You and Your Bacteria | CSI: Fake Drugs | Autism in the Brain

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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ JUNE 18, 2011

Final countdown

After 30 years, NASA retires the shuttle

Geometry Without Textbooks

Death to Zombie Ants

Milky Way Grows an Arm

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Lafayette, CA, USA *(Left)*

Blake Marggraff, Age 18
Lafayette, CA, USA *(Right)*

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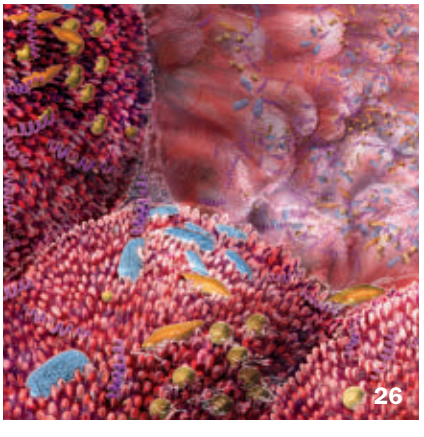
JUNE 18, 2011 • VOL. 179 • NO. 13



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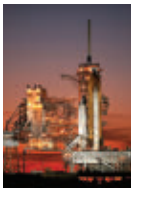

COVER NASA's space shuttle *Atlantis*, shown before a 2009 launch, will be the last orbiter to fly before the agency shuts down the shuttle program. *Bill Ingalls/NASA*

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FROM THE EDITOR

Finis for the shuttle, new launch for *Science News*

In the old days when the main mass medium was newspapers (teenagers, ask your grandparents), reporters indicated the end of a story by affixing the number "30." It's coincidental but somehow appropriate that the final flight of the space shuttle, scheduled for July, comes so close to the 30-year anniversary of the first shuttle launch, on April 12, 1981.

It's not a demise that everybody laments — the shuttle has always had its detractors, even apart from the two major tragedies that punctuated its many triumphs. Long before the shuttle flew, various politicians tried to prevent it from ever taking off in the first place.

Nonetheless, during its three decades in space the shuttle has compiled a substantial record of contributions to science, as Alexandra Witze's infographic timeline on Page 20 summarizes. Accomplishments from the Hubble Space Telescope alone, launched from a shuttle and repaired and refurbished during later shuttle missions, earn the shuttle program a prominent place among the historic tools that have facilitated scientific discovery.

In other realms, the shuttle has provided voluminous data on the behavior of materials, and living things, in the near-weightlessness of Earth orbit. And sophisticated instruments aboard the shuttle have given scientists a new perspective on the Earth itself, mapping its topography and monitoring atmospheric and oceanic phenomena.

Such occasions as the shuttle's retirement typically inspire recitations of clichés or aphorisms about another door opening when one closes or some similar parallel between beginnings and endings. While waiting for the next door to open in the space program, closer to home we can offer an event that will establish a new anniversary to celebrate someday. *Science News* this month is launching a new version of itself — for consumption on digital tablet devices that have become, for some people, a favorite medium for reading.

Science News' tablet alter ego will be known as *SN Prime*, a designation reflecting both its alternative identity status and the caliber of its contents. New issues will appear weekly; it will contain mostly the same news as the print magazine but will offer additional content and multimedia features suited to the tablet format. More details will be available soon.

—Tom Siegfried, Editor in Chief

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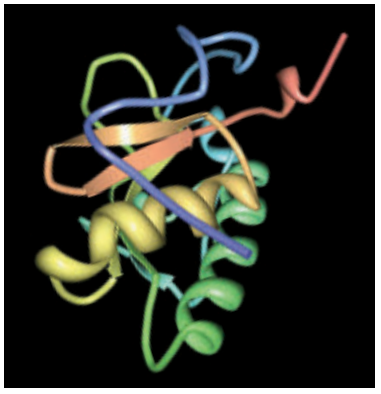


Say What?

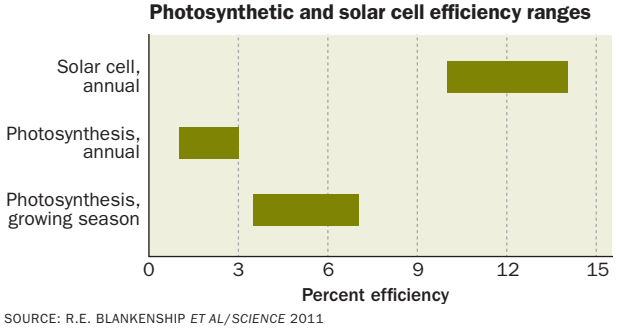
hedgehog protein \HEDJ-hahg PRO-teen\ *n.* A signaling protein crucial for healthy embryo development; mutation of the genes that code for hedgehog proteins in humans can lead to rare but severe birth defects or, more frequently, skin cancer. Scientists first discovered the hedgehog protein in fruit flies and gave it its name because larvae lacking the protein looked spiny. The most important form in vertebrates is Sonic hedgehog, named after the video game character. A recent *Proceedings of the National Academy of Sciences* study found that wounds and incisions in mice triggered hedgehog signaling, which in turn triggered cancer cell growth near the cut (*SN: 3/12/11, p. 9*). The study sheds light on why several cancer types appear near injury sites.

Science Past | FROM THE ISSUE OF JUNE 17, 1961

LONG-RANGE SYSTEM FOR SPOTTING SUBMARINES — A sonar system for detecting and tracking enemy submarines long before they reach United States shores is being developed by the U.S. Navy.... The sound transmitter, or transducer, which is five stories high and weighs hundreds of tons, will be carried on a former Navy tanker, the USNS Mission Capistrano. The ship is equipped to raise and lower the transmitter into the water and also provide power for its operation. The U.S. Navy has already built a relay tower, called Argus Island, on top of an extinct underwater volcano off the Bermuda coast. The man-made island, sticking nearly 100 feet above the ocean surface, will relay sound waves picked up by hydrophones scattered along the ocean floor.

Science Stats | CATCH SOME RAYS

Solar cells can use only a small amount of the sun's rays as energy to split water to make hydrogen, but their energy-conversion efficiency is higher than that of plants storing energy in biomass, scientists found.



SOURCE: R.E. BLANKENSHIP *ET AL/SCIENCE* 2011

Science Future

June 29
In Portland, Ore., learn about the chemistry of beer. See www.omsi.edu/afterdark

July 29
Delta Aquarid meteor shower. Go to http://bit.ly/l4xX7m

July 31
Sea turtle migration marathon begins in Florida. Track swimmers at www.tourdeturtles.org

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ATOM & COSMOS
A fireball over Indonesia sent sound waves around the world. Read "News in Brief: Atom & Cosmos."

MOLECULES
Chemists create a possible pain reliever from crepe jasmine (flowers shown). See "Natural pain-killing chemical synthesized."

BODY & BRAIN
Bacteria can linger on woodwinds for days. Read "Don't share that clarinet."

EARTH
A hot pocket, not a plume, may have formed Hawaii's island chain. See "Hawaii heat source debated."

How Bizarre

Don't throw that banana peel in the compost just yet: It could help clean toxic stuff from river water, Brazilian researchers reported online February 16 in *Industrial & Engineering Chemistry Research*. Minced banana peel, pulverized into micrometer-sized pieces, successfully pulled copper and lead out of water, the team found. A wash with nitric acid recovered more or less all of the metal adsorbed, and the same batch of peels could be used 11 times before recovery rates started falling. The researchers also tested the peel in raw river water, with similar results. Other natural extraction materials, such as peanut shells, have been tried before, but the banana peel's effectiveness was better, closer to the metal-sopping power of widely used silica gels, which can be toxic.

CLOCKWISE FROM TOP LEFT: PROTEIN DATA BANK/RESEARCH COLLABORATORY FOR STRUCTURAL BIOINFORMATICS; SRINI G/FLICKR; ALEXTOIS/SHUTTERSTOCK; T. DUBÉ

“You add an almost imperceptible amount of noise, and all sorts of wacky and unexpected things can happen.” —DANIEL SOLLI, PAGE 12

In the News

STORY ONE

Genetic analysis reveals clues to autism’s roots

Diverse disorder has common molecular changes in brain

By Laura Sanders

Though autism and related conditions vary widely from person to person, shared brain changes may be at the root of these afflictions.

Changes in the behavior of genes important for brain-cell development and function contribute to the poorly understood disorders, a study published online May 25 in *Nature* shows. Figuring out what goes wrong in the multifaceted disease will help scientists design better ways to treat it.

“For us to be able to develop specific therapies that treat the cause, you have to understand the genetics,” says pediatrician and autism researcher Hakon Hakonarson of the Children’s Hospital of Philadelphia.

In the study, a team led by Daniel Geschwind of UCLA analyzed postmortem tissue from the brains of 19 people with autism spectrum disorder and 17 without. Patterns of gene activity differed in the two groups, as measured by levels of RNA molecules that shuttle information stored in DNA to the protein factories in cells. By sorting through these molecular patterns, the researchers turned up a number of abnormalities that the autistic brains shared.

For example, the researchers found that in unaffected samples hundreds of genes behaved differently depending on which of two very different areas were examined: one in the brain’s frontal lobe, the other in the temporal lobe on the side of the brain. But in the autistic brains, only a handful of genes acted differently in the two areas, despite the fact that the regions are involved in completely different tasks. The frontal region manages planning, impulse control and other high-level reasoning tasks; among other things, the temporal region helps govern language and how a person relates to others.

This lack of distinction in gene activity may have behavioral consequences and probably emerges very early in a child’s life, Geschwind says.

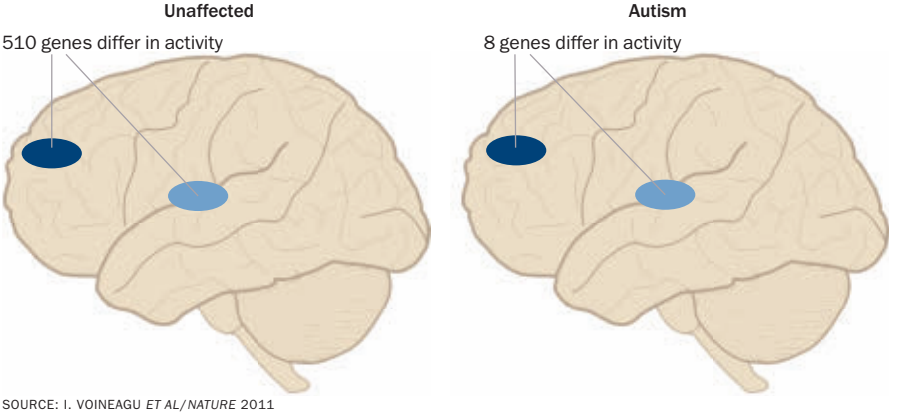
And though the affected brains differed from the unaffected brains, the autistic ones were surprisingly similar to one another, the team found. Among the 19 autistic samples, patterns of gene activity didn’t vary much from person to person. Since the disease is thought to be caused by a mishmash of many different genetic and environmental factors, this was an unexpected result.

“It looks like there’s a common pathology in autism, which is a surprising thing,” Geschwind says. “In spite of having many different causes, there’s some shared convergence.”

In the study, the team pinpointed a number of genes that underperform in people with autism, showing lower levels of activity than in unaffected brains. Many of these genes are required for proper brain development and function, regulating how nerve cells find their correct partners and communicate.

Earlier studies by Hakonarson and others have found that people with autism are more likely to have particular versions of many of these same nerve cell–related genes. By showing those same genes don’t just have slightly different DNA, but actually behave differently in the brains of people with autism, the new research confirms and

Regional differences Gene activity is surprisingly uniform in the brains of people with autism. In a recent study eight genes differed greatly in activity between the frontal (dark blue) and temporal (light blue) regions of autistic people; in unaffected people, 510 genes showed differing levels.



SOURCE: I. VOINEAGU *ET AL*/*NATURE* 2011

HANKEM/WIKIMEDIA COMMONS, ADAPTED BY E. FELICIANO

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extends those earlier results.

"This paper picks up the consequences of the genetic variants that we and others have shown are clearly clustering on certain [biochemical] pathways," Hakonarson says.

Changes in the activity of one particular gene, *A2BP1*, appeared to profoundly affect the autistic brains. The *A2BP1* protein is produced in nerve cells and helps cut and stitch pieces of RNA together to create the messenger RNA molecules that guide the production of proteins. In the autistic brains, over 200 distinct RNA molecules were stitched together incorrectly, the team found. While the researchers don't yet know the functional outcome of these errors, each of the 200-plus RNA molecules has the potential to be made into a dysfunctional protein in the brain.

"We didn't expect to see how generally important this gene looks," Geschwind says. "It looks to be one of the things that has major dysregulation in the brains of autistic kids."

A second cluster of genes that boost immune responses and inflammation was much more active in the autistic samples than in normal brains. Previous studies have shown that inappropriate immune responses may play a role in autism.

Geschwind and his colleagues don't fully understand how these immune factors impact the brain. Heightened immune responses in the brain might be a nongenetic way that environmental factors increase the risk of disease. This inflammation could also be a secondary effect, reflecting the fallout caused by the nerve cell–related RNA molecules going haywire.

Scientists know that autism is strongly heritable, but so far large-scale genetic studies have turned up genes that explain only a tiny fraction of cases, says neuroscientist Helen Barbas of Boston University. This new study adds to a growing body of evidence that autism can't be explained by the bad behavior of one or a few genes.

