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# ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ APRIL 20, 2013

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look increasingly dim

Fast Cars Drive Evolution

What Facebook Knows About You

The Booze-Fueled Brain



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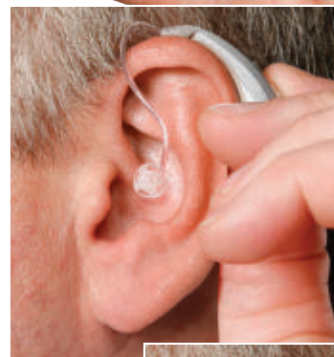
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# ScienceNews

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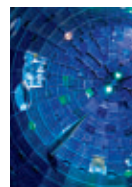
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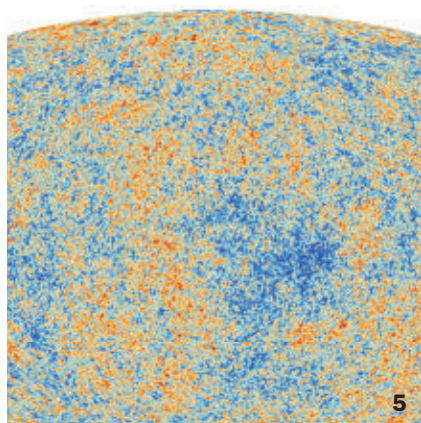
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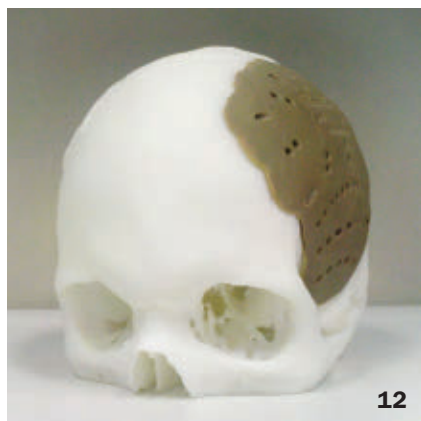
A science career born in prison



**COVER** An arm holding a tiny sphere of hydrogen fuel extends inside the target chamber at the Lawrence Livermore National Laboratory's National Ignition Facility. LLNL



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## FROM THE EDITOR

# Even bad news can help propel science forward



A reader recently reminded me how to find the good news in the bad. Michael Edelstein writes in his letter to the editor on Page 31 of a “gloomy” report earlier this year that the number of people with Alzheimer’s will triple by 2050 (*SN*: 3/9/13, p. 4). That will be true, Edelstein writes, only if science fails to make any advances in the prevention of Alzheimer’s disease in the next 37 years.

One could argue that simply defining a problem enables progress. Nobel Prize-winning chemist George Olah once told me that he had complete faith in human ingenuity and the power of the scientific process: If people realize there’s a problem, they can usually find a solution.

Take human papillomavirus, for example. In the 1980s, scientists showed that HPV can cause cancer. Since then, two safe and effective vaccines have been introduced. And, as Nathan Seppa reports on Page 20, a massive school-based vaccination program in Australia is already proving wildly successful in reducing HPV infections and genital warts. As the years pass, data on HPV-related cancers are expected to be similar. More good news: A new drug may be able to outsmart the wily malaria parasite (Page 13). In a St. Louis lab, bee venom shows promise in the fight against HIV (Page 12). Cell phone data are helping Italian law enforcement catch criminals (Page 15).

But not all the news is so sunny. Gloom-and-doomers might not be too surprised to hear that the dream of cheap energy from nuclear fusion remains a dream delayed. Physics writer Andrew Grant explains on Page 26 why the great hope of U.S. fusion research—the National Ignition Facility in California—failed to ignite a fusion chain reaction by its target date. It may be that lasers just can’t do the job—a question NIF physicists are now exploring. To the scientists, the opportunity to find out why the effort failed is the silver lining.

Bad news can help point scientists toward where they need to focus their ingenuity. A contagious cancer is decimating Tasmanian devils, but a new clue shows how the tumor evades the devils’ immune defenses (Page 10). A fungal disease has descended into flowerbeds across the nation, killing blooms in 33 states (Page 16). Now scientists are working to figure out why and what can be done.

In science, some good can come of even the worst news. That’s reason for optimism. — *Eva Emerson, Editor in Chief*

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*– Carol K., Benbrook, TX*



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## Say What?

**Terminal buzz** \TER-mihn-ahl buhz\ n.

An increasingly rapid series of echolocating calls fired off by a bat as it closes in on an airborne insect. These calls provide the bat with a burst of information on its prey's precise position. Some bats can reach more than 200 calls per second in the final stage of an attack. During the buzz, some species also lower the pitch of each call. Research has shown that a drop of about one octave broadens the sonar beam, giving the bat a wider acoustic field of view. In the April 23 *Biology Letters*, a team of researchers in Denmark argues that this specialized buzz evolved to foil the swerving evasive maneuvers of flying insects. —Allison Bohac



## SN Online

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### BECOMING HUMAN

Learn how people have been driving species to extinction since the Stone Age in a new column by Erin Wayman.

### LIFE

Wild insects are a key to bigger harvests. See “Native pollinators boost crop yields worldwide.”



## Science Past | FROM THE ISSUE OF APRIL 20, 1963

**TRANSPLANT FROM DEAD** — The surgeon's dream of transplanting organs from the dead to the living seems closer to reality. A man aged 54 died at Leeds (England) General Infirmary. One of his



kidneys was removed quickly and placed in a 37-year-old man gravely ill because his kidneys had failed. Four months later the borrowed kidney was still functioning and the doctors were somewhat elated. For the donor and the recipient were unrelated. Nearly all transplants that have approached success in the past have

been between identical twins.... Before cadaver transplants can become practical, improvement in overcoming rejections will be necessary, they said. Cyclophosphamid — trade name Cytoxan in the United States — which they used to lower the immunological response, may have some advantage over total body irradiation and other drugs sometimes used.

## Science Future

### April 18–28

More than 100 events at the Philadelphia Science Festival include a taxidermy demonstration, a CSI-themed “Nerd Nite” and a science carnival with hands-on activities. See bit.ly/SFphilly13

### May 12

Last day to catch an exhibit about birds of paradise at the National Geographic Museum in Washington, D.C. More information at bit.ly/SFparadise

### SCIENCE & SOCIETY

By tracking tweets, researchers identify communities. Read “Twitter maps New York City, language by language.”

### BODY & BRAIN

In developing rat and monkey brains, cells called microglia prune excess growth. See “Immune cells chow down on living brain.”

## Mystery Solved | SOURDOUGH'S SHELF LIFE SECRET

Bakers know that sourdough lasts longer than most other breads. Now, researchers at the University of Alberta in Canada report that the bread's fungus-fighting compounds come from the same bacteria that provide sourdough's characteristic flavor. The scientists found that *Lactobacillus hammesii*, one type of acid-producing bacteria that teams up with yeast during sourdough's fermentation process, converts the linoleic acid in bread flour into a fatty acid that may damage the cell membranes of invading fungi. Sourdough loaves produced with *L. hammesii* staved off mold two to three days longer than bread leavened with yeast alone, the team reported in January in *Applied and Environmental Microbiology*. —Allison Bohac

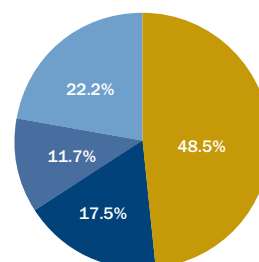


## Science Stats | CHILLY MANATEES

Endangered Florida manatees now rely mainly on warm-water outfalls from power plants for refuge from cold winter temperatures. Natural hot springs provide manatees the best protection from cold. Manatees that rely on power plants suffer the highest rate of cold-stress deaths.

SOURCE: D.W. LAIST ET AL./PLOS ONE 2013

### Manatee populations in winter habitats\*



■ Power plants  
■ Natural springs  
■ Thermal basins  
■ Other/unknown  
\*Totals 99.9%



“ Poor nutrition early in life seems to predispose individuals to a suspicious personality, which may then fuel a hostile attitude toward others. ” — ADRIAN RAINE, PAGE 8

**Mind & Brain** Brain adapts to booze

**Humans** People in Brazil 22,000 years ago

**Genes & Cells** Giant squid revealed in DNA

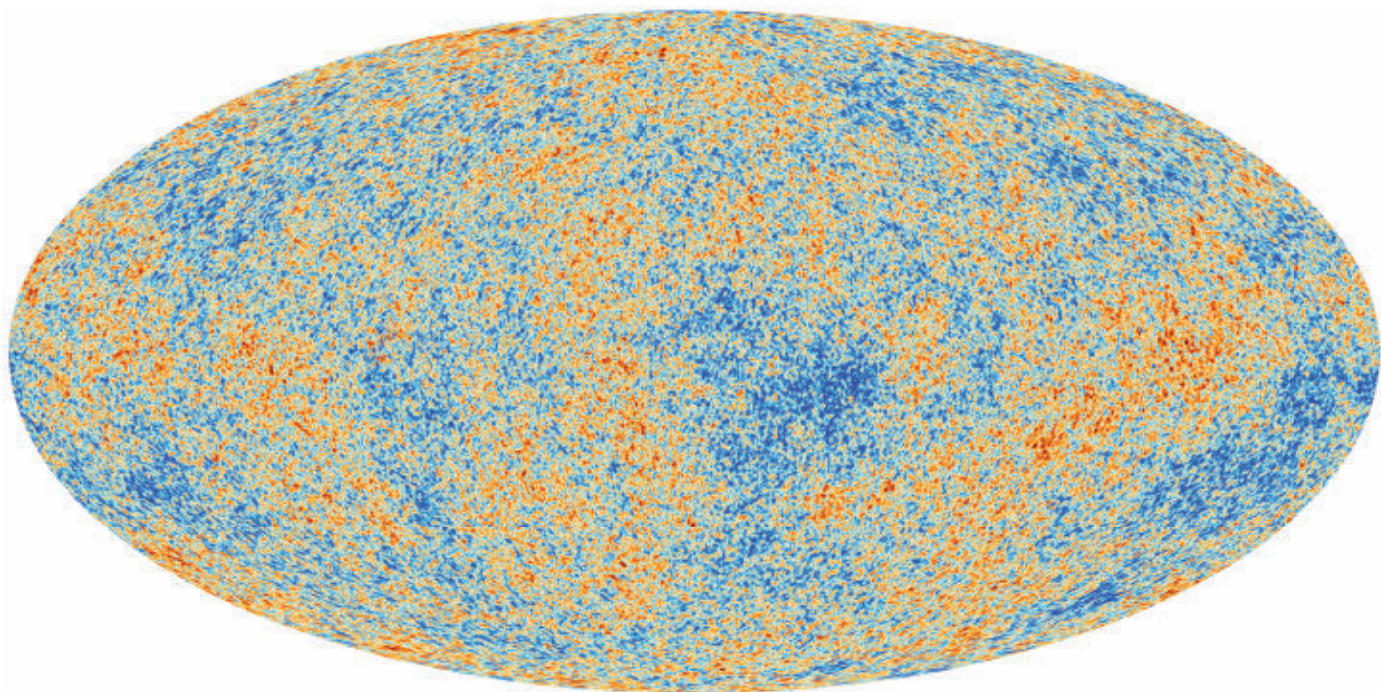
**Earth** Landslides detected seismically

**Health & Illness** Plastic skull implant

**Science & Society** Fighting crime with data

**Life** Swallows adapt to speeding cars

# In the News



## STORY ONE

### Planck sees slightly older universe with more matter

Most recent look at cosmic microwave background spurs only minor revisions to existing theory

By Andrew Grant

**T**he universe is a little older and perhaps a bit stranger than previously thought, according to the best measurements ever taken of the radiation left over from just after the Big Bang. Presented March 21 at a press conference in Paris, the data from the Planck satellite combine to form a map of the universe that largely affirms scientists' theories about the universe's early history. But they also reveal a few quirks that scientists will have to explain.

"The clarity and precision of Planck's map is stunning," says Richard Easther, an astrophysicist at the University of

Auckland in New Zealand, who is not on the Planck team. "It's as good as anyone could have hoped for."

Launched by the European Space Agency in 2009 (*SN: 4/11/09, p. 16*), the Planck satellite scans the sky for the cosmic microwave background, radiation that dates back to about 380,000 years after the Big Bang. That radiation was originally about 2,700° Celsius but has cooled to a mere 2.7 degrees above absolute zero. Planck is essentially a supersensitive thermometer that can probe the temperature of this radiation to millionths of a degree.

That extraordinary precision allowed researchers to find tiny temperature

**The Planck satellite's full-sky map of the cosmic microwave background depicts tiny fluctuations in the radiation that arose about 380,000 years after the Big Bang and now permeates the universe.**

fluctuations in the radiation. (The red spots in the map are about 0.001 percent hotter than the average temperature, while the blue spots are slightly colder.) Over billions of years, these subtle perturbations grew, allowing matter to clump into stars and galaxies.

The map, said George Efstathiou, an astrophysicist at the University of Cambridge who presented the Planck results in Paris, "might look like a dirty rugby



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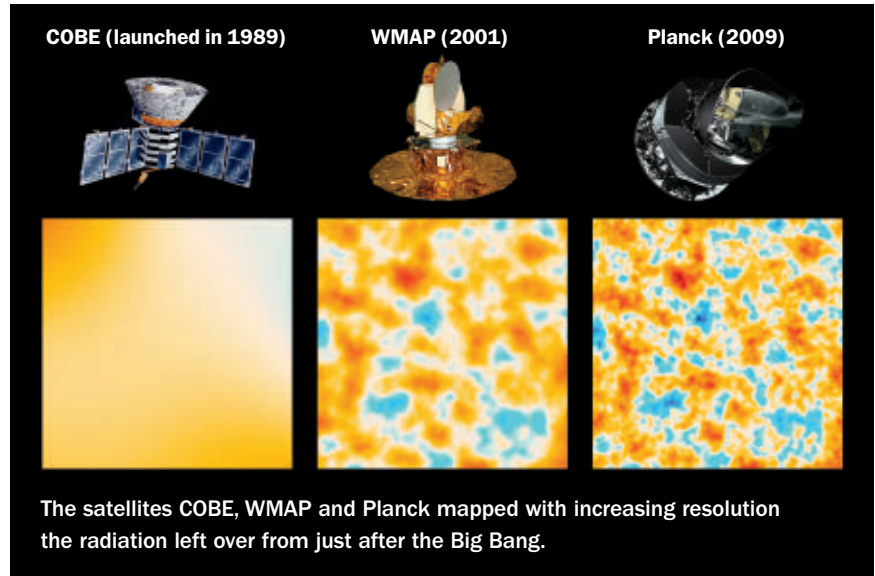
ball ... but some cosmologists would have given up their children to get a copy of this map.” Now that cosmologists have access to the map, they can learn about how the universe has evolved.

