test subjects, seeing whether they get the predicted disease, and recapturing the same pathogen from them.

Cox-Foster says that she and U.S. Department of Agriculture researchers are planning a version of the test, but it's not going to be easy in this case. For one thing, she suspects that bees become susceptible to the virus only when weakened by some other factor, such as pesticide exposure.

Whether IAPV contributes to colony collapse or just shows up as a consistent indicator, "both would be good news," says bee geneticist Gene Robinson of the University of Illinois at Urbana-Champaign. Such a marker would improve researchers' ability to screen colonies for disease.

"This is the first record of the virus in North America," says Cox-Foster, although she adds that no one has looked for it outside Israel. She and her colleagues have found IAPV in live bees from two suppliers



**CARRIER?** U.S. honeybees have been plagued by the varroa mite (dark, rounded parasite on this bee's back) which spreads and aggravates diseases, possibly including Israeli acute paralysis.

in Australia and in packages of royal jelly, bee food for larvae destined to be queens, exported from China.

The question of the virus' source could fuel debate over the rules for import and export of bees and bee products. In 2004, the first large-scale bee imports came from Australia. The United States also allows imports from New Zealand and Canada. At the time, the American Beekeeping Federation, based in Jesup, Ga., argued unsuccessfully for a quarantine system, says its executive director, Troy Fore.

He says that if imported IAPV were the only cause of the disease, he would have expected the path of infection across the United States to have been more straightforward. "If they tell us it's a virus, there will still be more questions than answers," he says. —S. MILIUS

### The Venter Decryption

Biologist decodes his own genome

For the first time, scientists have decoded and published a nearly complete readout of both sets of chromosomes in an individual. The diploid genome, of biologist J. Craig Venter, reveals much more human genetic variation than scientists had expected.

In 2001, two competing projects, one run by the federal government and the other by a private company, announced the sequencing of the human genome. However, those sequences, or readouts of DNA's letter order, were in essence only half finished.

Individuals inherit two copies of each of the 23 human chromosomes—one copy from each parent. To speed the task of sequencing the human genome, both teams decided to decode only one of each pair. The resulting genomes were haploid, meaning that they represented only half the chromosomes.

"It turns out with the haploid genomes, we missed most of human [genetic] variation," says Venter, who led the project to decode his own genome at the J. Craig Venter Institute in Rockville, Md.

Earlier, while at Celera Genomics, also in Rockville, Venter had led the private human-genome project that competed with the government effort. Celera compiled DNA from five individuals, including Venter, into a composite haploid genome.

Then, starting in 2003, the private-institute team isolated Venter's DNA sequence from the earlier project and, using an older but highly accurate DNA-sequencing technology, filled in the missing pieces.

New computer algorithms distinguished the genetic inheritances that Venter got

## SCIENCE NEWS This Week

from each of his parents and found that those two contributions to his DNA differed in many more ways than had been expected. Venter's team reported that 44 percent of known genes displayed variations between the versions inherited from each parent. In a few cases, Venter inherited one copy or more of a gene from one parent and no copies from the other parent.

Previously, scientists had estimated that all human genomes are about 99.9 percent identical. But when Venter's team compared his genome with the results of the government's Human Genome Project, it found that the degree of similarity may be only 98 to 99 percent. The comparison showed that Venter's genome and the government's reference genome differed at 4.1 million locations. Of these differences, 1.3 million were newly identified.

Except for the sex chromosomes, the project did not identify which parent contributed which piece of DNA. It simply marked the segments as coming from different parents. But Venter says the technology exists for precisely mapping each parent's individual contributions.

Edward Rubin, director of the Department of Energy's Joint Genome Institute, says Venter's project used a relatively old and expensive technology that produced a "Rolls Royce" version of Venter's genome. "I don't think there are any giant surprises," Rubin says. "But we now have a unique genome we can refer back to."

The effort to decode Venter's genome, reported online in the October *PLoS Biology*, took 5 years and cost about \$10 million. —B. VASTAG

### **Killer Collision**

Dino demise traces to asteroid-family breakup

A huge chunk of rock hit Earth 65 million years ago, setting off events that wiped out the dinosaurs. That chunk, astronomers now say, was a wayward fragment from a collision between two giant asteroids in the inner part of the asteroid belt, which lies between Mars and Jupiter. The new study adds to the evidence that both Earth and moon have been bombarded by about twice the usual number of asteroid fragments during the past 200 million years.

Earth is now at the tail end of this asteroid shower, say Bill Bottke of the Southwest



**KILLER ROCK** Artist's illustration shows collision of two giant asteroids (left). Ejected fragments might have struck the moon and Earth, creating the lunar Tycho crater (top right) and triggering widespread destruction on Earth some 65 million years ago (bottom right).

Research Institute in Boulder, Colo., and his colleagues in the Sept. 6 *Nature*.

The researchers began their study by pondering the pattern of craters on 951 Gaspra, a member of the Flora family of asteroids. Searching for objects that could have caused the impacts, the team examined a much darker, harder-to-detect group of asteroids, the Baptistina family, that resides close to the belt's inner edge and near the Flora family.

Bottke and his colleagues were intrigued to find that the Baptistina family stretches over a region containing two gravitationalescape hatches, places where a gentle nudge could kick an asteroid out of the belt and into the inner solar system toward Earth. Once ejected, members of the Baptistina family could wallop a lot more objects than just Gaspra.

Tracing the paths of the Baptistina asteroids back in time, the researchers calculate that the objects originated as a single, 170kilometer-wide body that was shattered by another big rock in the belt some 160 million years ago. About 20 percent of the Baptistina family escaped the belt, and about one-tenth of those asteroids would have continued on to Earth, doubling the number of objects striking the planet over the past 150 million years, Bottke and his collaborators say. Some 20 percent of the near-Earth asteroids are Baptistina-family escapees, they estimate.

"This is an amazing result and shows that recent events [in the asteroid belt] can strongly influence our impact history," says planetary scientist Derek Richardson of the University of Maryland at College Park.

To link these findings to the death of the dinosaurs, Bottke's team examined the composition of the 180-km-wide Chicxulub crater in Mexico. Most scientists accept the crater as proof that a space object collided with Earth 65 million years ago, causing the mass extinction at that time.

Sediments from the crater indicate that the impactor must have been a carbonaceous chondrite, an especially primitive meteorite. Such rocks have compositions matching that of the Baptistina asteroids but not that of several other candidates. Bottke's team calculates a 90 percent chance that the dinosaur killer came from the Baptistina family.

"Dead is dead, no matter where the bullet came from," notes asteroid researcher Alan W. Harris of the Space Science Institute in La Cañada, Calif. What's most important, he says, is that the team, studying recent data on hundreds of thousands of asteroids, has dated the origin of this family and argued that it eventually sprayed an "asteroid shower" toward Earth.

Another escapee from the Baptistina family probably gouged the 85-km-wide Tycho crater on the moon, the team suggests. -R. COWEN

#### **Live Wires** Axons can influence nerve impulses

The "wires" that carry electrical signals among nerve cells in the brain can influence the threshold at which the cells will send those signals, research on mousebrain tissue shows.

The finding challenges the conventional view of nerve cells, or neurons. In that sce-

nario, processes within a nerve cell determine whether or not to fire an electrical impulse, and the wire, called an axon, is a passive carrier of that signal.

"[Our research] says that the dogma is incorrect," says lead scientist Raju Metherate of the University of California, Irvine. A more active role for axons could be important for understanding how the brain processes sensory information. It could also have implications for the understanding of neurological diseases such as schizophrenia, Metherate says.

