FEBRUARY 23, 2008 PAGES 113-128 VOL. 173, NO. 8

SCIENCE NEWS

THE WEEKLY NEWSMAGAZINE OF SCIENCE

energy from randomness
a star's magnetic flip
lake mead running dry
teens online and at risk

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speed versus size

JELLYFISH MOVE TO DIFFERENT BEATS

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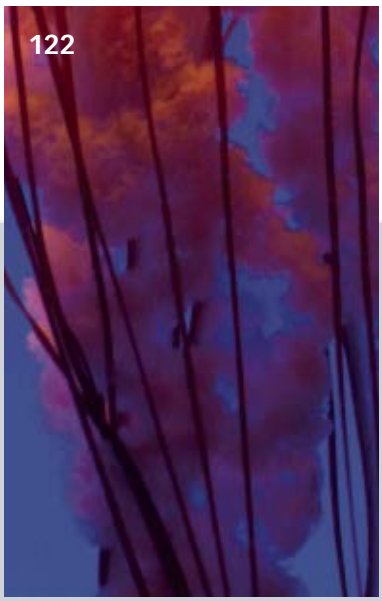

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Cover This Scyphozoan jellyfish, with its UFO-shaped bell, moves to a slower rhythm than its smaller, rocket-shaped relatives. New studies link jellyfish means of locomotion to body size and shape. (iStockphoto) Page 122

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MathTrek Her work almost lost to history, Sophie Germain was the first to propose a realistic plan to prove Fermat's last theorem.

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Benign—Not

Unexpected deaths in probiotics study

Prescribing "good" bugs for the gut—it may sometimes be bad medicine.

That's what Dutch doctors have concluded after reviewing the findings of a novel treatment in people with acute pancreatitis.

The researchers knew that some of their 296 patients would succumb to infectious complications of an inflamed pancreas, a gland that makes hormones and digestive juices. But they never expected that patients provided nutrition laced with probiotics—supposedly beneficial gut microbes—would experience a death rate nearly triple that of people fed just the nutrients.

STATS

80 thousand

Number of U.S. cases of acute pancreatitis each year

Yogurts and other foods or dietary supplements containing probiotics have reduced infections and the severity of gastrointestinal disorders in many trials. So, Dutch physicians looked to see if probiotics would similarly benefit newly diagnosed acute-pancreatitis patients.

All the patients received food pumped directly into the small intestine. For half the recruits, the food was laced with a novel mix of six strains of bacteria. During the trial, neither the patients nor the doctors running the experiments knew who had received the twice-daily supplements of bacteria, each for a 1-month period.

Although the overall death rate in the trial matched the value typically seen with acute pancreatitis—11 percent—just 6 percent of the untreated patients died. In contrast, 16 percent of patients receiving the probiotics died. This "was shocking," says study leader Marc G.H. Besselink of University Medical Center in Utrecht, the Netherlands. "We're quite devastated."

His group reports its findings in a paper the *Lancet* released online Feb. 14.

Nearly one-third of each group developed infections, but the probiotic bacteria did not cause them in the treated group. "We know," Besselink explains, "because we did blood cultures" to identify the agents responsible. Tests also ruled out any tainting of the probiotics with infectious germs.

What the team did find were nine cases of bowel ischemia—eight of them fatal—a condition in which tissue dies from oxygen starvation, allowing germs and toxins to escape into the body. In each case, the patient had received probiotics.

Besselink surmises that the oxygen demand of microbes introduced into an already stressed digestive system might have contributed to the suffocation of bowel cells. Or, he says, gut cells might simply have viewed the probiotic bacteria as a threat and inappropriately revved up an immune reaction against them, producing collateral damage to the bowel.

As the Dutch researchers begin animal tests of these hypotheses, they advise other physicians to avoid use of probiotics for patients with acute pancreatitis and for people in intensive care units, or where probiotics will be delivered through a tube directly into the intestines.

The study showed a striking survival benefit for administering food into the small intestine, already a type of therapy, notes gastroenterologist David C. Whitcomb of the University of Pittsburgh. The error, he suspects, was seeding probiotics into the same place, a region normally all but devoid of microbes.

The stomach and colon are rife with microbial life, he notes, and trials that deposited probiotics in these regions have shown promise. By contrast, he points out, earlier studies that sterilized the intestine with antibiotics—the antithesis of probiotics—improved the prognosis of acute pancreatitis sufferers.

Lee E. Morrow of Creighton University Medical Center in Omaha, Neb., sees no need to generalize the Dutch trial's findings to all critically ill patients. His team has been administering a single *Lactobacillus* GG probiotic to roughly 200 intensive care patients with head trauma and other conditions that require breath support from a ventilator. Doses are delivered partly by mouth and partly by tube into the stomach.

This ongoing trial is showing "clear, statistically significant benefits in reducing ventilator-associated pneumonia," Morrow says. "So [the Dutch findings] are certainly not stopping our study." —JANET RALOFF

Going Down

Climate change, water use threaten Lake Mead

If climate changes as expected and future water use goes unchecked, there's a 50 percent chance that Lake Mead—one of the southwestern United States' key reservoirs—will become functionally dry in the next couple of decades, a new study suggests.

Besides providing water for millions, flow from Lake Mead—the reservoir formed as the Colorado River collects behind Hoover Dam—generates prodigious amounts of hydroelectric power. Over the past century, on average, about 18.5 cubic kilometers of water flowed into Lake Mead each year, says Tim P. Barnett, a climatologist at the Scripps Institution of Oceanography in La Jolla, Calif.

BATHTUB RING Water levels in Lake Mead have dropped significantly in recent years, as chronicled by the white mineral deposits on rocks that were formerly submerged.

ISTOCKPHOTO; STAT SOURCE: NIDDK/NIH

Of that amount, about 2.1 km^3 evaporate into the dry desert air or soak into the ground beneath the lake each year. What's left in the lake is more than spoken for: The amount of water drawn from Lake Mead this year to meet demand in cities as far-flung as Los Angeles and San Diego will exceed 16.6 km^3.

And the situation will likely get worse, Barnett and colleague David W. Pierce speculate in an upcoming *Water Resources Research*. By 2030, the researchers note, annual demand for Lake Mead's water is projected to rise to 17.4 km^3. Also, some climate studies suggest that the Colorado's flow will drop between 10 and 30 percent in the next 30 to 50 years. Using these data, as well as weather simulations that impose random but reasonable annual variations in river flow volume, Barnett and Pierce used a computer model to estimate the remaining useful life of the Lake Mead reservoir.

Thanks in part to the worst drought in the Southwest in the past 500 years (*SN: 6/26/04, p. 406*), Lake Mead is now at about 50 percent capacity. If current allocations of water persist, there's a 50 percent chance that by 2023 Lake Mead won't provide water without pumping, and a 10 percent chance that it won't by 2013. Moreover, there's a 50 percent chance that Hoover Dam won't be able to generate power by 2017, the researchers estimate.

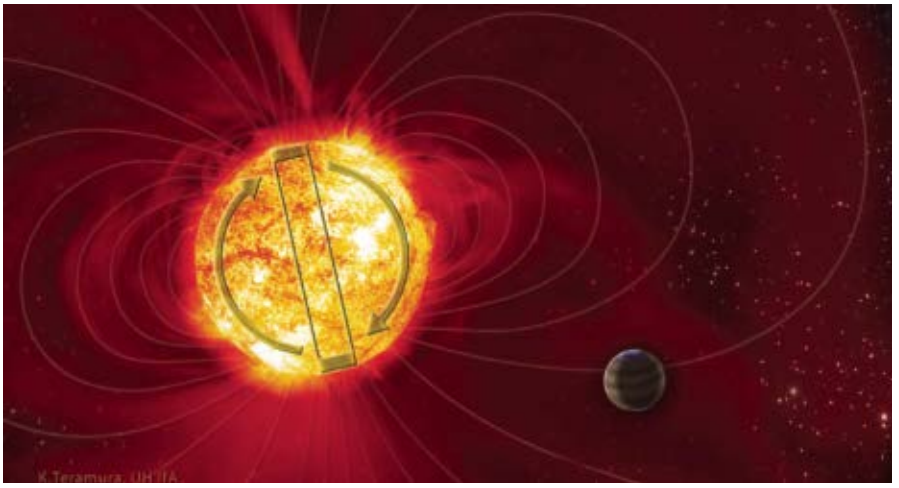
"We were stunned at the magnitude of the problem and how fast it was coming at us," says Barnett.