For the most part, Planck’s results align with theoretical predictions and observations from previous similar probes, COBE and WMAP. Their observations support the theory of inflation, which posits that around  $10^{-30}$  seconds after the Big Bang, the universe briefly expanded faster than the speed of light (*SN*: 7/28/12, p. 20).

“Not only is inflation continuing to look like a superb fit to the data,” says Alan Guth, the MIT physicist who proposed inflation in 1981, “but it still looks like the simplest inflationary models are the ones that fit best.”

Planck also reaffirmed calculations of the universe’s age and composition — with a few tweaks. Researchers who analyzed the telescope’s data announced that the universe is about 13.81 billion years old, or 80 million years older than previously thought. It contains more matter, both the ordinary kind we can see and the massive stuff we can’t, and less of the mysterious entity called dark energy than earlier observations suggested.

Planck also found several features that surprised scientists. Most notably, it confirms a quirky WMAP finding that one half of the sky seems to have more fluctuations than the other (*SN Online*: 12/23/08). Theory predicts that the universe should



look the same in all directions.

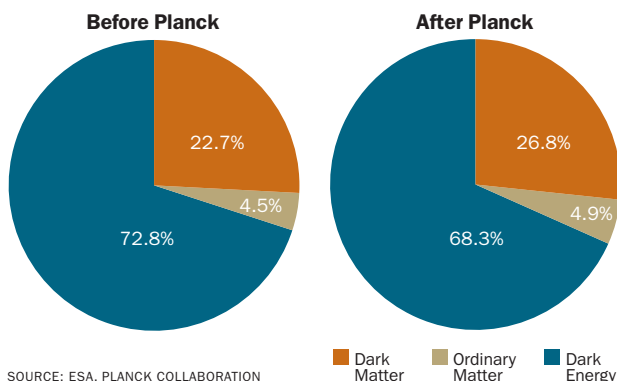
Efstathiou said researchers should be able to account for this lopsidedness without invoking new physics, but he left open more tantalizing possibilities, such as our universe’s being just one of many in a vast multiverse. That is music to the ears of New York University physicist Matthew Kleban, who plans to scour Planck data for evidence that our universe collided with another one in the distant past. “It’s much too early to say what [the anomalies] mean, but it looks like there is some very interesting work to be done,” he says.

The Planck data also delivered an unexpectedly low rate of expansion for

the universe, a figure called the Hubble constant that describes how dark energy is increasingly stretching the fabric of space. “This is one of the most exciting parts of the data,” says Martin White, a Planck scientist at the University of California, Berkeley. “The hope would be that this is actually pointing to extra physics we’re not aware of.”

Planck has already provided enough data to keep physicists busy for years, but it is not done. The telescope is still making observations, and in about a year researchers will add another heap of data to the mix. “Cosmologists will be climbing a mountain to make sense of the Planck data,” Easter says. ■

## Estimated composition of the universe



## Back Story | MORE MATTER

The universe contains more matter and less energy than previously thought, Planck measurements suggest. The data reveal that more than a quarter of the universe is made up of dark matter, strange massive particles that hold galaxies together yet do not interact with light. Another 5 percent is made up of ordinary matter, the atoms that make up stars, planets and people. Planck delivered its biggest surprise by suggesting a lower-than-expected abundance of dark energy, which stretches out empty space and causes the universe to expand at an ever-increasing rate. As a result, Planck scientists say the universe is not expanding quite as quickly as previous measurements had suggested.



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# Mind & Brain

“I don’t want people to start chugging vinegar.” —GRAEME MASON

## Metabolism gets used to drinking

Tipplers absorb more energy from alcohol by-product

By Meghan Rosen

Alcohol may give heavy drinkers more than just a buzz.

Long-term booze use boosts brain levels of acetate, an energy-rich by-product of alcohol metabolism, researchers report in the April 1 *Journal of Clinical Investigation*. In the study, people who downed at least eight drinks per week also sucked more energy from acetate than their light-drinking counterparts.

The extra energy may give heavy drinkers more incentive to imbibe, says study coauthor Graeme Mason of Yale University, and might help explain why

alcohol withdrawal is so hard.

“I think it’s a very good hypothesis,” says biochemical geneticist Ting-Kai Li of Duke University. Scientists had suspected that heavy drinkers absorb and burn more acetate, but, he adds, “Graeme Mason showed that this is actually happening.”

Acetate is best known as a chemical in vinegar. But when people sip a glass of wine or guzzle a beer, their livers break down the alcohol and pump out acetate as a by-product. The bloodstream then delivers acetate throughout the body, including to the brain.

Human brains typically run on sugar. But with enough acetate in the blood, Mason thought, brains might crank up their ability to burn it, too. So he and his colleagues peered into the brains of seven light drinkers, who quaffed fewer than two drinks per week, and seven heavy drinkers, who had at least eight drinks a week and at least four of them in one day.

The team injected sober volunteers with a form of acetate that was tagged with a traceable atom. Then the volunteers lay on their backs for two hours in an MRI machine while Mason’s group tracked the tagged acetate.

Heavy drinkers transported twice as much acetate to their brains and burned it faster than light drinkers did.

Though he had suspected that people with high blood acetate levels would be better at wringing energy from the chemical, Mason says, “the effect was way bigger than I thought.”

Next, he wants to figure out whether taking acetate would ease alcohol addicts’ withdrawal symptoms. But he cautions, “I don’t want people to start chugging vinegar.” Because the liver is very good at turning alcohol into acetate, he says, people would have to ingest quarts of vinegar to get as much acetate as they do from drinking alcohol. 🍷

## Early malnutrition mars personality

Food deprivation in infancy linked to negative traits at 40

By Bruce Bower

Malnutrition in the first year life, even when followed by a good diet and restored physical health, predisposes people to a troubled personality at age 40, a new study finds.

Compared with people who were well-fed throughout their lives, formerly malnourished men and women reported more anxiety, vulnerability to stress, hostility, mistrust of others, anger and depression, researchers report March 12 in the *Journal of Child Psychology and Psychiatry*. Survivors of early malnutrition also cited relatively little intellectual curiosity, social warmth, cooperativeness and willingness to try new experiences and to work hard at achieving goals.

Previous studies of people exposed prenatally to famine have reported increased rates of certain personality disorders and

of schizophrenia. Another investigation found that malnutrition at age 3 predisposed youngsters in Mauritius to delinquent and aggressive behavior at ages 8, 11 and 17.

“Poor nutrition early in life seems to predispose individuals to a suspicious personality, which may then fuel a hostile attitude toward others,” says University of Pennsylvania psychologist Adrian Raine, who directed the Mauritius research.

The new investigation was conducted by a team led by psychiatrist Janina Galler of Harvard Medical School in Boston and psychologist Paul Costa of Duke University Medical Center in Durham.

Participants included 77 adults who had been admitted to a hospital in Barbados for malnutrition at about age 7 months. After admission and up to age 12, the kids and their families participated in a government program that

provided health monitoring, home visits, nutrition education and food assistance.

Another 57 Barbados adults examined by the researchers were the same age as the formerly malnourished volunteers but had always had enough to eat.

All participants had normal birth weights, suggesting that none endured malnutrition in the womb.

About one-third of formerly malnourished adults scored high on a personality measure that taps into anxiety and other elements of emotional distress, versus 7 percent of the comparison group. Similar disparities in favor of the comparison group characterized three other broad personality traits — extraversion, openness to experience and conscientiousness.

Malnutrition shortly after birth could alter brain growth or activity in ways that shape personality traits later in life, Galler speculates. Or early food deprivation may indirectly influence adult personality by increasing children’s distress and wariness, boosting vulnerability to poor parenting. 🍷



# Humans

## Americans traced back 22 millennia

Controversial Brazil site predates arrival of Clovis culture

By Bruce Bower

Stones unearthed at a Brazilian rock-shelter have rekindled debate about whether ancient people reached the Americas long before the famed Clovis hunters spread through parts of North America around 13,000 years ago.

These relics add to evidence from nearby sites challenging the longstanding view of Clovis people as the first Americans (*SN*: 8/11/12, p. 15), a team led by geochronologist Christelle Lahaye of the University of Bordeaux<sup>3</sup> and archaeologist Eric Boëda of the University of Paris X reports March 4 in the *Journal of Archaeological Science*.

The new discovery came at the Toca da Tira Peia rock-shelter, which is in the same national park as Pedra Furada, another highly controversial pre-Clovis site. Toca da Tira Peia's location at a steep cliff's base raises the possibility that crude, sharp-edged stones found there resulted from falling rocks, not human handiwork, says archaeologist Gary Haynes of the University of Nevada,

Reno. Another possibility is that capuchins or other monkeys produced the tools, says archaeologist Stuart Fiedel of Louis Berger Group, an environmental consulting firm in Richmond, Va.

The artifacts' 22,000-year vintage hinges on calculations of how long ago the objects were buried. Various environmental conditions, including fluctuations in soil moisture, could have distorted these age estimates, Haynes says.

But archaeologist Tom Dillehay of Vanderbilt University in Nashville has seen some of the Toca da Tira Peia finds and regards them as human-made. Similar tools have been unearthed at sites in Chile and Peru, Dillehay says. His team has estimated that people settled Chile's Monte Verde site by 14,000 years ago, and possibly as long as 33,000 years ago.


An absence of burned wood or other finds suitable for radiocarbon dating at Toca da Tira Peia is a problem, because that's the standard method for estimating the age of sites up to around 40,000 years old, Dillehay says. But if people reached South America by 20,000 years ago, "this



**Excavations at Toca da Tira Peia in Brazil have yielded contested evidence of human settlers from at least 9,000 years before the appearance of Clovis hunters in North America.**

is the type of archaeological record we might expect: ephemeral and lightly scattered material in local shelters."

Lahaye and Boëda's team excavated 113 stone artifacts at Toca da Tira Peia from 2008 to 2011. Natural radiation damage in excavated quartz grains suggest that the last exposure of soil to sunlight ranged from about 4,000 years ago in the topmost layer studied to 22,000 years ago in the fourth layer.

Lahaye says that 15 as-yet-undated human-altered stones from two lower soil layers must be older than 22,000 years. 

## Stone Age prime time for trekking

Early human and Neandertal remains reflect life on the go

By Bruce Bower


Ancient people and Neandertals walked or ran far greater distances than any human groups that followed, including more recent hunter-gatherers and modern athletes, a study published February 27 in the *Journal of Human Evolution* suggests. Fossils of humans and their beetle-browed evolutionarily cousins display signs of extremely

extended travel that occurred between roughly 120,000 and 10,000 years ago, biological anthropologists Colin Shaw and Jay Stock of the University of Cambridge in England report.

Shaw and Stock's findings support an argument for extreme mobility among ancient people and Neandertals, says Erik Trinkaus of Washington University in St. Louis. Trinkaus notes the groups' exceptionally robust leg bones, a dearth of older individuals in fossil samples that suggests life spans were limited due to the rigors of constant travel and an absence of skeletal injuries that would have prevented vigorous movement in excavated fossils.

Shaw and Stock used a calculation of the lower leg's ability to withstand twist-

ing and other forces to compare Stone Age hominids' leg strength with that of human groups with known activity levels: varsity distance runners, varsity swimmers, nonathletic college students, Andaman Island foragers from the 1800s who swam constantly in pursuit of food and southern African hunter-gatherers who hunted over a vast territory between 11,000 and 2,000 years ago.

Ancient human and Neandertal legs substantially overpowered those of the hunter-gatherers, who had stronger legs than the other groups. Regular swimmers brought up the rear, perhaps partly because swimming emphasizes upper- over lower-body strength, the researchers suggest. 



## Tasmanian devils' disease unveiled

Deadly cancer turns off genes, evades immune system

By Tina Hesman Saey

A contagious cancer devastating Tasmanian devils makes itself invisible to the animals' immune systems, which might otherwise fight it off, a new study shows.

Devil facial tumor disease shuts down production of proteins that normally decorate the surfaces of cells, telling the body whether a cell belongs to it or not. As a result, a Tasmanian devil's immune system doesn't recognize cancer cells from another devil as invaders, Hannah Siddle, a geneticist at the University of Cambridge in England, and collaborators report in the March 26 *Proceedings of the National Academy of Sciences*.

The finding could lead to a way to stop the deadly disease. "It's really the first hope that there could be a vaccine or immune therapy," says Elizabeth

Murchison of the Wellcome Trust Sanger Institute and the University of Cambridge. Murchison discovered in 2009 that the tumor originated in cells of a single devil. Since that initial case, which probably occurred in the late 1980s or early 1990s, the disease has spread across eastern and central Tasmania, killing every devil it infects.



**On the faces of Tasmanian devils (shown), tumors avoid immune system attack by disguising their identity.**

Siddle and her colleagues discovered that devil facial tumor cells turn off genes that the immune system uses to distinguish between cells from its own body and foreign cells. Without the proteins made by these major histocompatibility complex, or MHC, genes, the tumor cell can conceal its true identity as a cancer cell and tissue from another animal.

In lab tests of devil tumor cells, the researchers were able to turn MHC genes

back on with a dose of either an antifungal drug called Trichostatin A — known to affect gene activity — or an immune chemical called interferon gamma. Dogs infected with a contagious cancer called canine transmissible venereal tumor keep the nonfatal cancer in check partly by making interferon gamma.

The drug or the immune chemical could rev up the devil's immune system to fight off the tumor, says study coauthor Jim Kaufman, an immunogeneticist at the University of Cambridge. Tumor cells that have had their MHC genes turned back on might serve as vaccines, a strategy already in development.

But other researchers aren't sure such a vaccine will work. Many tumors, including the contagious tumor that infects dogs, turn down production of MHC proteins. Yet immune cells still find and at least attempt to kill the cancers, unlike in the devils.

The devil facial tumor must take additional steps such as secreting chemicals to tamp down immune responses, says Robin Weiss, a virologist at University College London. To fight the disease, researchers will need to discover the tumor's other evasion strategies. 🧬

## Giant squid are one big species

Elusive deep-ocean dwellers have low genetic diversity

By Tina Hesman Saey

All giant squid are part of one global interbreeding species instead of the three that scientists thought existed, DNA evidence suggests.

The massive invertebrates have some of the lowest genetic diversity of any species, researchers report in the May 22 *Proceedings of the Royal Society B*. That finding and the squid's global interbreeding are difficult for scien-

tists to explain, says study coauthor M. Thomas Gilbert, a geneticist at the Natural History Museum of Denmark. "We were very surprised by the results," Gilbert says.