The scientists exposed the axons of isolated mouse neurons to nicotine, which mimics a natural chemical messenger in the brain called acetylcholine. Previous research had shown that axons in several regions of both mouse and human brains have receptors for acetylcholine, but the function of those receptors wasn't clear. Without nicotine, a weak input signal triggered the neurons to fire only 35 percent of the time. With axons exposed to nicotine, neurons in the tissue samples fired twice as often in response to the same signal. The change indicated that nicotine was lowering the neurons' thresholds, the researchers report in the September Nature Neuroscience.

"We believe this [influence by axons] is a major reason that nicotine enhances cognitive functioning," Metherate says. The neurons that Metherate's team studied connect a region in the center of the brain called the thalamus—which acts as grand central station for incoming sensory signals—and the brain's cortex, where thought occurs. So, lowering the firing threshold of these neurons would increase the amount of sensory stimulation reaching the cortex.

"I'm enthused by this research," comments Marina Picciotto, a psychiatrist and nicotine expert at Yale University. "It's only now that work on nicotinic receptors [on axons] is showing the role they play in modulating sensory input." Poor communication between the thalamus and cortex could contribute to disorders such as schizophrenia, some scientists hypothesize. If so, the new research could help explain why roughly 90 percent of people with schizophrenia smoke. "It may be that they're doing it to self-medicate," Picciotto says.

The mechanism by which acetylcholine receptors on axons lower neurons' firing thresholds remains uncertain, Metherate says. However, receptors located close to the base of an axon—which is where it meets the cell body and where nerve impulses originate—had a larger influence on the threshold than did receptors farther away.

The researchers didn't look at neurons in other brain regions. Scientists know, however, that at least some neurons, such as those making up the thick band that connects the brain's left and right hemispheres, don't have acetylcholine receptors on their axons. It remains unknown whether or not axons carry receptors for other chemical messengers, such as dopamine and serotonin. —P. BARRY

#### **Role Change** Mast cells show an anti-inflammatory side

As anyone who has reacted to poison ivy can attest, the plant can induce maddeningly itchy skin. Researchers have now found that a cell once thought to be one of the chief perpetrators of this immune overreaction may actually keep the reaction from getting out of hand.

Mast cells make proteins that contribute to the inflammation that characterizes allergic reactions. The cells are part of the innate immune system, the frontline defense that rushes inflammatory cells and proteins to scenes of irritation

or injury. Although mast cells play a valuable role in fighting bacteria and other pathogens, their conduct in allergic reactions appears rather like throwing gasoline on a fire.

A study in mice now shows that mast

cells produce a helpful immune protein a few days after skin contact with urushiol, the key culprit in poison ivy and its partners in skin crime, poison oak and poison sumac. The protein, called interleukin-10, ratchets down the inflammatory reaction, says study coauthor Stephen J. Galli, a pathologist at Stanford University Medical Center.

**DON'T TOUCH** The

reaction initiated in

New research shows

part by mast cells.

that these same

also limit the

reaction.

immune cells may

oil in poison oak

causes a skin

Galli and his colleagues conducted a series of experiments using normal mice, mice whose mast cells were unable to produce interleukin-10, and mice lacking mast cells.

Rather than simply looking at skin reactions that appeared immediately after contact with urushiol, Galli's colleague Michele A. Grimbaldeston decided to gauge the animals' responses to urushiol several days later. By the third day, the mice lacking mast cells and those whose mast cells didn't make interleukin-10 showed worse swelling and skin injury than did the normal mice.

As a backup test, the scientists repeated the experiments using an oft-studied chemical called 2,4-dinitro-fluorobenzene, which is known to cause allergic skin hypersensitivity. They found the same effect. A third set of experiments showed that interleukin-10 made by mast cells also limited the kind of damage from chronic sun exposure that leads to skin wrinkling and predisposes a person to skin cancer.

The findings appear in the October *Nature Immunology*.

Various cells make interleukin-10. Some studies have suggested that its main sources are immune system "brakes" called regulatory T cells.

The new findings show that interleukin-10 "may be produced by different cells at different stages of an immune response," says immunologist Anne O'Garra of the National Institute for Medical

Research in London.

Mast cells' long rap sheet had led some scientists to suggest that people might be better off without them. On the basis of the anti-inflammatory effect shown in this mouse study, however, Galli says, "you might want to think twice before eliminating this cell population." Inducing mast cells to crank out copious interleukin-10 as

needed would be beneficial, he says, but that would be a tall order.

Instead, researchers studying runaway immune reactions might now turn to asthma, in which mast cells have an inflammatory role. The new findings raise the question whether the cells might also limit airway inflammation during asthma attacks, says Galli. —N. SEPPA

#### **Sonic Sands** Uncovering the secret of the booming dunes

Marco Polo, Charles Darwin, and other adventurers marveled at the loud, thrumming sounds that emanate from sand dunes in certain desert locales around the world. Now, researchers say that they've solved the mystery of how the dunes produce their mysterious tones.

So-called booming dunes, which generate droning sounds that can last a minute or longer, have been found at around 30 places worldwide. Their often deafening tones are typically loudest at a single frequency between 70 and 105 cycles per second, says Melany L. Hunt, a mechanical engineer at the California Institute of Technology in Pasadena. (*Listen to a booming dune at www.sciencenews.org/ articles/20070908/boom.wav.*)

The sound originates when sand avalanches down the lee face of a dune, explains Hunt. Past studies suggested that

# his Week

the sound's frequency is related to the average size of the sliding sand grains, but new data gathered at several booming dunes in California and Nevada don't support that theory, say Hunt and her colleagues in the Aug. 28 Geophysical Research Letters.

Instead, the team's field studies suggest that a heretofore unrecognized property of such dunes-the thickness of a surface layer of dry sand-dictates the frequency of their tones.

In 2006, Hunt and her colleagues laid a string of sensitive microphones along the face of a 45-meter-tall dune at Dumont Dunes, just south of California's Death Valley. The researchers mapped the dune's internal structure by analyzing vibrations produced when they placed a metal plate on the dune and struck it with a hammer. The scientists also triggered avalanches.

The dune repeatedly boomed during tests in September 2006, when a 1.5-mthick layer of dry sand covered the dune's face. Data indicated that sound traveled through this surface layer at about 200 meters per second (m/s). At depths exceeding 1.5 m, where the sand was moist, vibrations traveled at speeds of 300 to 350 m/s, Hunt notes.

This abrupt difference causes the boundary between moist and dry sand to reflect sound waves, the team explains. The sound of avalanching sand bounces back and forth within the dry layer, creating a resonance that boosts the sound's intensity. Hunt says that the frequency of the sound that eventually escapes the dunes should be related to the layer's thickness.

In December 2006, when the dune had no dry layer, the sands remained silent, savs Hunt.

Michael Bretz, a physicist at the University of Michigan in Ann Arbor, says that Hunt and her colleagues "did a pretty nice job of collecting data." The booming dunes act somewhat like a stringed musical instrument, he notes. An avalanche, like a string of a violin, generates only a small sound. The dry layer of sand on the surface of the dune, like the body of the violin, acts as a chamber that magnifies the sound. —S. PERKINS

#### **Bipolar Express** Mental ailment expands rapidly among youth

The rate of bipolar disorder diagnoses for children and adolescents seen as outpatients by physicians shot up dramatically between 1994 and 2003, raising new concerns about possible overdiagnosis of this severe mood disorder among young people.

National medical surveys done during that time period show that the number of office visits that resulted in a bipolar diagnosis for kids and teens increased by a factor of 40, say psychiatrist Mark Olfson of Columbia University and his coworkers. That figure far exceeds the doubling of bipolar diagnoses for adults over the same stretch, the researchers add.

The team's findings appear in the September Archives of General Psychiatry.