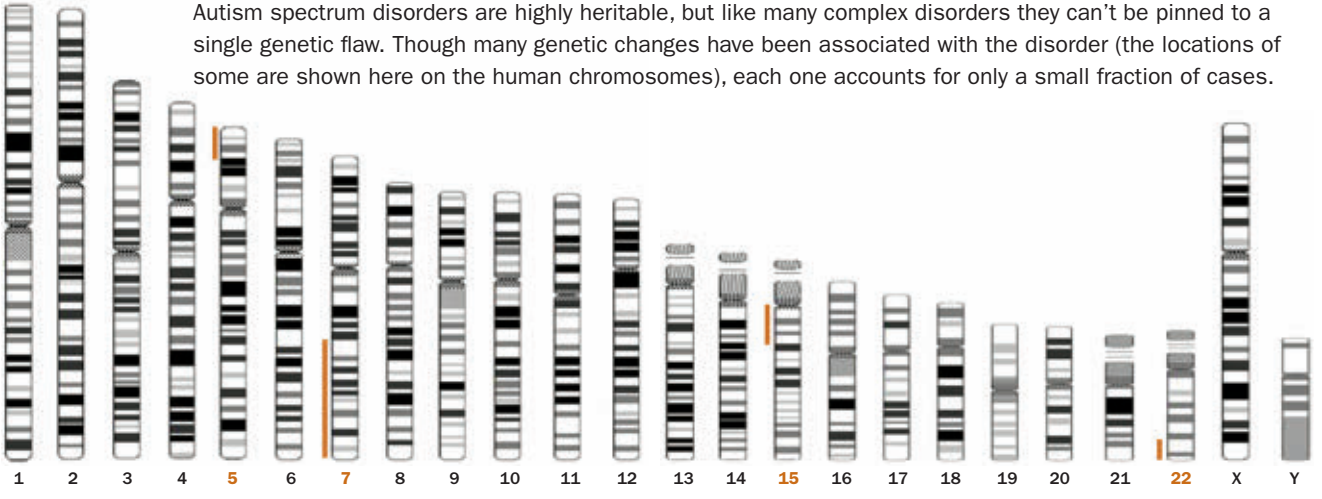
"Obviously it's much more complicated than that," she says. "I was glad to see this paper because unlike a lot of other similar studies, this looks at the relationship of variants that affect the network."

The vast majority of therapies available now are focused on easing symptoms, not treating autism's underlying cause, Hakonarson says. A detailed understanding of autism in the brain may lead to better treatments, he says.

In addition to pointing out potential new treatments, the results might also lead to a way to detect the disease earlier, Geschwind says. Once these common molecular changes in the brains of people with autism spectrum disorders are validated, scientists can begin looking for signatures of those changes in other tissues, perhaps even in the blood. Catching these genetic disorders early might lead to better outcomes for autistic kids. ■

Back Story | A GENETIC PUZZLE

Autism spectrum disorders are highly heritable, but like many complex disorders they can't be pinned to a single genetic flaw. Though many genetic changes have been associated with the disorder (the locations of some are shown here on the human chromosomes), each one accounts for only a small fraction of cases.



Chromosome 5
Several single-letter DNA changes at one end of chromosome 5 (orange line) have been associated with autism, but each of these variations appears to contribute only a very small amount to a person's risk of developing autism.

Chromosome 7
By studying inheritance patterns in families with autistic members, scientists have found a region of chromosome 7 (orange line) that appears to be relevant to the condition. Genes that tell nerve cells how to hook up with each other as the brain grows are located here.

Chromosome 15
About 1 percent of people with autism have duplications of a stretch of chromosome 15 (orange line). Large-scale duplications, deletions and rearrangements in other parts of the genome have also been linked to autism.

Chromosome 22
Mutations in a gene at one end of chromosome 22 (orange line) that is involved in nerve cell communication, *SHANK3*, are linked to some cases of one nonverbal form of autism. These mutations seem to arise spontaneously rather than being inherited.

C.M. FREITAG *ET AL./EUR. CHILD AND ADOLESCENT PSYCHIATRY* 2010

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FOR THE INVESTOR

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Life

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Tarantulas shoot silk from their feet

Unique ability may help protect the heavy spiders from falling

By Susan Milius

New research reopens debate over whether some spiders, such as this Mexican flame-kneed tarantula named Fluffy, can shoot silk from their feet.

Comic books may have gotten their science right after all. Some spiders may indeed grip walls by shooting silk Spider-man–style from their limbs.

New experiments support the idea that tarantulas can shoot silk from their feet to grip a slippery surface. The notion had been dismissed, but researchers say they have spotted silk footprints left behind by spiders in precarious positions. What's more, electron microscopy reveals hair-like projections on tarantula feet that could be silk extruders, Claire Rind and colleagues at Newcastle University in England report in the June 1 *Journal of Experimental Biology*.

"The controversy over [foot] silk is important for understanding the evolution of silk production in spiders," says evolutionary biochemist Todd Blackledge of the University of Akron in Ohio. Spiders are "preeminent silk craftsmen," he says. Many create multiple silks with different functions, made from complex structures called spinnerets with arrays of spigots and their own musculature.

When a 2006 *Nature* paper contended that zebra tarantulas had some kind of previously unnoticed silk glands in their feet, the possibility "made quite a splash in the arachnological community," Blackledge recalls. "It seemed almost too good to be true that morphologists working on tarantulas hadn't already described this."

Maybe it was too good to be true, Fernando Pérez-Miles of Universidad de la República in Montevideo, Uruguay, reported in 2009. He and his colleagues lined tarantula containers with small pieces of glass. Checking the glass with a microscope revealed wisps of silk on the vertical surfaces, but only when the tarantulas were free to use their abdominal spinnerets. When the researchers put wax on the tarantulas' abdomens to block the spinnerets, silk didn't show up on the vertical slides.

Rind, however, wasn't satisfied. The study hadn't forced the spiders into challenging climbs that might require foot silk. Also, Rind suspected that tarantulas in particular would benefit from silk-making feet as a way to prevent falls, which can crack their large bodies open.

To give the idea another test, Rind lined cages with glass slides. She and her colleagues videotaped three species of tarantula as their cages were tilted so the spiders were clinging vertically and then given a little shake. Where the videos showed a foot slipping a bit, Rind found tiny wisps of silk.

Rind did not wax the abdominal spinnerets closed, which Pérez-Miles says would have helped to convince him that the silk indeed came from the feet. Rind says the videos pinpointed foot location well enough to justify skipping the wax job, which ultimately kills the spiders.

Hey Kitty, dogs do drink like cats

Canines toss water into their mouths just like feline rivals

By Susan Milius

There may be some outraged sofa clawing and houseplant destruction over this, but a complex system of lapping liquids described last year for cats turns out to be the way dogs drink too.

High-speed video using X-rays now shows that dogs get water into their mouths by relying on the way liquid adheres to their tongues and the inertia of fluid columns, says evolutionary biologist A.W. Crompton of Harvard University. Dogs plunge their tongues into liquid and, like cats, swiftly pull up a little column of it through adhesion. Before gravity overcomes the column's inertia and the liquid splashes down into the bowl again, the dogs snatch a sip, Crompton and Catherine Musinsky, also of Harvard, report online May 25 in *Biology Letters*.

That's basically the same mechanism a team reported admiringly in *Science* last year when describing the way cats lap liquids (*SN: 12/4/10, p. 5*).

"We surely were surprised when we first saw their results," says Roman Stocker of MIT, a coauthor of the cat study.

Crompton and Musinsky's X-rays also add a new chapter to the story of lapping by detailing how liquid gets from the front of the tongue to the swallowing point. The tongue traps the water against the ridged roof of the mouth. As the tongue moves in and out again and again for subsequent laps, captured bits of liquid travel back. A particular bit of captured liquid may need three tongue extensions to get swallowed. Cats probably do this too, Crompton says.

F.C. RIND

"They were eating the biological material, and ... using it as a scuba tank at the same time."—MURRAY GINGRAS

Lunchtime of the living dead

Zombie ants usually take fatal bites around noon

By Susan Milius

Ants fatally infected with a fungus that turns them into staggering weirdos do most of their stumbling around midday, a team of biologists reports.

Noontime in the forest brings a spike in what may be the ants' most peculiar behavior, David Hughes of Pennsylvania State University in University Park and colleagues report online May 9 in *BMC Ecology*. Afflicted *Camponotus leonardi* ants bite into the vein of a leaf about 25 centimeters off the ground and stay clamped there even after death. Of 16 ants observed at their last chomp, nine bit the leaf within 30 minutes of noon. All the observed final bites, for unknown reasons, occurred between 11 a.m. and 1:45 p.m. Actual death, not easy to determine with zombies, occurred some hours later, possibly near sunset.

Ophiocordyceps fungal buildup may explain the infected ants' erratic gait and convulsions. Muscle atrophy, possibly from rapid post-bite fungal growth, may keep the ants from pulling their mouthparts loose from fibrous leaf tissue once they've bitten in.

"One of the alternative hypotheses in these cases is that the change in behavior is a side effect of infection, not something the fungus 'actively' does to the host," says behavioral physiologist Shelley Adamo of Dalhousie University in Halifax, Canada. So far though, she says, the zombie-maker fungus "fits most of the criteria for parasitic manipulation."

Zombie ants expire with their jaws clamped to leaf veins, possibly because a fungal infection freezes their muscles.

Where animals breathed their first

Microbial mats may have been an early source of oxygen

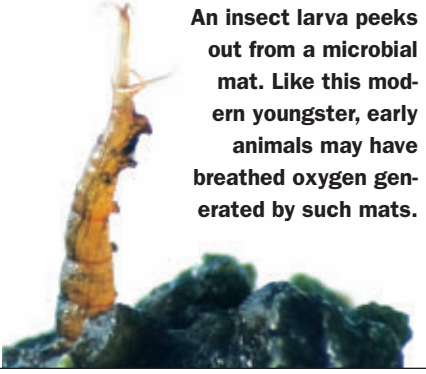
By Daniel Strain

Animals living more than 550 million years ago could have survived inhospitable oceans by associating with dense mounds of cyanobacteria called microbial mats, an international team of researchers argues. Such clumps of oxygen-producing gunk may have supplied the first mobile animals with food to eat and air to breathe, the group reports online May 15 in *Nature Geoscience*.

Recent fossil finds show that wriggling animals first emerged at least 555 million years ago, when atmospheric oxygen concentrations were about one-tenth what they are today. Yet as creatures moved more, they needed more oxygen. So how early mobile critters, which probably resembled worms or slugs, eked out a living in these choked environments has been a big puzzle for paleontologists, says study coauthor Murray Gingras. "Biomats provided the oxygen that ironically enabled the animals to better exploit biomats as food," he says.

He got his first clue after drilling into a frozen pond in Alberta, Canada. The pond, almost entirely deprived of oxygen, hosted a small number of insect larvae surrounding a layer of photosynthesizing algae. "They were eating the biological material, and they were using it as a scuba tank at the same time," says Gingras, a paleontologist at the University of Alberta in Edmonton.

Alberta's frozen lakes don't look much like ancient oceans, however, so Gingras and his colleagues turned to supersalty lagoons in Venezuela. Here, gelatinous masses of cyanobacteria, a type of oxygen-producing microbes with ancient origins, clog the waters. Animals first evolved in a similar "world ruled by microorganisms," Gingras says.



An insect larva peeks out from a microbial mat. Like this modern youngster, early animals may have breathed oxygen generated by such mats.

The modern lagoons, like their ancient counterparts, carry few traces of oxygen. But the gas does run high — reaching near or above typical water levels — right above and below the mats. These lagoons usually host scant animal life but, as in Alberta, clusters of insect larvae gather around the mats, taking bites and maybe breaths.

"In a way, it's dead obvious," says Mary Droser, a paleontologist at the University of California, Riverside.

But ancestral animals didn't necessarily need scuba gear, suggests Donald Canfield, a geobiologist at the University of Southern Denmark in Odense. Ancient critters may not have had the same insatiable need for air that most modern animals do, he explains. Even today, marine worms and other animals flourish in deep ocean habitats where oxygen is thin. Exploring how these worms survive, Canfield adds, might give scientists insight into how the first creatures with wanderlust grabbed a foothold in an unwelcoming world.

FROM TOP: D. HUGHES; STEFAN LALONDE

Body & Brain

58 percent Fraction of U.S. bacterial meningitis cases due to *S. pneumoniae*

14 percent Fraction of U.S. bacterial meningitis cases due to *N. meningitidis*

Drop in bacterial meningitis found

Vaccinations cut cases by nearly one-third over decade

By Nathan Seppa

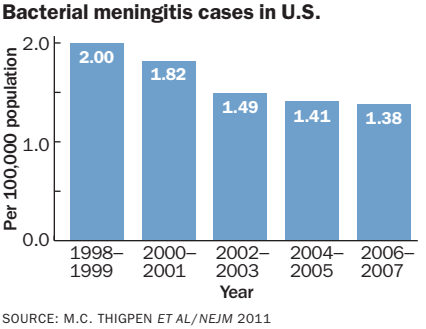
Just a few decades ago, a pediatrician getting a frantic phone call from a parent whose child was running a high fever would immediately consider bacterial meningitis. Today, that diagnosis is unlikely: Vaccination has slashed incidence of the deadly brain inflammation, a nationwide survey shows.

Researchers scanned data from more than 17 million people and found that the incidence of bacterial meningitis in the United States had fallen by 31 percent from 1998 to 2007, researchers report in the May 26 *New England Journal of Medicine*.

"For people taking care of kids since the 1980s, the world of meningitis has completely changed in the United States — and it's because of two vaccines," says Matthew Davis, a pediatrician at the University of Michigan Medical School who was not part of the new study. Parents know these as Hib, the vaccine for *Haemophilus influenzae* type B, and as PCV, for *Streptococcus pneumoniae*. Those two microbes were historically among the chief causes of bacterial meningitis.

The first hit to disease rates came in the 1980s and 1990s with the introduction of Hib, which remains a routine immunization for children. Then in 2000 the Food and Drug Administration approved a PCV vaccine called Prevnar-7 for *S. pneumoniae*, a microbe that can cause meningitis, pneumonia, ear infections and other ailments (*SN: 4/7/07, p. 222*).

On the wane Vaccination programs have lessened the toll of bacterial meningitis in the United States in recent years.



SOURCE: M.C. THIGPEN *ET AL*/*NEJM* 2011

That vaccine reduced meningitis due to *S. pneumoniae* by 26 percent between 1998 and 2007, the new data show. A recently approved version of the vaccine will further reduce cases by broadening coverage to 13 strains of the bacterium, predicts study coauthor William Schaffner, a physician at Vanderbilt University School of Medicine in Nashville.

A third vaccine, aimed at another meningitis bacterium, *Neisseria meningitidis*, was also approved in recent years. Called the meningococcal vaccine, it is commonly given at the start of adolescence and as a booster for college freshmen.

The new study suggests that giving these vaccines to kids has also limited meningitis outbreaks among adults, who are now less likely to catch the microbes from youngsters, says study coauthor Cynthia Whitney of the Centers for Disease Control and Prevention in Atlanta.

Bacterial meningitis is treated with antibiotics, but the inflammation that it causes in the membrane covering the brain and spinal cord can be lethal. Although the number of cases has dwindled, the fatality rate for bacterial meningitis in the nationwide sampling remains around 15 percent.

Treating pain changes brain activity

Fixing chronic back problems has benefits above the neck

By Laura Sanders

Wiping out chronic pain in the lower back doesn't just dull the agony. It allows the brain to recover, too. Six months after people's backaches were eased, their brains showed fewer signs of the abnormalities that accompany chronic pain, a new study shows.