Results of the new study are "fairly provocative, an eye-opener," says Connie Woodhouse, a climatologist at the University of Arizona in Tucson. Using estimates of river flow based on an average of the past century may be optimistic, she adds, because tree ring–based reconstructions of the region's climate suggest that the 20th century was one of the wettest in the past 500 years. "The more we learn about the Colorado River and its hydrology, the more worried we need to be," says Peter H. Gleick, a hydrologist at the Pacific Institute in Oakland, Calif. —SID PERKINS

Stellar Switch

Sun not alone in making magnetic flip-flops

It's a topsy-turvy world out there and astronomers have new evidence to prove it. Researchers have for the first time documented that a star other than the sun flips its magnetic poles. The magnetic reversal observed on the nearby star tau Bootis may shed light on the origin of the sun's 11-year magnetic cycle, which can affect Earth's climate. The finding also highlights the role that massive, close-in planets may play in regulating a star's magnetic activity.



FLIP-FLOP An artist's rendering shows the magnetic field (as a bar magnet) of the star tau Bootis. Astronomers discovered that tau Bootis has flipped its north and south poles, perhaps with help from a large, close-in planet. It is the first time a flip has been observed in a star other than the sun.

Every 11 years, the sun reverses the direction of its magnetic field, heralding the peak of the solar cycle. That's when the number of sunspots—regions where bundled loops of magnetic fields concentrate—reaches its maximum, and the sun is more likely to hurl billion-ton clouds of charged particles into space. Those eruptions can harm spacecraft and damage power grids on Earth.

In seeking other examples of magnetic flips, Andrew C. Cameron of the University of St. Andrews in Scotland and his colleagues homed in on stars with closely orbiting planets. That includes tau Bootis, just 51 light-years from Earth. The star harbors a hulking planet, some 6.5 times heavier than Jupiter, which resides close enough to graze the star's outer atmosphere.

Previous studies showed that mid-latitude regions on the star's surface rotate in sync with the planet's rapid 3.3-day orbit. That's a sign that the planet's gravity has spun up the star—and perhaps revved up the star's magnetic engine.

The researchers used instruments on the Canada-France-Hawaii Telescope atop Hawaii's Mauna Kea and the Bernard-Lyot Telescope at the Pic du Midi Observatory in France to record the polarization of light from the star and the magnetic splitting of spectral lines. The observations reveal that between the summers of 2006 and 2007, tau Bootis reversed its magnetic field, the team reports in an upcoming *Monthly Notices of the Royal Astronomical Society*.

Recording such a flip within just one year, the astronomers say, suggests that the star reverses its field much more frequently than does the sun—a conclusion also supported by a comparison with solar properties.

The rising and falling of parcels of charged gas within the sun's convection zone, the outer one-third of its roiling interior, generates a current, which in turn produces a magnetic field. Because the outer parts of the sun rotate more quickly at the equator than at the poles, the sun's overall magnetic field becomes distorted and twisted over time. The twisting gradually causes the field to reverse polarity.

On tau Bootis, notes Cameron, the convection zone is thinner and the relative difference in rotation between the equator and the pole is greater. Both traits can boost magnetic activity. So might the gravity of the nearby, massive planet.

This likelihood of frequent flips "makes it very attractive to monitor tau Bootis and possibly other similar stars with high differential rotation, which may improve our understanding of the generation and dynamics of magnetic fields in stars," says Marina Romanova of Cornell University. —RON COWEN

Eye Protection

Antibiotic knocks back blinding disease

Medicating an entire village twice a year can hamper a scourge that has blinded millions of people in developing countries, a study in Ethiopia shows.

The bacterial eye disease trachoma was wiped out in the United States and much of the industrialized world around the mid-20th century, thanks to improved hygiene, sanitation, and antibiotics. But the disease remains a problem in parts of Africa and Asia.

Trachoma often begins as minor itching

K. TERAMURA / UNIV. HAWAII

called pinkeye. But repeated infections cause scarring of the inner eyelid. As the lids curl in, eyelashes rake the cornea, clouding it and leading to blindness.

In the new study, researchers targeted 16 villages in the impoverished Gurage region of Ethiopia where trachoma is rife. They used eyelid swabs to diagnose infections among preschool-aged children. After recording the infection rate, the scientists distributed the oral antibiotic azithromycin to everyone over 1 year of age. People in half the villages received a single annual dose while those in the others received a similar dose every 6 months.

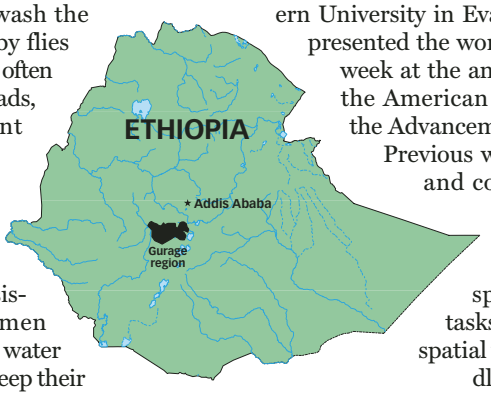
After 2 years, the trachoma rate among preschoolers treated once annually had dropped from 43 percent to 7 percent. In villages where people got two doses a year, the rate plummeted even further—from 32 percent to less than 1 percent. The findings appear in the Feb. 20 *Journal of the American Medical Association*.

The bacterium *Chlamydia trachomatis* spreads by personal contact, sharing of towels, failure to wash the hands and face, and by flies and gnats. Preschoolers often carry high bacteria loads, making them efficient conveyors of infection.

Gurage is a hilly land of small villages, rough roads, and poor sanitation. Most residents live on subsistence farming. Women must often carry clean water several kilometers to keep their families supplied, says study coauthor Jenafir House, a public health researcher at the University of California, San Francisco. As a result, hygiene suffers. Moreover, because much of Gurage is more than 7,000 feet above sea level, warm water for washing is scarce. Heating it means competing for fuel, she says.

Despite the promising findings, public health officials don't agree on the best way to control trachoma. Mass medication "is a stopgap measure," says Ibrahim Jabr, president of the International Trachoma Initiative in New York City, which partly funded this research. "I have great respect for this study," he says. But long-term control can't be established without access to clean water, education about hygiene, and improved living conditions, he says. "For that you need mega-investment." Morocco wiped out trachoma in recent years using this combination plus medication, he says.

However, such improvements are difficult to achieve without broad economic gains, says David Mabey, an infectious disease physician at the London School of Hygiene & Tropical Medicine. In the meantime, knocking out infections with antibiotics has greatly reduced—though not eliminated—the disease in Gambia (*SN: 9/25/99, p. 203*) and Nepal, he says. Fortunately, *C. trachomatis* doesn't show signs of becoming antibiotic resistant. —NATHAN SEPPA



MEDICATE MANY
In Ethiopia's Gurage region (shaded), treating villagers en masse with antibiotics reduced the occurrence of trachoma.

CARTESIA/S. NORCROSS

On Top of Words

Spatial language spurs kids' reasoning skills

Think before you speak may be apt advice, but new research suggests that speaking first fosters the ability to think later. Studies of spatial reasoning in deaf children support the idea that words help people encode certain concepts, and also suggest that using spatial words with children boosts overall reasoning skills.

"We learn in a specific context, but language invites us to compare across contexts," says Dedre Gentner of Northwestern University in Evanston, Ill., who presented the work in Boston last week at the annual meeting of the American Association for the Advancement of Science. Previous work by Gentner and colleagues found that preschool children perform better at spatial-reasoning tasks when they hear spatial words like "middle," "on top of," or "under" before and during the task. In the latest study, the researchers studied deaf children who hadn't learned conventional sign language to see whether they were at a disadvantage for spatial reasoning.

The researchers worked with 13 hearing and 13 deaf 5-year-olds in Istanbul whose hearing parents hadn't exposed them to conventional sign language. Each child was shown two boxes having a top, middle, and bottom shelf; each child also saw three cards, one with a star on the back designated the "winning" card. The researchers placed the winning card on a shelf in one box, and the child was then asked to find a duplicate winning card in the other box. The card was always placed on the same shelf in each box. After several trials, the researchers upped the ante by using cards that looked different on the front.

On both tasks the hearing children fared significantly better than the deaf children, especially on the second task, Gentner says. "If you are doing something where you have to carve up the world in a spatial way, language is going to come in really handy," she says.

The research team also tried to establish that the deaf children didn't have gestures for spatial relations. Both the deaf and hearing children watched short videos of spatial events such as a baby crawling toward a cat. Then the children were asked to describe the events. While the hearing children often used spatial words such as "to" or "top" in their descriptions, the deaf children rarely used gestures that seemed to refer to spatial relations.