Further research needs to examine how physicians decide that a child's emotional travails qualify as bipolar disorder and how



SAND FALL DOWN, GO BOOM Dunes at 30 or so sites around the world, such as these at Dumont Dunes in Southern California, sometimes generate loud, thrumming tones during avalanches of sand. The booming sounds can often be heard for kilometers.

often youngsters with other mental disorders get misclassified as bipolar, the investigators suggest.

"It's likely that this impressive increase reflects a recent tendency to overdiagnose bipolar disorder in young people, a correction of historical underrecognition [of the disorder], or a combination of both," Olfson says.

His team probed data from an annual nationwide survey of about 1,200 officebased physicians. The scientists focused on information from every second year from 1994 through 2003.

They estimate that during that period, the number of office visits yielding a bipolar diagnosis for patients age 19 or younger jumped from 25 out of every 100,000 to 1,003 out of every 100,000. For adults, the number of office visits resulting in a bipolar diagnosis increased from 905 per 100,000 to 1,679 per 100,000.

Since the national survey records data for office visits rather than for individual patients, an unknown number of youth and adults were counted more than once, Olfson cautions.

About two-thirds of youth visits that produced a bipolar diagnosis were made by males. In contrast, females accounted for most adult-bipolar diagnoses.

In addition, one-third of young people given a bipolar diagnosis also received a diagnosis of attention-deficit hyperactivity disorder (ADHD), compared with only 3 percent of bipolar adults.

Some ADHD symptoms, such as an elated mood and extreme excitability, overlap with the manic symptoms of bipolar disorder. Prior studies have suggested that physicians may mistake ADHD as well as mild manic symptoms displayed by some adolescents for bipolar disorder.

Whatever accounts for the national diagnostic trend, Olfson's team found that most youngsters and adults diagnosed with bipolar disorder received prescriptions for the same psychoactive medications. Comparable proportions of both age groups received prescriptions for lithium, anticonvulsants, antidepressants, and antipsychotics.

Much research has outlined treatment guidelines for adult-bipolar disorder. The new report underscores the need to study the safety and effectiveness of medications commonly prescribed to youth with bipolar disorder, Olfson says.

Diagnostic trends described in Olfson's study may partly reflect increased accuracy in adolescent-bipolar disorder diagnoses, comments psychiatrist Melissa P. DelBello of the University of Cincinnati College of Medicine. Overdiagnosis might also occur, but such cases need to be confirmed through detailed psychiatric interviews of kids and teens dubbed bipolar by physicians, DelBello says. -B. BOWER

## What *Really* Is the Universe Made of? Welcome to the Dark Side

Tackle this intriguing cosmic question with a theoretical physicist at the California Institute of Technology

There's more to the universe than meets the eye—a lot more. In recent years scientists have discovered that 95 percent of the contents of the cosmos is invisible to all of our current methods of direct detection. Yet something is definitely there, holding galaxies and galaxy clusters together, and governing the shape and fate of the universe.

Scientists call these invisible components dark matter and dark energy— "dark" because these phenomena don't emit light, not because we aren't learning more and more about them. Indeed, dark matter and dark energy are the most eagerly studied subjects in astronomy and particle physics today. And for good reason—what could be more exciting than cracking the mystery of the fundamental constituents and overall composition of the universe?

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#### About Your Professor

Professor Sean Carroll is a Senior Research Associate in Physics at the California Institute of Technology. He received his Ph.D. in Astrophysics from Harvard, did postdoctoral research at MIT and UC Santa Barbara, and taught at the University of Chicago. He has received research grants from NASA, the U.S. Department of Energy, and the National Science Foundation. In 2006 he was awarded the Arts and Sciences Alumni Medallion from Villanova University.

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## WHAT GOES UP

#### Big-city air pollution moves to the burbs and beyond

**BY SID PERKINS** 

effrey S. Gaffney, a sunburn-prone atmospheric scientist, set off one morning in March 2006 for a day of field work in Mexico City-without his hat and sunscreen. At Mexico City's altitude, 2,240 meters above sea level, sunlight beating down through the thin air delivers as much as 30 percent more ultraviolet radiation than reaches coastal regions. "I thought I'd be fried at the end of the day, for sure," he recalls.

But Gaffney, a researcher at the University of Arkansas in Lit-

tle Rock, came through the day unscathed. The sunburn that he'd feared never developed because much of the sun's ultraviolet radiation was blocked by the city's notoriously dirty air. Some of the radiation was scattered back to space by the high-altitude haze smothering the city; some was absorbed as it stimulated chemical reactions within that soup of pollutants.

He and more than 450 other researchers from Mexico, Europe, and the United States had come to Mexico City for a monthlong study of air pollution in, above, and around the metropolis. The MILA-GRO campaign-the Megacity Initiative: Local and Global Research Observations-was designed to scrutinize local and regional air quality, the effects of pollutants on human health, and the influence of Mexico City's pollution on regional and global climate. Mexico City, whose 20 million inhabitants endure constantly nasty air, was an ideal study site.

Any urban area with more than 10 million residents is considered a megacity. Many studies suggest that these gigantic urban areas have become the world's dominant sources of atmospheric pollutants. Some of their emissions are long-lived and apt to drift far from home. Pollution from Asian megacities routinely wafts to North America (SN: 12/12/98, p. 374; SN: 1/1/00, p. 4). Other research suggests that as much as one-third of the low-altitude ozone in some parts of Europe originates in North America.

MILAGRO data will enable scientists to better understand how air pollution evolves, says Gaffney. Increasingly, field studies and lab experiments indicate that the color, chemical reactivity, and other characteristics of airborne particles and droplets can change dramatically over time. Such findings may eventually affect how such pollutants are regulated.

Because Mexico City is the world's second-largest megacity,

many of the problems observed there may foreshadow troubles to come in smaller, rapidly growing urban areas throughout the world. On the other hand, computer simulations suggest that many smaller megacities export a proportionately higher share of their pollution to distant regions even than Mexico City does.

A GROWING PROBLEM In 1800, only 3 percent of the world's population lived in cities. Today, more than half of our planet's 6.6 billion people reside in urban regions. By 2030, if forecasts by the United Nations are correct, three-fifths of the world's projected population of 8.3 billion will live in cities.

The growth of population in cities leads to increased energy consumption within relatively small areas, a trend that typically decreases air quality and increases the prevalence of adverse

> health effects, says Luisa T. Molina, an atmospheric scientist at the Massachusetts Institute of Technology. Those consequences are particularly pronounced in Mexico City, she noted in May at a meeting of the American Geophysical Union in Acapulco, Mexico. In recent years, for example, ground-level concentrations of ozone in Mexico City have exceeded the country's air-quality standards 284 days per year, on average. Geography doesn't help: Mexico City lies in a broad basin ringed by tall mountains that can block the movement of air masses that might clear out pollution.

> Furthermore, the city's rapid spread in recent decades has aggravated its pollution problems. Mexico City now covers about 1,500 square kilometersabout 10 times as much land as it occupied just 50 years ago, says Molina. That sudden sprawl, coupled with unregulated land use, has translated

into a drop in population density that has in turn necessitated people and goods moving greater distances throughout the metropolis, says Luis G. Ruiz-Suarez, an atmospheric scientist at the National Autonomous University of Mexico in Mexico City. Many residents commute long distances through areas that lack mass transit.

All told, the 3.5 million vehicles traveling in and around the Mexico City area burn about 40 million liters of fuel each day. Their emissions, along with those from power plants, agricultural burning, and other sources, render the air over the city a noxious stew.

Hence the need for the MILAGRO campaign, the first comprehensive, multinational effort to assess the impact of a megacity on regional and global air quality, says Molina. To supplement observations from orbiting satellites and from ground



spreading over the Gulf of Mexico and toward the United States. Red denotes the highest concentrations of the gas.

stations throughout the city, MILAGRO-project scientists flew six sensor-laden aircraft, and even one ultralight craft, through plumes of pollution at various altitudes.