This brain recovery is "a concrete message that certainly brings hope and relief to those suffering from this condition," says UCLA neuroscientist Dante Chialvo.

In the study, neuroscientist Laura Stone of McGill University in Montreal and colleagues scanned the brains of people who had experienced back pain for at least a year. Compared with healthy controls, chronic pain sufferers had thinning in a brain region that's been linked to pain modulation, the left dorsolateral prefrontal cortex. This region also showed abnormal activity when people with chronic back pain took a simple cognitive test while in a brain scanner, the team found.

But six months after treatment with either spine surgery or pain-relieving injections, scans revealed that the pain sufferers' brains bounced back. The patients' thin dorsolateral prefrontal regions grew larger, and their brain activity began to look more normal. These brain changes depended on the level of pain relief: The less pain a person reported after treatment, the greater the brain's improvement, the team reports in the May 18 *Journal of Neuroscience*.

"We know that pain causes brain changes, and now we know that taking pain away reverses those changes," Stone says.

If it turns out that the dorsolateral prefrontal cortex controls pain, she says, clinicians might one day be able to reduce suffering by targeting that region with noninvasive techniques such as cognitive behavioral therapy, meditation or exercise. ■

20 hertz | Frequency of male alligator's bellow

600 hertz | Frequency of male mosquito's buzz

Gator mating takes fancy physics

Subsonic bellows generate Faraday waves in overlying water

By Devin Powell

Alligators flirt with physics. When males attract attention by quivering their spiky backs underwater, they create Faraday waves, researchers reported May 23. These sophisticated patterns are usually seen only in man-made devices.

"Faraday waves haven't really been seen in nature before," says acoustician John Allen of the University of Hawaii at Manoa, who was not part of the research team.

When a male alligator craves company, he issues a sound from his lungs that is too low to be heard. This infrasound then causes him to vibrate violently and whips the water on his back into a froth of waves and leaping fountains.

While watching a video showing this "water dance," R. Glynn Holt, an acoustician at Boston University, was reminded of the British physicist Michael Faraday. In 1831 Faraday discovered that liquid above a vibrating object sometimes forms surface waves that move up and down at half the speed of the vibrations.

In search of Faraday waves, Boston University undergraduate Peter Moriarty traveled to Gatorama, a roadside attraction in Palmdale, Fla. He played alligator calls to a gator named Mr. Chicken and recorded the enthusiastic response, an 18- to 20-hertz rumble.

Hidden in this sound was the telltale sign of a Faraday wave: another sound at half the vibrational frequency, 9 to 10 hertz.

Surface waves with this frequency should have a wavelength of about 3 centimeters — which agrees with measurements made from photos of amorous alligators.

Three centimeters is also almost exactly one-third the distance between the rough protrusions, or scutes, on the creature's back.

"We think that the shape of their scutes helps them create these waves," said Moriarty. The shapes of some backs may make better waves for signaling mates, he speculates — possibly a kind of sexual selection. ■

What it means to 'feel the noise'

Hearing, touch appear to be physically linked in the brain

By Devin Powell

About a year and a half after her stroke, a 36-year-old professor started to feel sounds. A radio announcer's voice made her tingle. Background noise in a plane felt physically uncomfortable.

Now Tony Ro, a neuroscientist at the City College of the City University of New York, may have figured out the cause of this synesthesia, or overlapping sensation. Sophisticated imaging of the professor's brain revealed that new links had grown between its auditory part, which processes sound, and the somatosensory region, which handles touch.

"The auditory area of her brain started taking over the somatosensory area," says Ro, who used diffusion tensor imaging, which focuses on the brain's white matter connections, to spot the change.

The connection between sound and touch may run deep in everyone, Ro and colleagues reported May 25. Both hearing and touch rely on nerves set atwitter by vibration. A cell phone set to vibrate can be sensed by the skin of the hand, and the phone's ring tone generates sound waves — vibrations of air — that move the eardrum.

Elizabeth Courtenay Wilson, a neuroscientist at Beth Israel Deaconess Medical Center in Boston, has also seen strong connections between areas of the brain that process hearing and touch. She has published papers showing that people with normal hearing were much better at detecting the combination of an extremely weak sound and an extremely weak vibration applied to the skin than at detecting either stimulus on its own.

The connection between sound and touch may run deep.

Other researchers have shown that hearing a sound can boost touch sensitivity. Ro calls this the mosquito effect: The bug's buzz makes skin prickle. The frequency of the sound and the frequency of the vibrations that hands feel must match for this to work, Ro and colleagues showed in a study published in 2009 in *Experimental Brain Research*.

Frequency may be a two-way street in the brain that unites the two senses, says Jeffrey Yau, a neuroscientist at the Johns Hopkins University School of Medicine.

The ability of skin and ears to confuse each other also extends to volume, Yau says. A car radio may sound louder to a driver than to his passengers because of the shaking of the steering wheel.

"As you make a vibration more intense, what people hear seems louder," says Yau.

Functional MRI scans of people's brains have shown that the auditory region can activate during a touch, and some scientists speculate that chunks of brain specialized for understanding frequency may play a role in crossing the wires. But exactly where touch and hearing might be coming together in the brain remains a muddle.

Earth

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Rogue waves caught by scientists

Re-creating monster swells in a tank helps explain their origin

By Devin Powell

Freak waves that swallow ships whole have been re-created in a tank of water. Though these tiny terrors are only centimeters high, a devilishly difficult mathematical equation describing their shape may help to explain the origins of massive rogue waves at sea.

Sailors have long swapped stories about walls of water leaping up in the open ocean — even in calm water — without warning or obvious cause. But for centuries, rogue waves were little more than talk; no one had ever measured one with scientific instruments.

Then on New Year's Day of 1995, a laser on an oil rig off Norway's coast recorded one of these rare events: a wave 26 meters from bottom to top, flanked by deep troughs on either side.

The interactions that allow for such waves were described by mathematician Howell Peregrine in 1983. His solutions of nonlinear Schrödinger equations showed that pulselike waves called Peregrine solitons can pop out of sine waves undercertain conditions.

"For a long time, nobody really thought this mathematics would be applicable to the ocean," says Al Osborne, a physicist at the University of Turin in Italy. "Not only is it applicable, but we're now undergoing a paradigm shift in understanding ocean waves."

To make a Peregrine soliton, mathematician Amin Chabchoub of the Hamburg University of Technology in Germany wobbled a paddle back and forth at one end of a long water tank. Regularly spaced waves about a centimeter high emerged and rolled across the surface. Then he gave the paddle a precise jerk.

"It's possible that the wind could generate a similar modulation or perturbation in the open sea," says Chabchoub. He and his colleagues describe the experiment in the May 20 *Physical Review Letters*.

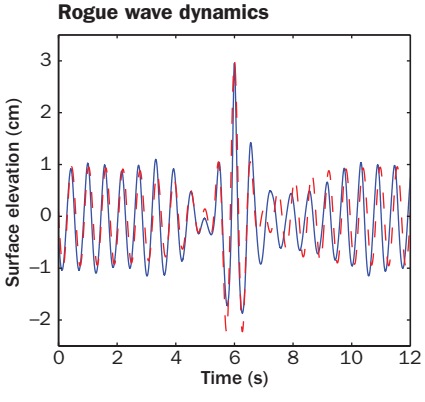
In the 15-meter-long tub, this spot grew to a height of about 3 centimeters before dying down — hardly enough to make a rubber ducky quack in fear. Flanked by two deep troughs, the rising peak moved half as fast as the background waves. It satisfied both Peregrine's mathematics and a common statistical view that a rogue wave is something at least two to three times the average size of the tallest one-third of the other waves.

In theory, the toy waves in the water tank should scale up to oceanic proportions. But oceans are much messier than water tanks. Normal ocean waves come in a variety of sizes and speeds, and other effects may play a role in creating rogue waves.

"You add an almost imperceptible amount of noise, and all sorts of wacky and unexpected things can happen," says UCLA physicist Daniel Solli, who created the first Peregrine soliton in light waves.

Chabchoub and his colleagues are exploring ways to introduce a little more mess into their tank to see what other wacky conditions can give rise to freak waves. ■

Surf report In a series of tiny waves (blue), a 3-centimeter-high rogue (middle peak) closely corresponds to a theoretical equation solved during the 1980s (dashed red line).




Hailstones

Germy with a chance of hail

Aerial microbes can influence weather, and maybe climate

By Janet Raloff

Bacteria often leave their hosts feeling under the weather. And even when the hosts are high-altitude parcels of air, microbes can be a source of inclement conditions, researchers from Montana and Ohio find. Cloudborne bacteria might even pose climate threats by boosting the production of a greenhouse gas, another team proposes.

Both groups reported their findings May 24 at the American Society for Microbiology meeting in New Orleans.

These data add to a growing body of evidence that biological organisms are affecting clouds, says Anthony Prenni of Colorado State University in Fort Collins, an atmospheric scientist who did not participate in the new studies.

"We still don't know on a global scale how important these processes are," he says. "Within a few years, I think we're going to have a much better handle on it."

Alexander Michaud's new research was triggered by a June 2010 storm that pummeled Montana State University's campus in Bozeman with golf ball–sized and larger hailstones. The microbial ecologist normally studies subglacial aquatic environments in Antarctica. But after saving 27 of the hailstones, he says, "I suddenly realized: No one had really ever thought about studying hailstones, in a layered sense, for biology."

FROM TOP: PSYM/FLICKR; A. CHABCHOUB

26 meters | Height of first verified rogue wave, in 1995

27 meters | Estimated height of wave striking *QE2* in 1995

48 meters | Height of Irish light beacon damaged by 1985 wave

His team dissected the icy balls, along with hundreds of smaller ones collected during a July hailstorm. Michaud reported finding germs throughout, with the highest concentrations by far — some 1,000 cells per milliliter of meltwater — in the hailstones' cores.

Since at least the 1980s, scientists have argued that some share of clouds, and their precipitation, probably traces to microbes. Strong winds can loft germs many kilometers into the sky. And since the 1970s, agricultural scientists have recognized that certain compounds made by microbes serve as efficient water magnets around which ice crystals can form at relatively high temperatures (occasionally leading to frosts that devastate crops).

In 2008, Brent Christner of Louisiana State University in Baton Rouge and his colleagues reported isolating ice-nucleating bacteria from rain and snow. A year later, Prenni's group found microbes associated with at least a third of the ice crystals sampled from clouds at an altitude of 8 kilometers.

"But finding ice-nucleating bacteria in snow or hail is very different from saying they were responsible for the ice," says Noah Fierer of the University of Colorado at Boulder.

Pure water won't freeze in air above about –40° Celsius, Christner notes. Add tiny motes of mineral dust or clay, and water droplets may coalesce around them at perhaps –15°. But certain bacteria can catalyze ice nucleation at even –2°.

Through chemical techniques, Michaud's group determined that the ice nucleation in their hail occurred around –11.5° for the June hailstones and at roughly –8.5° for the July stones.

At the meeting, Pierre Amato of Clermont University in Clermont-Ferrand, France, reported biological activity in materials sampled from a cloud at an altitude of 1,500 meters. The air hosted many organic pollutants, including formaldehyde, acetate and oxalate. Sunlight can break these down to carbon dioxide, a greenhouse gas, something Amato's group confirmed in the lab. But sunlight didn't fully degrade some organics unless microbes were also present.

Moreover, certain cloudborne bacteria degraded organic pollutants to carbon dioxide at least as efficiently as the sun did. Amato's team reported these findings online February 9 in *Atmospheric Chemistry and Physics Discussions*.

This microbial transformation of pollutants to carbon dioxide occurs even in darkness. Amato has calculated the total nighttime microbial production of carbon dioxide in clouds and pegs it "on the order of 1 million tons per year." Though not a huge sum (equal to the carbon dioxide from perhaps 180,000 cars), this amount could increase, he cautions.

Atom & Cosmos

For a map of the Milky Way's new extension, visit **www.sciencenews.org/scarm**

Galaxy gets an arm extension

New finding suggests Milky Way has a rare symmetry

By Ron Cowen

A new study suggests the Milky Way doesn't need a makeover: It's already just about perfect.

Astronomers base that assertion on their discovery of a vast section of a spiral, star-forming arm at the Milky Way's outskirts. The finding indicates that the galaxy is a rare beauty with an uncommon symmetry — one half of the Milky Way is essentially the mirror image of the other.

Thomas Dame and Patrick Thaddeus of the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., say the structure they've discovered is most likely the outer extension of the Scutum-Centaurus arm from the inner galaxy. It appears that Scutum-Centaurus wraps all the way around the Milky Way, making it a symmetric counterpart to the galaxy's other major star-forming arm, Perseus.

The two arms seem to extend from opposite ends of the galaxy's central, bar-shaped cluster of stars, each winding around the galaxy, the researchers report in the June 10 *Astrophysical Journal Letters*.

Dame found evidence for the new structure while reviewing galactic data on atomic hydrogen gas, which radiates at a radio wavelength of 21 centimeters. After tracing the extension of the arm in the 21-centimeter radio emission, "I was in the unique position of being able to walk up two flights of stairs to the roof of my building [at Harvard] and search for carbon monoxide emissions from molecular clouds using the CfA 1.2-meter radio telescope," says Dame.

What he saw confirmed his initial finding.

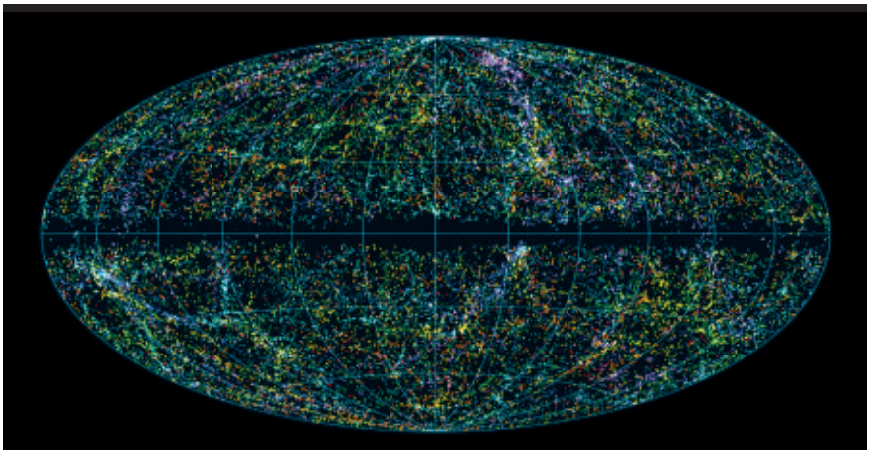
"This is a major new discovery," comments Robert Benjamin of the University of Wisconsin–Whitewater. "Dame and Thaddeus have found evidence for a large-scale coherent structure, spanning 60 degrees in the sky ... which contains giant molecular gas clouds very far from the galactic center."