"Language does give you a kind of scaffolding to reason from," says Karen Emmorey, director of the Laboratory for Language and Cognitive Neuroscience at San Diego State University in California. But she cautions that it is difficult to tease out how spatial language might be encoded in the deaf children's gestures. In fact, users of sign language often fare better than non-signers at tasks that involve spatial reasoning. Emmorey and Gentner are now considering collaborating on future projects. —RACHEL EHRENBERG

Defining Toxic

Federal agencies look to cells, not animals, for chemical testing

Government scientists are launching an ambitious collaboration to shift the testing of potentially toxic chemicals away from animals to methods that use high-speed automated robots. The robots would test chemicals on human cells at various concentrations, generating data relevant to humans faster and more cheaply than current methods, researchers from the National Institutes of Health (NIH) and the Environmental Protection Agency (EPA) announced in Boston last week during a teleconference at the annual meeting of the American Association for the Advancement of Science. The project is also described in a paper in the Feb. 15 issue of *Science*.

In the past 30 years the National Toxicology Program (NTP) of the NIH has tested about 2,500 chemicals in great detail, says NTP Associate Director John R. Bucher. Now, with advances in molecular and computational biology, the same number could easily be done in an afternoon. Human cells of interest, such as liver or skin cells, can be placed in each of 1,536 tiny wells in a single dish, says NIH Chemical Genomics Center Director Christopher Austin. Concentrations that vary more than a thousandfold can be applied to each well, or 1,536 different chemicals could be applied. Scientists can then analyze the cells to see which survive, grow, die, or stop

dividing. They may also determine whether a particular cellular biochemical pathway is affected, says Austin.

The agencies will initially focus on the roughly 2,500 chemicals for which solid data have been collected in previous studies, the researchers say.

Historically, much testing involved injecting a chemical into an animal, watching to see whether it got sick and then investigating its tissue, says Francis Collins, director of the NIH's National Human Genome Research Institute (NHGRI). "It's slow, expensive, and has limited predictive power," says Collins. "We are not rats."

But animal testing can't be abandoned overnight, says Elias Zerhouni, director of the NIH. Animal and human studies will remain intertwined until the effects that have been observed in previous studies are validated, he says.

The memorandum of understanding for the project outlines a 5-year effort combining the forces of two NIH agencies—NTP and NHGRI—and the EPA's recently formed National Center for Computational Toxicology. The high-speed robots to be used in the project are from NIH's Chemical Genomics Center. The EPA will pull together the data, comparing the animal and human studies.

Previously, there has been cross-agency pollination on some projects, but each group was guided by its respective priorities and budgets, says Anne Miracle, a senior research scientist with the Environmental Sustainability Division of the Pacific Northwest National Laboratory in Richland, Wash. Now, she says, "It's very heartening to see that these agencies are going to pool their efforts."

The robots will study human cells and test chemicals on cells from model organisms such as zebra fish and roundworms, which are studied extensively for insight into biochemical reactions. —RACHEL EHRENBERG

Internet Seduction

Online sex offenders prey on at-risk teens

Widespread fears that online sexual predators mainly target naive children are largely inaccurate, according to a new study of Internet-initiated sex crimes.

AT RISK New research suggests that online sex offenders usually target psychologically vulnerable teens, especially girls, for seduction into sexual relationships.

Instead, the vast majority of online sex offenders are adults who contact vulnerable 13- to 17-year-olds and seduce them into sexual relationships, says a team led by lawyer and sociologist Janis Wolak of the University of New Hampshire in Durham. In other words, Internet sex crimes usually represent cases of statutory rape, involving the exploitation of teens legally defined as too young to consent to sex with adults. Forcible sexual assault and child molestation represent only a small minority of online-initiated sex crimes, the team reports in the February-March *American Psychologist*.

"The things that we hear and fear about Internet sex crimes and the things that actually occur may not be the same," Wolak says.

In 2000, Internet-initiated sex crimes accounted for about 7 percent of reported statutory rapes in the United States, the investigators estimate. That proportion has probably grown since then with increased Internet use and better law-enforcement training regarding Internet crimes, the team notes.

Wolak and her colleagues consulted data gathered via phone interviews in 2000 and 2005 from national samples that totaled 3,000 Internet users, ages 10 to 17. The researchers also conducted 612 interviews with federal, state, and local law-enforcement officials from October 2001 to July 2002. Interviews focused on officials' knowledge of Internet-related sex crimes that targeted children and teens.

The patterns for how offenders reach the victims suggest that existing educational programs for children and teens may not be effective, the scientists suggest. For instance, they found that teens' use of social networking sites such as MySpace and Facebook did not increase their likelihood of being contacted by a sex offender.

Instead, adult offenders primarily use instant messages, e-mail, and chat rooms to meet and develop intimate relationships with adolescent victims, the scientists say. Offenders promise victims romance and interpersonal connection but exploit them for sex.

Particularly vulnerable youths often have a background of sexual or physical abuse, depression, delinquency, or serious family problems, Wolak says. They also take various risks, such as talking to unknown people online about sex and seeking pornography on the Internet.

Three-quarters of the victims of sex crimes studied in the new report were girls.

The researchers found that male victims typically described themselves in online communications as gay or as questioning their sexual orientation.

Existing educational programs discourage children from sharing or posting personal information online, warn about deceptive online messages, and urge parents to monitor children's Internet use. Wolak recommends that prevention efforts also teach teens how adults can seduce them into sexual relationships and how to recognize appropriate and inappropriate types of communication from adults.

The new findings fit with evidence that many teens discuss romantic and sexual interests in online chat rooms, remarks psychologist Kaveri Subrahmanyam of California State University, Los Angeles. However, most teens use online forums to extend relationships with friends from daily life, she notes.

"An adolescent not interacting online with offline contacts is a red flag of sorts," Subrahmanyam says. —BRUCE BOWER

PHOTODISC

Evolution...Textbook Theory or Vital Force?

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Professor Barbara J. King (Ph.D., University of Oklahoma) is a biological anthropologist and Professor of Anthropology at The College of William and Mary. At William and Mary, Professor King has won four awards including the Thomas Jefferson Teaching Award. She received a Guggenheim Foundation Fellowship and has published three books on anthropology, including *The Information Continuum: Social Information Transfer in Monkeys, Apes, and Hominids.*

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ENERGY IN MOTION

How the nanomachines of life harvest randomness to do the cells' work

BY DAVIDE CASTELVECCHI

Occasionally, scientists stumble upon what seems to be a free lunch. But they're not concerned about possibly violating the laws of economics. It would be much more shocking to break the laws of physics.

To physicists, the no-free-lunch rule is precious. One form of it is the first law of thermodynamics, which says that energy cannot be created from nothing. The second law of thermodynamics goes even further, declaring not only that lunches are never free but also that they come at some minimum price.

Nonetheless, some natural phenomena seem, at first glance, to violate the spirit, if not the letter, of those laws. Take living cells. In recent years, scientists have found that some molecular machines—proteins that perform crucial tasks of life, from shuttling molecules through membranes to reading information off of DNA—seem to move spontaneously. These machines are likely powered by the random motion of water molecules in their environment, the "thermal noise" that thermodynamics insists is not available for doing work.

While some researchers debate how such machines work without breaking physical laws, other scientists have begun to exploit similar phenomena to create artificial molecular motors—nanomachines that imitate nature by putting randomness to work. "The idea is, let's take advantage of thermal noise, rather than fight against it," says Dean Astumian, a theoretical chemist at the University of Maine in Orono.

Researchers have just begun to build artificial nanomachines that perform simple tasks, such as moving molecules, by steering random motion in one direction rather than another. In the Feb. 13 *Journal of the American Chemical Society*, a team led by David Leigh, a chemist at the University of Edinburgh in Scotland, describes the first molecule designed to use chemical energy to open or close a gate and allow one of its parts to randomly cross the gate in one direction, but not the other.

It's very much like the task assigned to a hypothetical "demon" by the 19th-century Scottish physicist James Clerk Maxwell. His thought experiment was an early attempt to show how the second law defines group behavior and thus applies only to large numbers of particles.

MAXWELL'S ANGEL The second law requires that in any given activity, some of the expended energy will end up as waste heat.

For example, even an efficient power plant can lose half or more of its fuel's energy to waste heat. This waste heat cannot be recovered without expending more energy—and producing more waste heat—in the attempt.

Ultimately, waste heat manifests as random molecular motion, like the incessant hailstorm of water molecules buffeting proteins in a cell's watery guts.

"It's sort of like you're riding a bicycle and there's a Richter-12 earthquake going on all the time," says George Oster, a molecular biology theorist at the University of California, Berkeley.

It's hard to see how the molecular movements (called Brownian motion) produced by such violence could accomplish anything useful. Every second, a typical molecular motor will exchange millions of times as much energy with the environment through these random collisions as it will in the performance of its actual task, Astumian explains. But beginning in the early 1990s, scientists began to suspect that certain protein motors can perform their tasks not despite Brownian motion, but thanks to it.