The researchers relied on a variety of chemical fingerprints to identify pollution sources, says James J. Schauer, an atmospheric scientist at the University of Wisconsin–Madison who participated in the study. For example, burning cellulose produces levoglucosan, which accounts for about 15 percent of the organic carbon in particles wafting from wood and grass fires. This substance doesn't degrade in the atmosphere. Combustion of fossil fuels, such as diesel, gasoline, and coal, produces hopanes, a group of hydrocarbons with multiringed structures. By determining the atmospheric concentrations of such chemicals, Schauer and his colleagues could divvy up the blame for Mexico City's pollution.

One of the group's sampling sites was in a downtown area near major traffic arteries and residential, commercial, and light-industrial neighborhoods. Gasoline-burning motor vehicles generated about 47 percent of the light-colored aerosols containing organic carbon collected at the site, while diesel engines produced some 88 percent of the dark-colored aerosols, Schauer and his colleagues report in an upcoming *Atmospheric Chemistry and* 

*Physics*. Pollution was particularly bad during morning rush hour, when traffic moved slowly, if at all, they note.

Pollution was lighter at a site about 35 km northeast of the downtown site, in an agricultural area on the city's fringe. Over the course of a day, motor vehicles were the largest contributors to air pollution. About 31 percent of the organic-carbon aerosols and 82 percent of the dark-colored aerosols came from gasolineor diesel-powered engines, data suggest.

Amounts also varied over time. Gasoline-powered vehicles accounted for 37 percent of the organic-carbon aerosols measured downtown on weekdays but 67 percent of those collected during week-



ends. Air samples collected during nighttime hours contained an estimated 13 percent fewer diesel emissions.

Wood smoke was another prevalent pollutant. Downtown, it was second only to vehicle emissions, says Schauer. At times, it accounted for as much as 30 percent of the organic aerosols, he adds. At the rural site, it sometimes accounted for 50 percent of organic aerosols.

Variations during the day in the concentrations of wood smoke measured downtown did not correlate with those seen at the rural site, indicating that wood-smoke pollution in the two areas probably came from different sources, says Schauer. Downtown, it may have derived from wood-fueled fires used to cure tiles or adobe bricks. At the rural site, the increased concentrations of nanometer-size, unburned fragments of plant material in smoke samples suggest that the smoke came from brush and grass fires, says Schauer.

**CHEMICAL EVOLUTION** Researchers couldn't identify pollution sources for a significant fraction of the organic-carbon aerosols detected during the MILAGRO campaign. Many of those particles were probably secondary organic aerosols (SOAs), which form in the atmosphere as a result of chemical reactions among various pollutants. Sunlight often stimulates such reactions.

During the field study, concentrations of SOAs varied dramat-

ically, Schauer says, from as little as 6 percent of organic-aerosol samples at the downtown site at some times of day to as much as 63 percent at others. One SOA, pinonic acid, forms in a reaction between oxygen and alpha-pinene, a chemical given off by certain species of trees and other plants. Atmospheric concentrations of pinonic acid typically spiked just a few hours after the researchers detected a rise in wood smoke, suggesting that woodfueled fires were the source of this pollution.

The MILAGRO data contain clues to many such transformations, says Gaffney. Observations from aircraft were particularly revealing. Early in the morning, haze over the city tended to be dark, a sign of diesel exhaust. As the day progressed, the aerosols reacted with other pollutants in the air and became lighter in color, scattering more light than they absorbed. "These reactions are rapid and probably take place within a couple of hours," Gaffney notes.

MILAGRO and other atmospheric studies provide opportunities to better understand the formation, evolution, and transport of SOAs. Gaffney and his colleagues observed, for example, that because the thick, high-altitude haze prevented much of the sun's ultraviolet light from reaching ground level, pollutants there didn't react with each other as quickly as they would have

under sunny conditions. So, Gaffney says, SOAs often didn't form until their ingredients wafted out to the surrounding region, where skies were relatively clear.

Such implications, coming from MILAGRO and other recent field studies and lab experiments, are revolutionizing air-quality research, says Neil M. Donahue, an atmospheric chemist at Carnegie Mellon University in Pittsburgh. "The study of air pollution has been flipped on its head in the last year," he notes.

In particular, SOAs are turning out to be a much bigger problem than scientists had previously realized. As Allen L. Robinson, also at Carnegie Mellon, puts it, "Pollutants that come out of

the tailpipe aren't the only ones you need to worry about."

Experiments by Donahue, Robinson, and their colleagues indicate that current models may drastically underestimate the extent of air-pollution migration from cities. They released diesel exhaust into a 12-cubic-meter, Teflon-coated chamber and zapped it with enough ultraviolet light to simulate radiation exposure on a summer day.

After 3 hours, the number of aerosols in the chamber had approximately doubled, says Robinson. The researchers then added what they thought would be enough toluene to again double the SOA count. Toluene is a hydrocarbon of modest molecular weight, used as an octane booster in some fuels, and thought to be an important source of SOAs. As it turned out, aerosol concentrations barely budged. Results were similarly negative when the scientists added other common pollutants, the team noted in the March 2 *Science*.

Contrary to prior belief, the recent experiments suggest that emissions of small hydrocarbon molecules actually account for only 15 percent of SOAs. Instead, the researchers suggest, most SOAs come from the oxidation of long-chain hydrocarbons that scientists had previously assumed would remain inert, says Robinson. When his team incorporated these new processes into *(continued on page 156)* 

## **GENOME 2.0**

#### Mountains of new data are challenging old views

BY PATRICK BARRY

hen scientists unveiled a draft of the human genome in early 2001, many cautioned that sequencing the genome was only the beginning. The long list of the four chemical components that make up all the strands of human DNA would not be a finished book of life, but a road map of an undiscovered country that would take decades to explore.

Only 6 years later, the landscape of the genome is already proving to be dramatically different than most scientists had expected.

The established view of the genome began to take shape in 1958, just 5 years after Francis Crick and James D. Watson worked out

the structure of DNA. In that year, Crick expounded what he called the "central dogma" of molecular biology: DNA's genetic information flows strictly one way, from a gene through a series of steps that ends in the creation of a protein. That principle developed into a modern orthodoxy, according to which a genome is a collection of discrete genes located at specific spots along a strand of DNA. This old view got the basics right: that genes encode proteins and that proteins do the myriad work necessary to keep an organism alive.

Researchers slowly realized, however, that genes occupy only about 1.5 percent of the genome. The other 98.5 percent, dubbed junk DNA," was regarded as useless scraps" left over from billions of years of random genetic mutations. As geneticists' knowledge progressed, this basic picture remained largely unquestioned. "At one time, people said, 'Why even bother to sequence the whole genome? Why not just sequence the [protein-coding part]?" says Anindya Dutta, a geneticist at the University of Virginia in Charlottesville.

Closer examination of the full human genome is now causing scientists to return to some questions they thought they had settled. For one, they're revisiting the very notion of what a gene is. Rather than being distinct segments of code amid otherwise

empty stretches of DNA-like houses along a barren country road-single genes are proving to be fragmented, intertwined with other genes, and scattered across the whole genome.

Even more surprisingly, the junk DNA may not be junk after all. Most of this supposedly useless DNA now appears to produce transcriptions of its genetic code, boosting the raw information output of the genome to about 62 times what genes alone would produce. If these active nongene regions don't carry code for making proteins, just what does their activity accomplish?

"What we thought was important before was really just the tip of the iceberg," says Hui Ge of the Whitehead Institute for Biomedical Research in Cambridge, Mass.