The newfound structure lies about 49,000 light-years from the galaxy's center, and one of the arm's many large molecular clouds contains an amount of molecular hydrogen equivalent to that of 50,000 suns.

Virtually every spiral arm in the Milky Way has been found in sections, Dame notes. When astronomers realized that the Sagittarius arm (found in the northern sky) and the Carina arm (in the south) were part of a single, larger structure, they became known as the Sagittarius-Carina arm. Similarly, since Dame and Thaddeus believe the new arm is an extension of Scutum-Centaurus, "we suggested 'Outer Scutum-Centaurus' as a more logical name," Dame says. The structure is longer than the known parts of the Scutum-Centaurus arm, he adds.

The new feature was previously overlooked because it tilts out of the plane of the galaxy, following the outer galaxy's warp. Most studies that examine spiral arms focus on the galaxy's plane.

The team's "identification of the feature as a discrete structure is new, and the discovery that it contains molecular gas makes a very strong case for this being a spiral arm," Benjamin says. ■



TOM JARRETT/IPAC/CALTECH, 2MASS REDSHIFT SURVEY TEAM

Survey sees local universe in 3-D

The cosmic backyard will never look the same, thanks to a new three-dimensional map of some 45,000 galaxies. Covering 95 percent of the sky, the map includes galaxies as far as 1 billion light-years away and is the most detailed map ever assembled out to 380 million light-years. It uses dust-penetrating infrared observations to show features that in visible light are obscured by the Milky Way. "We get a more detailed look at major structures that are almost hidden by our galaxy," says Karen Masters of the University of Portsmouth in England. She unveiled the map on May 25 at a meeting in Boston of the American Astronomical Society. Redshift measurements, which gauge the amount by which cosmic expansion lengthens the wavelength of light, provide the map's crucial third dimension, the distance of objects from Earth. Purple galaxies are closest; those in red lie about 1 billion light-years away. Because the map encompasses nearly the entire sky rather than the smaller wedges revealed by previous surveys, it shows in new detail how clusters of galaxies congregate into vast walls and filaments, says Michael Hudson of the University of Waterloo in Canada. —*Ron Cowen*

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Geometry comes naturally to the unschooled mind

Amazonian villagers grasp abstract spatial concepts

By Bruce Bower

In a South American jungle, far from traffic circles, city squares and the Pentagon, beats the heart of geometry.

Villagers from an Amazonian group called the Mundurucú intuitively grasp abstract geometric principles despite having no formal math education, say psychologist Véronique Izard of the Université Paris Descartes and her colleagues.

Mundurucú adults and 7- to 13-year-olds demonstrate as firm an understanding of the properties of points, lines and surfaces as adults and school-age children in the United States and France, Izard's team reports online May 23 in *Proceedings of the National Academy of Sciences*.

U.S. children between ages 5 and 7 partially understand geometric space, but not to the same extent as older children and adults, the researchers find.

These results suggest two possible routes to geometric knowledge. "Either geometry is innate but doesn't emerge until around age 7, or geometry is learned but must be acquired on the basis of general experiences with space, such as the ways our bodies move," Izard says.

Both possibilities present puzzles, she adds. If geometry relies on an innate brain mechanism, it's unclear how such a neural system generates abstract notions about phenomena such as infinite surfaces and why this system doesn't fully kick in until age 7. If geometry depends on years of spatial learning, it's not known how people transform real-world experience into abstract geometric concepts — such as lines that extend forever or perfect right angles — that a forest dweller never encounters.

Whatever the case, the Mundurucú's keen grip on abstract geometry contrasts with past evidence from Izard's group that these Amazonian villagers cannot add or otherwise manipulate exact numbers larger than five. Geometry may have a firmer evolutionary basis in the brain than arithmetic, comments cognitive neuropsychologist Brian Butterworth of University College London.

"If so, this would support recent findings that people who fail to learn arithmetic, or dyscalculics, can still be good at geometry," Butterworth says.

Study coauthor and Harvard University psychologist Elizabeth Spelke argues that evolution has endowed people with "core knowledge" about several domains, including physical space.

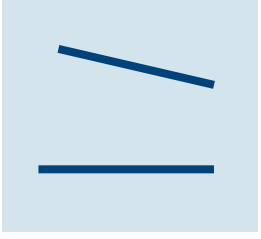
In 2006 and 2007, Izard and study coauthor Pierre Pica of Université Paris 8 tested 22 adults and eight children in three Mundurucú villages located more than 100 kilometers upriver from any other settlements.

Izard and Pica first probed knowledge of straight lines. Participants viewed images of 2-D planes and 3-D spheres on a computer screen, which the researchers described as imaginary worlds. Dots located on the surfaces of planes and spheres corresponded to villages that were connected by straight paths.

Volunteers responded to 21 questions, such as "Can more than two lines be drawn through a point?" and "Can a line be made to never cross another line?" Illustrations appeared with each question to depict the problem visually.

Mundurucú answered many more questions correctly than would be expected by chance. Accuracy reached more than 90 percent in response to questions about a flat world and more than 70 percent for questions about a spherical world.

Next, Izard and Pica tested knowledge about triangles. Volunteers again saw a plane and a sphere. In each make-believe world, a pair of dots represented two villages. Two arrows coming out of each dot formed angles, with bottom arrows designating a straight path between the villages and top arrows pointing toward a third, unseen village that completed a triangular shape.



Lines of reasoning
Researchers tested Amazonian villagers' geometry skills by showing sketches like this and asking questions such as "Can a line be made to never cross another line?" The villagers answered correctly much more often than chance would predict.

Participants estimated the location of the third village by pointing on the screen. Mundurucú then gauged the angle of paths connecting the unseen village to the visible villages. Average Mundurucú estimates for absent angles on flat surfaces, added to measures of the two visible angles, came within 5 degrees of 180, the constant sum of the angles in a planar triangle. Average angle estimates for spherical surfaces, added to existing angles, exceeded the constant sum by 9 degrees to 22 degrees.

On the same tests, 35 U.S. adults and eight French schoolchildren performed comparably to the Mundurucú.

Izard's team suspected that U.S. 5- to 7-year-olds would show similar geometric insights, providing unambiguous support for core knowledge of concepts about space. To the scientists' surprise, the 52 kids in this age range that they tested performed better than chance on line and triangle tests but fell well short of marks set by older children and adults.

In particular, younger children had difficulty taking into account spherical space when thinking about relations between lines and the size of missing angles in triangles.

Izard and her colleagues are now probing the development of geometric knowledge in U.S. and French youngsters during the first few years of life.

V. IZARD *ET AL*/*PNAS* 2011, ADAPTED BY T. DUBÉ

"People who fail to learn arithmetic … can still be good at geometry." —BRIAN BUTTERWORTH

Kids perceive ownership principles

Concept of property rights may come naturally to preschoolers

By Bruce Bower

Young children are possessed by possessions. Preschoolers argue about what belongs to whom with annoying regularity, a habit that suggests limited appreciation of what it means to own something.

But it's actually just the opposite, psychologist Ori Friedman of the University of Waterloo in Canada reported on May 28. At ages 4 and 5, youngsters value a person's ownership rights — say, to a crayon — far more strongly than adults do, Friedman and psychology graduate student Karen Neary found.

Rather than being learned from parents, a concept of property rights may automatically grow out of 2- to 3-year-olds' ideas about bodily rights, such as assuming that another person can't touch or control one's body for no reason, Friedman proposed.

"Parents and adults may teach kids when it's appropriate to disregard personal ownership," he said. One such instance would involve a mother's advice on when to lend a toy to another child who wants to borrow it.

Friedman's team presented a simple quandary to 40 preschoolers, ages 4 and 5, and to 44 adults. They saw a cartoon image of a boy holding a crayon, appearing above the word "user," and a girl who appeared above the word "owner." After hearing from an experimenter that the girl wanted her crayon back, volunteers were asked to rule on which cartoon child should get the prized object.

About 75 percent of 4- and 5-year-olds decided in favor of the owner, versus about 20 percent of adults.

In a second experiment, more than 100 kids, ages 3 to 7, and 30 adults were told that the crayon belonged to the school that the imaginary boy and girl attended. Nearly everyone, regardless of age, said that the user should keep the crayon for as long as needed. In other words, kids distinguished between people using an owned or an unowned object.

In a final experiment that presented two cartoon adults, one using a cell phone that the other owned, most 4-year-olds but only a minority of adults declared that it should be returned to its owner even before the borrower had a chance to use it. Children showed some flexibility in allowing borrowers to keep the phone — say, if it was needed for an emergency — but adults adjusted their opinions more readily to such circumstances.

MEETING NOTES

Familiarity breeds congeniality

Snap judgments about others sometimes depend not on what the person looks like but on whom they look like. Women tend to prefer male strangers who facially resemble the woman's romantic partner, Cornell University psychologist Gül Günaydin reported May 27. Such social attraction often occurs unconsciously, her team found. For unclear reasons, men showed no signs of especially liking women who resembled a romantic partner. —*Bruce Bower*

Om-tastic vision

Intensive meditation, like that practiced by Buddhist monks, can give eyesight a lift. After completing one to three months of training in either of two Buddhist meditation techniques, volunteers performed much better than before the training on a difficult visual task that required perceiving the lengths of briefly flashed lines, Katherine MacLean of the University of California, Davis reported May 27. For those who still meditated daily five months after training, visual perception remained improved. —*Bruce Bower*

Accentuating the negative

Life has its ups and downs, but the downs have a bigger impact. In a 25-year study of 50,000 Germans tracked from young adulthood on, marriage and other happy events preceded modest boosts in self-reported well-being over the next year, relative to large well-being declines following negative events, such as a spouse's death, psychologist Denis Gerstorf reported on May 28. Most people returned to former levels of well-being within five years of negative events, but 15 percent reported life satisfaction levels below those of sick people preparing for death. —*Bruce Bower*

Genes & Cells

For more coverage of the 2011 ASM Meeting, visit **www.sciencenews.org/asm2011**

Ulcer bug may trigger Parkinson's

Mouse study finds *H. pylori* infection can also affect brain

By Tina Hesman Saey

Brain cells may be the latest victim of a bacterial bad guy already charged with causing ulcers and stomach cancer.

Helicobacter pylori, a bacterium that lives in the stomachs of about half the people in the world, may help trigger Parkinson's disease, researchers reported May 22. Parkinson's disease is a neurological disorder that kills dopamine-producing cells in some parts of the brain. People with the disease have trouble controlling their movements. About 60,000 new cases of the disease are diagnosed each year in the United States.

Previous studies have suggested that people with Parkinson's are more likely to have had ulcers.

Some previous studies have suggested that people with Parkinson's disease are more likely than healthy people to have had ulcers at some point in their lives and are more likely to be infected with *H. pylori*. But until now the connections between the bacterium and the disease have amounted to circumstantial evidence.

Now researchers are gathering new evidence that may pin at least some blame for Parkinson's disease on the notorious bacterium.

Middle-aged mice infected with *H. pylori* developed abnormal movement patterns over several months after infection, said Traci Testerman, a microbiologist at Louisiana State University Health Sciences Center in Shreveport. Young mice infected with the bacterium didn't show any signs of movement problems. Testerman's colleague Michael Salvatore, also at LSU Shreveport, found that *H. pylori*–infected mice make less dopamine in parts of the brain that control movement, possibly indicating that dopamine-making cells are dying just as they do in Parkinson's disease patients.

The bacteria didn't have to be alive to cause the problem. Feeding mice dead *H. pylori* cells produced the same effect, suggesting that some biochemical component of the bacterium is responsible.

One candidate for the disease-causing molecule is modified cholesterol. *Helicobacter* can't make its own cholesterol, so it steals cholesterol from its host and then sticks on a sugar molecule. The structure of the modified cholesterol resembles a toxin from a tropical plant called a cycad; people in Guam who have eaten the plant's seeds have developed a disease called ALS-parkinsonism dementia complex. Testerman and her colleagues are trying to determine if the modified cholesterol alone can lead to Parkinson's-like symptoms in mice or if some other factor from the bacterium is also needed.

Even if the scientists show that *H. pylori* can cause or contribute to Parkinson's disease, it's not clear whether getting rid of the organism would be a good thing. Although the bacterium causes ulcers and stomach cancer, it helps protect against allergies and asthma as well as esophageal cancer and other acid reflux diseases (*SN: 6/18/11, p. 29*). It is hard to know at this point exactly how keeping *Helicobacter* or getting rid of it will affect any individual person, said microbiologist Stanley Maloy of San Diego State University. But it is clear that a possible link between Parkinson's disease and the stomach bacterium can no longer be ignored.

"There's enough solid data that it would be wrong not to look into it more closely," Maloy said. ■

MEETING NOTES

Greenhouse gas may affect populations of soil bacteria

Rising levels of carbon dioxide in the air may have profound effects on underground microbes. Researchers led by Zhili He of the University of Oklahoma in Norman compared soil microbial communities that formed under current atmospheric conditions with communities that developed under the elevated levels of carbon dioxide that are predicted for 2050. Fewer bacteria and less diverse microbe mixtures were present under elevated carbon dioxide conditions, He reported May 23. Some of the differences in the bacterial mixes could be attributed to carbon dioxide directly, but the gas can also change microbial communities indirectly by altering plant physiology and soil conditions. —*Tina Hesman Saey*

Cell phones may mess with body's bacterial guests

Weak magnetic fields that are generated by cell phones, microwave ovens and other consumer devices may alter the growth of friendly microbes in the body. Exposure to weak fields caused *E. coli* bacteria to thrive, but impaired growth of a common skin bacterium called *Staphylococcus epidermidis* and also of a pathogenic bacterium called *Pseudomonas aeruginosa*, reported Sanghoon Kang, a microbiologist at the University of Houston–Clear Lake on May 24. "I don't have a good answer to why," Kang said. It's also not clear whether bacteria in the body would be affected in the same way as those grown in the lab. —*Tina Hesman Saey*

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Good-bye Shuttle

Looking back at the space plane's scientific legacy

By Alexandra Witze

Three decades and 135 flights after its first launch, the space shuttle is ending its reign. After the final orbiter, *Atlantis*, touches down—on a trip scheduled to begin no earlier than July 8—NASA will officially close the books on the shuttle program. For the near term, the agency will buy seats aboard Russian Soyuz spacecraft to get U.S. astronauts to the International Space Station. For the long term, private businesses are trying to develop ways to fly crews into low-Earth orbit, as NASA focuses on designing a new heavy-lift rocket to take astronauts deeper into space.