One example is RNA polymerase (RNAP), an enzyme responsible for reading genetic information from DNA. RNAP latches on to a DNA double strand at the beginning of a gene, cleaves the two strands apart, and clamps around one of them. It then moves along DNA's bases—the A's, C's, G's, and T's that constitute the genetic code's alphabet—and assembles a corresponding molecular chain of RNA. The RNA molecule then acts as a template for producing proteins.

RNAP, however, does not always move forward. Brownian motion can push it either way. "It's like a zipper—it slides back and forth," says Evgeny Nudler, a biochemist at New York University.

> "Let's take advantage of thermal noise, rather than fight against it."
>
> — DEAN ASTUMIAN, UNIVERSITY OF MAINE IN ORONO

Roger Kornberg, a structural biologist at Stanford University, and his collaborators first decoded the structure of RNAP in 2001, earning him the 2006 Nobel Prize in Chemistry. In the same award-winning papers, the team suggested that RNAP may be able to select the Brownian fluctuations that propel it forward and discard those that would set it back. That sounds suspiciously like a free lunch, but in fact, the laws of physics do not prevent it.

RNAP's secret lies in the fact that the second law is statistical in nature. At the scales of molecules, random fluctuations can temporarily create small amounts of seemingly "free" energy. Cells can take energy out of Brownian motion by selecting the favorable fluctuations and rejecting the others—very much in the spirit of Maxwell's demon.

Maxwell asked whether the random differences among the energies of particles could somehow be harnessed. He imagined a box filled with a gas and divided into two parts by a wall that didn't conduct heat. The wall had a tiny door, and standing by it, "a being whose faculties are so sharpened that he can follow every molecule in its course," Maxwell wrote in *Theory of Heat* (1871). This "demon" could open or close the door whenever a gas molecule approached, in such a way as to let the faster molecules cross in one direction only, and the slower ones in the opposite direction. After a while, the faster molecules would make one side of the box hotter than the other. Heat would flow in the "wrong" direction.

For decades, physicists argued whether such a demonic being could actually violate the second law. Ultimately, modern thinking goes, the energy that the demon's brain spends on processing (and

erasing) information about the particles would offset any recovery of waste heat, and thereby preserve the second law's validity.

So, molecular motors such as RNAP could work like microscopic Maxwell demons, using energy to select favorable fluctuations of energy when opportunities arise. In fact, RNA polymerase is so far the best-established example of a biological Maxwell demon, says Steven Block, a biophysicist at Stanford University.

But that doesn't mean it gets a free lunch.

When they decoded RNAP's structure, Kornberg and his team discovered that RNAP includes a system of two moving parts, located next to the site within RNAP where new RNA bases bind to the DNA template. When this two-part system folds, it falls onto the binding site like a trigger onto a bullet casing. Perhaps, some researchers thought, such a trigger pushes the newly formed DNA-RNA double strand forward by one step.

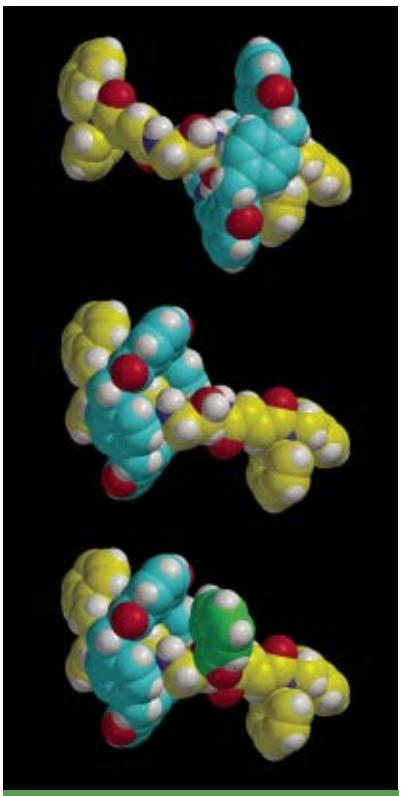
Indeed, in 2005, Nudler and his collaborators showed that mutations altering the trigger structure rendered the RNAP unable to move preferentially forward.

However, Kornberg suggests, the trigger may not be what pushes the zipper forward. Instead, the trigger's role could be to test the strength of the binding in the latest DNA-RNA base pair. If the wrong, noncomplementary RNA base had gotten there by mistake, it would not be bonded as strongly as a complementary base would be, and the trigger would dislodge it, correcting the transcription error. The trigger's "principal role would not be in motion, but in recognition," he says.

Here is where the Maxwell-demon analogy could be useful, Kornberg adds. Once a correct complementary base pair has formed, Brownian motion would allow the zipper to move forward. The trigger would prevent a backward step.

Block's team measured the pull exerted by single RNAP molecules during the transcription process. Those measurements seem consistent with this picture, Kornberg says.

So, Brownian motion would provide the energy for RNAP to crawl along DNA. The higher chemical affinity of complementary pairs—and the larger amounts of energy they release when they bind—would do the demon's work. And pay for lunch.



TAMING CHANCE — Thermal or Brownian motion moves a ring-shaped molecule (blue) from one side to another of a dumbbell-shaped molecule (yellow). But a "gate" molecule (green) is designed to lock the ring molecule to just one side of the dumbbell. Brownian motion provides energy to move the ring, but the gate molecule steers it.

S. GOLDUP/UNIV. OF EDINBURGH

GEOGRAPHY AS DESTINY No matter what the details of its machinery are, RNAP is an example of how evolution has invented ways of doing complex tasks in the forbidding environment of Brownian motion. Researchers who are trying to build artificial machines at the molecular scale—one of the promises of nanotechnology—would very much like to do the same, says Astumian.

The molecule described by Leigh's team at Edinburgh is a step in that direction, operating just like a Maxwell demon by opening and closing its gate to let molecules through.

"We made a molecule that works with the process that Maxwell envisaged," says Leigh, who proudly remarks that his house is just around the corner from the place where Maxwell once lived.

Leigh's molecule is really three molecules. Two form a type of rotaxane, which is a dumbbell-shaped molecule plus a ring molecule around the dumbbell's axle. Because of Brownian motion, this ring is generally free to bounce between the dumbbell's ends, where it can loosely bind. Left alone, the ring will keep randomly jumping between the two sides.

The researchers put their rotaxanes in water and added to the solution the third molecule, which is designed to bind to the middle of the axle. This third molecule would act as a gate, blocking the ring to one side and holding it there.

The ring's two sides have different shapes. When the ring is on one side of the dumbbell, the gate can bind to the axle. When the ring is on the other side, its shape will prevent the gate from binding.

The researchers demonstrated that in 70 percent of the molecules, the rings ended up sticking to the preferred side of the dumbbell, trapped into position by the gate.

The team described a similar molecule for the first time a year ago in *Nature*—although in that case, the gates were controlled by shining ultraviolet light on the solution rather than by the presence of molecules in the solution itself.

In both cases, the energy moving the ring comes from Brownian motion, but the molecules determine where the ring ends up. "It's a chemical way of implementing Maxwell's demon," says Astumian, who in 1998 envisaged a similar working principle with Imre Derényi, now at Eötvös University in Budapest.

Leigh says that one could imagine stringing together many rotaxanes. The rings would still move mostly at random, but on average the gates would tend to push them in a specific direction, from one rotaxane to the next.

EINSTEIN RULES Meanwhile, physicists, inspired in part by the discoveries about protein motors, have found renewed interest in the small fluctuations that characterize thermodynamics at microscopic scales.

"On average, the second law will never be violated," says Christopher Jarzynski, a theoretical physicist at the University of Maryland in College Park.

But, as Maxwell suggested, the second law may apply more to macroscopic thermodynamics. It thus is not always helpful for understanding phenomena such as the spontaneous folding of newly minted proteins, which take place in the cell's thermal bath.

In the 1990s, Jarzynski and others developed new theoretical tools to predict how much energy the Brownian bath can spontaneously make available, for example, to help out a molecular motor.

In 2002, Berkeley biochemist Carlos Bustamante and his collaborators tested Jarzynski's hypothesis for the first time on a biological molecule. They took single RNA molecules in a folded state and repeatedly pulled them apart to unfold them, while measuring the force exerted during the process. In accordance with Jarzynski's predictions, Brownian fluctuations would sometimes impede the process, and sometimes help it by providing a bit of free energy. In such cases, says Bustamante, "the work is being done by the bath, in a sense."

Last year, another team performed similar measurements by unfolding proteins (*SN: 7/14/07, p 22*). Experiments such as these can help researchers understand why biological molecules fold in one way rather than another—knowledge that may help them understand diseases caused by protein folding gone wrong.