With the genome sequence in hand, exploration has moved at a brisk pace during the past 6 years. A milestone was reached in June, when a project called the Encyclopedia of DNA Elements (ENCODE) thoroughly mapped the functional regions in 1 percent of the human genome. The effort involved was staggering: Thirty-five teams of scientists from around the world worked for 4 years and compiled more than 600 million data points, the consortium reported in the June 14 Nature.

From the accumulating mountains of data, scientists are

building a new picture of how the genome works as a whole. They have found mutations in nongene regions of DNA that are linked to common diseases such as diabetes and forms of cancer. And some researchers propose that DNA once labeled junk could have spawned the complex bodies of higher organisms-even the complexities of the human brain.

#### SECOND FIDDLE TO SUPERSTAR In

the emerging picture of the genome's functioning, many of the key elements identified so far are molecules of RNA, a chemical cousin of DNA.

In the old central dogma, RNA had a strictly subservient role in the all-important task of making proteins. An RNA molecule is made from units of genetic code strung together, much like DNA. But while DNA has two strands twisted together into a double helix, RNA usually has only a single strand.

Protein synthesis begins when the two strands of a section of DNA unzip. Units of RNA then pair up with their counterparts on one of the DNA strands, forming a complementary messenger RNA (mRNA) molecule. The mRNA detaches and floats off to other parts of the cell, where it hooks up with machinery that transcribes its coded message into a protein.

If RNA's only job were making proteins, then nearly all the RNAs produced in cells should be transcripts of protein-coding genes. (A small fraction of RNAs serve in the protein-transcription machinery.) But in 2005, Jill Cheng and her colleagues at Affymetrix, a



JUNK BOOM — Simpler organisms such

as bacteria (blue) have a smaller percent-

age of DNA that doesn't code for proteins

than more-complex organisms such as

fungi (grey), plants (green), animals

(purple), and people (orange).

represented transcripts of traditional genes. In the team's experiments, 57 percent of the RNA was transcribed from noncoding, "junk" regions.

The results from ENCODE were even more striking. In the slice of DNA studied in that project, between 74 percent and 93 percent of the genome produced RNA transcripts. What becomes of this tremendous output is uncertain. John M. Greally of the Albert Einstein College of Medicine in New York says it's likely that some portion of it is made accidentally and simply discarded. But the discovery that so much of the genome is being transcribed into RNA underscores how out-of-date the central dogma has become.

Indeed, the closer researchers look, the more functions they find that RNA transcripts perform. An alphabet soup of new acronyms describes the newfound roles of RNAs. First there were short nuclear RNAs (snRNAs) and short nucleolar RNAs (snoRNAs), both of which reside inside the nucleus and help control production of other RNAs. These were joined by microRNAs (miRNAs) and short interfering RNAs (siRNAs), which can modulate the activity of protein-coding genes. In mice, about 34,000

of the RNA transcripts produced by the genome are nonprotein-coding, outnumbering the roughly 32,000 transcripts that code for proteins, according to a 2005 study by an international group of scientists called the Functional Annotation of Mouse Consortium.

These new families of RNAs add a layer of regulation that fine-tunes the production of proteins. While scientists already knew that some proteins influence the activity of other genes, "there are many more RNAs than proteins that play a regulatory role," Ge says.

Gene regulation may not sound sexy, but it's a powerful way for a cell to evolve complex behaviors using the tools—proteins—that it already has. Consider the difference between a one-bedroom bungalow and an operate the complex bodies and brains of people, as compared with the simplicity of roundworms? "If we just look at the number of genes, it doesn't make sense," Ge says.

While the number of genes isn't much different in roundworms and people, the human genome is 30 times the size of the roundworms'. People have a much larger quantity of DNA beyond what codes for proteins. Since much of this "junk" DNA is being transcribed into RNA, perhaps it's responsible for much of the complexity of human bodies and brains. In fact, organisms simpler than roundworms, such as single-celled bacteria, carry little noncoding DNA and may have no regulatory RNA at all.

"Scientists have been suspecting that it is the regulatory networks that lead to this amazing complexity" in higher organisms, Ge says.

John S. Mattick of the University of Queensland in Brisbane, Australia, points to a known example of the importance of regulatory RNAs: their crucial role in fetal development. For example, most multicellular animals possess a gene called *Notch* that helps guide neural development. While the gene itself has much



**TANGLED GENES** — In the classic view of the genome (top), individual genes were distinct segments of DNA that a cell transcribed into RNA whole and in one direction. New data show that multiple and overlapping genes can occupy a single strip of DNA that also produces several functional RNAs that don't encode proteins (bottom, not to scale).

ornate, three-story McMansion. Both are made from roughly the same materials—lumber, drywall, wiring, plumbing—and are put together with the same tools—hammers, saws, nails, and screws. What makes the mansion more complex is the way that its construction is orchestrated by rules that specify when and where each tool and material must be used.

In cells, regulation controls when and where proteins spring into action. If the traditional genome is a set of blueprints for an organism, RNA regulatory networks are the assembly instructions. In fact, some scientists think that these additional layers of complexity in genome regulation could be the answer to a long-standing puzzle.

## **GENOME AS NETWORK** The biggest surprise in the first sequence of the human genome was how few protein-coding genes it contained.

"We humans do not have that many more genes than simpler organisms like flies or mice," Ge says. Earlier guesses of the number of genes in humans ran as high as 100,000, but the published sequence in fact contained only about 23,000. That's not much more than the roughly 21,000 genes possessed by the roundworm, a microscopic creature without a brain. If protein-coding genes are the only functional elements in an organism's DNA, where does

the extra information come from that's needed to assemble and

the same form in both simple and complex animals, its activity is regulated by miRNAs that are highly variable from one animal to another. Such miRNAs also influence a gene called *Hox*, which acts in many animals to define a fetus' body axis and the placement of its limbs.

What's more, the changes that distinguish human brains from those of chimpanzees and other apes could be due in part to evolutionary changes in RNAs that don't encode proteins. A group led by Katherine S. Pollard of the University of California, Davis identified DNA sequences shared by people and chimpanzees, but with large differences, meaning that they have evolved rapidly since the two species shared a common ancestor.

The researchers found that one of these sequences is a non-

coding region of DNA that's related to brain function, they reported in the Sept. 14, 2006 *Nature*. Pollard and her colleagues speculate that this region produces a regulatory RNA and that changes in this RNA contributed to the evolution of the human brain.

With regulatory RNAs appearing to play such an instrumental role in animal development, it's no surprise that scientists are finding disease-associated mutations in regions of the genome formerly regarded as junk.

David Altshuler of the Broad Institute in Cambridge, Mass., and his colleagues looked for DNA mutations in 1,464 patients with type 2 diabetes. Three of the mutations that correlated with the disease were in DNA segments that don't code for proteins, the team reported in the June 1 *Science*. Other scientists have found mutations in noncoding DNA that link to diseases such as autism, breast cancer, lung cancer, prostate cancer, and schizophrenia.

To be sure, the specific functions of most of the noncoding DNA remain unknown. Projects such as ENCODE have focused on identifying the broad functional categories for active regions of the genome without working out the specific cellular function of each transcript, a task that will take biologists years, if not decades.

In fact, scientists debate whether some fraction of the genome's copious RNA output might do nothing at all. It may simply be that once the cellular machinery that transcribes DNA into RNA gets started, it sometimes doesn't know when to stop. On the other hand, making lots of RNA that does nothing would be a waste of a cell's energy. That's something that natural systems tend to avoid, so the fact of its production argues for at least some of this RNA being biologically active.

**THE GENE IS DEAD** In the old view, each gene sat in splendid isolation on its segment of the genome. Other genes might be nearby, but scientists assumed that they didn't overlap each other.