Science was never the driving goal for the shuttle, which NASA conceived of as a cheap and routine way to get astronauts and supplies to space. Yet along the way researchers took advantage of the shuttle's journeys, by having astronauts launch and regularly upgrade the orbiting Hubble Space Telescope, for example. Some 2,300 experiments have flown aboard shuttles, most focusing on how materials and organisms behave differently in very-low-gravity environments.

Though the shuttle program is ending, research in space continues. The 16 countries that operate the space station plan to keep it going as an orbiting laboratory through at least 2020. ■

APRIL 1981: Shuttle *Columbia* becomes the first to fly into orbit.

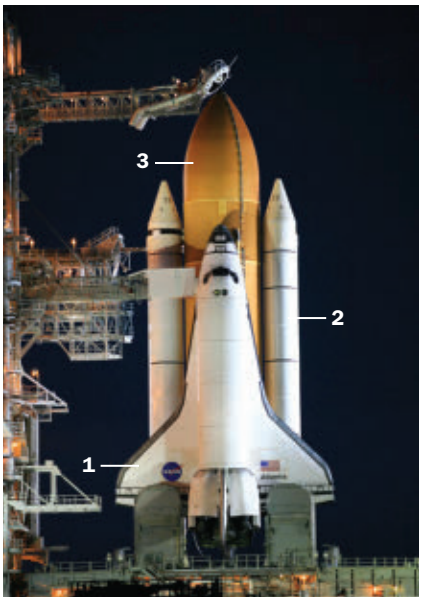
MAY 1989: *Atlantis* launches the first space probe from a shuttle: Magellan, a mission to Venus.

APRIL 1990: *Discovery* launches the Hubble Space Telescope. In December 1993, astronauts fix its flawed primary mirror.

APRIL 1998: For Spacelab's final flight, *Columbia* devotes an entire mission, dubbed Neurolab, to neuroscience.

Neuroscience

Neurolab tackled brain development, plasticity, motor balance and other neural systems. Researchers learned, for instance, that cells in the inner ears of rats made more connections in microgravity than on Earth, and that parts of the rat brain receiving balance signals changed during a 16-day spaceflight. Findings from such basic studies may offer insight into brain-related problems such as Alzheimer's disease and motion sickness.



Shuttle's parts

1. The orbiter, roughly 37 meters long and weighing as much as 80 metric tons, houses the crew and the payload bay, where cargo is packed. NASA has built six orbiters, five of which have flown in space. Orbital altitudes typically reach 300 to 500 kilometers and speeds are roughly 28,000 kilometers per hour.

2. The solid rocket boosters provide the shuttle, weighing 2,000 metric tons at launch, with lift for the first two minutes of flight. Before the shuttle reaches an altitude of 50 kilometers, the spent boosters are jettisoned; later they are recovered from the ocean for reuse.

3. The external tank contains the fuel for the main engines, about 720 metric tons of liquid oxygen and liquid hydrogen. It is released once the main engines are shut off and then breaks apart in the Earth's atmosphere.

THIS PAGE, FROM LEFT: DIMITRI GERONDIDAKIS, NASA; NASA; OPPOSITE PAGE, FROM TOP: NASA; NASA; JPL/NASA, NIMA; JACK PFALLER, NASA; ICONS: E. FELICIANO

NOVEMBER 1983: First flight of Spacelab, a reusable laboratory for microgravity research developed by the European Space Agency. It was carried on about two dozen shuttle missions in various permutations.

Materials and biological research

Early on, Spacelab (shown in this fish-eye view) flew in the shuttle's payload bay. In microgravity, researchers have found, proteins crystallize at different rates and at different sizes than on Earth, suggesting new ways to develop drugs. Infectious bacteria become more virulent, leading to other ideas for medicines and vaccines. And flames burn and spread differently, a finding that has helped NASA develop new methods for fighting fires on spacecraft.

JANUARY 1986: *Challenger* explodes 73 seconds after the launch of its 10th mission, derailing flights until fall 1988.

Astronomy

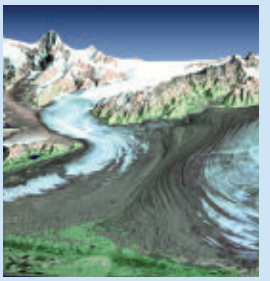
For pure scientific return, no other shuttle-related research can compete with the Hubble Space Telescope (shown). It has peered at galaxies dating back more than 13 billion years, helped discover that the universe is rushing apart at an ever-faster rate and sent back jaw-dropping images of newborn stars swaddled in dust. During five shuttle missions, astronauts swapped out old instruments for new ones on Hubble, giving it a new lease on life each time. Other "Great Observatories" deployed from the shuttle include the Compton Gamma-Ray Observatory (1991) and the Chandra X-ray Observatory (1999).

OCTOBER 1990: *Discovery* launches the Ulysses probe to the sun.

JUNE 1995: *Atlantis* becomes the first shuttle to dock at Russia's Mir space station, where U.S. astronauts conduct experiments, such as investigating the effects of spaceflight on bone loss, over several visits.

DECEMBER 1998: Construction begins in space on the International Space Station, meant to provide a permanent platform for research in orbit.

FEBRUARY 2000: *Endeavour* flies a radar mission that gathers the most detailed information to date about Earth's topography.

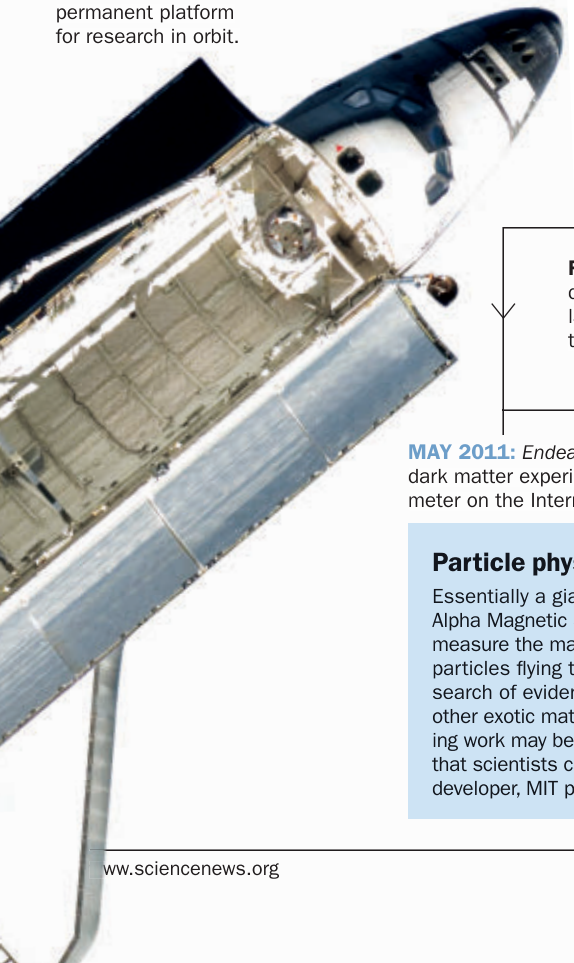


Remote sensing

From a few hundred kilometers below most Earth-observing satellites, shuttle astronauts have taken shots of haze from volcanic eruptions, hurricanes powering across oceans and urban sprawl blighting the landscape. In 2000, the Shuttle Radar Topography Mission compiled the first detailed global map of the Earth's topography (generating this view of Alaska's Malaspina Glacier).

FEBRUARY 2003: *Columbia* disintegrates on re-entry; launches are postponed for two years.

FEBRUARY 2001: *Atlantis* delivers NASA's Destiny laboratory, the main U.S. contribution to research facilities on the International Space Station.

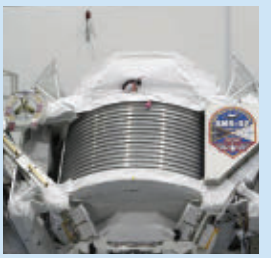


MAY 2011: *Endeavour* launches and mounts the dark matter experiment Alpha Magnetic Spectrometer on the International Space Station.

JULY 2011: Planned flight of *Atlantis* (center), the final shuttle mission.

Particle physics

Essentially a giant orbiting magnet, the Alpha Magnetic Spectrometer (shown) will measure the mass, charge and speed of particles flying through the cosmos in search of evidence for dark matter and other exotic matter. Its most groundbreaking work may be serendipitous discoveries that scientists cannot yet imagine, says its developer, MIT physicist Samuel Ting.



DECEMBER 2011: SpaceX, a private company based in Hawthorne, Calif., intends to fly its Dragon capsule to the International Space Station as a proof of principle for future commercial spaceflights.

Counterfeit CRACKDOWN

Police in China examine counterfeit drugs confiscated in March 2009. Fraudulent online pharmacies make counterfeit drugs a big health concern.

New scientific tools help tell fake meds from the real thing

By Rachel Ehrenberg

When Interpol seized an estimated $2.6 million worth of drugs in a blitz last fall, the international crime fighters weren't after cocaine or heroin. They confiscated thousands of packages of antibiotics, insulin and heart and cancer medications.

The sting, dubbed Operation Pangea III, was part of a less familiar war on drugs — the fight against counterfeit meds. It's a high-stakes battle: A $1,000 investment in fake drugs can return $30,000, 10 times the typical profit from the same investment in heroin, the U.S. Department of Commerce estimates. This version of drug trafficking also has deadly collateral damage: A 22-year-old woman in Argentina with mild anemia died from liver failure after receiving counterfeit iron injections. More than 50 kids in Nigeria died after taking a teething medication containing the poisonous solvent diethylene glycol. And a Canadian woman died from fake drugs she purchased online; they were loaded with metals, including aluminum, titanium and arsenic.

Counterfeit drugs have long been a problem in regions where the path from manufacturer to consumer is circuitous and full of holes. But the Internet has made it easy for anyone, anywhere, to circumvent legitimate supply chains, taking counterfeit drug trading to new highs — and lows.

Operation Pangea III specifically targeted online drug sales, investigating 694 websites, 297 of which have since been shut down. More than 40 countries participated in the effort, which involved customs officials, the electronic payments industry and the European Heads of Medicines Agencies.

Scientists weren't lauded in Interpol's press release. But they played a crucial role in producing key weapons for fighting the counterfeit-drug trade. These tools uncover what can't be seen with the naked eye — a pill's ingredients at the scale of molecules or atoms.

While 20th century chemists developed an impressive suite of methods for revealing a substance's anatomy, in the last decade researchers have developed next-generation versions that simplify the equipment and eliminate tedious sample preparation. New techniques can analyze compounds in seconds, and one recent tweak offers X-ray vision, so a pill's contents can be assessed without even opening a bottle. Researchers are also finding ways to construct exquisite maps that show the location of ingredients within a pill, intelligence that may lead inspectors to the source of fakes.

"The scientific community is realizing this is an important problem and we can help," says analytical chemist Facundo Fernández of Georgia Tech in Atlanta. "It used to be people said, 'This is a problem for law enforcement.' Now we've started developing new tools, and there is more interest from scientists."

Spins on spec

Evidence suggests that the fake-drug problem is widespread. Knockoffs include aspirin, antibiotics and drugs for treating heart attacks, hepatitis B and HIV. (Surgical mesh and blood glucose test strips have also been counterfeited.) In the United States and other countries with

relatively effective regulatory systems, the proportion of medicines that are fakes is probably less than 1 percent, still a staggering figure considering that more than a billion pills are sold in the United States each year. In countries with less secure supply chains, the problem is worse.

In Cambodia, for instance, a survey of intestinal-parasite drugs found that more than 4 percent were counterfeit, researchers reported last year in *Tropical Medicine & International Health*. An investigation reported in 2008 that half of malaria drugs collected from parts of Southeast Asia were counterfeit.

When medications contain little to none of the active ingredient, the consequences can be severe. In February 2005, for example, a 23-year-old man arrived at a hospital in Myanmar infected with the malaria parasite. He received pills thought to contain artesunate, the treatment of choice. By the third night he was in a coma and his kidneys had failed; he died soon thereafter.

Infectious-disease specialist Paul Newton of the University of Oxford, who works out of Mahosot Hospital in Laos, and colleagues were called on to figure out what had happened. Analyzing the medication using a technique known as DART-MS revealed that the man's pills were counterfeit, mostly containing the pain reliever acetaminophen.

The analysis was among the first in which the newly invented DART-MS blew the lid off counterfeit drugs. Short for Direct Analysis in Real Time-Mass Spectrometry, DART-MS is a variant on traditional mass spectrometry, an old analytic technique. At its most basic, mass spec involves vaporizing a sample and electrically charging, or ionizing, the resulting molecules in a vacuum. Those ions are shot through a combination of electric and magnetic fields.

Just as it's easier to divert the path of a tennis ball than a cannonball, lighter ions (with the same charge) are deflected more than heavier ones. The ions, sorted by their mass-to-charge ratios, pass through a detector. Computer analyses yield a chemical bar code, or spectrum, that reveals a sample's makeup when compared with a library of the spectra of different elements and compounds. It's like putting a piece of cake through a machine to find out the precise recipe.

Though traditional mass spec is powerful, a sample has to be carefully prepared to facilitate molecule separation, the analysis has to be done in a vacuum and testing one sample can take 30 minutes. DART-MS and another new twist on mass spec, known as DESI-MS, can reveal a drug's constituents and relative amounts in seconds, with no sample prep and in open air. People had always assumed that charged particles outside the safety of a vacuum would be too unstable for analysis, immediately getting swept up in a frenzy of reactions.

"Really revolutionary was the realization that ... ions are perfectly ordinary stable species and you can move them around in air," says R. Graham Cooks of Purdue University in West Lafayette, Ind., father of DESI. "It's still a surprise to some people."