In any case, it seems that the free lunches of molecular motors do always carry some sort of cost. Consequently, most scientists today would still agree with the sentiment Einstein expressed about thermodynamics in 1949: "It is the only physical theory of universal content which I am convinced that, within the framework of the applicability of its basic concepts, will never be overthrown." ■

JELLY PROPULSION

Studies of medusan motion reveal secrets of the Earth's first muscle-powered swimmers

BY RACHEL EHRENBERG

From the Jetsons to James Bond, flying via jet pack has become an icon of the futuristic way to travel. But jet propulsion is actually older than the Flintstones. It's a standard means of locomotion for jellyfish, the earliest animals to swim the seas using muscles. Jellies have been jet-propelling for at least 550 million years, yet only recently have scientists begun to understand how the challenges of moving in fluid have shaped jellyfish evolution.

Jellyfish invented muscle-powered movement, a feat that allowed them to diversify into a number of ecological nooks and crannies. But jelly muscles are relatively meager and the jet-pack method of motion requires serious strength. That has presented a mystery about how some species of jellyfish can get so big. New studies have begun to explain how enormous gelatinous creatures muster the strength to swim. The answers may lead to novel designs for underwater vehicles and are prompting scientists to rethink how to harness energy from wind currents.

If you've seen a jellyfish washed up on the beach, its brawn probably wasn't the first thing that struck you. Their bell-shaped bodies are mostly gelatinous goo, surrounded by a network of nerves and a paper-thin layer of tissue. But on the interior wall of the bell is a layer of muscle. Contracting this muscle ejects water from the opening at the base of the bell, propelling the animal on its path.

STEADY AS SHE GOES — The spotted jellyfish, *Mastigias papua*, uses a combination of jet and paddle to swim.

"There's probably no source of locomotion that's easier to evolve—it's a pipe with a muscle around it," says biomechanics expert Steven Vogel of Duke University in Durham, N.C.

THE JET SET In fact, jet propulsion appears again and again in animal evolution, Vogel says. Dragonfly larvae make use of an anal jet, and some squid can blast themselves to speeds of 25 miles an hour. But while the jet pack allows for a speedy escape, it is inefficient energetically, releasing a lot of kinetic energy into the water that can't be recovered, says John Dabiri, an expert in fluid dynamics at the California Institute of Technology in Pasadena. He points to more efficient swimmers such as dolphins or tuna, which glide through the water without a lot of disturbance.

And jet propulsion is not the best strategy for bigger beasts. A large jellyfish must expel a large volume of water behind it to move forward. Such an expulsion requires brute strength.

Jellyfish don't have those muscular capabilities. The muscle that lines their interiors is a mere one cell-layer thick. Making it bigger would take more than calisthenics—it would take a circulatory system that could supply those muscles with oxygen and nutrients.

"As you get bigger, you have less and less wiggle room evolutionarily," says Vogel. "Jet propulsion is fabulous when you are a micron in size and fabulously bad when you are big."

Yet jellyfish do get big—some, such as the well-named giant jellyfish (*Nemopilema nomurai*), can grow to almost 8 feet across and weigh in at 400 pounds. But when Dabiri modeled the forces required for jet propulsion and did the math, the numbers said that jellyfish much bigger than a softball shouldn't even exist.

Then Dabiri took closer notice of a relationship between the size of a jellyfish and the shape of its bell. The smaller jellyfish tend to look like thimbles or little rockets, their bells always taller than wide. The larger jellies had bells shaped more like UFOs—wider than they were tall. To investigate, he ordered some crystal jellies, *Aequorea victoria*, little thimble-shaped creatures small enough to swim comfortably in a petri dish. As a jellyfish explored its surroundings, Dabiri's colleagues Sean Colin and John Costello squirted a bit of harmless fluorescent dye behind the animal, to better see the water's motion. The small, thimble-shaped jelly zipped around jet-pack style, and the dye revealed the lost kinetic energy swirling in its wake.

IN THE SLOW LANE Then the research team filmed some broad, UFO-shaped jellies known as moon jellyfish, or *Aurelia aurita*, in shallow waters of the Adriatic Sea and in a saltwater lake on the Adriatic island of Mljet. Again, the scientists used dye to visualize the animals' wakes. The researchers immediately noticed that these jellies didn't zip to and fro, but meandered, using a leisurely half-jet, half-paddle approach. Like their rocket-shaped relatives, these broader, flatter jellies moved by contracting their meager muscles, squeezing water from their bells into a swirling vortex behind them. But when a moon jellyfish relaxed, postsqueeze, and water rushed in to refill its bell, the dye revealed a second vortex forming at the bell's edge. Dabiri realized that this second vortex was swirling in the opposite direction of that of the first, like water swirling inward at the edge of a bowl pushed down into a basin of water. The collision of these opposing, swirling masses of water was providing enough thrust to propel the moon jellyfish forward.

Dabiri crunched the numbers again, incorporating bell dimensions and the force of the second vortex into his equations. His new model, published with Colin and Costello in the June 2007 *Journal of Experimental Biology*, suggests that broad jellies, no matter how big, should be able to generate enough force to swim, albeit via a gentle, slow paddle, not a jet. And because of

A. MIGOTTO

the superior elasticity of a jelly's gooey cellular matrix, the critter doesn't use extra energy to generate the second vortex. It's like a spring that's been compressed and wants to recoil, says Dabiri. "The relaxation phase is essentially for free."

Dabiri is impressed by the fancy footwork of these broad jellies and by how they've managed with the hand (or tentacles) that they've been dealt.

"We think of them as blobs on the beach that don't have the capabilities of complex swimmers," Dabiri says. In fact, the signature move of the broader jellies, the jet-paddle, is sophisticated enough to inspire Dabiri to rethink the constraints faced by underwater vehicles. His graduate student Lydia Trevino is working on modifying propellers in such a way that they could generate enough force to move an otherwise cumbersome machine more efficiently in the fluid environment of the sea.

While the two swimming styles of jellyfish appear to allow for the breadth of sizes seen in jellies today, scientists such as Allen Collins of the National Oceanic and Atmospheric Administration seem more struck by the fact that Dabiri's equations predict the limits on jelly bell shapes that are manifest in nature.

"They can't seem to get beyond what is theoretically possible," says Collins, who is also curator of the Smithsonian Institution's jellyfish and glass sponge collections at the National Museum of Natural History.

IN THE SWIM Before choosing betwixt jet and paddle, jellies had to become free-floating beasts, a first for their lineage. Jellyfish belong to a larger group of animals known as Cnidarians, united by their ability to make stinging, poisonous barbs, a feat they presumably inherited from a common, ancient ancestor (*knidï* is Greek for "stinging nettle"). Corals and anemones are part of this group, as are critters known as sea fans and sea pens. Like jellyfish, most Cnidarians have a tubular body with a mouth on one end surrounded by tentacles. But many of these creatures are anchored to sand or rock. They can't move, by jet or by paddle.

Young jellies are also limited in terms of purposeful movement. They begin life as small larvae dispersed by currents and eventually settle on the bottom of the sea. The majority then grow into polyps, small finger- or pear-shaped lumps. Some species have polyps that can crawl around a bit, but mostly they stay put, waiting for something tasty to stumble into their tentacles. This was life in the 'burbs for Cnidarians, until the day, roughly 550 million years ago, that a polyp ancestor of today's jellies grew a little bud that broke off and got into the swim of things. Called medusans, these free jellies are the adult jellyfish that marinelife fans know and love (or fear). Almost all of today's jellies still begin as larvae, become polyps, and eventually medusans, free to roam the seas.