Now it's clear that a single length of DNA can be transcribed in multiple ways to produce many different RNAs, some coding for proteins and others constituting regulatory RNAs. By starting and stopping in different places, the transcription machinery can generate a regulatory RNA from a length of DNA that overlaps a protein-coding gene. Moreover, the code for another regulatory RNA might run in the opposite direction on the facing strand of DNA. According to the ENCODE project results, up to 72 percent of known genes have transcripts on the facing DNA strand as well as the main strand.

"The same sequences are being used for multiple functions," says Thomas R. Gingeras of Affymetrix. That introduces complications into the evolution of the genome, which had until recently been assumed to act through single DNA mutations affecting single genes. Now, "a mutation in one of those sequences has to be interpreted not only in terms of [one gene], but [of] all the other transcripts going through the region," Gingeras explains.

The implications of this single mutation-multiple consequence model are still a matter of debate. In some cases, the RNA transcripts from DNA that overlaps a protein-coding gene regulate that same gene, so a mutation could affect both the structure and the regulation of a protein. But often, those transcripts regulate genes that are far away, or even on different chromosomes. This complex interweaving of genes, transcripts, and regulation makes the net effect of a single mutation on an organism much more difficult to predict, Gingeras says.

#### (continued from page 153)

computer models that simulate the formation and spread of air pollution, they found a 15- to 30-percent rise in pollution in rural areas downwind of cities.

Most such simulations consider the reactions among, at most, a few dozen atmospheric gases and pollutants. However, emissions from tailpipes and smokestacks typically contain hundreds, if not thousands, of hydrocarbons and other compounds. They have "so many different molecules, it's a soup," says Robinson. Scientists, he notes, are increasingly recognizing SOAs as "unpleasant surprises." In fact, SOAs probably account for the majority of pollutants to which people are exposed. Robinson and his colleagues suggest that air-quality regulations may need to be revised to account for the most common SOAs.

**BIG FOOTPRINTS** Megacities, despite their sprawl, occupy a relatively small part of the landscape. Even so, the air masses driven by Earth's weather systems can carry a megacity's pollution thousands of kilometers.

Some atmospheric pollutants have extremely short lifetimes. Nitrogen oxides, for example, which form as by-products of fossil fuels burned at high temperatures, last only a couple of days before they react with other substances, says Tim M. Butler, an atmospheric chemist at the Max Planck Institute for Chemistry in Mainz, Germany. Ozone, on the other hand, persists in the atmosphere for an average of 25 days and can waft across oceans.

Because wind spreads air pollution, a region's weather patterns dictate whether its megacities are aggressive exporters of bad air. Butler and his colleagues have used computer models to simulate how pollutants with various atmospheric lifetimes would spread from 30 large urban areas, including 20 megacities, throughout the world. Although pollution concentrations vary among the megacities, the researchers assumed that each urban More fundamentally, it muddies scientists' conception of just what constitutes a gene. In the established definition, a gene is a discrete region of DNA that produces a single, identifiable protein in a cell. But the functioning of a protein often depends on a host of RNAs that control its activity. If a stretch of DNA known to be a protein-coding gene also produces regulatory RNAs essential for several other genes, is it somehow a part of all those other genes as well?

To make things even messier, the genetic code for a protein can be scattered far and wide around the genome. The ENCODE project revealed that about 90 percent of protein-coding genes possessed previously unknown coding fragments that were located far from the main gene, sometimes on other chromosomes. Many scientists now argue that this overlapping and dispersal of genes, along with the swelling ranks of functional RNAs, renders the standard gene concept of the central dogma obsolete.

**LONG LIVE THE GENE** Offering a radical new conception of the genome, Gingeras proposes shifting the focus away from protein-coding genes. Instead, he suggests that the fundamental units of the genome could be defined as functional RNA transcripts.

Since some of these transcripts ferry code for proteins as dutiful mRNAs, this new perspective would encompass traditional genes. But it would also accommodate new classes of functional RNAs as they're discovered, while avoiding the confusion caused by several overlapping genes laying claim to a single stretch of DNA. The emerging picture of the genome "definitely shifts the emphasis from genes to transcripts," agrees Mark B. Gerstein, a bioinformaticist at Yale University.

Scientists' definition of a gene has evolved several times since Gregor Mendel first deduced the idea in the 1860s from his work with pea plants. Now, about 50 years after its last major revision, the gene concept is once again being called into question. ■

area emitted a total of 1 kilogram of pollutant per second. The researchers also tracked whether the simulated pollutants rose to high altitudes or remained near ground level.

On average, about 5.5 percent of a pollutant that lasts for 10 days in the atmosphere would remain at altitudes below 1 km and travel more than 1,000 km from Mexico City, the team found. Eventually, such substances could show up at concentrations exceeding 10 nanograms per cubic meter across an area of more than 1.2 million

#### "We have one globe, and it has one atmosphere."

— JEFFREY S. GAFFNEY, UNIVERSITY OF ARKANSAS, LITTLE ROCK km<sup>2</sup>. That's an area about 800 times as large as the city itself, but it's a small reach compared with that of pollution plumes from most other megacities, Butler and his colleagues report in the July 26 *Atmospheric Chemistry and Physics*.

The simulation's biggest exporters of bad air were cities at middle and high latitudes, where weather systems less frequently lift pollution to high altitudes, says Butler. Relative to its amount of emissions, the worst long-distance pol-

luter was Moscow. More than 34 percent of a pollutant with a 10day lifetime would travel more than 1,000 km from that city. Over time, such a pollutant could be found at concentrations of 10 ng/m<sup>3</sup> or higher across more than 11.1 million km<sup>2</sup>, an area larger than all of Europe.

Long-lasting pollutants would eventually spread to cover the entire Northern Hemisphere, Butler notes. These include carbon monoxide, for example, which lasts about 60 days. Substances that last months or years, such as methane, would travel farther and diffuse worldwide.

Results of such simulations, as well as data from satellites and field studies such as MILAGRO, highlight the simple fact that, as Gaffney says, "We have one globe, and it has one atmosphere."

## OF NOTE

#### PLANETARY SCIENCE A different view of Uranus' rings

As seen from Earth, the rings of Uranus are now precisely edge on. It's the first time this

alignment has occurred since Uranus' rings—now known to number 13—were discovered in 1977, and the event is providing an unprecedented view of the planet's small, inner rings.

Twice in every 84-year orbit of Uranus, the tilted plane of its rings lines up with the center of the solar system.

In the edge-on configuration, the bright outer rings, which ordinarily dominate the view of Uranus from Earth, grow fainter because their relatively large dust particles obscure one another. Meanwhile, the normally dim inner rings brighten as their finer dust appears to merge into a thin band.

Near-infrared images taken by the Keck II telescope atop Hawaii's Mauna Kea reveal that the inner rings are brighter now than they were when the Voyager 2 spacecraft flew past 21 years ago, indicating that the population of micrometer-size dust particles has increased in these rings. Either a broad inner ring called Zeta has moved several thousand kilometers since 1986 or astronomers are seeing a completely new inner ring, says Mark Showalter of the SETI Institute in Mountain View, Calif. He and his collaborators report the Keck observations in an upcoming *Science*.

The team is analyzing images, taken by the Hubble Space Telescope on Aug. 14, to hunt for previously unknown, faint moons suspected of corralling Uranus' rings. —R.C.

#### NEUROSCIENCE HIV is double trouble for brain

SHOWALTER, NASA, ESA

People who live a long time while infected with HIV sometimes develop dementia. The virus that causes AIDS is known to damage brain cells, and it now appears that the virus halts the creation of new neurons as well.

A single protein in the virus' outer shell triggers both dementia-inducing effects, new research shows. Brains normally generate a steady stream of new nerve cells in the hippocampus, a region associated with learning. But the HIV protein called gp120 inhibits the stem cells in the brain from producing new nerve cells.