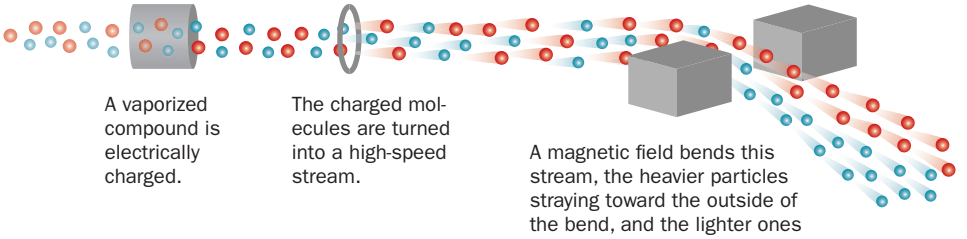
DART uses plasma and heated gas to turn the sample's molecules into ions, whereas DESI (short for Desorption Electrospray Ionization) sprays a liquid solvent that ionizes the sample and then evaporates away, leaving the ions behind. Both have become favorite analytical tools, and not just among those investigating counterfeit drugs. DESI, for example, is helping researchers detect explosives, chemical warfare agents, industrial polymers and proteins.

The late John Fenn, a chemist who shared a Nobel Prize for developing the

Molecular exposure

Researchers have many ways to determine a material's constituents. Some, such as mass spectrometry and Raman spectroscopy, have been around for decades. New tweaks on the classic methods are providing faster and easier ways to spot counterfeit drugs.

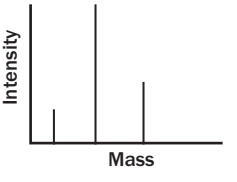
Mass spectrometry



A vaporized compound is electrically charged.

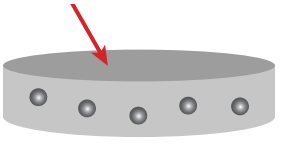
The charged molecules are turned into a high-speed stream.

A magnetic field bends this stream, the heavier particles straying toward the outside of the bend, and the lighter ones staying toward the inside.

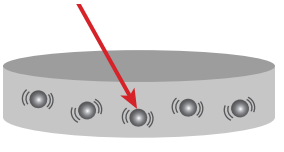


The particles are analyzed and a readout is given in the form of a spectrum. Comparison with reference spectra reveals what is in the compound tested.

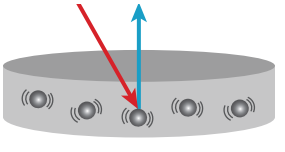
Raman spectroscopy



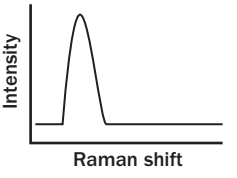
Light is shined on a sample, with little or no preparation required.



Some of the light hits the sample's molecules, causing them to vibrate.

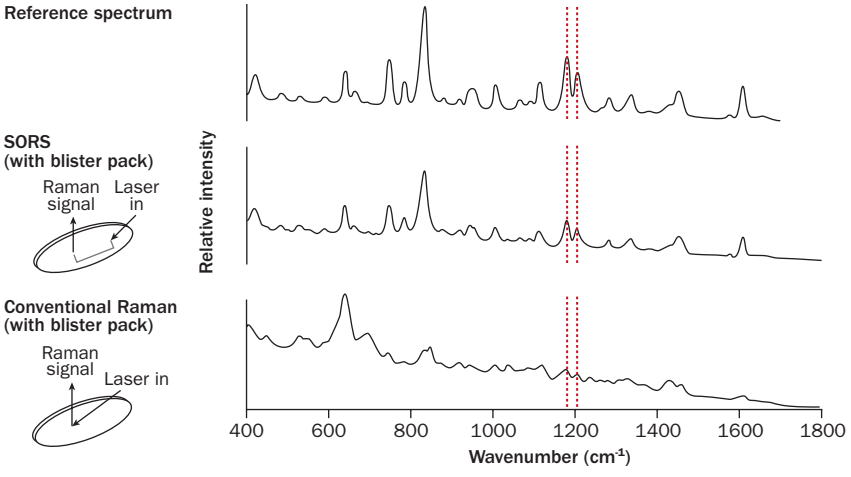


The re-emitted light differs in color, a change in wavelength called the "Raman shift."



Reflected light is analyzed to produce a spectrum that can be used to identify the substance.

T. DUBÉ



Laser vision A twist on Raman spectroscopy called SORS can see through drug blister packs by recording signals offset from where a laser beam hits a sample. Two spectral peaks (marked with dotted lines) signaling ibuprofen in a reference sample (top) are revealed by SORS (middle) but obscured by interference from the blister pack when examined with conventional Raman (bottom).

mass spec technique on which DESI is based, was quoted as calling DESI-MS "the greatest thing since night baseball."

A newer version of DESI, reported by Cooks' lab in 2006, dopes the stream of solvent with additional molecules that can grab onto ingredients of interest, revealing their presence with much greater sensitivity. Reporting in *Analytical Chemistry* in 2007, Fernández and colleagues found that "reactive DESI" was 170 times more sensitive than DESI at detecting artesunate in antimalarial meds. In some fakes, the technique also revealed a cheap and less effective chemical relative of the real antimalarial active ingredient.

"Reactive DESI is one of the stars," Fernández says. "It's very dynamic. You can use it to selectively detect certain molecules and even quantify them. And you can do it on the fly."

The method also proved useful for screening Tamiflu, fake versions of which sold widely on the Internet during recent flu outbreaks.

Tickled with light

While lack of active ingredients means that a patient isn't getting the expected benefit, the wrong ingredients can result in symptoms that make diagnosis difficult. And in some cases, wayward ingredients can be deadly.

In Singapore in 2008, 149 men were admitted to hospitals with severe low blood sugar; these men were not diabetic, but seven went into comas and four subsequently died. The culprits were various versions of fake sexual enhancement and erectile dysfunction drugs contaminated by glyburide, a powerful diabetes drug, scientists reported in the *New England Journal of Medicine* in 2009.

The embarrassment and high price associated with erectile dysfunction drugs such as Viagra and Cialis, known as phosphodiesterase type 5 inhibitors or PDE5Is, make them among the most commonly purchased over the Internet, a land rife with cons. Since Viagra hit the market in 1998, it has also become one of the most widely counterfeited drugs in the developed world. From 2004 to 2008, 35.8 million fake Viagra tablets were seized in Europe. In Japan, sales of illicit PDE5Is are estimated at 2.5 times larger than the market for genuine counterparts, researchers reported last year in *Environmental Health and Preventive Medicine*.

In another paper published last year, in the *International Journal of Clinical Practice*, researchers cited a laundry list of other pharmaceuticals that have turned up in fake erectile dysfunction drugs, including acetaminophen; the ovary-stimulating drug clomiphene; fluoxetine, the active ingredient in Prozac; and dipyrone, an anti-inflammatory used by veterinarians to treat horses. Other ingredients include lactose, talcum powder and printer ink (used to paint the fake little blue pills blue).

In addition to the mass spec techniques, researchers are tickling medications with light to betray unwanted components. Light can offer a spectral readout without destroying the compound — an important consideration for patients who want to take the drug if it's real and for law enforcement officials who would use a fake as evidence.

One light-tickling technique can analyze bottled samples without opening the bottle. It's a play on Raman spectroscopy, in which a laser beam set to one wavelength, or color, is shined on a sample. A small number of photons from the beam will send the sample's molecules oscillating like a spring, emitting light of a different color, which when analyzed yields a chemical bar code.

Normally, shining a laser light on a turbid bottle would just produce a dazzling glare, obscuring the bottle's contents. But Pavel Matousek of the Central Laser Facility at the Rutherford Appleton Laboratory in England and his team figured out a way to ignore this glare.

Regular Raman light is focused, hitting only about a millimeter's worth of sample, and the emitted signal is collected from this illuminated zone. But Matousek and colleagues record a signal from a region offset by 5 to 10 millimeters from where the laser light is focused. This signal comes from photons that migrated into the bottle and through the sample. As with regular Raman, when these photons interact with the sample, they send out photons of a different color.

This setup evades the glare of focused central light. "It's like shutting off the sun so you can see the stars," Matousek says.

Since developing this technique, called Spatially Offset Raman Spectroscopy or SORS, in 2005, Matousek's team has tested it with both tablets and capsules in several types of packaging. While a bottle or blister pack distorted a regular Raman signal, SORS revealed active ingredients in four different meds

C. ELIASSON AND P. MATOUSEK/*ANAL. CHEM.* 2007, ADAPTED BY T. DUBÉ

through their containers, including Sudafed capsules and Nurofen caplets (a brand of ibuprofen), Matousek and Rutherford colleague Charlotte Eliasson reported in *Analytical Chemistry* in 2007.

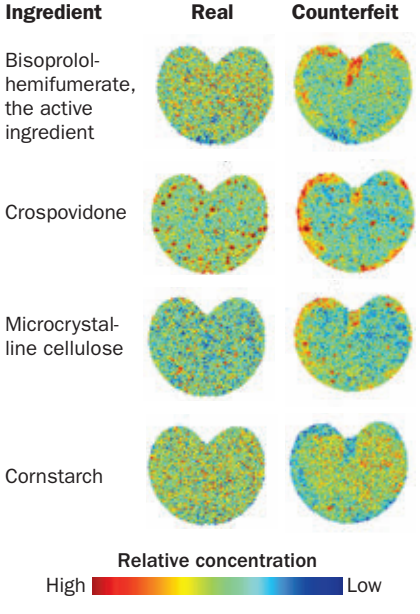
Matousek and others are now fiddling with the lasers and data collection to assess liquids through bottles. Once refined, the method could mean that airline travelers will again be allowed to carry on more than 3 ounces of shampoo.

And Matousek and colleagues hope a new version of SORS, described in *Chemical Science* earlier this year, could allow bone and tissue to be probed, perhaps identifying tumors without invasive biopsies. That approach introduces metal particles to the sample before bombarding it with light.

Mapping meds

Beyond determining what's in a sample, some methods can also reveal where. By combining existing spectroscopy with a microscope, camera and some heavy mathematical analyses, researchers can get a pixelated picture of ingredients' distributions in a pill with stunning detail.

Clues to fraud By combining new spectroscopy and imaging techniques with complex data analyses, researchers mapped the concentrations of various ingredients in a real and counterfeit hypertension drug. The ingredients are unevenly distributed in the counterfeit.



In an early use of one such imaging technique, researchers with the U.S. Food and Drug Administration compared medications bought online with versions from local suppliers. Tickling the samples with near-infrared light, an approach similar to Raman spectroscopy, the team integrated information about absorbed photons with images of the drug itself and some serious number crunching. The near-infrared (or NIR) method showed that the ingredients were poorly mixed in some online versions, the team reported in the *International Journal of Pharmaceutics* in 2005.

"NIR imaging is slow, but you get a fantastic amount of information," says Anthony Moffat, former head of the Center for Pharmaceutical Analysis at the University of London.

More recently, Fernández and colleagues from Georgia Tech and France screened antimalarials using several techniques, including a version of DESI that incorporates imaging technologies. Not only did the analysis reveal that some counterfeit antimalarials were chock-full of acetaminophen, but this amped-up DESI also showed that the painkiller was very evenly distributed in the fake tablets, suggesting a fairly sophisticated operation, the team reported in *Analytical Chemistry* in 2009.

Knowing how well-mixed a counterfeit's ingredients are might point law enforcement to counterfeiters with high-end equipment who know what they are doing versus a ramshackle setup in a garage. If chemical maps show specks of an active ingredient that appear only on the surface, that might suggest that the pills were pressed in machinery typically used for genuine drugs.

Though such intelligence can help crime fighters bust counterfeiters, many researchers are more concerned with preventing bad meds from getting to patients. Such prevention requires

Misspelled words or easily smudged ink on packaging can betray counterfeits. While these two holograms both appeared on artesunate blister packs, the one on the bottom is fake and has misaligned blocks along its rim.

not just new fancy science, but also people and money directed at the right places, says Newton, a leader in the push to deal with counterfeit antimalarials.

In all of Africa, only three countries have labs with the analytical tools needed to monitor the supply chain the way the FDA does in the United States, Newton notes. "There's more awareness now than 10 years ago, but that awareness hasn't been translated into interventions and people dealing with the problem," he says.

Researchers are making headway, though, in the development of portable devices that can be brought out of the lab to the places where people are getting their meds. China has taken NIR spectroscopy mobile, outfitting more than 300 vans with units for screening drugs at local clinics and drugstores in rural regions. There are also compact and portable — though still expensive — Raman devices that make for quick detection by nurses in remote locations. Fernández and colleagues have been working on a portable DART unit, which they described in *Analytical Chemistry* earlier this year.

"What I would really like to see is a nurse in a clinic in the middle of nowhere being able to put a tablet in a handheld device and be told, 'You are good to go,' or 'No, it is fake,'" Fernández says. "The most important thing is to preserve the health of the patient." ■

Explore more

- For more on Interpol's effort to fight pharmaceutical crimes: www.interpol.int/Public/PharmaceuticalCrime/Default.asp

FROM TOP: P.N. NEWTON *ET AL/PLOS MEDICINE* 2008; T. PUCHERT *ET AL/JOURNAL OF PHARMACEUTICAL AND BIOMEDICAL ANALYSIS* 2010

Inside job

Teams of microbes pull strings in the human body

By Tina Hesman Saey

NICOLLE RAGER FULLER

You are surrounded, grossly outnumbered and being manipulated from within.

Teeming masses of bacteria are in your mouth, on your skin, up your nose and on the surface of your eye, in your stomach, deep in your bowels and well, just about everywhere. In fact, the number of bacterial cells you harbor exceeds the count of your own body's cells by 10-to-1.