Most of what is known about giant squid comes from studying carcasses. Researchers can describe the physical traits of the animals, which grow to be about 18 meters long with parrotlike beaks, sucker-studded tentacles and eyes bigger than a person's head. But not much is known about how the creatures live.

Gilbert and his team got a glimpse by examining mitochondrial DNA from 43 giant squid. Scientists can trace a species' history through the DNA carried in mitochondria, the energy factories inside cells.

Researchers had thought there were three species of giant squid: one in the North Atlantic, a second in the southern oceans and a third smaller species in Japanese waters, says Clyde Roper, a marine biologist emeritus at the Smithsonian Institution's Museum of Natural History in Washington, D.C. The new analysis puts squid worldwide into one of the species, *Architeuthis dux*.

The genetic homogeneity suggests that somehow squid must travel long distances. A previous chemical analysis of the giant squid's sharp beak indicated that adults don't migrate far. That means the juveniles and larvae must leave local waters and migrate around the world to keep the breeding population well mixed. 🧬



# Earth

## Seismic activity reveals landslides

Earthquake monitoring system can detect rock avalanches

By Erin Wayman

A computer and a comfortable chair may be all that's necessary to investigate catastrophic landslides worldwide. Geologists can now remotely detect the seismic energy of landslides just as they identify and characterize earthquakes.

The technique may help scientists unravel the complicated physics governing these natural disasters, researchers report in the March 22 *Science*. The method also provides data that could inform landslide hazard assessments, says Steve Evans, a geomorphologist at Canada's University of Waterloo who wasn't involved in the work.

A landslide strikes when erosion and other factors weaken a steep incline.


Once friction can no longer hold rocks in place, a mass of debris will fall down a slope, sometimes for many kilometers.

In the last several years, researchers have realized that, like an earthquake, a landslide creates seismic waves that travel through Earth's crust. These waves have a distinct pattern because landslides occur steadily over a couple of minutes, rather than creating a burst of energy in a few seconds as an earthquake does.

Although the events can be destructive, officials may not realize for days that a landslide has occurred in a remote area, says coauthor Colin Stark, a geophysicist at Columbia's Lamont-Doherty Earth Observatory in Palisades, N.Y.

When global sensors pick up a seismic event that doesn't correspond to

an earthquake, Stark and seismologist Göran Ekström, also of Lamont-Doherty, check whether it's a landslide. From seismic data alone, the pair can calculate the landslide's magnitude, its location to within 100 kilometers and the direction the landslide traveled. The researchers then check satellite images to confirm the event was a landslide. By combining seismic and satellite data, the team can estimate the length of the landslide's path and the mass of debris that fell. The process can take a day or two, Ekström says.

Right now, the method can detect only giant landslides that dislodge millions of metric tons of debris and unleash at least as much energy as a magnitude 4.5 earthquake. And without satellite images, the technique would produce 10 false-positives for every true landslide, David Petley of Durham University in England points out in a commentary published in the same issue of *Science*. 



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## Health & Illness

### Bee venom toxin acts against HIV

Nanoparticles deliver toxic cargo to halt virus in lab study

By Nathan Seppa

A toxic component of bee venom packaged in supertiny blobs can knock out HIV, a new study finds. Researchers testing the delivery system in laboratory dishes report that these nanoparticles attach to and destroy the virus but don't damage cells, offering an early glimpse of a technology that might — with a lot more testing — prevent HIV infection in some people.

"This is definitely a novel approach," says Antony Gomes, a physiologist at the University of Calcutta in India who studies the medical use of venoms. "There are very few reports available on venom-based treatment against viruses. This type of research has the potential to pro-

ceed further for product development."

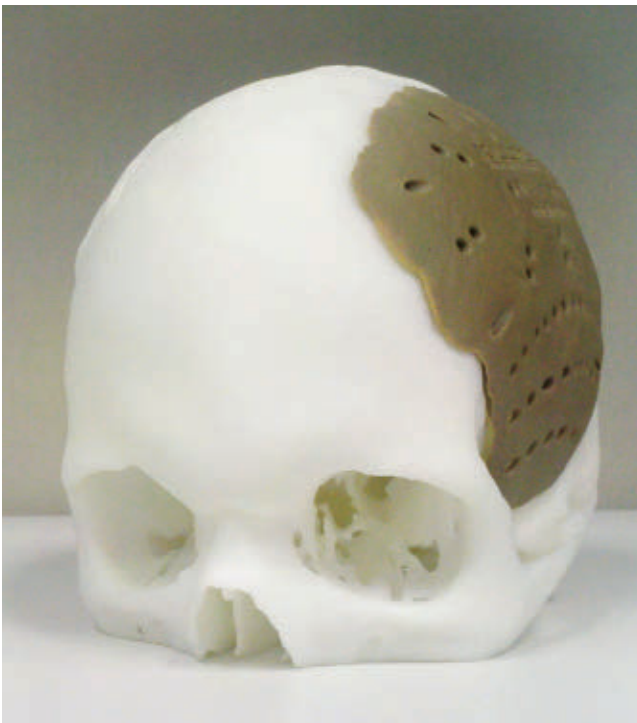
Physician-researcher Joshua Hood of Washington University in St. Louis and his colleagues tested the toxin-carrying nanoparticles on HIV in the lab. The particles locked onto HIV and delivered their cargo, the venom component melittin. The toxin poked holes in HIV's protective protein coat, leading to sharply reduced amounts of virus, the researchers report in *Antiviral Therapy*.

The team also tested the nanoparticles on healthy human cells obtained from vaginal walls. Although melittin degrades cell membranes, these vaginal cells were largely unperturbed by the treatment because the nanoparticles holding the melittin come equipped with protective structures on the outside.

These act as bumpers to prevent the nanoparticles' interiors — and particularly their toxic cargo — from contacting the cell membrane. That allows a nanoparticle to bind the much smaller virus using a specific lock-and-key structure that fits onto the virus's protein shell.

The study authors tested cells from vaginal walls because the vagina is often where HIV enters the body in women. Hood suggests these early findings could prepare the way for further testing, with a long-term goal of creating a vaginal gel containing the nanoparticles. If such a product killed HIV on contact, the scientists note, it would be especially valuable in heterosexual couples in which one partner is infected with HIV and the other is not.

Much still needs to be mastered if this is to become a working drug, says Bruno Sarmento, a biotechnology researcher at the University of Porto in Portugal. "Particular attention and care must be taken in order to reproduce nanoparticles in a robust and homogeneous way to guarantee uniformity of the drug," he says. Also, a vaginal gel using this technology would need adhesive properties, Sarmento says, to guarantee that the nanoparticles remain in the right place to prevent the virus from entering the bloodstream. ■



### Skull patched with plastic

Surgeons have replaced 75 percent of a man's skull with a custom-designed polymer cranium constructed with a 3-D printer. The operation took place on March 4 and is the first U.S. case following FDA approval of the implants in February. The patient's reason for needing such extensive replacement surgery has not been revealed; a less extensive implant is shown at left. Similar surgeries may follow in other cases where sections of the skull are removed because the brain has swollen during a surgery or after an accident, says Scott DeFelice, president of Connecticut-based Oxford Performance Materials, which created the prosthetic. Guided by the patient's CT scans, a 3-D printer (SN: 3/9/13, p. 20) that uses lasers to fuse granules of material built the prosthetic layer by layer out of a special plastic called PEKK. While inert like titanium, PEKK is riddled on its surface with tiny pocks and ridges that promote bone growth that anchors the implant in place, DeFelice says. Such implants have value as a brain-protecting material, says Jeremy Mao, codirector of Columbia University's center for craniofacial regeneration. But doctors will need to keep an eye out for long-term problems. — Rachel Ehrenberg



“This type of research has the potential to proceed further for product development.” —ANTONY GOMES

# Drug candidate may fight malaria

## Parasite doesn't develop resistance to synthetic compound

By Nathan Seppa

An experimental drug zaps the malaria parasite at multiple stages of infection, tests in mice show. And it may have an important upside: The parasite is unlikely to develop resistance to the compound, the Achilles' heel of malaria medicines.

While preliminary, the findings offer welcome news in a field beset by uneven performance as malaria protozoa subvert drug after drug. The situation has gotten so bad that the World Health Organization now recommends that doctors prescribe two drugs at once to increase the odds of killing the parasite without allowing a resistant form to emerge.

In the face of this gloomy picture, authors of the new study are decidedly optimistic. “We do hope this is a game changer,” says biochemist Michael Riscoe of Oregon Health & Science University in Portland. The report appears in the March 20 *Science Translational Medicine*.

Other scientists inject a note of caution. “No matter how good the drug looks at this point, most likely the parasite will figure out how to become resistant to it,” says Roland Cooper, a pharmacologist at Dominican University of California. “The parasite is just a clever beast.”

But the experimental drug could still offer patients a benefit, he says. Since the drug candidate takes a long time to break down, it might last long enough in the body to clear infections. What's more, the multipronged attack is unusual for

malaria drugs. “It's just exciting to have a drug look this good,” he says.

Riscoe and his colleagues tested hundreds of compounds to find ones that combat malaria parasites, including *Plasmodium falciparum*, the species responsible for the most severe form of the illness. The novel drug candidate, dubbed ELQ-300, showed a strong antimalarial effect against multidrug-resistant strains of *P. falciparum* and *P. vivax* malaria obtained from the blood of patients on the island of New Guinea.

ELQ-300 targets the parasite's mitochondria, the intracellular factories that supply energy for a cell. In the single-celled parasite, the mitochondria are also instrumental in manufacturing DNA building blocks, which are essential for survival. Lab tests showed that ELQ-300 sabotages the activity of mitochondrial proteins.

One currently used drug, atovaquone, also binds to mitochondrial proteins. But the malaria parasite has developed a genetic mutation that hinders this binding, says study coauthor Roman Manetsch, a chemist at the University of South Florida in Tampa. To test for resistance to the new drug candidate, the scientists exposed *P. falciparum* in the lab to atovaquone or ELQ-300 and checked whether the parasite survived over eight weeks. As the scientists expected, some parasites exposed to atovaquone became resistant to the drug and survived. However, none survived ELQ-300 exposure.

People get malaria from the bite of an infected mosquito. The parasite goes through three broad stages once inside a human. One is in the liver and two are in the bloodstream: an active stage that causes symptoms and a reproductive stage that can be transmitted via mosquitoes to other people.

When tested in malaria-infected mice, ELQ-300 looked like a triple threat, hitting the parasite at each of these life stages. Like many antimalarials, ELQ-300 bested the parasite in the bloodstreams of the mice. But the experimental drug also stopped it in the liver. Parasites lodged in the liver can reemerge later, Manetsch says. “If you don't clean out the whole host, there might be enough left to start a

new infection.” These data are particularly heartening, Cooper says, because few drugs can do this.

Another experiment showed that the drug kills the parasite in its reproductive stage in mosquitoes that had eaten a blood meal containing ELQ-300. The malaria protozoa reside in the female mosquito for a week or two, Riscoe says — so if the mosquito draws blood during this time from people who have ELQ-300 in their system, the drug should kill the parasites inside the bug, rendering it unable to infect people.

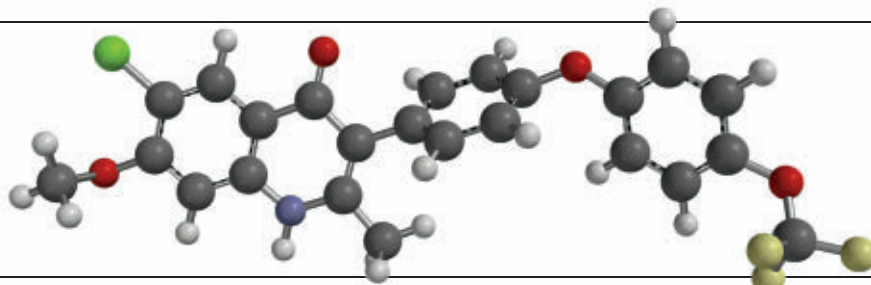
That means the drug candidate “has potential for malaria control,” Cooper says. “Not only would you do yourself a favor by taking it, you'd be doing your neighbor a favor.”

If the experimental drug passes more safety tests, Riscoe expects the first trials in people in a couple of years. ■

**“We do hope this is a game changer.”**

**MICHAEL RISCOE**

The synthetic compound ELQ-300 has found success as an antimalarial when tested in mice. ELQ-300 appears to target the malaria parasite in blood and the liver, and may also thwart forms of the parasite responsible for transmission by mosquitoes.





# What a Facebook ‘like’ reveals

## Researchers predict personal traits using social media data

By Rachel Ehrenberg

You might expect that most fans of the satirical, Fox News–mocking show *The Colbert Report* are Democrats. But it turns out that liking rapper Nicki Minaj and enjoying cuddling also hint at a leftward political slant. A new study finds that the things someone “likes” on Facebook can predict personal attributes such as political leaning, age, gender and sexual orientation.

The study harnessed data from 58,000 volunteers who used an app on Facebook called myPersonality, which study coauthor David Stillwell of the University of Cambridge in England created several years ago. Participants shared private information such as the results of IQ tests and, via the app, completed personality questionnaires that asked, for example, whether they smoked or drank alcohol and whether their parents were married.

The researchers compared those data with the pages participants had “liked” on Facebook. After learning from a subset of the data which “likes” linked with which traits, a computer program then predicted traits for the other participants based on “likes” alone.

Many of the study’s findings are intuitive or even obvious: Liking Jesus Christ is strong evidence of being Christian, the researchers report March 11 in the *Proceedings of the National Academy of Sciences*. Similarly, liking Cover Girl makeup is a strong indicator that a participant is female. But some less obvious connections also emerged: The computer program could predict 73 percent of the time whether someone was a smoker, for example, based on “likes” that included the heavy metal rock band Slayer and the Facebook group “I Bottle Everything Up Until I Finally Snap.”

The computer also correctly identified

88 percent of gay men, even though less than 5 percent of them had liked things explicitly related to sexual orientation. Predictions instead relied on links such as liking the TV show *Desperate Housewives* or the musical *Wicked*.

And then there were connections that seemed to come from left field: Being a fan of thunderstorms and curly fries, for example, were each weakly linked to higher intelligence.

“I’m glad that many of the findings seem to be intuitive,” says coauthor Michal Kosinski, who studies psychology at the University of Cambridge and works part-time for Microsoft. “It is striking that the computer can pick up on sexual orientation,” he adds.

The study’s methods are sound, says New York University’s Sinan Aral, an expert on information diffusion in social

networks. However, since the researchers didn’t compare the technique with any others, he says, it’s hard to know how its predictive power would stack up against correlations based on other easily available data such as census information and voting records.