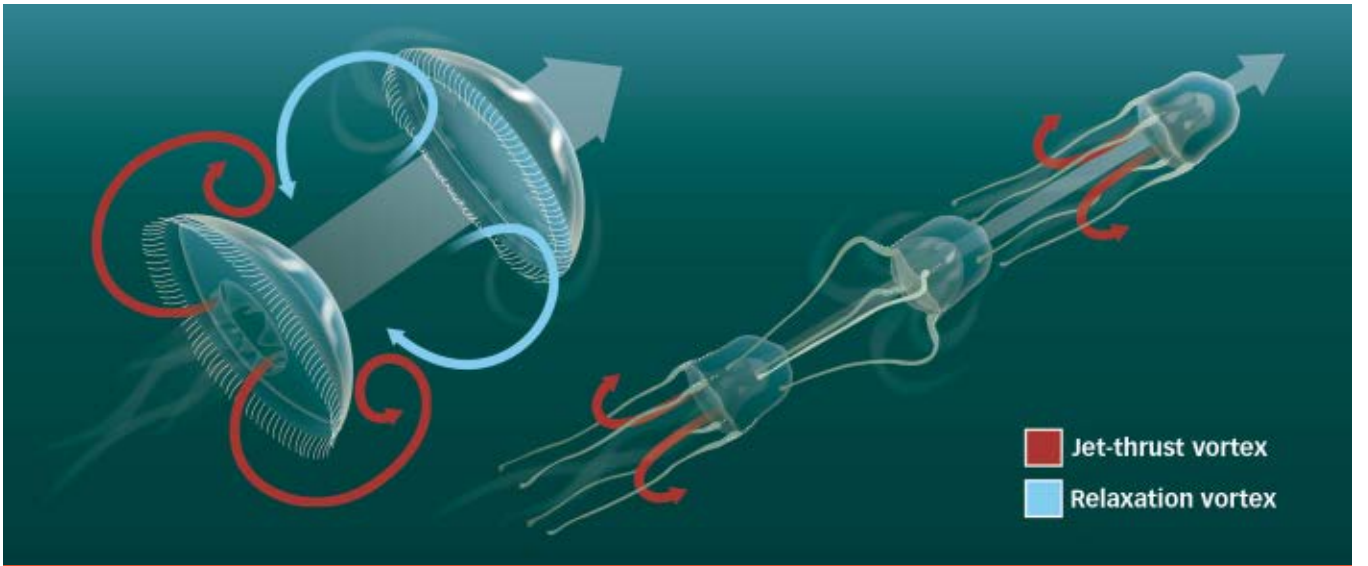
It's likely that the first free-floating jellies were the only swimmers in the ancient seas, says Collins. There would have been algae and coral larvae and such floating around, and eventually ancient versions of lobsters and other marine arthropods. But the highways were basically clear. No sharks. No fish. Certainly no people. The jellies had the pool to themselves.

> "Jet propulsion is fabulous when you are a micron in size and fabulously bad when you are big."
>
> — STEVEN VOGEL, DUKE UNIVERSITY

JET VS. PADDLE But what stroke the earliest jellyfish used isn't as clear. When Dabiri and his colleagues realized that the same swimming styles cropped up in distinct groups of jellies, the researchers wondered whether the first ancient swimming jelly blasted from place to place via jet pack or gently paddled around. So the researchers looked up the most recent version of the jellyfish family tree. (The tree was generated using molecular data by Collins and colleagues published in *Systematic Biology* in 2006.)

When Dabiri's team plotted swimming strategies onto the tree, it appeared that both swimming styles have been invented again and again in jellyfish evolution. But Collins cautions that jellyfish are understudied beasts. Without surveying all of the species in every group it is difficult to say if jets or paddles emerged first. Scientists often look to the fossil record for answers to what-came-first kinds of questions. And while some fossilized jellies have been found, the record remains murky.

It is clear that some groups tend to favor one mode of motion. Among the box jellies (Cubozoans), which are known for their fierce venom and distinct cube shape, bell size has been restricted and many of these jellies are small, jet-propelled species. The hydrozoans, a sister group of the box jellies, show more variation. Hydrozoans called Trachymedusae have diminutive bells and belong to the jet set. Other hydrozoans called siphonophores include species like the Portuguese man-o-war that may grow up to several feet long, but are actually colonies made up of many



CONTRAST IN CADENCE — A jellyfish with a broader bell, left, propels itself by creating two opposing vortices of water—the first results from a jet thrust, the second forms after the jelly relaxes in a paddlelike stroke. Rocket-shaped jellies, right, use a purely jet-pack approach.

R. ROGGE

smaller bells chained together. While technically too large to jet, siphonophores pull off jet propulsion through the coordinated thrusts of the individual bells.

The leisurely paddle propulsion also appears more than once in the greater jellyfish family tree, and different groups have made use of various body parts to enhance the paddlelike edges of their bells. Thimble-shaped hydrozoans have a velum, a sort of muscular shelf at the inner edge of the bell, that boosts propulsive power by providing a stiff collar through which to blast the water. The larger, flatter paddling hydrozoans known as Narcomedusans sport a tweaked velum—a flapping paddlelike appendage—that helps generate the second vortex.

Some of the wispy creatures' body plans fall between the extremes, or switch as teens, going from UFO-shaped juveniles to rocket-shaped adults. But it appears that it isn't advantageous to take the middle road. Examining dining preferences hints at why, say Dabiri and his colleagues in an upcoming issue of *Invertebrate Biology*.

BUILT FOR SPEED — Jet-propelled jellyfish like this *Cladonema pacifica* are small but fast, using their speed to escape predators and ambush prey.

A. MIGOTTO

HUNTERS AND GATHERERS Jet-propellers tend to be what ecologists call ambush predators—they lie in wait for a small creature to swim by, then ensnare it in a stinging mass of tentacles. Like Agent 007, most of these jellies appear to employ the jet pack to escape from an enemy rather than to attack. On the other hand, what's known of the paddling jellyfish suggests that they are largely cruising foragers—they amble along, capturing soft-bodied, slow-moving prey such as drifting eggs or tadpole-like creatures.

Of course, jellies may have done it first, but most animals have since figured out how to generate force by contracting muscles, points out Edwin DeMont of St. Francis Xavier University in Antigonish, Nova Scotia. But many creatures use two muscles where jellies use one. Human biceps and triceps, for example, pair up so that when one contracts, the other pulls back to rest. The equivalent in jellies is the springy, post-squeeze expansion of their goo.

"They can't increase that rate—it is passive," says DeMont. "They've had to capture the fluid processes in the environment."

From Dabiri's perspective, the ability to harness these fluid processes is one of the marvels of these graceful ghosts of the sea. He hopes to do something similar with air currents. Inspired by the flow dynamics employed by the jet-paddling jellies, he has begun investigating how to capture the energy of winds whipping through a city. Because this wind can quickly change direction and strength as it slides down buildings, turns corners, or blasts down streets, taking advantage of it requires thinking more like a jelly than a tuna. Dabiri recently received funding from the National Science Foundation to explore the energy conversion that happens when eddies and vortices are generated by animals like jellyfish.

"Whether water or air," Dabiri says, "it all comes back to the same equations." ■

OF NOTE

COMPLEX SYSTEMS

Birds network too

On winter evenings in some southern European towns, tens of thousands of starlings congregate over their roosts. Above the ruins of Rome's ancient Baths of Diocletian, huge black clouds of starlings assemble and continually morph into new shapes, possibly to signal their position to buddies who are still navigating their way home.

Scientists have proposed several explanations for how bird flocks, fish schools, and other large groups of animals coordinate their acrobatics, especially when they have to quickly change course to avoid predators, says Andrea Cavagna, a physicist at Italy's National Research Council (CNR) in Rome. The assumption has been that individuals match their trajectories to those of all animals within a given distance.

COUNT ME IN Each starling in this flock adjusts its trajectory to those of its six or seven neighbors, no matter how close or far they are.

STARFLAG PROJECT/INFM-CNR

But precise observations were limited largely to movies of, say, fish schools, which scientists used to manually track the positions of single individuals, frame by frame. Scientists could study groups of a few dozen members at most.

Cavagna and his collaborators used computers to track the motions of single birds in flocks of up to 4,000 starlings flying over Rome. The team set up three pairs of high-speed digital cameras on a museum's rooftop, and developed software that matched the cameras' different views to reconstruct each bird's 3-D coordinates.

The results, which appear in the Jan. 29 *Proceedings of the National Academy of Sciences*, suggest that starlings count and then follow the six or seven neighbors closest to them, rather than all birds within a certain distance. It's like a computer network, Cavagna says, in which "what matters is not physical distance [between two nodes], but how many nodes there are in between." The team's computer simulations showed that such behavior most effectively keeps the flock together, even when the birds' average spacing changes. —DAVIDE CASTELVECCHI

BIOMEDICINE

Cancer drug limits MS relapses

The anticancer drug rituximab thwarts inflammatory nerve damage in the brain and curbs relapses in people with multiple sclerosis (MS), a study suggests.

Rituximab, marketed as Rituxan by Genentech and Biogen Idec, is a synthetic antibody. The drug has anti-inflammatory as well as anticancer effects. In MS patients, immune-orchestrated inflammation damages myelin fatty sleeves that protect nerves. These inflammatory lesions lead to nerve damage and loss of muscle control.

In the new study, scientists gave 69 patients with the relapsing-remitting form of MS two intravenous infusions of rituximab, while 35 similar patients got placebo infusions. Within 4 weeks, brain scans showed less inflammatory damage to myelin sheaths in those treated with the drug, says study coauthor Stephen Hauser, a neuroimmunologist at the University of California, San Francisco. Scans done 12 to 24 weeks after treatment revealed fewer than one lesion on average in rituximab-treated patients compared with nearly six in the other patients, the team reports in the Feb. 14 *New England Journal of Medicine*.

Assessments at 6 and 11 months after treatment showed that the rituximab patients had experienced roughly half as many relapses as those on the placebo.