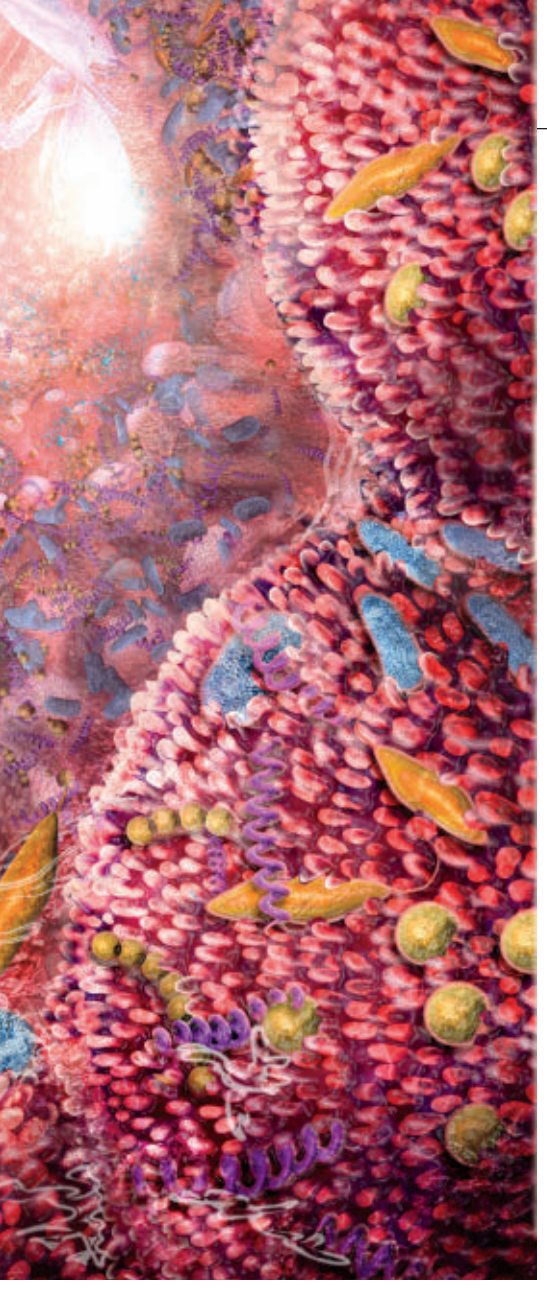
But don't be too hasty in reaching for the disinfectant. You can't wash these microbes away. Nor should you. They are — for the most part — friendly. So friendly that many scientists now view humans as conglomerate superorganisms composed of thousands of species. Scientists have dubbed this internal flora the "microbiome," a nod to the little ecosystems that have blossomed in the body throughout human evolution.

These microbes are no mere hitchhikers. They're hard at work cleaning up your insides and pumping out compounds that have all kinds of effects on health, development and perhaps even some behavior, emerging evidence suggests.

While humans are definitely in a relationship with microbes, the status of that relationship is probably best described as "It's complicated." On the positive side, studies show that intestinal bacteria help to digest food, provide key vitamins and even feed cells lining the intestines. Friendly microbes in the gut and vagina and on the skin can protect against infections from disease-causing bacteria and educate the immune system. Some bacteria in the mouth even help prevent tooth decay.

Other bacteria may turn out to be "frenemies." These otherwise friendly microbes might break your heart and even control your brain. New experiments — mostly with mice — are uncovering secrets about how bacteria beguile, coax and outright manipulate their hosts, including humans.

And just as scientists are learning what these microbes are capable of, it's starting to look like clean living is breaking up some of the healthy friendships between people and microbes, contributing to



L. LU AND W.A. WALKER/*AMER. JO. OF CLINICAL NUTR.* 2001, ADAPTED BY JANEL KILEY

Both helpful and harmful microbes live in human intestines. Some digest food or prevent infections, while others are more nefarious and can cause illness.

disease. Unfriending a bacterial buddy, even one that is sometimes disruptive, can have unforeseen and potentially unpleasant side effects.

Whether they're helping or hurting, these trillions of tiny passengers are here to stay, so new research is mapping their preferred human habitats and figuring out what they do. Ultimately, understanding how bacteria operate inside their human hosts might reveal ways for humans to manipulate their own microbiomes to prevent or treat disease.

Meet your microbiome

Researchers are just beginning to compile a Who's Who of human-inhabiting microbes (*SN: 12/6/08, p. 11*; *SN Online: 11/5/09*). But even when bacteria are identified, it's often not clear which are do-gooders and which are troublemakers.

"We've moved away from saying 'What are healthy bacteria?' to 'What are normal bacteria?'" says Julie Segre of the National Human Genome Research Institute in Bethesda, Md. Segre is one of the researchers taking inventory of the bacteria that grow on skin as part of the National Institutes of Health's Human Microbiome Project. "Having acne — is it healthy? I don't know, but it's normal," she says. The same goes for dandruff and other common microbe-related skin problems.

It may take a shift in the numbers of microbes in a mix to cause illness. Skewed microbial mixes have been fingered as contributors to obesity (*SN: 6/17/06, p. 373*) and high cholesterol. How much fat gets into the liver may also depend on the blend of bacteria in a person's intestines, researchers at the University of North Carolina at Chapel Hill and colleagues reported in the March *Gastroenterology*.

In a study of bacteria inhabiting healthy women's vaginas, Jacques Ravel of the University of Maryland School of Medicine in Baltimore and his colleagues found that each woman had one of five major communities of microorganisms. Four of the communities were dominated by types of *Lactobacillus*, bacteria like those found in yogurt that are well-known for making infection-fighting lactic acid, the researchers reported in the March 15 *Proceedings of the National Academy of Sciences*.

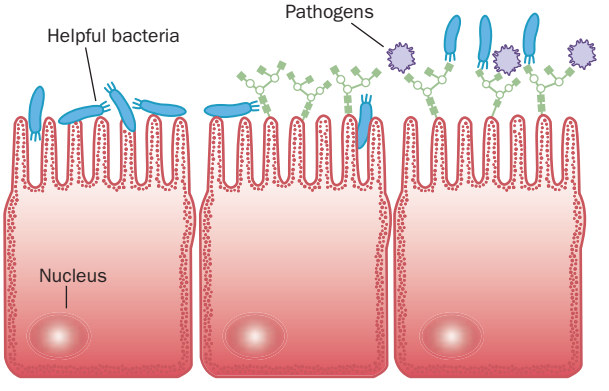
But the fifth group of bacteria contained few lactobacilli, which usually signals an infection. "If you were to give those samples to a physician, they would probably say the women were sick and had bacterial vaginosis," Ravel says. In fact, the women were perfectly healthy. Some researchers think that what bacteria do is far more important than which bacteria colonize the body. In this case, even though most of the bacteria in the fifth group weren't *Lactobacillus*, the microbes still made plenty of lactic acid that could ward off serious infections.

Bacteria can also have effects far beyond where they're found in the body. Problems can arise in the heart, for example, from the digestive habits of bacteria in the gut. What intestinal bacteria eat usually depends on what the human host has for dinner. Just as eating lots of beans can cause bacteria to produce an embarrassing amount of certain gases, chowing down on meat, eggs and some fish can lead intestinal bacteria to produce substances that may hurt the heart more than the pride.

A study by Stanley Hazen of the Cleveland Clinic and his colleagues found that people who had heart attacks or strokes due to clogged arteries had higher blood levels of a substance made when bacteria break down a dietary fat than did people who didn't have heart disease (*SN Online: 4/7/11*). The study, published in the April 7 *Nature*, showed that the people and their microbes ran a macabre relay, handing off metabolic by-products to

Cross talk

The human body has ways to communicate with its microbes. When helpful bacteria colonize intestinal cells (cell at left), the cells get a message to make compounds that help the bacteria attach (center). Sometimes pathogens overhear this chatter and horn in (right).



each other in a race ending in cardiovascular disease.

Microbes as manipulators

The heart-breaking bacteria are just doing their jobs by breaking down a type of fat called lecithin. Other bacteria are far more direct in meddling with the goings-on of the human body.

Take a humble gut bacterium called *Bacteroides fragilis*. This species is ancient, at least 500 million years old, and has probably been living in the gut from humankind's beginning, says Caltech microbiologist Sarkis Mazmanian. He and his colleagues showed that *B. fragilis* could prevent and cure inflammatory bowel diseases in animals, mostly by making a sugar coating called polysaccharide A. But no one knew how the sugar helps or why the bacterium makes the molecule.

"Is this bacterium really so altruistic that it is going to maintain expression of polysaccharide A for the exclusive benefit of the host?" Mazmanian wondered. Probably not. It turns out that the sugar helps keep the immune system calm so that it doesn't toss *B. fragilis* and its bacterial buddies right out of the colon.

Polysaccharide A interacts with an immune-cell protein that normally turns on inflammation, yet this particular interaction actually turns off inflammation, Mazmanian and his colleagues reported in the May 20 *Science*. The inflammation-stimulating protein, called a Toll-like receptor, usually acts as a detector for pathogens. And indeed, if the bacterium doesn't make the sugar, the immune system gears up, leading to inflammation.

"This organism is quite unusual because it doesn't hide from the immune system, or disarm the immune system, but co-opts it," Mazmanian says.

Shifting alliances In addition to widespread use of antibiotics to battle infections and purposely kill bacteria, humans are changing their microbial makeups in some unexpected ways.

Change	Consequence
Clean water	People pick up fewer fecal bacteria
Bathing	Changes a person's mix of bacteria on skin
Reduced breast-feeding	Babies get fewer bacteria from contact with mother
Smaller families	Fewer hand-me-down bacteria from siblings
Increase in cesarean sections	Babies get fewer bacteria from the birth canal
Dental fillings	Changes a person's mix of bacteria in mouth

SOURCE: M.J. BLASER AND S. FALKOW/*NATURE REVIEWS MICROBIOLOGY* 2009

It's not just the immune system that is subject to microbial manipulation. Bacteria help build the brain and influence behavior, scientists in Sweden and Singapore have learned.

Mice raised in environments without any bacteria were far more likely to take risks than mice that had a normal mix of microbes, Sven Pettersson, a cellular microbiologist at the Karolinska Institute in Stockholm and the Genome Institute of Singapore, discovered with his colleagues. Mice generally skulk around in shadows and stay close to walls, but that behavior may not be the mice's idea alone.

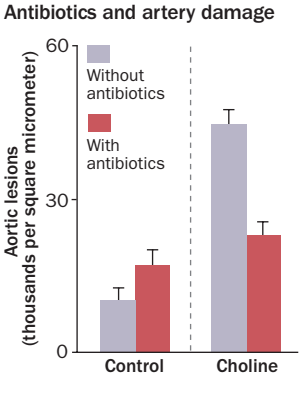
Mice raised in a sterile environment were much bolder, literally going out on a ledge more often than mice reared with bacteria in their bellies, Pettersson's team reported in the Feb. 15 *Proceedings of the National Academy of Sciences*. Bacteria-free mice were also more active overall than their bacteria-laden counterparts. Inoculating bacteria-free newborn mice with intestinal bacteria reversed the changes in behavior. But restoring gut bacteria in adult bacteria-free mice did not change the rodents' behavior, indicating that whatever bacteria do to the brain, they do it early in life.

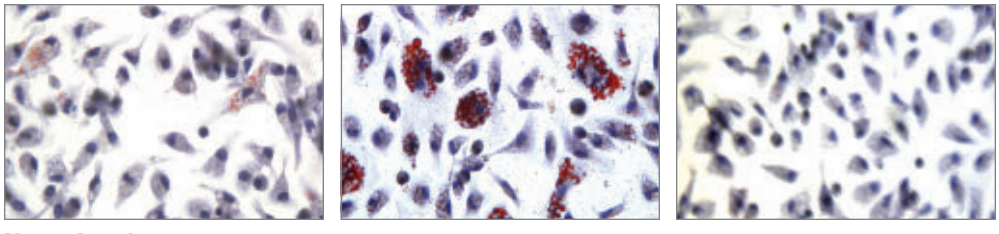
Bacteria's presence or absence affected how the mice used certain brain chemicals and genes involved in brain development. Taken together, the results indicate that intestinal bacteria somehow shape the brain and make mice more anxious — or cautious, depending how you look at it, Pettersson says.

Translating these results to humans is tricky, though. Taking on friendly bacteria isn't likely to make adventurous people more timid, and antibiotics won't turn a shrinking violet into a daredevil.

"At the moment this applies only to rodents," says Pettersson, "but I wouldn't be surprised if we would find bacterial metabolites or bacterial signaling acting on the pregnant mother and affecting the development of the child." If so, the findings could have implications for developmental disorders such as autism.

And bacterial influences are probably not all in the head. "It doesn't take Einstein to realize that if you can do that for the brain, then symbiotic relationships could affect other organs in the body," Pettersson says. "At the moment





Heart breakers Experiments in mice show that gut bacteria, combined with a high-fat diet, can lead to heart disease. Antibiotics that kill intestinal bacteria reduce the amount of artery damage in mice on high-fat diets rich in the nutrient choline (chart, left). When mice are fed a high-fat diet, microbes in the gut convert a fat containing choline into an artery-damaging substance. This triggers more inflammation-inducing cells called macrophages (red, above) to flock into arteries (center) compared with mice fed regular chow (left). When mice on a high-choline diet are given antibiotics to kill intestinal bacteria, macrophages no longer crowd heart arteries (right).

THIS PAGE: CHART: JANEL KILEY; IMAGES: Z. WANG *ET AL*/*NATURE* 2011; FACING PAGE: JANEL KILEY

that's just astrology, but it's tickling to think about."

Going germless

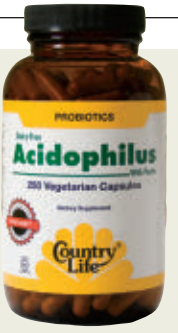
The thought of microbes controlling the body may tickle Pettersson, but most people are squeamish about even having bacteria around. "Everywhere you look people are trying to make the world germfree," says Martin Blaser, a microbiologist at New York University.

But a bacteria-free world is neither practical nor healthy. Blaser and others think that hygienic practices are not only getting rid of pathogens but are also causing populations of helpful bacteria to dwindle, leading to disease. This disappearing-microbiota theory is slightly different from the hygiene hypothesis, which holds that reduced exposure to pathogens leads to a maladjusted immune system, which in turn causes allergies and asthma (*SN: 8/26/00, p. 134*). Breaking up with the bacterial buddies that humans evolved with could have even more profound effects on health.

"Clean water is great. I wouldn't choose otherwise, but sometimes there are unforeseen consequences," Blaser says.

Consider *Helicobacter pylori*. These stomach bacteria have earned a bad reputation for causing ulcers and stomach cancer (*SN: 9/1/07, p. 134*), and most people have shed no tears over the organism's declining presence in Europeans and North Americans. As the percentage of people carrying *H. pylori* has decreased, so have cases of ulcers and stomach cancer. But the loss of the bacteria is also associated with an increase in gastroesophageal reflux disease, Barrett's esophagus (in which stomach acid damages the esophageal lining) and esophageal cancers. Those conditions are all caused by stomach acid getting into the esophagus; *H. pylori* helps reduce stomach acid production, partly by making its own version of an antacid.

People who have been treated with antibiotics to get rid of *H. pylori* also have higher levels of a hunger-inducing hormone called ghrelin in their stomachs. Blaser speculates that the loss of the bacteria may contribute to today's obesity epidemic.



Weeding the microbial garden

Some scientists aren't content to kowtow to manipulative microbes. New methods aim to bend bacteria to people's wills, or at least influence which microbes are allowed to take up residence. The task isn't easily accomplished.

Antibiotics can change the body's microbe composition, but the results are far from controllable, says Rob Knight, a microbial ecologist and Howard Hughes Medical Institute researcher at the University of Colorado at Boulder. "Antibiotics are like driving a bulldozer through your garden and hoping that what pops back up is what you want," he says.