However, "there is a silver lining to this," says research leader Stuart A. Lipton of the University of California, San Diego. That's because gp120's ability both to kill

> mature brain cells and to hinder the birth of new ones depends on a single brain-cell enzyme. This enzyme, called p38 mitogen-activated protein kinase (MAPK), could provide a target for drugs against the dementia.

> "If you can inhibit that enzyme, you might be able to reduce the brain damage," Lipton says. Drugs that block MAPK are currently in latestage clinical trials for treating arthritis.

> Lipton's team had previously demonstrated gp120's lethal effect on mature neurons by injecting it into mice. In the new research, reported

in the August *Cell Stem Cell*, mice getting such injections ended up with few stem cells, which appeared not to be dividing. —P.B.

#### **ANTHROPOLOGY**

#### Men's fertile role in evolving long lives

Well past age 50, men can still impregnate women of childbearing age. That lengthy period of fertility spurred the evolution of relatively long lives in both sexes, a new study suggests.

In modern hunter-gatherer societies, a substantial number of men in their 60s and 70s continue to father children, say Stanford University biologist Shripad D. Tuljapurkar and his colleagues. A mathematical model that they describe in the August *PLoS ONE* indicates that, if this mating pattern had occurred throughout human evolution, it would have preserved genes that favor both male and female survival for as long as men can reproduce, until roughly age 70.

That conclusion builds on a review of mortality patterns in hunter-gatherer and other nonindustrial societies published in the June *Population and Development Review*. Anthropologists Michael D. Gurven of the University of California, Santa Barbara and Hillard Kaplan of the University of New Mexico in Albuquerque conclude that nearly one in three members of such populations live past age 55, many into their 70s. Older, high-status men often monopolize access to reproductive-age women in these groups, Gurven and Kaplan say.

The same mating pattern applied to many Stone Age groups, Tuljapurkar proposes.

A female life span extending beyond menopause also evolved as a result of grandmothers increasingly assisting their daughters in caring for their own offspring, asserts anthropologist Kristen Hawkes of the University of Utah in Salt Lake City.

However, this grandmother effect can't explain why menopause evolved in the first place, notes University of New Mexico anthropologist Kim Hill. In a majority of hunter-gatherer groups, moreover, men who are older than 55 generally father few children, undermining Tuljapurkar's conclusions, Hill contends. —B.B.

### Virus thrives by hiding

After invading a cell, some viruses cozy up to it's internal membranes before reproducing, but scientists haven't been sure why. Now they've seen that one such microbe, the flock house virus, reproduces in cocoons within the membranes.

The cocoons are havens where the virus can replicate safe from the cell's defenses, says Paul Ahlquist at the University of Wisconsin–Madison. But before the virus can hide itself, it must produce proteins that make up the pouches. "The early phase of [viral] replication is a point of significant vulnerability," says Ahlquist, who led the research. Drugs that interfere with the cocoons' proteins or otherwise thwart the creation of the cavities could leave the viruses exposed to attack by the cell, Ahlquist says.

The protein pockets made by flock house virus are similar to protective protein shells created by viruses in other major virus classes. Unlike flock house virus, however, these other viral types use the shells to travel between cells. The similarity between the shells and the cocoons suggests an evolutionary link among the virus classes, the team reports in the Aug. 14 *PLoS Biology*.

Scientists could exploit this commonality to develop treatments that are broadly



**EDGY PORTRAIT** Uranus flanked by its rings, seen edge on by the Hubble Space Telescope.

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effective against diseases including AIDS, severe acute respiratory syndrome, and hepatitis C, Ahlquist suggests. - P.B.

#### **ENVIRONMENT** Lack of oxygen stunts fish reproduction

Seasonal hypoxia, when dissolved oxygen concentrations in water drop below 2 milligrams per liter, is a normal summer occurrence in estuaries. Over the past 20 years, however, pollution has increased the severity and frequency of hypoxia in waters worldwide. That trend could put a crimp in the reproductive capacity of coastal fish, new research shows.

Earlier laboratory studies indicated that in species that can survive hypoxia, reproduction shuts down (SN: 3/1/03, p. 132). Peter Thomas and his colleagues at the University of Texas Marine Science Institute in Port Aransas have now shown that some Atlantic croakers (Micropogonias undulatus) in the Gulf of Mexico have underdeveloped sperm and eggs. The fish were living in parts of Florida's Pensacola Bay that are hypoxic for extended periods each year.

"The extent of impairment was profound in comparison to what you normally find with pollution," Thomas says. "It was much worse, and it affects both sexes." Laboratory experiments showed that hypoxia disrupts hormones that stimulate reproduction, the researchers report online and in an upcoming Proceedings of the Royal Society of London B.

Shutting down reproduction is probably a survival strategy that croakers developed to cope with brief periods of hypoxia, Thomas says. The fish's reproductive problems could imply similar difficulties for other fish populations in areas such as the Chesapeake Bay as well as elsewhere in the Gulf. -S.W.

#### **BEHAVIOR Orangutans hand it** to researchers

Orangutans try to communicate by gesturing in the same way as people do, researchers find.

In a series of sessions with captive female orangutans, Richard Byrne and his colleagues at the University of St. Andrews in Scotland offered individual animals a whole

serving of a favorite food, a half serving, or a food that the apes didn't prefer. The scientists recorded signals that the animals made before food appeared, when it was offered, and after the food was given over.

"They have gestures that have more or less precise meanings," Byrne says. He notes that such abilities are often considered uniquely human.

"It's what orangutans do when they're thwarted that reveals what's in their minds," Byrne says.

He and his colleagues found that when presented with half a portion of a favorite food, the ape would typically increase the frequency of whatever gesture it was making

before the food appeared-signaling that it wanted more, the researchers infer.

When the offered food wasn't a favorite, the animal changed the motion that it had been making before food appeared, which the researchers interpret as a message that the food giver didn't understand the animal.

The observations reveal that orangutans were "reacting to the mental state" of the food giver, Byrne says. This is the same method used by people when playing the party game charades, he adds.

"The ability to understand the audience and to do something appropriate about it may go back a long way in evolution," says Byrne. The report appears in the Aug. 7 Current Biology. -C.B.

#### **NEUROSCIENCE Aura origins** show the way in epilepsy surgery

Epileptic seizures are often preceded by auras, which patients experience in many ways: visual disturbances, butterflies in the stomach, or even déjà vu. An aura can reveal which part of the brain is spawning a seizure, but multiple auras in a person have heretofore offered little guidance to doctors.

A new study finds, however, that multiple auras tend to originate in the right hemisphere of the brain, often from an identifiable starting point. Pinpointing the trouble spot has now enabled surgeons to remove it in some patients.

Such brain surgery is usually reserved for epilepsy patients with single auras whose seizures can't be controlled with medication. Patients with multiple auras, which are assumed to originate from multiple trouble spots, have been considered poor candidates for surgery, says study coauthor Prakash Kotagal of the Cleveland Clinic.

Using brain scans and electroencephalograms, he and his colleagues created detailed maps of the brains of 19 people who regularly experienced multiple auras. The doctors used these maps to track



**GET MY MEANING?** Orangutans try different gesturing strategies when they think they're being misunderstood, researchers say. the misfiring pattern of each sequence of auras back to a single starting point, which became the target of surgery.

Six months later, 10 of the 19 patients remained free of seizures, the team reports in the Aug. 21 Neurology.

The technique seems to work only in the right hemisphere of the brain, which is less essential to language and consciousness than the left is, Kotagal says. Patients with

multiple auras traceable to the right hemisphere can better describe them to doctors before a seizure occurs, he says. -N.S.