Scientists have long suspected that immune T cells direct myelin damage. But rituximab ignores T cells and instead targets immune B cells. T cells may indeed be at fault, Hauser says, but B cells might play a key role in the cascade of events that cause T cells to trigger MS's damaging inflammation. —NATHAN SEPPA

CELL BIOLOGY

It takes a village of proteins

When a nerve cell in the brain sprouts a new "tentacle" to forge a connection with a neighbor, the proteins in the budding arm differ from those in the cell's body, a new study shows.

Using techniques from the burgeoning field of proteomics—the effort to study the cell's entire set of proteins—researchers tracked the concentrations of 4,855 distinct proteins in human-nerve cells. With this big-picture view of protein activity in hand, the scientists discovered how some proteins fine-tune the growth of new connections among neurons.

Understanding these key proteins might eventually lead to new therapies for Alzheimer's disease, paralysis, and other neurological disorders, suggests team leader Richard L. Klemke of the University of California, San Diego.

"What we're all shooting for someday is to treat some of these awful neurodegenerative diseases," Klemke says.

The group separated nerve cell extensions called neurites from the cell bodies and then profiled the suites of proteins in the cell bodies and the neurites using a technique called large-scale mass spectrometry—a way of simultaneously identifying thousands of proteins. Of the surveyed proteins, 1,676 were more abundant in the cell bodies than in the neurites, while 1,229 were more abundant in the neurites, the team reports in the Feb. 12 *Proceedings of the National Academy of Sciences*.

Using databases of protein structures and functions, Klemke and his colleagues pieced together the interactions among many of these proteins. Nine proteins thought to play interchangeable roles in the formation of neurites actually control separate parts of the process, the researchers discovered. —PATRICK BARRY

PALEONTOLOGY

From China, the tiniest pterodactyl

Researchers excavating the fossil-rich rocks of northeastern China have discovered another paleontological marvel: a flying reptile the size of a sparrow.

The tiny, toothless creature, dubbed *Nemicolopterus crypticus*—meaning "hidden flying forest dweller"—lived about 120 million years ago, says Alexander W.A. Kellner, a vertebrate paleontologist at the National Museum of the Federal University of Rio de Janeiro. Other fossils found in the same rocks suggest that the fine-grained sediments were deposited on the bottom of a lake in a heavily forested region, Kellner and his colleagues report in the Feb. 12 *Proceedings of the National Academy of Sciences*.

OF NOTE

Many of the bones in the creature's feet were strongly curved, a sign that *N. crypticus* probably spent much of its time grasping limbs, Kellner says. Studies of modern birds have often noted a link between the curvature of a bird's claws and its lifestyle (*SN: 10/26/02, p. 270*).

N. crypticus was a reptile but wasn't a dinosaur. It was a pterodactyl, part of a group of flying reptiles called pterosaurs. While some species had a wingspan approaching 10 meters, *N. crypticus* probably had a wingspan of just 25 centimeters, says Kellner. Many of the fossilized bones were fully ossified but those in the skull weren't fused together, so this creature was a juvenile or young adult, the researchers speculate.

How much more the creature might have grown is up for debate, says Kellner. However, he notes, "even if it were doubled in size, it would still be the smallest pterosaur yet found." —SID PERKINS

TINY FLYER An artist's rendition of *Nemicolopterus crypticus*, a sparrow-sized pterodactyl that inhabited forests of northeastern China about 120 million years ago.

ASTRONOMY

Organic ring around nearby star

Astronomers have known since 1991 that a ring of dust, a likely vestige of planet formation, surrounds the nearby star HR 4796A. Researchers now report the first evidence that the ring contains complex organic molecules.

Alycia Weinberger of the Carnegie Institution of Washington (D.C.) and her colleagues observed the ring with a near-infrared camera on the Hubble Space Telescope. Comparing those images with Hubble images made in visible light, the team showed that the dust scattered much more infrared light than visible light. And that's the same pattern displayed by a group of organic compounds called tholins.

Astronomers have found tholins in comets and the atmosphere of Saturn's moon Titan, but the new study provides the first strong evidence for the material outside the solar system, Weinberger's team says in the Feb. 1 *Astrophysical Journal Letters*.

A youthful 8 million years old, HR 4796A lies 220 light-years from Earth. Astronomers believe the star's narrow ring, which has a radius nearly twice that of Pluto's average distance from the sun, may be left over from a planet-making disk of gas and dust particles. Tholins may coat comets or other ice particles that lie within the chilly confines of the ring, the team suggests.

No one knows whether the star has planets. But if it does, comets from the ring could pepper inner orbs with organic compounds in much the same way that comets are thought to have delivered these building blocks of life to the primitive Earth, says Weinberger.

Bruce Macintosh of the Lawrence Livermore (Calif.) National Laboratory says tholins "are the most likely" explanation for the disk's color. Observations at a longer infrared wavelength, taken by Macintosh and his colleagues with the Keck II telescope on Hawaii's Mauna Kea, may shed further light on whether tholins are present. —RON COWEN

CHEMISTRY

Spying asbestos

Contractors and building inspectors may soon find themselves dyeing to see asbestos.

Owing to the mineral's strength, limited chemical reactivity, and insulating properties, manufacturers have added traces of asbestos over the years to a host of building materials, including those made from concrete. But identifying which materials host the carcinogenic mineral is crucial for detection and cleanup. Doing so has proven problematic because the fibers are both microscopic and colorless.

Unless you tint them. And that's just what Japanese researchers have done to chrysotile—the most commonly used form of asbestos.

They identified a red dye and an indigo-hued dye that bind to magnesium, a component of asbestos. Each dye can impart visible color even when the fibers account for no more than 0.1 percent of the mass of a piece of concrete—the minimum asbestos content triggering regulatory action in Japan and some other nations.

Because the coloring agents also bind to the calcium in cement, concrete must first be treated with a chemical to tie up its calcium. But in such pretreated concretes, dyes tint only the asbestos—and the intensity of color increases quantitatively with growing fiber content. Yoshihiko Oke of Tohoku University in Miyagi, Japan, and his colleagues describe the technique in an upcoming issue of *Environmental Science & Technology*.

"We can easily do the test onsite"—and in minutes, Oke says. —JANET RALOFF

IN THE PINK Until treated, asbestos doesn't show up in cement (top). A new red-dye treatment can highlight even small traces (bottom).

M. SKREPNICK; AMERICAN CHEMICAL SOCIETY

ZOOLOGY

People bring both risk and reward to chimps

Getting used to people hanging around has been a mixed blessing for chimps in Africa's Côte d'Ivoire.

Groups of chimpanzees in the Tai National Park have become habituated to people, allowing both researchers and ecotourists close access for decades. Respiratory diseases broke out among these chimps five times between 1999 and 2004, killing at least 15 animals. An international team now confirms the researchers' fears: The pathogens probably came from people.

The samples available from seven chimps that died revealed either human respiratory syncytial virus or human metapneumovirus, says Fabian Leendertz, a wildlife epidemiologist at the Robert Koch Institute in Berlin. The viruses, common among people, infect the upper-respiratory tract and can open the way for fatal pneumonia. Adults typically suffer mild bouts, but in parts of the world with strained medical systems, the viruses account for considerable infant mortality.

Leendertz, the Tai project team, and colleagues compared the respiratory pathogens from the chimps with strains circulating among humans. The relationships nailed people as the disease source. "It's a bit like Europeans bringing diseases to North America," he says. The Tai researchers have started taking precautions such as wearing masks and touching as little as possible when out in the forest.

People aren't all bad, say the researchers. They also analyzed poaching and found that signs of illicit hunting were less common closer to the research and tourist bases. So overall the human presence does benefit the chimps, the team reports in the Feb. 26 *Current Biology*. —SUSAN MILIUS

Books

A selection of new and notable books of scientific interest

TEETH
WINGS

SNEED B. COLLARD III

In these two books, Collard provides a grand tour of animal diversity. By focusing on variations in two traits, teeth and wings, he harks back to the days when animals were classified on the basis of type rather than on descent from a common ancestor. Winged birds and bats were grouped together, as were legless snakes and worms. After all, such innovations occur time and time again in animal evolution. The wings and teeth highlighted in these two books are accurately rendered and from a plethora of animals. Artist Robin Brickman illustrates *Wings* in vivid detail with painted and paper-collage prints. Fox bat wings look leathery; butterfly wings appear scaly. In *Teeth*, snarling, yawning, and feeding animals are painted in realistic, and occasionally gory, illustrations by artist Phyllis Saroff. For example, a vampire bat slices a hoof with razor-sharp teeth, and a hyena gnaws on a dismembered zebra leg. Collard includes more than obvious animals: These might be the first children's books to display the gaudy pink feathers of Australian galahs, or the hard, flat teeth in the throats of bullnose rays. ***Charlesbridge, 2008, 32 p., color illus., hardcover, $16.95 each.***