He adds that the data come from people who are willing to share information about themselves and take online tests. The volunteers may not represent the average Facebook user. But that weakness might not matter to marketers.

“The dream of every marketer is to learn more about their customers so they can deliver more useful content and gain more trust,” says social media marketing expert Adam Steinberg of the Atlanta digital marketing firm Silverpop. “Anything that helps them understand their customers more is valuable.”

The study did not look for connections between any personality traits and liking *Science News*. But liking science weakly correlated with higher intelligence.

**You are what you like** Researchers developed a computer program that uses data on which Facebook pages people “liked” to predict certain personal traits. For example, liking the page for Gillette Venus razors reliably pegged the gender of the user as a woman, and a thumbs-up for gospel music predicted a person’s religion as Christian.

Category	Type	Examples of predictive Facebook page “likes”
Gender	Male	ESPN, Dos Equis, Bruce Lee
	Female	TV Fanatic, Gillette Venus, ShoeDazzle
Age	Old	Dr. Mehmet Oz, The Closer, Fly the American Flag
	Young	Walt Disney Records, I Hate My ID Photo, Dude Wait What
Race	White	Harley Davidson, David Bowie Official, ASPCA
	Black	I Support My President, Fantasia, Erykah Badu
Sexual orientation among men	Gay	Kathy Griffin, Human Rights Campaign, Sue Sylvester Glee
	Straight	WWE, Wu-Tang Clan, Foot Locker
Religion	Christian	The Bible, Jesus Daily, Gospel music
	Muslim	Hadith of the Day, I Love Islam, Desihits.com

SOURCE: M. KOSINSKI ET AL./PNAS 2013



“The dream of every marketer is to learn more about their customers so they can deliver more useful content and gain more trust.” —ADAM STEINBERG

## Phone data dial in crime network

Program mines mobile calls for incriminating patterns

By Rachel Ehrenberg

Sometimes not picking up the phone can be as indicting as spilling the beans on a wiretapped call. After recent robberies in Italy, a new forensic tool that makes it easy to explore reams of cell phone data revealed an incriminating pattern: Leading up to and after each robbery, members of a gang suspected in a series of supermarket thefts exchanged flurries of calls. But in the end, it was silence that betrayed the gang. No calls were made during the minutes the crimes were committed.

The new data analysis tool called

LogAnalysis makes it especially easy to visualize the relationships among conspiring suspects as revealed by their phone calls. Developed by scientists at the University of Messina in Italy, the program starts with algorithms that researchers typically use to investigate relationships among organisms in an ecosystem or the flow of information in a friendship network. The program brings that math together in a manner tweaked specifically for investigating crime. Described in a paper posted March 7 at arXiv.org, LogAnalysis is being tested using criminal cases in Italy.

To begin, investigators import the call data into the program, which transforms the information into a diagram of people connected by phone calls. The program has features that make it easy to see who called whom the most and to identify clans and go-betweens. Investigators can also trim people and calls out of the

visualized network if they are deemed irrelevant to a case.

A temporal analysis feature helped alert investigators to the supermarket holdup crew’s nefarious doings, says police detective and study coauthor Salvatore Catanese. The gang was in rapid communication leading up to a particular heist, and those calls all mapped to one cell station in the store’s neighborhood. There was also a burst of calls after the robbery. But all was silent during the deed.

The temporal analysis feature is quite clever, says Pål Roe Sundsøy, a complex systems researcher at the Norway-based communications company Telenor. But he notes that in today’s wired age, cell phone records might tell only part of the story. “Smart criminals will have more ways to communicate — Skype, Facebook. These data would not be captured.” ■

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EXTREME WEATHER EVENTS

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# Disease attacks garden impatiens

## Once mild, downy mildew suddenly devastates popular bloom

By Susan Milius

A puzzling plant disease may uproot one of the most popular and reliable flower-bed plants in North America, the garden impatiens.

For decades, U.S. gardeners rarely noticed downy mildew on their impatiens. But in the last two years, impatiens downy mildew disease has ravaged flower beds in some of the more humid parts of the country. After rain or fog followed by balmy nights, the disease can turn a lush flower border into bare stalks that eventually collapse and die.

In recent years, aggressive impatiens downy mildew has flared up during disease-friendly weather in parts of Europe, South Africa and Australia. But the United States hadn't seen more than a few scattered reports until widespread outbreaks began in 2011. By the end of 2012, pathologists had confirmed the disease in 33 states and Washington, D.C.

Since weather affects outbreaks, it is hard to predict what 2013 will bring. But impatiens downy mildew was already active in Florida when the year began, says plant pathologist Colleen Warfield of Ball Horticultural Company, a Chicago-based plant breeder and distributor.

The disease is unlikely to eradicate

impatiens, but in some areas the risk might change a gardener's mind about what to plant. In advice that would have been shocking a decade ago, plant pathologist Nancy Gregory of the University of Delaware cooperative extension program in Newark suggests gardeners skip impatiens for now unless they are willing to cope with the risk of an unsightly die-off.

Preventing an outbreak would require diligent pesticide treatment several times a month on a plant that is prized in part for its low maintenance requirements. Once the disease shows up in a plant, there's no cure.

The pathogen can waft along on air currents, swim in water and perhaps survive the winter in soil. Gregory warns landscapers in her hard-hit state that even if they're careful, "chances are someone down the block or around the corner could have some infected plant material that could spread to your nice clean garden full of impatiens."

The presumed cause of the disease has been reported in North America since the 19th century. Called *Plasmopara obducens*, it's one of the oomycetes, or water molds, a group that includes the pathogen that caused the Irish potato famine and the one wreaking havoc in California and Oregon with sudden oak death.

Until recently, *P. obducens* seemed relatively mild mannered in Europe, says Marco Thines, an evolutionary biologist at Germany's Biodiversity and Climate Research Centre in Frankfurt who has studied oomycetes. Cells of the pathogen whip through a film of water by lashing their propeller-like flagella, burrowing into leaves and colonizing plant tissues by punching through cell walls. Once inside, the pathogen pokes nutrient-harvesting nubbins against the cell membrane like fingers squeezing a balloon.

Downy mildews typically attack only a restricted range of species, says plant pathologist Phil Jennings of the United Kingdom's Food and Environment Research Agency. *P. obducens* strikes garden impatiens (*Impatiens walleriana*) and some cousins. It doesn't destroy a related blooming annual, the New Guinea impatiens (*I. hawkeri*).

Delving into the genetics of the pathogen may clarify how the disease has become more virulent. What has been considered one species may actually be several, and some variant may have evolved into an alarming form.

"I don't think this is our grandfather's *Plasmopara obducens*," says plant pathologist and former U.S. national mycologist Joe Bischoff of the American Nursery & Landscape Association.

Preliminary analyses show at least three distinct genetic groups within the pathogen populations, Warfield says. In the lab, all three "are equally destructive," she reports. Each can wreak havoc in at least some gardens, but whether they survive equally well in varied environments remains to be seen.

Garden impatiens may come in an array of colors, but all commercial varieties and interspecific hybrids that have a garden impatiens parent are susceptible to the disease. "Developing a downy mildew-resistant garden impatiens is likely to take many years," Warfield says. "And it may not even look like the garden impatiens of today."



**Impatiens downy mildew is a disease that has recently become more aggressive in the United States for reasons that have yet to be understood. In five weeks, the pathogen can turn a lush floral display (left) into a denuded cluster of stalks (right).**



## Swallows evolve shorter wings

On Nebraska roads, 30-year decline in birds killed by cars

By Meghan Rosen

Crossing the road has gotten easier for some cliff swallows. Over generations, the mortal threat of speeding cars appears to have made the birds nimbler fliers by shortening their wings.

The number of cliff swallows killed along roads in southwestern Nebraska has plunged over 30 years as the birds' average wing length has shrunk, researchers report March 18 in *Current Biology*.

The data are "jaw dropping," says animal behaviorist Colleen Cassady St. Clair of the University of Alberta in Edmonton, who was not involved with

the work. The results suggest that years of smacking into windshields has adapted swallows to life by the road.

Cliff swallows can plaster thousands of cantaloupe-sized mud nests to highway bridges and overpasses, says study coauthor Charles Brown of the University of Tulsa in Oklahoma. Every summer for 29 years, he and coauthor Mary Bomberger Brown of the University of Nebraska–Lincoln counted nests and picked up a total of more than 2,000 dead birds.

Starting in 1983, the researchers collected fewer birds killed by cars each year, until they found only four in 2012. When Charles Brown measured preserved specimens' wing lengths, he saw that, compared with the rest of the population, swallows that died on the road had wings a few millimeters longer.

Petite wings let birds take off quickly and maneuver deftly through the air,



Cliff swallows build mud nests under bridges and overpasses, putting the birds at risk of becoming roadkill.

Charles Brown says, potentially helping them avoid cars.

The team ruled out other possible explanations, such as declining swallow populations or an increase in avian scavengers stealing carcasses. Still, Charles Brown says, factors other than wing length may be involved. Cars may kill off daredevil swallows, for example, leaving more cautious birds behind. 🐦

## Blooms' caffeine buzz brings bees

Compound improves insects' long-term memory for flowers

By Rachel Ehrenberg

Bees apparently have their own version of Starbucks, and the joe sharpens their minds. Honeybees are more likely to remember a flower that laces its nectar with a hit of caffeine, a new study shows.

"This is the first instance to show that something we use as a drug is also a drug ecologically," says Geraldine Wright, a specialist in the neuroscience of animal behavior at Newcastle University in England. Experiments probing the effects of caffeine on bees suggest the drug may boost memory by strengthening brain reward circuitry, Wright and her colleagues report in the March 8 *Science*.

Many plants have bitter compounds in their leaves — caffeine itself or opiates, for example — that may deter animals from eating them. And it's fairly routine for such compounds to show up

in nectar, even though the sweet stuff is all about attraction, not deterrence. "It's very paradoxical and surprisingly common," says pollination biologist Rebecca Irwin of Dartmouth College.

For the new study, Wright and her colleagues began by measuring the amount of caffeine found naturally in the nectar of four species of citrus plants and three



The nectar of some flowers, such as those of a coffee plant (shown), isn't just rich in sugar. It also provides bees with a caffeine hit.

species of coffee. The flowers of tangerine and sweet orange had the lowest concentration, while the flowers of *Coffea canephora* contained roughly the same concentration as a cup of instant coffee. Then the researchers trained honeybees, Pavlov-style, to associate a floral scent with a reward. When bees were exposed to a smell, they were rewarded with a sip of sugary cocktail. The cocktail was laced with caffeine in doses similar to those found naturally in nectar. Eventually, bees extended their tongue-like proboscises when exposed to the scent alone.

The caffeine boosted the bees' long-term memory, the researchers discovered. Compared with bees trained on sugar water alone, bees trained on sugar water doped with caffeine were three times as likely to remember 24 hours later that the floral scent came with a reward. After 72 hours, the caffeine-trained bees were twice as likely to remember the scent-reward connection, as revealed by their sticking out their proboscises. 🐝

# News in Brief



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## LIFE

### Fire ants prefer damp soil

Their name aside, fire ants aren't afraid of a little water. In fact, the insects need just the right amount of moisture in soil to build superior nests, new experiments show. Researchers from Georgia Tech in Atlanta filled 14.5-centimeter-deep aluminum tubes with an artificial soil made up of tiny glass beads and various amounts of moisture. The team then gave the stinging, invasive insects 20 hours to build their nest. CT scans revealed that at about 10 percent moisture content—a medium amount—the ants (*Solenopsis invicta*) built tunnels twice as long as they did in parched soil. The researchers speculate that the dash of water makes the soil particlesglom together in a manner that makes for easy digging. "If you keep your backyard dry, they may leave and dig in your neighbor's backyard," said Daria Monaenkova, who presented the research in Baltimore on March 20 at an American Physical Society meeting. When the researchers tried varying the size of the soil particles, the fire ants chugged along fine with small or large grains, at least until the soil particles became as big as small worker ants. —Rachel Ehrenberg

## MATTER & ENERGY

### Nanocrystals navigate tiny tubes

Physicists have seen a small iron crystal slide through a tube with an opening one-quarter the diameter of the crystal itself. The finding could lead to remotely controlled nanomachines that navigate through confined spaces. Using an electric field, the researchers drove an iron crystal 20 nanometers in diameter through a carbon nanotube like a train in a tunnel. The surprise came when the tube constricted to 5 nanometers in diameter: The iron nanocrystal altered its shape and squeezed through. Microscope images showed that the iron remained a crystalline solid. "It was mind-boggling to watch," said Sinisa Coh, a physicist from the University of

California, Berkeley, who presented the results in Baltimore March 21 at a meeting of the American Physical Society. Coh and his team attribute the crystal's dexterity to the collective movement of its atoms. The researchers think that only the surface atoms move; the ones at the back of the crystal migrate along the tube's edges to settle at the front, allowing the crystal to conform to the size of the tube. —Andrew Grant

## ENVIRONMENT

### Extreme storm surges may occur more often with climate change

Deadly flooding caused by storm surges will occur more frequently as the climate warms, scientists predict. A storm surge is the rise in water above normal tide level that occurs when hurricanes push water toward a coast. In 2005, Hurricane Katrina smacked the Gulf Coast with a storm surge of up to 8.5 meters. During the 20th century, storm surges of this magnitude hit the United States about once every 10 to 30 years. To calculate how the frequency of extreme storm surges will change, Aslak Grinsted of the University of Copenhagen and colleagues combined records of storm surges in the southeastern United States since 1923 with several climate simulations. For every 1 degree Celsius increase in global average temperature, the results suggest, large storm surges will become two to seven times as frequent, the team reports in the April 2 *Proceedings of the National Academy of Sciences*. In 2007, the Intergovernmental Panel on Climate Change estimated that global average temperature could increase by 2 to 4 degrees Celsius by 2100. —Erin Wayman