Powerful antibiotics such as ciprofloxacin (which gained fame as a treatment during the anthrax letter scare of 2001) can wipe out much of the gut's microbial diversity. Some people's bacterial populations rebound fairly quickly to their previous composition, Stanford researchers reported in the March 15 *Proceedings of the National Academy of Sciences*. Others never really recover, and repeated rounds of antibiotics lead to bigger and bigger shifts in community makeup.

Some people advocate supplements of bacteria, called probiotics, to boost friendly bacteria. Others favor prebiotics—chemicals to encourage certain bacteria to thrive. Clinical trials are trying to determine if those approaches will work.

Another treatment involves starting over with somebody else's gut bacteria. In a few places doctors are performing fecal transplants to treat people with serious infections of *Clostridium difficile*. The bacterium causes severe diarrhea and can inflame and damage the colon to the point that part of the intestines must be surgically removed. The fecal transplant procedure "is exactly as disgusting as you would imagine," Knight says. But transplanting a healthy person's fecal bacteria into the sick person's colon cures the disease in most people. Still, that's a drastic measure and one most people aren't likely to use to help mold their microbes. —*Tina Hesman Saey*

What's more, people with *H. pylori* in their stomachs have lower risks of getting childhood asthma (*SN: 8/16/08, p. 9*) and allergies, and the organism's disappearance may also be adding to the rise of those conditions.

Those are the potential consequences of getting rid of just one microbial frenemy. Treatments that disturb many microbes could have even more far-reaching consequences. A study published in the April *Antimicrobial Agents and Chemotherapy* showed that antibiotics altered the levels of 87 percent of the compounds made in mouse intestines by bacteria and the mouse hosts. Many biological processes that are also important for human health were affected, including production of bile salts and steroid hormones.

Blaser and others hope that as people become more aware of how important bacteria are to human well-being, gentler therapies might toss out the bad guys but keep the good.

It's been slow in coming, but an awareness is growing that small creatures can wield great influence on the development of the human brain, immune system and other parts of the body. It should come as no great surprise, Mazmanian says. After all, bacteria shape their environments all the time, creating teeming colonies around vents in the ocean floor and helping build coral reefs and rain forests. "I don't see us as being any different from a coral reef," he says. "But humans are narcissists by nature, and most of the rest of the world isn't ready to admit that little, ignorant bacteria could be in charge." ■

Explore more

- The National Institutes of Health's Human Microbiome Project: http://commonfund.nih.gov/hmp

Feathers: The Evolution of a Natural Miracle

Thor Hanson

Feathers are a multipurpose marvel. Birds, the only modern-day creatures to sport plumage, use feathers for flight, insulation and courtship displays. As it turns out, so do people: Feathers help arrows fly true, trap body heat inside parkas and adorn everything from attention-grabbing hats to the glitzy costumes of Las Vegas showgirls. Hanson, a conservation biologist, presents feathers in a sweeping natural and cultural history, bringing them to life not just as a practical item but as a source of inspiration throughout history.

Hanson artfully explores the many functions of feathers through the stories of people who, like him, are fascinated by them — the fishing guide who embellishes trout lures, the family that jealously guards trade secrets for dyeing feathers used in fashions and the Smithsonian researcher who can identify the species of bird that was sucked into a jet engine by examining tiny shreds of plumage left behind. While only a few cultures have used feathers as money, many have considered plumage valuable: The most expensive cargo on the *Titanic* wasn't gemstones or gold; it was dozens of cases of feathers, estimated to be worth about $2.3 million today, destined for hatmakers in New York City.

This captivating book also delves into paleontologists' latest ideas about how and why feathers evolved millions of years ago, and how recent studies identifying tiny pigment-bearing structures in fossil feathers are helping researchers determine the color scheme of ancient birds and feathered dinosaurs. Looking toward the future, scientists are now trying to figure out how to convert the tons of feathers that now go to waste on poultry farms into a renewable fuel called biodiesel. — *Sid Perkins*

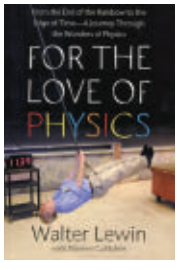
Basic Books, 2011, 336 p, $25.99.

For the Love of Physics

Walter Lewin, with Warren Goldstein

Everyone knows that rainbows appear after a storm. But in his new book, Lewin reveals nature's more unusual rainbows hiding in spray kicked up by ocean waves, in fog swirling around headlights, even in glass particles floating above construction sites.

After more than 30 years of teaching undergraduate physics at MIT, Lewin has honed a toolbox of clear, engaging explanations that present physics as a way of uncovering the world's hidden wonders. Quirky, playful and brimming with earnestness, each chapter is a joyful sketch of a topic — from Newton's laws to Lewin's own pioneering discoveries in X-ray astronomy.



The masterful explainer writes in a conversational style that's light on math and peppered with real-world examples and autobiographical anecdotes. His grandmother, for instance, taught him that we're all a little taller when lying down.

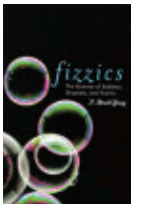
Lewin's creativity offers lessons both for students and for educators. He sucks on cranberry juice to figure out the longest usable snorkel, swings from a giant pendulum to prove Galileo correct and lights cigarettes to create patches of blue sky from a white spotlight. Throughout it all, his sense of wonder is infectious. "It's so much more important to me for students to remember the beauty of what they have seen than whether they can reproduce what you've written on the blackboard," he writes.

As a physicist and an enthusiastic art collector, Lewin seems equally at home with Newton and van Gogh. Both, he writes, can provide everyone with "new ways of seeing." — *Devin Powell*

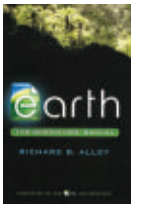
Free Press, 2011, 302 p., $26.

A Planet of Viruses
Carl Zimmer
The engaging essays in this slim volume are chock-full of information about viruses, from the common cold to smallpox. *Univ. of Chicago Press, 2011, 109 p., $20.*

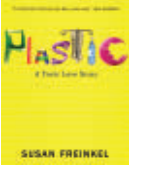
Inside Jokes
Matthew M. Hurley, Daniel C. Dennett, Reginald B. Adams Jr.
Humor isn't just fun, these authors argue; it's evolution's mechanism for building a brain that handles open-ended thinking. *MIT Press, 2011, 359 p., $29.95.*



Fizzics
F. Ronald Young
A friendly foray into the humble bubble, from honeycombs and soaps to sunset flashes, written by a physicist in the field. *Johns Hopkins Univ. Press, 2011, 114 p., $25.*



Earth: The Operator's Manual
Richard B. Alley
A climate scientist uses real-world stories to survey climate problems and solutions. A companion PBS documentary is available online. *W.W. Norton & Co., 2011, 479 p., $27.95.*



Plastic: A Toxic Love Story
Susan Freinkel
A well-researched history shows how plastics became a staple and examines current health and environmental concerns. *Houghton Mifflin Harcourt, 2011, 324 p., $27.*

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NASA budget blunder

My thanks and admiration to Ron Cowen for writing about NASA's "culture of deception" in his recent article on the James Webb Space Telescope mission ("Star cents," *SN: 4/9/11, p. 22*). If the astronomy community (and Congress) had decided years ago that spending $7 billion or $8 billion on JWST would be our best use of funds, then I would be happy to live with that. Instead, we have swallowed the bait of a series of low-ball estimates, and are now held hostage by a project that is "too big to cancel."

Patrick Broos, University Park, Pa.

Another critical consideration for the JWST is that this unique object, costing at least $6.5 billion, will be placed on a launch vehicle. What vehicle will be used to launch it, and what is the calculated probability of a launch success according to knowledgeable people other than at NASA or the company building the vehicle?

Clinton Brooks, Glen Mills, Pa.

The telescope will be launched from Arianespace's launch complex located near Kourou, French Guiana. The launch vehicle is an Ariane 5 ECA with a cryogenic upper stage, provided by the European Space Agency. ESA will also provide a payload adapter, which serves as the mechanical and electrical interface between JWST and the launch vehicle. At press time, ESA hadn't responded to a question about the probable success of the launch and deployment. — Ron Cowen

Fire ants' lasting impression

Regarding "U.S. is biggest exporter of fire ants" (*SN: 3/26/11, p. 15*): I encountered these nasty critters in 1962 while training Laotian troops. I had rested my hand on the top of a rotten fence post colonized by the ants. I had to admire their organization. Several dozen (felt like thousands) stealthily moved onto my arm before they began to sting.

John Fanning, North Port, Fla.

Solar memories

Regarding "Spots suggest sun's doldrums likely to continue" (*SN: 3/26/11, p. 5*): From 1956 to 1961, I and Lorne Galloway represented General Electric's Mobile Radio Communication business in Oregon. We were very much aware of an upsurge in what we called "skip interference," particularly for radio communication in the 25 to 50 megahertz band. I recall installing a radio base station on a mountain in central Oregon, and the first signal we heard was from southern California. This long-distance skip for systems that should normally cover only a radius of 30 to 50 miles was caused by increased sunspot activity. So it is interesting to see that, as mentioned in your article, we were then in the middle of the highest sunspot activity in recorded history!

Phil Dellwo, Lynchburg, Va.

Send communications to: Editor, Science News, 1719 N Street, NW, Washington, D.C. 20036 or **editors@sciencenews.org**. Letters subject to editing.

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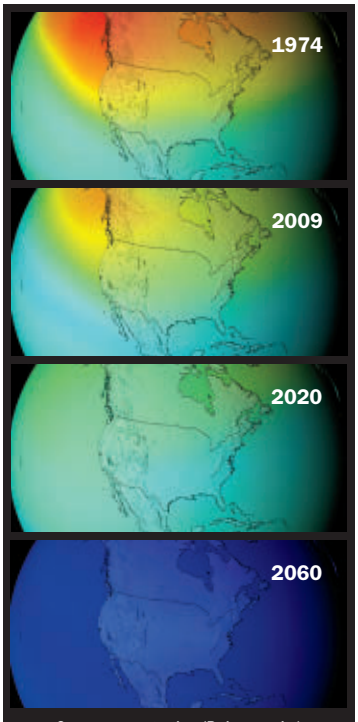

A NASA-led team predicted in 2009 what the stratospheric ozone layer would have looked like over North America had the Montreal Protocol not phased out ozone-depleting compounds.

Freon: Destroying the ozone layer?

A fascinating paradox has surfaced regarding man, ozone and the atmosphere that adds an ironic twist to the story of technological advancement. Researchers have noted during the past two decades that nitrous oxides and hydrocarbon pollutants building up in the lower atmosphere are acted upon by sunlight to produce ozone (O_3). High levels of ozone, in turn, cause respiratory problems and kill plants.

Now, it seems, Freon and other fluorocarbon pollutants in the upper atmosphere may be removing ozone, which acts as a protective layer against harmful ultraviolet light. (Freon is a DuPont tradename but is used as a generic term by many scientists.) By polluting his own air, man may be creating too much ozone below, too little above and possibly deleterious effects from both conditions.

Frank S. Rowland and Mario J. Molina, physical chemists at the University of California at Irvine, have proposed a model for freon breakdown and ozone destruction. It is based on a similar reaction between nitrous oxide and ozone in the lower atmosphere. First, they propose, freons in the stratosphere absorb ultraviolet light in the 1,750 to 2,200 angstrom range, and chlorine is liberated. The liberated chlorine atom in turn attacks ozone, breaking it into oxygen. Each chlorine atom can remove thousands of ozone molecules from the stratosphere in this way, Rowland predicts.

Concentrations of fluorocarbons can be expected to reach 10 to 30 times their present levels if production continues to increase at the current nine percent per year. The result would be the destruction of 10 percent of the stratospheric ozone layer within 50 years, Rowland says. He has already calculated a one percent reduction in stratospheric ozone — a reduction that could result in about 8,000 additional cases of skin cancer this year, according to National Academy of Sciences statistics on skin cancer.

UPDATE

CFCs go from craze, to controversy, to congé

In the mid-1970s, a domestic craze became an environmental enemy. For more than two decades, aerosols had been praised as handy household helpers: "Merely by waving science's newest gadget, you will be able to apply leg paint, extrude whipped cream, squirt shaving lather, waft a perfume, distribute insect killers ... and fill the waffle iron" (*SNL: 4/7/51, p. 218*).

But these "aerosol bombs" relied on chlorofluorocarbons. In 1974, scientists proposed that these compounds could deplete ozone in the stratosphere. In 1985, researchers reported an ozone hole over Antarctica, bolstering the idea. International efforts to phase out CFCs have been highly successful, and the Antarctic ozone hole now appears to be on the mend (*SN: 6/4/11, p. 15*).

Though leg paint is no longer a cheap fashion solution, people still use non-CFC–based aerosols widely. Today's propellants don't destroy ozone but do pose other problems. Hydrocarbons can contribute to ground-level ozone formation, a health threat. And some hydrofluorocarbons belong among another class of environmental enemies: the atmosphere-warming greenhouse gases. — *Elizabeth Quill*

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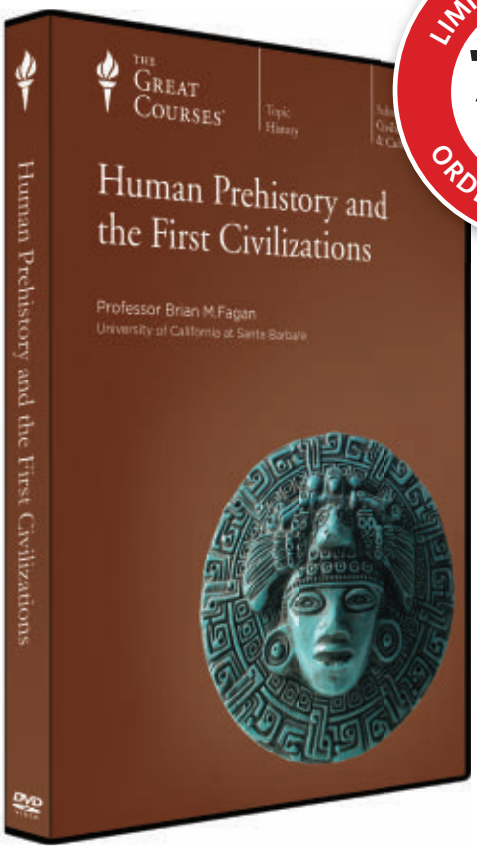

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