#### **ENVIRONMENT** Laser printers can dirty the air

The smaller an air-pollution particle is, the more likely it will be inhaled deep into the lungs, where it can trigger disease. A new study finds that office laser printers can spew especially small particles.

Lidia Morawska of the Queensland University of Technology in Brisbane, Australia, says that her team stumbled onto the finding while attempting to evaluate the effectiveness of office ventilation by comparing indoor and outdoor pollution. In the office building studied, airborne concentrations of nanoscale specks were higher than they were near a busy expressway.

Using air monitors, the physicists tracked down the major indoor culprits: 13 of the building's 62 laser printers were high emitters of fine particulates, another 2 were midlevel emitters, and 7 were low emitters.

During workdays, at least, the building's ventilation system couldn't remove all the printers' combined pollution. For the dirtiest printers, emissions climbed as the amount of toner increased. Once emitted, fine particles circulated widely and took hours to settle out. The researchers didn't chemically identify the particles.

Brand names and model numbers offered no clear guide to a printer's emissions. For instance, three Hewlett-Packard models had representatives on lists of both the worst polluters and machines emitting no particles, the researchers report in the Sept.1 Environmental Science & Technology. -J.R.

## Books

A selection of new and notable books of scientific interest

#### 112 MERCER STREET: Einstein, Russell, Gödel, Pauli, and the End of Innocence in Science BURTON FELDMAN, KATHERINE WILLIAMS, EDS.

In 1943, Albert Einstein invited three friends—pacifist and philosopher Bertrand Russell, physicist



Wolfgang Pauli, and mathematician Kurt Gödel—to his home on Mercer Street in Princeton, N.J. Little is known about what was actually said, but Feldman uses the meeting as a starting point for examining the lives of these four men and their groundbreaking work. Rivalries among the four were strong. But by the

time of their reunion, the men also had something in common: They had been sidelined from the ongoing war effort, notably the research at Los Alamos. They also were united by a concern over the politicization of science. It was, the author notes, the end of innocence in science. Feldman rounds out his account with profiles of two of the men's contemporaries, both of whom represented science's new direction: Werner Heisenberg, who did fission research in Germany, and J. Robert Oppenheimer, leader of the Manhattan Project. *Arcade, 2007, 243 p., hardcover, \$26.00.* 

#### HOW MATHEMATICIANS THINK: Using Ambiguity, Contradiction, and Paradox to Create Mathematics WILLIAM BYERS

Many people assume that mathematicians' thinking processes are strictly methodical and algorithmic. Integrating his experience



as a mathematician and a Buddhist, Byers examines the validity of this assumption. Much of mathematical thought is based on intuition and is in fact outside the realm of black-and-white logic, he asserts. Byers introduces and defines terms such as mathematical ambiguity, contra-

diction, and paradox and demonstrates how creative ideas emerge out of them. He gives as examples some of the seminal ideas that arose in this manner, such as the resolution of the most famous mathematical problem of all time, the Fermat conjecture. Next, he takes a philosophical look at mathematics, pondering the ambiguity that he believes lies at its heart. Finally, he asks whether the computer accurately models how math is performed. The author provides a concept-laden look at the human face of mathematics. *Princeton*, 2007, 415 p., hardcover, \$35.00.

#### OF A FEATHER: A Brief History of American Birding SCOTT WEIDENSAUL

Birding, which began as an eccentric pastime, has become one of the most popular forms of outdoor recreation in the United States. Weidensaul reviews the history of birding, beginning with the frontiersmen who marveled at the diversity of bird species in the New World and including the expeditions of ornithologist James Audubon. The author describes



A Brief Bistory of American Birding talists, including a group of women who, at the end of the 19th century, protested hunting birds for collecting and advocated observing live specimens. He tells the tale of an unassuming schoolteacher, Roger Tory Peterson, who originated the

the efforts of early environmen-

Peterson, who originated the now-famous bird guide. Weiden-

saul speculates on the reasons for the growing popularity of birding, describing events such as birding competitions with cash prizes. He concludes with a plea for bird-habitat conservation. *Harcourt, 2007, 358 p., b&w plates, hardcover, \$25.00.* 

#### SUPER CRUNCHERS: Why Thinking-by-Numbers Is the New Way to Be Smart IAN AYERS

Conventional wisdom dictates that experience and intuition are unfailingly valuable when it comes to making decisions. Ayers, an econometrician and a



lawyer, makes a case that may revolutionize that mind-set. We have entered an era in which decisions based on the analysis of data sets can produce far better results than decisions based

on experience, he says. Companies use data-driven formulas, called super crunchers, to determine everything from who will

buy their products (and for how much) to which baseball players have the most promise (without even seeing them play). Companies such as Google, auto-insurance agencies, airlines, and online dating sites have already begun to use super-cruncher technology. Ayers warns readers of the need to be vigilant in the face of such tactics and ponders the ethics, if not the efficacy, of super crunching. Bantam, 2007, 260 p., hardcover, \$25.00.

#### WHY BEAUTIFUL PEOPLE HAVE MORE DAUGHTERS

ALAN S. MILLER AND SATOSHI KANAZAWA Ever wonder why people act the way they do? The question remains one of life's mysteries, and for good reason. Although scientists have paid great



attention to the way in which learning and the environment shape human nature, mainline research has sidestepped an examination of how evolution has formed human behavior. Much of this reluctance, Miller and Kanazawa propose, stems from a fear of suggesting that some of people's less-than-flat-

tering tendencies are innate. In a question-andanswer format, the authors examine several of these tendencies. For example: Why are women better at child care? Why are most violent criminals men? The authors even take on the origins of religion. They answer each question from an evolutionary biologist's perspective, offering evidence that many of our behaviors served adaptive purposes and that human evolution has not kept pace with other developments in the world. Miller and Kanazawa provide a new take on the nature-versus-nurture debate. *Perigee, 2007, 252 p., hardcover, \$23.95*.

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## LETTERS

#### **Patent pending**

If Drs. Glass and Venter succeed in assembling a viable synthetic bacterial genome ("Life Swap: Switching genomes converts bacteria," *SN: 6/30/07, p. 403*), will the genome or the new life form itself be patentable?

VIRGIL H. SOULE, FREDERICK, MD.

The team that performed this work stirred controversy when it applied for a patent on a synthetic bacterial genome in October 2006. The patent hasn't yet been granted. —P. BARRY

#### Whisky or sour?

It has been reported that vinegar, taken before a meal, can lower postmeal blood glucose. If so, the lowering of postmeal blood glucose by alcohol, as reported in "Alcohol Answer? Drinks lower glucose to protect heart" (*SN: 6/30/07, p. 405*), may be the result of the alcohol being metabolized to acetic acid by the body. WILLIAM HAAG, BLOOMER, WIS.

While both alcohol and vinegar lower blood glucose after a meal, they act through different pathways in the body. Vinegar lowers blood glucose by retarding the release of food from the stomach. —C. BARRY

#### One more thing

"Antibiotics in infancy tied to asthma" (*SN*: 7/7/07, *p. 14*) offers two explanations for the correlation of asthma with early infancy antibiotics: a need for the immune system to be trained by early exposure to microbial toxins and a need for normal intestinal microflora in the development of normal immune response. Another possibility is that the rashes and infections that prompted the use of antibiotics share a common cause with the subsequent asthma.

MATTHEW H. FIELDS, ANN ARBOR, MICH.

**Corrections** "New Clues: Gene variations may contribute to MS risk" (*SN*: 8/4/07, p. 70) reversed the possible relationship between sun exposure and multiple sclerosis (MS) risk. The story should have said that a *lack* of childhood exposure to sunlight apparently contributes to MS risk. "Light reaches deep in southeast Pacific" (*SN*: 8/4/07, p. 77) perpetuated an incorrect spelling for Lake Vanda in Antarctica.

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