## HEALTH & ILLNESS

### Heart benefits of quitting smoking outweigh costs of extra pounds

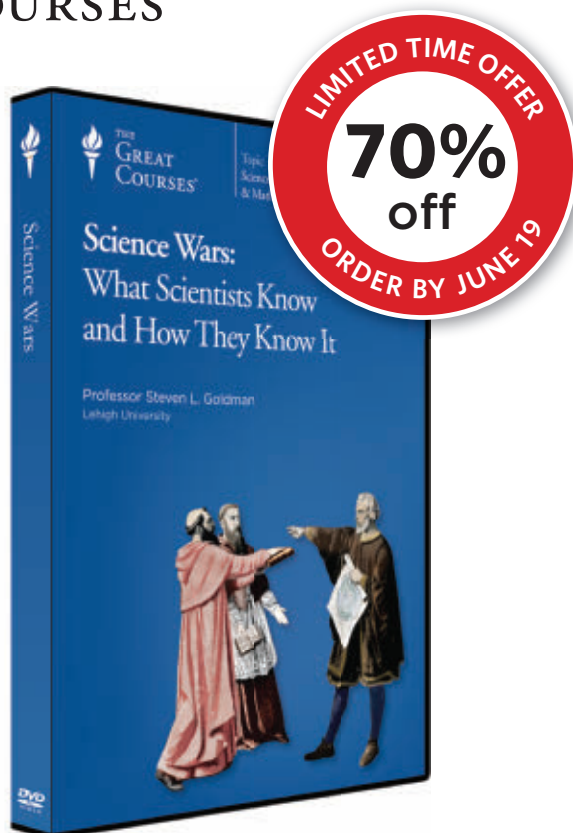
Weight gain, a common downside of quitting smoking, doesn't appear to wipe out the cardiovascular benefits of kicking the habit. People in a long-term

study who quit smoking were about half as likely to experience a heart attack, stroke or other cardiac problem as were people who continued to smoke, researchers report in the March 13 *JAMA*. Carole Clair of the University of Lausanne in Switzerland and a team of U.S. researchers analyzed heart health data from 3,251 people over six years of an ongoing Massachusetts health project in which participants undergo physical exams every four years. The group included current smokers, those who quit within the last four years, people who had quit more than four years ago and people who had never smoked. Between-visit weight gain was highest, averaging six pounds, in the recent quitters. But the researchers conclude that quitting smoking still yields "a net cardiovascular benefit" on average, no matter the weight gain. —Nathan Seppa

### HIV may increase heart attack risk

Having HIV may boost a man's risk of heart attack, a study of more than 82,000 veterans suggests. Researchers analyzed information on the vets, 97 percent of whom were men, between 2003 and 2009, excluding anyone who had heart disease. There were 871 heart attacks among the remaining HIV-positive and uninfected veterans. About 1.34 percent of the HIV-positive group had a heart attack during 5.9 years of follow-up, compared with 0.92 percent of the others. After accounting for factors that could affect cardiac health—including smoking, cholesterol levels and substance abuse—the HIV patients' risk of heart attack was about 1.5 times that in the non-HIV group. Physician Matthew Freiberg of the University of Pittsburgh and his colleagues suggest that inflammation, depleted immune T cells and antiretroviral therapy somehow increase heart attack risk. There were not enough women in the study to assess whether HIV affects their heart attack risk. The report appears March 4 in *JAMA Internal Medicine*. —Nathan Seppa





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Preteen and adolescent girls and boys are priority groups for vaccines that prevent human papillomavirus infection.

# DOSE of reality

HPV is epidemic, which is odd since it is largely preventable **By Nathan Seppa**

**T**here are two vaccines that guard against human papillomavirus, and they are in rare company among medical inventions—the vaccines prevent cancer. Only the hepatitis B vaccine can make the same claim. Cancer-causing HPV can trigger abnormal cell growth on the cervix, and cervical cancer still kills up to 4,000 U.S. women each year. The virus is also implicated in cancers occurring in the anus and the throat. All told, according to a 2011 study, 29 percent of sexually active U.S. girls and women carry a potentially cancer-causing HPV infection.

Back in 2006 and 2009, when the HPV vaccines Gardasil and Cervarix came onto the market, health officials dreamed of halting the spread of HPV, which is sexually transmitted, in a single

generation. Scientists call such blanket coverage herd immunity—in which a pathogen gets vaccinated into oblivion, becoming so rare that even unvaccinated people are protected.

With such heady potential, Gardasil, developed by Merck, and Cervarix, created by GlaxoSmithKline, should be an easy sell. They rev up a potent immunity against HPV 16 and 18, the two types of the virus that account for most cases of cervical cancer. Gardasil also prevents most genital warts. The immunity the vaccines provide is many-fold better than the weak protection engendered by a run-in with the virus itself, and since approval, both vaccines have proven safe. A study of nearly 190,000 girls and women, published in 2012 in *Archives of Pediatric and Adolescent Medicine*, found

that the shots' most common side effects were mild skin infections and fainting.

But the hope for herd immunity against HPV anytime soon is fading fast in most of the West. By 2011, only 53 percent of U.S. teenage girls from 13 to 17, a target group for the vaccines, had received them.

"It's a disaster," says Andreas Kaufmann of Charité University Medicine Berlin, who sees the problem from the perspective of a biologist. "HPV is strictly species-specific. It only occurs in humans."

That means with mass vaccination, the virus would have no safe harbor in nature. "Theoretically, we could eradicate these HPV types, like we did smallpox," he says. "We could end it."

## What's the problem?

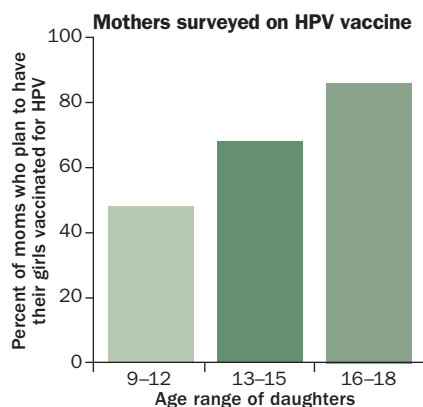
Most childhood immunizations are doled out in infancy. Although preteens and older kids routinely get shots or boosters for whooping cough, measles and meningitis, the HPV vaccines stand apart from those other shots like an unpopular kid.

For one thing, parents are uneasy



about vaccinating a preteen against a virus associated with sexual activity. Researchers have found that some parents believe vaccination might lead to greater promiscuity. And a public scare about vaccines in general — including a false report linking the measles vaccine to autism — has contributed to the confusion. Not only that, but the vaccine is delivered in a three-shot regimen. Even among girls who get vaccinated, completing the course isn't a certainty. Many U.S. preteen and teenage girls who start the course fail to get all three shots, and thus are less apt to be protected.

In the United States, responsibility for tracking kids' HPV shots often falls to pediatricians, since the vaccine isn't administered in schools. But pediatricians are notoriously overworked and — relative to many other physicians — underpaid. Doctors often need to cover vaccine costs up front to have them ready for patients, says Kevin Ault, a gynecologist at Emory University in Atlanta. Pediatricians also have to remind a patient to return for subsequent shots and often find themselves on the front line in contending with doubtful parents, says Noel Brewer, a health psychologist at the University of North Carolina in Chapel Hill. Instead of mass vaccinations in schools, the HPV vaccines depend on this hit-or-miss distribution system managed by individual doctors who, even if they advocate vaccination, may not want to cross parents. The result is often family indecision, pro-



**Why wait?** Many U.S. mothers are reluctant to have preteen daughters vaccinated, even though that's when protection is most likely to prevent a future HPV infection.

SOURCE: J. KAHN ET AL./PEDIATRICS 2009

crastination and outright rejection.

Then there's the behavior of the virus itself. The vaccines don't work in people who have active HPV infections, and it's difficult to know who those people are. The cancer-causing HPV types are stealthy, giving rise to phantom infections with no symptoms and an iffy risk of cancer far off in the future. These characteristics make the risks posed by HPV hard to grasp, says Christina Dorell, a physician at the Centers for Disease Control and Prevention. "With polio, people were getting sick and going to the hospital," she says. "When the image of illness is removed from a group, you may have a little less sense of urgency coming from parents."

Girls might see it differently, studies show. Doctors' opinions matter to them.

Those who receive a recommendation from a doctor are 2.6 times more likely to get vaccinated than girls getting no counsel, researchers reported in *Pediatrics* in 2011. Also, "there is no evidence of increased sexual-risk behavior, such as decreased condom use or earlier intercourse," says Gregory Zimet, a clinical psychologist at the Indiana University School of Medicine in Indianapolis. Other work has found no increase in sexually transmitted diseases after HPV vaccination. "The whole [promiscuity] argument is false, actually," Zimet says.

More likely, many parents are in denial about their teens' sexuality, says Kaufmann: "Parents don't believe that a 15-year-old daughter may already be sexually active." But a 2010 U.S. survey found that at least 12 percent of 14- and 15-year-old girls had engaged in oral sex or intercourse or both.

One way to skirt the problem might be to vaccinate earlier. Health psychologist Jo Waller of University College London says focus groups show that parents like the idea of vaccinating girls as young as age 8 or 9, since that means skipping the chat about how the vaccine prevents sexual transmission of HPV. "They wouldn't have to open that can of worms," she says. Some countries do begin vaccinating at age 9, and several trials are under way testing the effectiveness of the shots at that age.

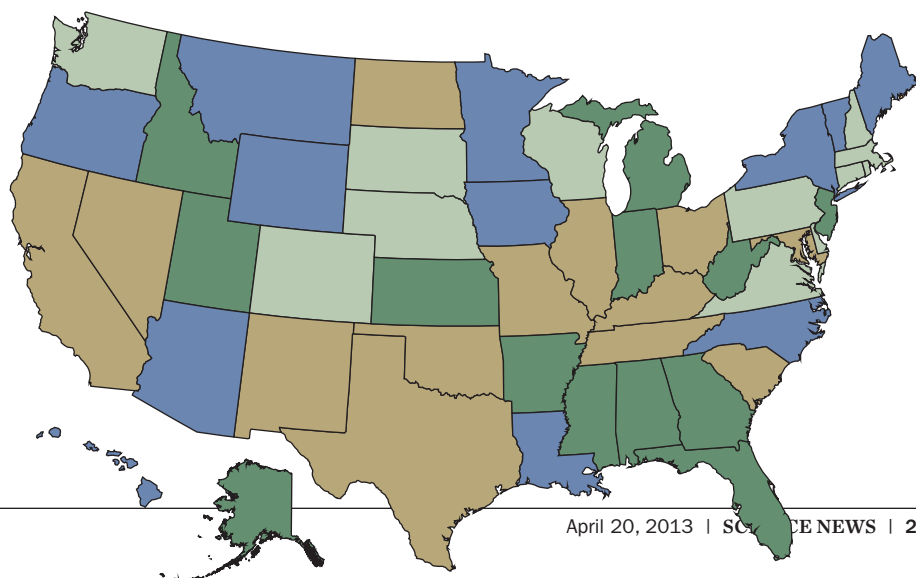
The fact of the matter is that the science underlying the HPV link to cancer is unassailable. German scientist Harald

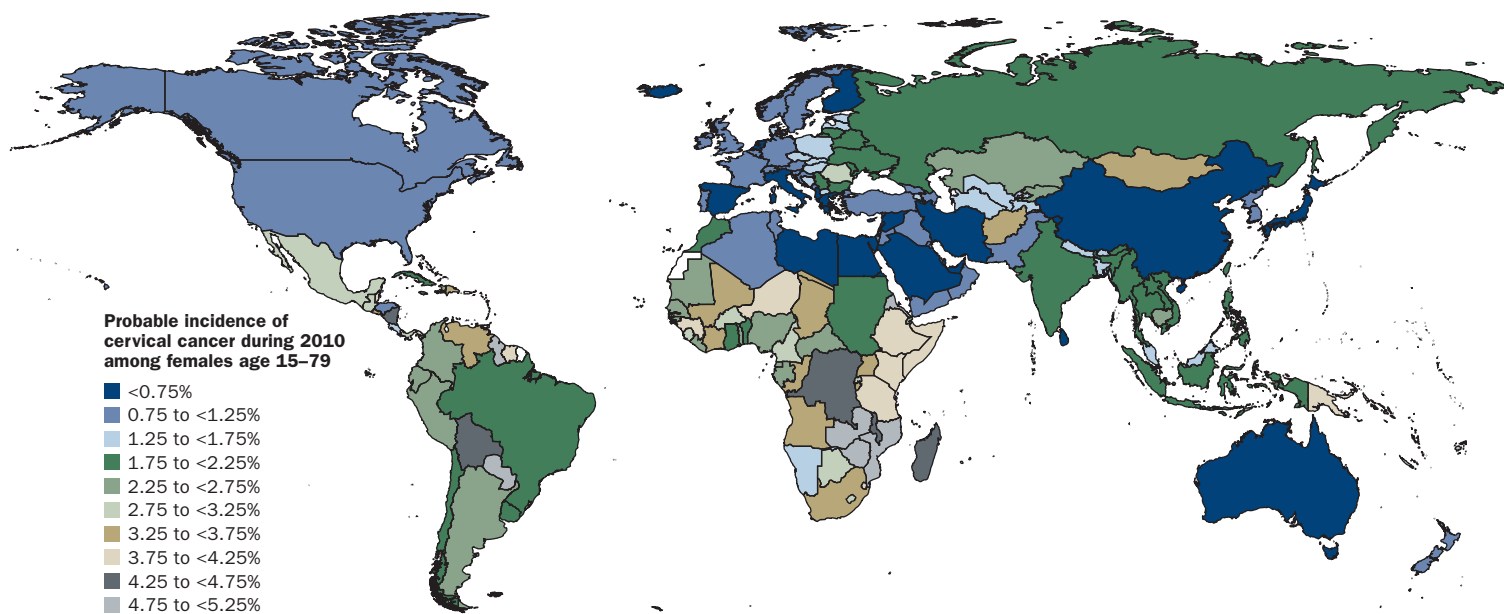
**Falling behind** Health guidelines recommend the three-shot HPV vaccine for the best protection against cancer. But recipients don't always complete the regimen. Compliance is worse in some states than in others.

**Percentage of U.S. adolescent girls who have received three doses of HPV vaccine**

■ 17.6–25.4 ■ 32.1–40.3  
■ 25.5–32.0 ■ 40.4–55.1

SOURCE: A. JEMAL ET AL./JNCI 2013





**World view** HPV vaccines can prevent cervical cancers. Although roughly 40 countries worldwide now have HPV vaccination in their national health guidelines, few low-income countries—where cervical cancer remains a major problem—are in this group. However, pilot programs in some poorer nations indicate that the vaccine is well accepted, particularly when delivered at schools. SOURCE: M. FOROUZANFAR ET AL./LANCET 2011

zur Hausen discovered the connection in the 1980s and was awarded a 2008 Nobel Prize for his efforts (*SN*: 10/25/08, p. 10). While Pap smears have averted most deaths from cervical cancer in the United States, the malignancy remains a leading cause of women's cancer worldwide. Three shots of Gardasil or Cervarix protect against HPV types responsible for 70 percent of cervical cancers.