THE VOID

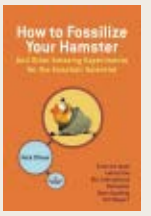
FRANK CLOSE

Nothing is an immense subject. Philosophically speaking, can it even exist? How has the concept developed since the age when it was called ether? And for the scientist, how does nothing affect the structure of matter? Close, a particle physicist at Oxford University, covers these topics as well as the basics of relativity theory, quantum mechanics, and cosmology for people with little knowledge of physics. Close explores today's science in a chapter on the Higgs vacuum (the counterpart to the Higgs boson particle). The Higgs vacuum is a hypothetical field that pervades space and whose presence gives matter its mass. Though this quantum void is perhaps most relevant to the book's topic, after all else, Close pays the Higgs boson and vacuum relatively little attention. ***Oxford Univ. Press, 2008, 166 p., hardcover, $19.50.***

HOW TO FOSSILIZE YOUR HAMSTER: And Other Amazing Experiments for the Armchair Scientist

MICK O'HARE

Mad science is back. Only here, it's less evil and not just for kids. Eighty simple and charming experiments meant to be conducted in the comfort of one's own home illustrate scientific principles in action. Activities include dropping Mentos into cola, and conducting electricity with a hair comb. Those over 21 may be the instant hit of any (nerdy) party by performing tricks involving martinis, vodka, and beer. Readers won't learn genetics, but they will learn how to extract their own DNA with a mix of dishwashing liquid, 100-proof vodka, salt, spit, and water. Accompanying each experiment is a section explaining what happens. In the case of DNA extraction, the detergent breaks down membranes from mouth cells in spit. For those wishing to fossilize their pets, O'Hare explains where to bury them. Namely near a rumbling volcano, in a tropical river floodplain during a heavy rain, or in the deep sea, far from a tectonic subduction zone. Patience is needed: Fossilization may take 200,000 years. ***Holt Paperbacks, 2008, 240 p., paperback, $14.00.***



DEADLY COMPANIONS: How Microbes Shaped Our History

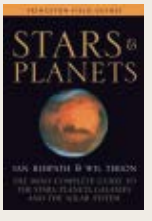
DOROTHY H. CRAWFORD

Humans have always coexisted with microbes. By causing disease, infection, and pandemics, microbes shape human history. Despite medical advances, these microscopic germs are still responsible for some 14 million deaths each year. Here, the history of microbes and their role in human cultural evolution is traced. Crawford, a professor of medical microbiology at the University of Edinburgh, examines what makes humans so vulnerable to microbial attack. The growth of trade and political conquests helped spread malaria and smallpox. Today, crowded cities, air travel, and widespread use of antibiotics aid the opportunistic spread of microbes. Crawford suggests that when it comes to microbes, despite our scientific knowledge, we are not better-off than our ancestors. ***Oxford Univ. Press, 2007, 250 p., b&w illus., hardcover, $35.95.***

STARS & PLANETS: The Most Complete Guide to the Stars, Planets, Galaxies, and the Solar System

IAN RIDPATH & WIL TIRION

This fourth edition has been revised and expanded. Though it is small enough to fit into a coat pocket on a cool, dark evening, the amount of the material within could fill volumes. The book seems designed to convert curious readers into stargazers. Many of the celestial sights described in the book can be seen with binoculars, and all are accessible with an average telescope used by an amateur astronomer. Thorough guides explain how to read star charts for each hemisphere, monthly, and constellation. And at least two pages are devoted to every officially recognized constellation as well as to other patterns of stars belonging to one or more constellations (such as the Big Dipper, a part of Ursa Major). The section on stars, nebulae, planets, and more contains a six-page moon map with every crater named. This is your atlas to the observable universe. ***Princeton Univ. Press, 2007, color photos and illus., 400 p., paperback, $19.95.***



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LETTERS

Music of sound

I was intrigued by the article "Embracing the Dark Side" (*SN: 2/2/08, p. 74*). It states: "The interaction of gravity, matter, and radiation in the early universe set up acoustic oscillations, cosmic sound waves that left their imprints on the distribution of galaxies across the sky." Spanish poet Antonio Machado [1875–1939] put a similar mode of thinking into a poem dealing with dreams. In English: "While dreaming, perhaps, the hand/of the sower of stars caused the forgotten music to sound,/ like a note from an immense lyre,/ and the humble wave came to our lips/ in the form of a few words of truth."

PETER KLAUSMEYER, LEXINGTON, MASS.

Chill factor

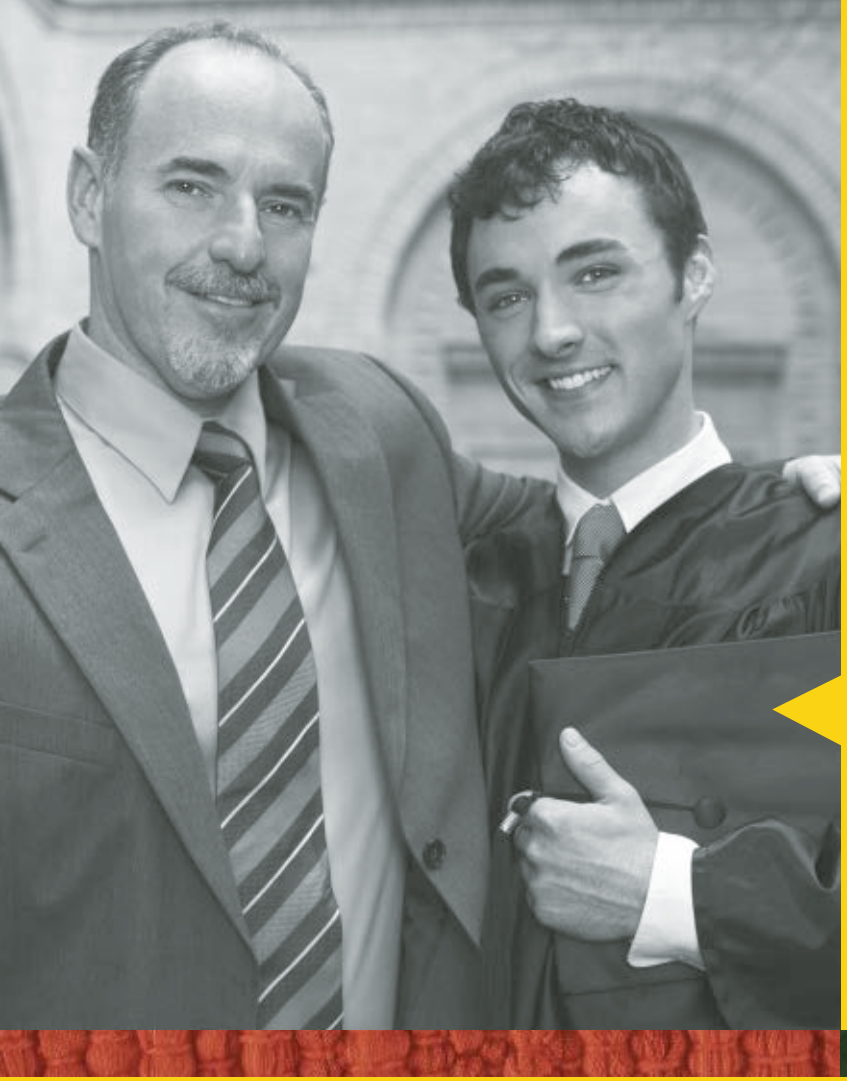
"Supercool, and Strange" (*SN: 1/26/08, p. 58*) keeps the reader on track with accurate, entertaining metaphors. It ends with a riveting observation from the White Mountains of New Hampshire: The tree line occurs where windchill temperatures reach 220 kelvins, the temperature at which supercooled water "undergoes a phase transition." Windchill temperatures are not physical temperatures—neither the trees nor the air is at a temperature of 220 kelvins. Windchill temperatures answer the question, "At what lower temperatures would air have to be to achieve the same rates of cooling observed at the actual, higher temperatures in the absence of winds?"

GENE BARTH, CHICAGO, ILL.

Windchill does not equate to actual temperature, so the phrasing in the story was misleading. However, high winds also play a role in limiting tree growth. On Mount Washington, winds can exceed 50 miles per hour and temperatures can plunge as low as –47°F. Also, as moist air is forced up the mountain, supercooled water droplets form around 4,500 feet. When those droplets contact a tree, they freeze into a deadly coat of ice. —SUSAN GAIDOS

Your article "Supercool, and Strange" reminded me of the excitement about "polywater" in the late 1960s. Just as in the new report, polywater was produced by studying water confined in capillary tubes. Could we be seeing the same phenomenon all over again?

DIETRICH MARCUSE, LAKEWOOD, N.J.



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