### The other half of the equation

While cervical cancer is the most common malignancy prevented by the vaccines, in the United States nearly two-fifths of HPV-related cancers occur

in men. That's because HPV can cause cancers in the mouth or throat areas, and those strike both sexes. HPV is implicated in roughly 60 percent of oral cancers that affect the back of the tongue, throat and tonsils. Although many of these malignancies arise from alcohol and tobacco consumption, those types of cancers have declined in the United States in recent years even as overall oral cancer rates have stayed the same. HPV-related oral cancers account for the rise, particularly in men. In Denmark, the past decade has brought a shift in tonsil cancers, from 43 percent containing HPV to 75 percent.

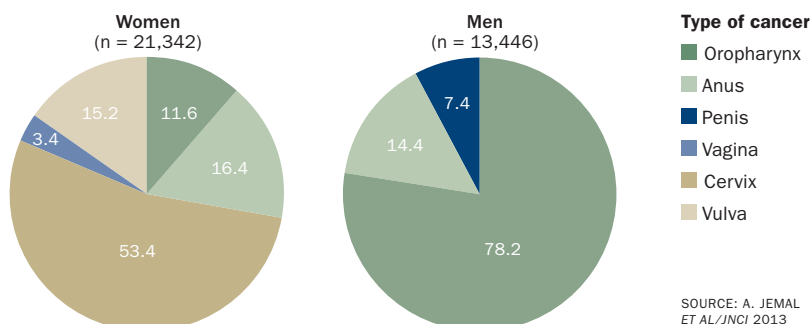
Scientists established a link between oral cancer and HPV more than a decade ago when studies revealed HPV 16 lurking in many oral tumors. In 2007, researchers at Johns Hopkins University found that oral cancer patients were three times as likely as people without the cancer to have had six or more partners on whom they had performed oral sex. But there's much still unknown about the dynamics of oral HPV transmission, says epidemiologist Marc Brisson of Laval University in Quebec. "Kissing may be involved." He and others think that changing sexual practices may be behind the rise in oral cancers.

HPV vaccination is now recommended for boys in the United States (*SN Online*: 10/26/11). But because approval came later than it did for girls, only about 8 percent of boys ages 13 to 17, the initial target group, got at least one shot in 2011. As with girls, 11- to 12-year-old boys are the main vaccination target. But teenagers and young adults of both sexes can get the shots as part of a catch-up effort.

The HPV vaccines are given to prevent genital or anal HPV infections. Vaccine companies can't make any claims regarding oral cancer because the vac-

**Risk assessment** More than a dozen types of HPV can trigger abnormal tissue growth and malignancy in humans. The cancer burden affects women and men differently, as this chart of U.S. cases demonstrates.

### HPV-linked cancers by site, 2009



SOURCE: A. JEMAL ET AL./JNCI 2013



cines haven't been tested to prevent it. But the evidence is strongly suggestive.

"It's time to start vaccinating boys," says Margaret Stanley, a pathologist at the University of Cambridge in England. Boys and young men in Britain are not yet getting the shots, but Stanley and others are pushing for it. "It will protect 50 percent of the population, and not doing so would be truly discriminatory because that would include gay men, who are very much at risk of anal cancer," she says. "And if you vaccinate boys, you start to get herd immunity."

### A shot at the herd

The slow launch of HPV shots in many countries is reminiscent of an earlier campaign that also could have stopped a sexually transmitted virus and the cancer it causes. "With the hepatitis B vaccine, we essentially lost a generation," says Basil Donovan, a sexual health physician at the Kirby Institute and the University of New South Wales in Sydney. Slow implementation since the hepatitis B vaccine became available three decades ago has left the 350 million hepatitis B carriers worldwide at an increased risk of liver cancer.

Similarly, delayed HPV vaccination chalks up a daily cost as more teens become sexually active without protection. About 6 million new genital HPV infections occur each year in the United States, mostly in teens and young adults. Oral HPV infections go uncounted. Canada is faring better, but a study there found that while parents permitted their daughters to get hepatitis B shots in school at an 88 percent rate, only 65 percent consented to HPV vaccination. Germany has lagged behind some other European countries because shortly after the HPV vaccines were introduced, vaccine opponents raised questions about side effects of the shots. "Doctors stopped recommending it," Kaufmann says.

Life is different in Australia. There, public health officials have now documented mass HPV vaccination and the first glimmers of herd immunity. Australian authorities have left little to chance, vaccinating preteen and teenage girls

#### 1940s

George Papanicolaou develops Pap smear

#### 1970s

Harald zur Hausen's team isolates HPV in genital warts

#### 1980s

zur Hausen's team isolates HPV in cervical cancer

Early vaccine development

#### 1990s

HPV vaccines developed  
HPV linked to oral cancers  
HPV found in 99.7 percent of cervical cancers

#### 2000s

Clinical trials of HPV vaccines  
Gardasil recommended for girls and young women (2006)  
zur Hausen wins Nobel Prize (2008)  
Cervarix recommended for girls and young women (2009)

#### 2010s

HPV vaccines recommended for boys and young men (2011)

## Vaccinating against cancer

There are over a hundred types of human papillomavirus, says Robert Burk, a medical geneticist at the Albert Einstein College of Medicine in New York. But only about a dozen cause the vast majority of HPV-related cancers—and they take years or decades to do it. Still, those few viruses' stealth makes them dangerous. Over millennia the viruses have perfected the art of colonizing humans and create very little stir when they do.

"In most of us the immune system recognizes the virus and deals with it," says Margaret Stanley, a pathologist at the University of Cambridge in England. But these viruses can evade people's immune reactions better than most. In some unlucky few, HPV triggers genetic mutations in the cells it infects, leading to abnormal cell growth and even to cancer. "A fraction of immune systems cannot handle these viruses well," Stanley says. "We don't know why."

The Gardasil and Cervarix vaccines alert the immune system to the two most-studied cancer-causing HPV types, HPV 16 and 18. Together, these two viruses are thought to cause some 70 percent of cervical cancer. The vaccines against them appear effective, with evidence suggesting that even two doses may provide protection.

Research has now targeted several other cancer-causing members of the HPV family, and work is under way to test a nine-type vaccine that would add protection against HPV 31, 33, 45, 52 and 58. Gardasil and Cervarix may induce the immune system to develop partial cross-protection against these other HPV types. However, such cross-protection is not as strong as direct immunity.

Basil Donovan of the University of New South Wales in Sydney estimates that by the end of a young woman's first sexual partnership, she has a 30 percent chance of having acquired an HPV infection. A 2011 study found that 43 percent of sexually active U.S. girls and women up to age 59 were carrying some type of HPV infection. Among U.S. men, the rate was about 50 percent for an HPV infection. In Germany and Denmark, the infection rate is roughly 35 to 40 percent among young women, says Andreas Kaufmann of Charité University Medicine Berlin.

"The vaccine has no effect on existing infections," Burk cautions. But women who have been vaccinated before being diagnosed with an abnormal cell growth on the cervix—and treated to have the potentially precancerous growth removed—may benefit from that prior vaccination, researchers reported in *BMJ* in 2012. Vaccinated women were about half as likely as their unvaccinated counterparts to be diagnosed with a repeat lesion. Whether it's useful to vaccinate a woman after she has cleared a lesion with surgery remains an open question, says gynecologist Kevin Ault of Emory University. But if it does help, those women would be prime candidates for vaccination since they would certainly be members of the unlucky few. —Nathan Seppa

in schools since 2007. They mainly use Gardasil, which prevents genital warts, and such warts are vanishing in young women coming into city clinics. This year Australia began vaccinating boys, too, but herd immunity in them started showing up even before the first shot was fired into a boy's arm. It seems that protecting girls means protecting boys.

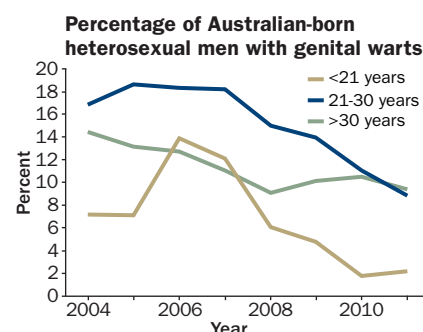
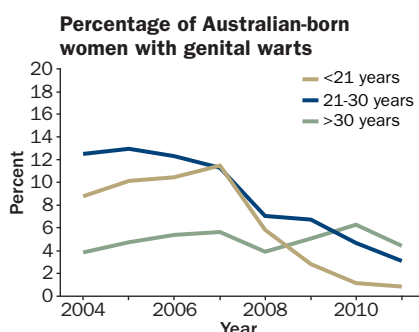
Australia's school-based vaccination program, which offers Gardasil free of charge for students, has set the pace for other nations. Between 2007 and 2009, 83 percent of preteen and teenage girls designated for vaccination had gotten at least one shot and 70 percent had received all three. More than half of young adult women got at least one shot, too.

Within two years of the program's start, the rate of genital warts among girls and women was dropping every quarter at clinics monitored by scientists, Donovan says. Among women under age 21 examined at a eight clinics in Australia in 2011, less than 1 percent had genital warts, compared with more than 8 percent during the pre-vaccination years. Also in 2011, of 235 women who had been vaccinated against HPV, none had any warts, Donovan says. "Warts were a fairly obvious thing to monitor," he says, since they can appear within months of infection. "In contrast, for cancer it's measured in decades."

Updated Australian data were released in late 2012 at conferences in Melbourne and San Juan, Puerto Rico. What really shocked attendees was the finding that genital warts in young men also dropped — from a range of 7 to 14 percent in pre-vaccination years to about 2 percent in 2011 — even though the widespread vaccination of boys hadn't yet started in Australia.

The findings have changed how some people view HPV vaccination campaigns, Brewer says. "The data in Australia are just jaw-dropping." Danish researchers recently reported substantial declines in warts as well.

Waller says the findings in heterosexual Australian men offer proof that there is herd immunity developing from having vaccinated women in Australia. "That



**Trending downward** Australia's school-based program to vaccinate girls against HPV, mainly with Gardasil, is showing benefits for both sexes. Public health officials examining urban clinic records have documented a steady decline in genital warts. The findings hint at herd immunity.

SOURCE: H. ALI ET AL./INTERNATIONAL UNION AGAINST STI WORLD CONGRESS IN MELBOURNE 2012

leaves men who have sex with men as the main unprotected group," she says.

The United States has special problems with school-based vaccination programs because there is no national health insurance that will cover the cost of the vaccine, as is the case in Britain, Canada and Australia. Still, a demonstration project in Denver is investigating a school-based program, says Lauri Markowitz, a medical epidemiologist at the CDC. While states can make vaccinations mandatory for school entry, mandates for HPV are rare, with only schools in Virginia and the District of Columbia requiring the shots.

In the long run, herd immunity remains the goal, and it's not exotic. Anyone with children sees herd immunity in action. Routine childhood vaccines given to babies nowadays largely maintain herd immunity against scourges that beset previous generations. "The risk is near zero for an individual ever getting polio again," Zimet says. "We continue to use the Salk vaccine to maintain herd immunity."

The outlook for HPV may improve in coming years. Markowitz reported at the Puerto Rico meeting that among U.S. teenage girls, the rate of HPV infections of the types covered by the vaccines fell from 11.5 percent before vaccination introduction to 5.1 percent in the years after it, based on a nationwide database. And California public health authorities reported in 2012 that medical records show a substantial decline in genital wart diagnoses in

girls in the post-vaccination years and a modest drop in boys.

Also, Merck is testing a new vaccine that covers the four HPV types in Gardasil as well as five others that can cause cancer. Math models suggest it could have a big impact on the HPV infection rate. "This seems like a great step forward," says Zimet, who expects a nine-type vaccine to get cleared within a year or two.

Such a vaccine would help turn the tide, Stanley says. "You really want to prevent 90 percent of cervical cancers," she says, "and that's what it should do. Eventually, you wouldn't need to screen for them [with a Pap smear]. You'd be looking for a rare disease. We ought to have no cervical cancer in 20 years."


Other help might come financially. The Affordable Care Act — "Obamacare" — will eventually require insurance plans to cover all recommended vaccines, including HPV.

"The solution to the problem," says Brewer, "is to improve the public health system we have. It may not rest solely on getting parents to act." He suggests delivering HPV vaccines in schools and at pharmacies, like flu shots, and getting doctors to implement a system to recommend them routinely. "One or all of those would work," he says. ■

## Explore more

■ J. Berkhof and J. Bogaards. Vaccination against human papillomavirus types 16 and 18: the impact on cervical cancer. *Future Oncology*. Volume 6, 2010, p. 1817.



Two young boys are dressed as scientists. They are wearing metal colander helmets with various wires and small electronic components attached. The boy on the left is wearing round goggles and a dark bow tie with a diamond-patterned sweater. The boy on the right is also wearing round goggles and a striped bow tie with a dark sweater. A complex wire structure hangs above them, resembling a model of an atom or a scientific apparatus. The background is a plain, light color.

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## How America's latest attempt at fusion power fizzled

By Andrew Grant

If all goes according to Mike Dunne's plan, the United States will build its first nuclear fusion power plant by the end of the next decade. Sixteen times a second, a two-millimeter-wide capsule of cryogenic hydrogen will drop into a steel chamber and get zapped by a 384-beam laser. Matter will transform into energy, driving a turbine that injects up to a gigawatt of clean power into the electrical grid.

But all is not going according to plan. To be viable, a fusion power plant would need to generate more energy than it consumed. Yet except in nuclear weapons, scientists have never produced a

fusion reaction that does that. For a half-century they have strived for controlled fusion and been disappointed, only to adjust their theories, retry and be disappointed again.

The \$3.5 billion National Ignition Facility at the Lawrence Livermore National Laboratory in California was supposed to end that cycle of frustration. Computer simulations showed that firing 192 beams from the world's most powerful laser at a hydrogen capsule would compress it within a millionth of a second to 1/40th its original diameter, the equivalent of shrinking a basketball to the size of a pea. The swiftness of that implosion would cause the hydrogen fuel to ignite in a brief, self-sustaining fusion reaction releasing a helium nucleus, a neutron — and up to 100 times as much energy as the laser delivered.

In 2009, NIF officials confidently stated that by September 30, 2012, they would demonstrate a fusion reac-

**A National Ignition Facility scientist adjusts the target for 192 laser beams that will fire on a hydrogen capsule in an attempt at fusion and ignition.**

tion producing net energy, a milestone known as ignition. That deadline has come and gone. The laser works just as physicists hoped it would, delivering a powerful punch right where it was supposed to go. But ignition failed. For reasons scientists still can't explain, the simulations were off the mark. Crushing an already minuscule sphere of hydrogen into a perfectly round speck turns out to be unexpectedly tough.

"Nature just wants to break you," says John Edwards, NIF's associate director of fusion.

Now he and other officials fear that the difficulty of shrinking a little ball of hydrogen could derail their laser fusion dream. Their new goal is just to figure out if laser ignition is achievable at NIF

or at any future facility.

If not, then the only foreseeable hope for fusion power lies in ITER, a \$20-billion facility under construction in France that uses magnets instead of lasers to induce fusion. Though saddled by their own logistical and financial obstacles, ITER physicists hope to achieve ignition and start work on a magnet-based fusion power plant by the late 2020s.

The next few years will be pivotal in determining whether NIF's laser approach is even an option for energy production, or whether all hopes for fusion will turn overseas to ITER.

"We don't know what it is going to take to get ignition," says Kirk Levedahl, the program manager for NIF's ignition effort at the U.S. Department of Energy.

### Star power

NIF's slogan is "Bringing Star Power to Earth," but that is a rather grandiose description of what the facility was built to do. The sun's gravity is so great that the energy output from one second of nuclear fusion in that gargantuan star would, if converted into electricity, satisfy the planet's needs for a million years. No machine is ever going to compete with that.

NIF was designed to be the next best thing: a facility that could, on a very small scale, achieve starlike conditions and stimulate fusion for fractions of a second at a time. In lieu of the gravity, NIF would use the world's most powerful laser to compress a peppercorn-sized capsule of hydrogen fuel into a hot, dense ball 1/60,000th its original volume. Inside that tiny sphere, a cascade of fusion reactions would release many times more energy than the laser delivered.

Prior to 2009, physicists had never used a laser with even a hundredth the energy of NIF's. They had never studied matter packed into a ball as hot and dense as the sun's core. An external review panel warned that "substantial scientific challenges remain to achieving ignition." Yet NIF officials were confident enough to put a stake in the ground and claim that they would ignite a cap-

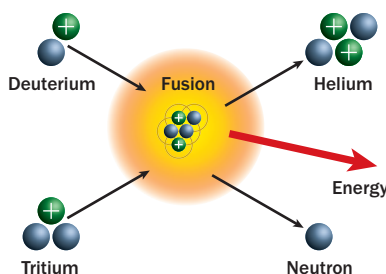
sule by September 2012. "I think we'll get ignition relatively shortly after we turn the facility on," said George Miller, then-head of Livermore, at NIF's dedication ceremony in 2009.

A lot of that confidence came from computer simulations. These were no video game-like approximations of reality. Each simulation consisted of more than a million lines of code filled with numbers and equations describing every push and pull that nuclei in the fuel capsule would encounter once the laser fired. All the data included in the simulations were based on well-tested theories and rigorous experiments, including measurements from hundreds of thermonuclear bomb explosions. The world's fastest supercomputers required days or weeks to spit out the results.

Many of these simulations predicted that NIF's 192-beam laser would comfortably achieve ignition. They showed that a short, powerful laser pulse coming from all directions would compress the pellet enough to create heat and pressure more intense than that in the sun's core, forcing hydrogen nuclei together to form high-energy helium nuclei and neutrons.

The payoff hinged on the fate of the newly formed helium nuclei, which would jet out from the center of the capsule in all directions. If the capsule compressed as the simulations predicted, then the helium would not be able to escape. Similar to running through a dense forest in the dark, it would have a very good chance of slamming into

**Nuclear fusion** The merging of two hydrogen isotopes, deuterium and tritium, results in a helium nucleus and a neutron—and the release of energy.



**"Nature just wants to break you."**

JOHN EDWARDS

a tree — or, in this case, a hydrogen nucleus. Each of those collisions would create heat, which in turn would encourage more hydrogen to fuse, thus producing more helium. Fusion would briefly become self-sustaining, leading to a huge jump in the energy produced.

It all sounded good, but the scientists involved were cautiously optimistic. They knew that any simulation is only as good as the information that goes into it. "Everyone knew this was an extrapolation beyond what we believed we could extrapolate to," Levedahl says. "But it was the best we could put together at the time."

### A hard slog

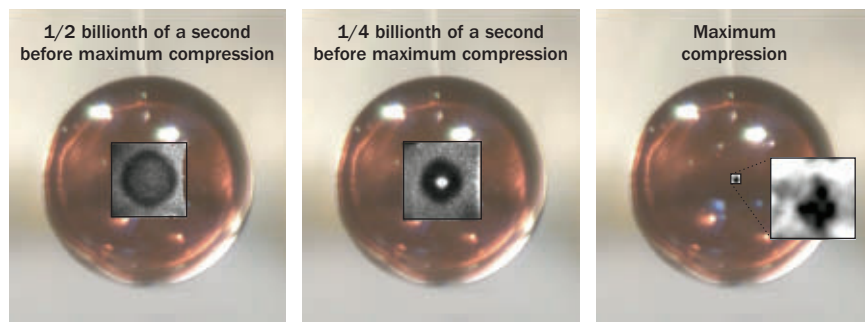
In September 2010, prognostication finally yielded to experimentation. Physicists fired the NIF laser at a centimeter-long metal cylinder called a hohlraum. The quick pulse stimulated the hohlraum to emit X-rays, which bombarded the plastic-coated hydrogen fuel capsule stored inside. The capsule's coating vaporized and exploded, triggering a rocket effect that sent the hydrogen hurtling inward.

All those steps went according to plan. But strange things happened once the capsule began to collapse. Instead of remaining spherical, as the simulations predicted, the capsule warped into an amorphous blob. Physicists had designed NIF with 192 laser beams fired from all directions specifically to preserve the capsule's symmetry as it imploded; yet the compressed capsules looked more like water balloons getting squeezed by two hands.

During other trial runs, a capsule would start to compress symmetrically, but then little bumps would emerge on its surface. As the implosion continued, these minor imperfections grew exponentially. Little hills on the capsule's surface became mountains. Gently sloped troughs morphed into steep valleys. Within billionths of a second what began as a perfectly smooth ball looked more like a medieval knight's spiky mace.

These confounding early experiments





**Fusion flop** X-ray photography shows how a hydrogen capsule loses its symmetry as it compresses. Just after laser beams are fired the capsule is spherical (left). Hydrogen begins to fuse to form helium (center). When the capsule's symmetry is lost (right), ignition has failed.

clearly revealed that ignition was not going to be handed over on a silver platter. “The results told us it was going to be a really hard slog,” Levedahl says.

Physicists quickly shifted their plan. Throughout 2011 and early 2012, when many of them had expected they would be on the cusp of ignition, they were simply trying to figure out what was going wrong. They designed custom targets and installed monitoring equipment to probe specific properties of the implosion.

NIF physicists determined that the X-rays released by the zapped hohlraum were not compressing the capsule inside evenly. In addition, the warped capsule sometimes fractured as it collapsed, allowing cold particles on the outside to mix with the hot stuff inside and short-circuit any fusion reaction.

In response, the NIF team tweaked the design of the hohlraum and redirected the beams slightly to trigger a more symmetrical response. The physicists also tuned the laser pulse so it would deliver the optimal force to kick-start compression of the fuel shell. By mid-2012, NIF had made considerable progress in imploding the capsules, compressing them more while maintaining a spherical shape.

Even so, ignition was not even close to attainable when the September 2012 deadline arrived. The highest energy output achieved to that point, according to a December report, was at most a third of the amount needed to trigger the helium collisions that would ignite the fuel.

### Facing the unexpected

Walking through the Livermore campus, a former training ground for World War II Navy pilots, it is hard to tell that NIF has missed the mark. A giant “Bringing Star Power to Earth” banner hangs on the outside of the main complex. Scientists seem upbeat, eager to overcome the curveballs fusion keeps throwing them.

That’s because generally, physics is as much about being wrong as it is about being right. Physicists want their theories to be as accurate as possible, but they also know their theories are incomplete. Identifying unexpected phenomena is the key to constructing even better theories.

NIF director Edward Moses points to another record-setting facility: the Large Hadron Collider in Europe, the world’s most powerful particle accelerator. The machine’s main goal was to observe a particle called the Higgs boson. The Higgs is an essential element of the Standard Model, a leading theory that describes every particle and force in the universe. On July 4, 2012, physicists proudly announced that they had found it.

But since then the LHC physicists’ excitement has dimmed considerably. Yes they discovered the Higgs, but so far the particle looks exactly like the theory said it would. The experiment affirmed the Standard Model, but unless anything strange turns up, physicists won’t be able to add to and improve the theory. NIF physicists wish their simulations were better; LHC physicists complain that theirs were too good.

“Mother Nature has been very cruel,” says LHC physicist Steve Blusk of

Syracuse University, in a statement awfully reminiscent of Edwards’ “Nature wants to break you” complaint.

While the pace is frustrating, NIF’s problems are helping physicists understand how matter behaves in environments hotter and denser than the core of the sun (*SN: 1/14/12, p. 26*). The things they learn will then be incorporated into the simulations, Moses says, giving them better predictive power. Still, his comparison of the two multibillion-dollar facilities only goes so far. The LHC was built to learn fundamental things about the universe, but NIF was built to achieve ignition. “There’s a whole different dynamic for fusion,” Moses says.

### Fusion’s eternal future

Fusion ignites furious debate as few other scientific endeavors can. Advocates point out that fusion packs the highest punch of any known energy-generating process, with one gram of hydrogen fuel possessing the same energy content as 13.5 metric tons of coal. The fuel is readily available, there are no radioactive or environmentally hazardous waste products, and there is no risk of nuclear meltdown.

Opponents argue that fusion is impractical and overwhelmingly expensive to achieve. Just consider the frustrating history of physicists’ attempts to harness the process.

The quest began with the first demonstration of fusion in a nuclear weapon. In 1952, Manhattan project scientists Edward Teller and Stanislaw Ulam developed a thermonuclear weapon that was essentially two bombs in one — a runaway fission reaction emitted X-rays that compressed a canister of hydrogen atoms and forced them to fuse, releasing energy equivalent to millions of tons of TNT.

In the late 1950s Livermore physicist John Nuckolls used the bomb as inspiration for a peaceful application of fusion power. He realized that if he significantly scaled down the size of the hydrogen canister, he could induce fusion without the need for a fission spark plug. He envisioned a small capsule of hydrogen placed inside a hohlraum. If the

hohlraum were zapped with a substantial (but not nuclear-sized) burst of energy, it would emit X-rays that would implode the hydrogen, much like in the bomb.

### Getting started—again

The laser, invented in 1960, seemed to be the perfect delivery mechanism to start the fusion process rolling. Beginning in 1974, Lawrence Livermore marched out a parade of lasers—Janus, Cyclops, Argus, Shiva—to test Nuckolls' idea. With laser technology in its infancy, scientists were mainly focused on improving the reliability and integrity of the laser shots. Then came Nova, a 10-beam laser at Livermore built in 1984 to achieve ignition. While many computer simulations predicted Nova would succeed, it never came close.

The quest for laser fusion may have stopped there if not for President Bill Clinton. In 1993 he announced his support for a comprehensive nuclear test ban treaty and ordered the Department of Energy to find ways to maintain the nuclear stockpile without detonating any bombs. Building a laser facility to achieve ignition could test components of the nuclear arsenal sans explosions—after all, Nuckolls' original idea was based on the architecture of H-bombs. NIF was conceived as a defense project, overseen

by the National Nuclear Security Administration, that just so happened to benefit fusion energy research.

The downside of this defense-energy relationship is that it added yet another stigma to an already controversial line of research. When NIF failed to meet the ignition deadline last September, NNSA noted that the facility had nonetheless resolved several nagging physics questions regarding the U.S. nuclear stockpile. That's probably good news for the U.S. military, but it's impossible to say for sure because the details are classified. The public data, on the other hand, are not very encouraging, especially to politicians who have to justify NIF's multi-billion-dollar price tag.

NIF physicists feel the pressure but defend their track record. "There's been an enormous amount of progress," says Alex Hamza, who leads production of NIF's hohlraum targets. "I don't think the outside community understands that."

Recent reports released by NNSA, the University of California and the National Research Council agree with Hamza's assessment. They cite the researchers' steady progress since their first disastrous laser shots as proof that NIF can proceed further toward ignition. But reports also conclude that the compression problems may be too much for NIF and perhaps any facility. NNSA's

stated goal is no longer to achieve ignition but rather, by September 2015, to determine whether achieving it is even possible with NIF's approach. At the same time, the agency has reduced the number of laser shots dedicated to ignition in favor of more weapons and basic science research.

The NRC recommends that fusion scientists hedge their bets, calling for increased study of alternative laser and target designs. The Omega laser at the University of Rochester in New York, for example, is testing an approach to fire on the hydrogen pellet directly rather than on a hohlraum. Livermore officials had hoped that the rapid achievement of ignition would allow scientists and politicians to rally around NIF's laser fusion approach; instead, resources are being spread around in a desperate attempt to find other promising approaches to imploding hydrogen fuel. "The fact is that we don't have any predictive capability right now," says Steve Cowley, a fusion physicist at Imperial College London who contributed to the NRC review. "Any progress is going to be a guess. But that's why you take measurements: It allows you to understand what to do next."

Cowley also points out that using a laser is not the only way to strive for fusion. Many physicists favor ITER's alternative approach of using powerful magnets to heat and confine hydrogen plasma, though that approach has its own history of expensive disappointments. Six countries plus the European Union are spending \$20 billion on the project. With so much money at stake between NIF and ITER, the next decade could very well determine the fate of fusion energy.

That uncertainty still isn't stopping Mike Dunne. He continues plotting his prototype fusion power plants, optimistic that he will get the chance to put his plan into action. "I never trust plasma physicists' ability to project the future," he says. "But I'm confident they'll come through soon." ■

### Explore more

■ NIF: [lasers.llnl.gov](http://lasers.llnl.gov)

**A window outside NIF's vacuum-sealed experiment chamber lets researchers observe as 192 lasers fire on a hydrogen capsule in a target container called a hohlraum.**



## Antifragile: Things That Gain From Disorder

Nassim Nicholas Taleb

Just as a campfire feeds off random wind gusts, well-prepared people and organizations can benefit from volatility and chance events, risk researcher and former derivatives trader Taleb argues. But more often, he says, modern institutions handle unexpected jolts — say, the recent financial crisis — about as well as a candle flame resists a windstorm.

Taleb calls things that get stronger in the face of disorder antifragile. A merely resilient entity takes a licking and keeps on ticking, but an antifragile one turns lemons into lemonade. Antifragility occurs, for instance, when bones get stronger after hoisting heavy loads.

Governments, corporations and other engines of modern life have become so complex, with so many interdependent parts, that they can trigger unpredictable events with massive consequences. In a previous book, Taleb dubbed these game-changing twists Black Swans.

Many institutions try in vain to forecast Black Swans with mathematical models based on past data, he says. But these formulas greatly underestimate the probability of novel, momentous turns in complex environments.

Black Swans can't be avoided but can be minimized and even exploited by scaling down modern institutions,



Taleb suggests. Policy makers and businesses could look for simple ways to tame complex problems and profit from inevitable volatility. Research increasingly supports

Taleb's argument that imperfect rules of thumb can work surprisingly well.

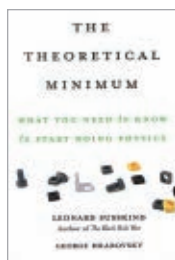
These ideas upset economists and risk-assessment specialists, among others. Taleb welcomes a debate. As he argues in this book, "what doesn't kill you makes you stronger." — *Bruce Bower*  
*Random House, 2012, 519 p., \$30*

## The Theoretical Minimum: What You Need to Know to Start Doing Physics

Leonard Susskind and George Hrabovsky

Most popular books on physics attempt to explain ideas without equations (the popular dogma says that each equation cuts sales in half). But when the book's advertised purpose is to provide the (minimum) knowledge needed to actually do physics, equations are a must. And this book is full of them.

Susskind and Hrabovsky introduce dynamical systems and vectors, then lay out the basics of calculus, building the basic mathematical toolkit that physicists rely on. Then come energy, symmetries and conservation laws, along with increasingly elaborate mathematical notions to deal with them. Once you get through Lagrangians, Hamiltonians and Poisson brackets, you'll just have to grasp gauge



symmetries and vector potentials. Then you can dazzle your friends by analyzing the decay channels for the Higgs boson.

Or maybe not. This is a spectacular effort to make the real stuff of theoretical physics accessible to amateurs. But it's hard to see how anyone not already comfortable with calculus will be able to stick with it. Even those with math skills won't be ready to travel with pioneers at the theoretical frontiers. This "theoretical minimum" is for classical physics — there's no relativity, no quantum physics, no cosmology. That will all presumably have to wait for the next book (which will, in fact, be worth waiting for).

But even if this first effort fails to make every reader capable of doing what physicists do, it certainly will improve most readers' ability to comprehend what physicists say. And that may be even more valuable: No doubt the world needs a better understanding of physics more than it needs more amateur physicists. — *Tom Siegfried*  
*Basic Books, 2013, 238 p., \$26.99*



## Wolves in the Land of Salmon

David Moskowitz

An expert wildlife tracker paints a portrait of wolves' lives

and value to ecosystems, set against the backdrop of conflict over rising wolf populations. *Timber Press, 2013, 334 p., \$29.95*



## Love in the Time of Algorithms

Dan Slater

A journalist argues that the calculations powering online dating websites are shaping the

love lives of the 80 million American singles who use the services.

*Current, 2013, 245 p., \$25.95*



## Blackett's War

Stephen Budiansky

A small group of scientists helped win World War II and changed the way wars are fought, a military historian postulates. *Knopf, 2013, 336 p., \$27.95*



## Animal Wise

Virginia Morell

A science writer presents recent research that demonstrates a large repertoire of intellectual skills in a

variety of animals. *Crown, 2013, 291 p., \$26*



## Turing

B. Jack Copeland

The ideas of mathematician and computer visionary Alan Turing are explored through inter-

views of his friends and colleagues. *Oxford Univ., 2012, 300 p., \$21.95*

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# Pacing Alzheimer's

Science Stats ("Alzheimer's advancing," *SN*: 3/9/13, p. 4) reports a new analysis extrapolating from 2010 U.S. Census data that concludes Alzheimer's disease will triple by 2050. Omitted in such an analysis is the accelerating advance of science and medicine over the next 40 years. The gloomy prediction makes little sense unless science stops short while the disease continues to progress. **Michael Edelstein**, San Francisco, Calif.

*Researchers are working hard on treatments for Alzheimer's. But until they find ways to prevent the disease, more people will continue to be diagnosed. That trend is driven by the demographics of an aging population. — Erika Engelhaupt*

# Technicalities in 3-D

Rachel Ehrenberg's article about 3-D printing ("The 3-D printing revolution," *SN*: 3/9/13, p. 20) was informative but did not mention exactly how a 3-D

printer would make the complex structures mentioned in the article, such as a human kidney. And how would such a printer make a mechanical object with many moving parts made of different materials that may or may not be directly connected to one another?

**Robert Walty**, Stephens City, Va.

*Researchers are still a long way from printing a functioning kidney, but labs are exploring "bioprinting," in which the printer lays down cells that can, for example, filter blood like a kidney. Challenges include the need for modeling software that captures the complexity of biological parts. It's already possible to print objects with moving parts such as gears, though the process is difficult to imagine. You can find videos showing how it works by searching "3D printed wrench" on YouTube. — Rachel Ehrenberg*

The 3-D printer has unpredictably powerful potential. But the device is

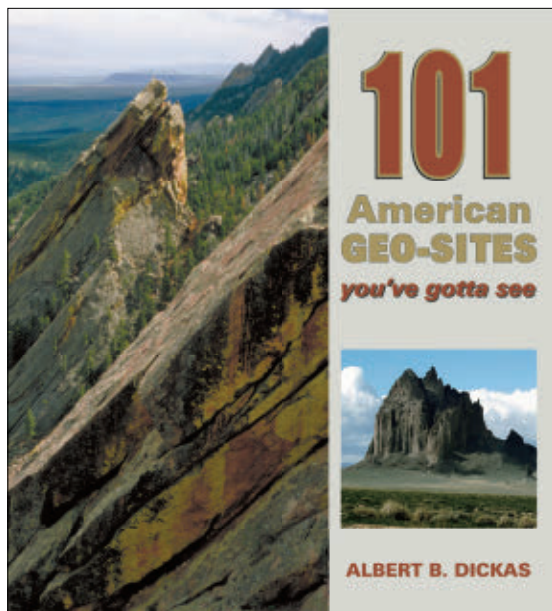
an advance in technology, not science. What contribution by this machine to our knowledge of the universe warrants its coverage by *Science News*?

**William Vietinghoff**, Thousand Oaks, Calif.

*We chose to introduce our readers to 3-D printing in part because it is an increasingly important tool in basic and applied scientific research. For example, the April 6 issue has an article describing the creation of fluid vortices using a pretzel-shaped plastic wing made with a 3-D printer (*SN*: 4/6/13, p. 8). On Page 12 of this issue is a 3-D printed polymer skull implant. We considered confining ourselves to scientific applications of 3-D printing, but ultimately decided that the technology's role in design and the "maker" movement added valuable and interesting context. — Matt Crenson*

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

# Take a Tour through America's Geologic Hall of Fame



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# The Science Life



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Two Cedar Creek Corrections Center inmates care for flowering plants destined for the wild. The project teaches prisoners about Northwest landscapes and environmental restoration.

## Prisons an unlikely laboratory

Graduate student Craig Ulrich carried out his first published research project not in a university lab, but as a prison inmate.

In 2004 Ulrich accidentally shot and killed a college classmate. Convicted of first-degree manslaughter (which in Washington state means a death caused through recklessness), he ended up at the Cedar Creek Corrections Center in Littlerock, Wash. His college background in biology made him a perfect candidate to work in the facility's composting program, set up by Evergreen State College in nearby Olympia. Data he collected appeared in a 2009 research paper showing that composting programs can help prisons cut landfill-bound waste in half and improve wastewater quality. Today



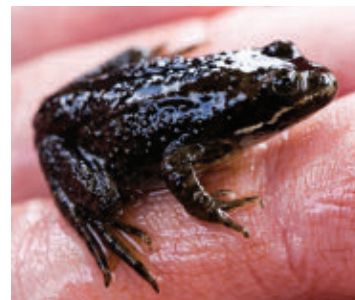
Ulrich (left) is pursuing a Ph.D. in biochemistry at the University of Nevada School of Medicine in Reno.

"I went into prison and came out a scientist," says Ulrich, one of many Washington prisoners connected to science and nature by collaborative projects between Evergreen and the Washington State Department of Corrections.

About an hour's drive from Ulrich's former cell, a women's prison works with the Oregon Zoo in Portland on a project raising and releasing endangered Taylor's checkerspot butterflies. Inmate Carolina Landa had no experience in science, but she helped develop a technique for grinding up plantain leaves that helped the butterflies digest them.

"We call it 'plantain pesto,'" says Evergreen graduate student Dennis Aubrey, who worked with Landa. "It really worked. Insects that ate the pesto went through their first three molts almost twice as fast." Inmates at three prisons grow indigenous plants that provide the butterflies and other insects with food and places to lay eggs outside the prison fences. To date, almost a million golden paintbrush and other prairie plants have been raised at the facilities, and many have been transplanted into the wild.

The programs have another side effect, says Charlie Washburn, correctional program manager at Cedar Creek. One inmate working in the plant program "was always uptight, always angry and always mad," he remembers. "That anger went away out there in the greenhouse," Washburn says. "I got a call after he got out of prison. He said, 'I'm looking for a job in a nursery, and I need a reference.'" — *Devin Powell*



One program at Cedar Creek Corrections Center has prisoners raising endangered Oregon spotted frogs (above). The prisoners collect data on water quality, frog growth and mortality while rearing the animals. Last fall, a crop of 246 frogs was released into the wild at Joint Base Lewis-McChord near Tacoma, a safe haven for the species.

CLOCKWISE FROM TOP: BENJAMIN DRUMMOND, N.J.; DRUMMOND; SCOTT BARNETT

# Cell Phone Inspires Chicago Doctor to Design Affordable Hearing Aid

## Outperforms Most Higher priced Hearing Aids

Reported by J. Page

**CHICAGO:** A local board-certified Ear, Nose, Throat (ENT) physician, Dr. S. Cherukuri, has just shaken up the hearing aid industry with the invention of a medical-grade, affordable hearing aid. **This revolutionary hearing aid is designed to help millions of people with hearing loss who cannot afford—or do not wish to pay—the much higher cost of traditional hearing aids.**

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—Dr. Babu, M.D.  
Board Certified ENT Physician**

Dr. Cherukuri knew that untreated hearing loss could lead to depression, social isolation, anxiety, and symptoms consistent with Alzheimer's dementia. **He could not understand why the cost for hearing aids was so high when the prices on so many consumer electronics like TVs, DVD players, cell phones and digital cameras had fallen.**

Since Medicare and most private insurance do not cover the costs of hearing aids, which traditionally run between \$2000-\$6000 for a pair, many of the doctor's patients could not afford the expense. Dr. Cherukuri's goal was to find a reasonable solution that would help with the most common types of hearing loss at an affordable price, not unlike the **“one-size-fits-most” reading glasses** available at drug stores.

He evaluated numerous hearing devices and sound amplifiers, including those seen on television. Without fail, almost all of these were found to amplify bass/low frequencies (below 1000 Hz) and not useful in amplifying the frequencies related to the human voice.

### Inspiration from a surprising source

The doctor's inspiration to defeat the powers-that-be that kept inexpensive hearing aids out of the hands of the public actually came from a new cell phone he

- **Designed By A Board Certified Ear, Nose and Throat (ENT) Doctor**
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had just purchased. “I felt that if someone could devise an affordable device like an iPhone® for about \$200 that could do all sorts of things, I could create a hearing aid at a similar price.”

### Affordable Hearing Aid With Superb Performance

The high cost of hearing aids is a result of layers of middlemen and expensive unnecessary features. Dr. Cherukuri concluded that it would be possible to develop a medical grade hearing aid without sacrificing the quality of components. The result is the MDHearingAid PRO®, starting well under \$200. **It has been declared to be the best low-cost hearing aid that amplifies the range of sounds associated with the human voice without overly amplifying background noise.**

### Tested By Leading Doctors and Audiologists

The MDHearingAid PRO® has been rigorously tested by leading ENT physicians and audiologists who have unanimously agreed that the **sound quality and output in many cases exceeds more expensive hearing aids.**

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### Doctors and patients agree: “BEST QUALITY SOUND” “LOWEST AFFORDABLE PRICE”

*“I have been wearing hearing aids for over 25 years and these are the best behind-the-ear aids I have tried. **Their sound quality rivals that of my \$3,000 custom pair of Phonak Xtra digital ITE**”  
—Gerald Levy*

*“I have a \$2,000 Resound Live hearing aid in my left ear and the MDHearingAid PRO® in the right ear. **I am not able to notice a significant difference in sound quality between the two hearing aids.**”  
—Dr. May, ENT Physician*

*“We ordered two hearing aids for my mother on Sunday, and the following Wednesday they were in our mailbox! Unbelievable! Now for the best part—they work so great, my mother says she hasn't heard so good for many years, even with her \$2,000 digital! **It was so great to see the joy on her face. She is 90 years young again.**” —Al Peterson*

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All my friends have new cell phones. They carry them around with them all day, like mini computers, with little tiny keyboards and hundreds of programs which are supposed to make their life easier. Trouble is... my friends can't use them. The keypads are too small, the displays are hard to see and the phones are so complicated that my friends end up borrowing my Jitterbug when they need to make a call. I don't mind... I just got a new phone too... **the new Jitterbug Plus.** Now I have all the things I loved about my Jitterbug phone along with some great new features that make it even better!

GreatCall® created the Jitterbug with one thing in mind—to offer people a cell phone that's easy to see and hear, simple to use and affordable. Now, they've made the cell phone experience even better with the Jitterbug Plus. It features a lightweight, comfortable design with a backlit keypad and big, legible numbers. There is even a dial tone so you know the phone is ready to use. You can also increase the volume with one touch and the speaker's been improved so you get great audio quality and can hear every word. The battery has been improved too— it's one of the longest lasting on the market— so you won't have to charge it as often. The phone comes to you with your account already set up and is easy to activate.

**The rate plans are simple too.** Why pay for minutes you'll never use? There are a variety of affordable plans. Plus, you don't have to worry about finding yourself stuck with no minutes— that's the problem with prepaid phones. Since there is no contract to



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Monthly Rate	\$14.99	\$19.99
Operator Assistance	24/7	24/7
911 Access	FREE	FREE
Long Distance Calls	No add'l charge	No add'l charge
Voice Dial	FREE	FREE
Nationwide Coverage	YES	YES
Friendly Return Policy <sup>1</sup>	30 days	30 days

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sign, you are not locked in for years at a time and won't be subject to early termination fees. The U.S.-based customer service is knowledgeable and helpful and the phone gets service virtually anywhere in the continental U.S. Above all, you'll get one-touch access to a friendly, and helpful GreatCall operator. They can look up numbers, and even dial them for you! They are always there to help you when you need them.

**Call now and receive 100 FREE Minutes and FREE Car Charger** – a \$41.98 value. Try the Jitterbug Plus for yourself for 30 days and

if you don't love it, just return it for a refund<sup>1</sup> of the product purchase price. Call now – helpful Jitterbug experts are ready to answer your questions.

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