

Menu for Mars | Black Death Bug Deciphered | Stone Age Painters

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ScienceNews

MAGAZINE OF THE SOCIETY FOR SCIENCE & THE PUBLIC ■ NOVEMBER 19, 2011

Teen IQ Ups
and Downs

Talk's
Evolutionary
Tales

How Genes
Make Brains



Drool

diagnoses

Saliva holds clues to disease

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COVER Scientists are devising ways to analyze spit for signs of cancer, Alzheimer's and heart disease, among other disorders.
David Trood/The Image Bank/Getty Images

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FROM THE EDITOR

To understand the brain, it might help to go 'ome'



Devotees of Eastern philosophies sometimes chant “om” while contemplating mysteries of the cosmos. For contemplating the complexity of the brain, the more appropriate chant is “ome.”

If you’ve been paying attention over the years, you’ll have noticed that “-omes” are a big part of the science of life. Most prominent among them, of course, is the human genome, the entire catalog of genetic instructions encoded in a cell’s DNA. It’s the genome that encrypts the secret blueprint for building the whole human body, brain included. But once you’ve got a body and brain, something else has to tell the brain how to wire itself and do its various jobs.

In other words, you need another -ome. Scientists call this one the “transcriptome,” jargon for the set of molecules that are actually at work transmitting genetic information.

Busy genes — the ones that are “active,” or “turned on” — are those whose codes are being deciphered by the cell’s protein-making process. The blueprints in DNA are written in a chemical language in which molecular units called bases represent letters, and three-letter combinations of those letters represent words. Each word specifies the identity of an amino acid; the “sentences” are long chains of amino acids, aka proteins.

To construct the protein sentences, a cell copies DNA’s code into a mobile messenger molecule, a form of RNA, that carries the information to the protein-producing factory, the ribosome. Copying DNA’s info to a messenger RNA molecule is called transcription; the set of all the RNA molecules in a cell — including those carrying the information from genes actively engaged in producing proteins — is designated the transcriptome.

In this issue (Page 5), Laura Sanders reports (without using -ome jargon) on groundbreaking examinations of the brain transcriptome, research that is revealing surprising patterns in its makeup over time. Details of the transcriptome offer clues to how the young brain develops and how its genetic activities change as it ages. Transcriptome features may prove crucial in understanding various brain diseases.

Of course, the brain’s transcriptome doesn’t tell the whole story. An important part of determining the brain’s behavior is the precise network of connections linking its nerve cells and structures. So be on the lookout for future reports on ... the connectome. — *Tom Siegfried, Editor in Chief*

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The cell phone that's right for me. Sometimes I think the people who designed this phone and the rate plans had me in mind. The phone fits easily into my pocket, and flips open to reach from my mouth to my ear. The display is large and backlit, so I can actually see who is calling. With a push of a button I can amplify the volume, and if I don't know a number, I can simply push "0" for a friendly, helpful operator that will look it up and even dial it for me. The Jitterbug also reduces background noise, making the sound loud and clear. There's even a dial tone, so I know the phone is ready to use.

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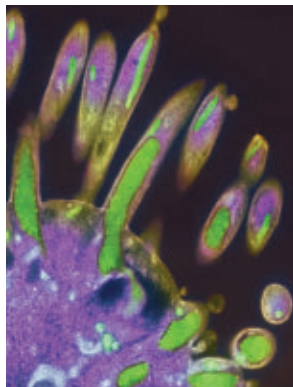
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Say What?

sporozoite \spohr-uh-ZOH-ayt\ *n.* A mobile, infective stage of development in certain protozoa, especially the malarial parasite *Plasmodium*. *Plasmodium* sporozoites make their way from a mosquito's gut (left, bursting from gut wall) to the salivary glands, from there infecting people bitten by the mosquito. Scientists at the Naval Medical Research Center in Silver Spring, Md., and their colleagues have found that irradiated sporozoites

could serve as a base for a malaria vaccine. Irradiated parasites kicked off an immune response that killed infected cells in volunteers. Though promising, the vaccine may need to be given intravenously to be effective, the team reports in the Oct. 28 *Science*. — *Camille M. Carlisle*

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LIFE

Cycads, often called “dinosaur plants,” aren’t so ancient after all. Read “Cycads not ‘living fossils.’”



HUMANS

Ancient cooking pots show diets shifted slowly from fishing to agriculture. See “Early farmers’ fishy menu.”

Science Past | NOVEMBER 18, 1961

NEW EVIDENCE FOUND OF EXPANDING UNIVERSE — The universe is expanding, then collapsing again after a long time, evidence from photographs taken with the 200-inch telescope atop Mt. Palomar indicate.



Dr. William A. Baum of Mt. Wilson and Palomar Observatories, Pasadena, Calif., said that present-day observations are not compatible with a steady-state universe in which matter is continuously being created. The observations were

made on very distant galaxies belonging to clusters of galaxies, he told the Royal Astronomical Society meeting in London. The observations are based on the red-shift of the light from these galaxies.

Science Future

November 22

Learn cocktail chemistry at the Houston Museum of Natural Science. Go to www.hmns.org

December 1

Explore all things that glow at San Francisco’s Exploratorium. Ages 18 and up. See www.exploratorium.edu/afterdark

December 5

Make folded structures in a workshop at St. Paul’s Science Museum of Minnesota. See www.smm.org/librarylaboratory

ON THE SCENE BLOG

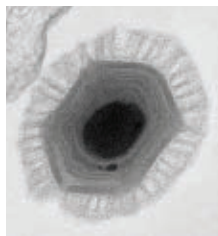
The Drake Equation for tallying alien life turns 50. See “The Drake Equation: All in the family,” with a link for *SN* subscribers to a Q&A with Frank Drake.

BODY & BRAIN

Air pollution boosts blood pressure in at-risk groups. Read “A particulate threat to diabetes.”

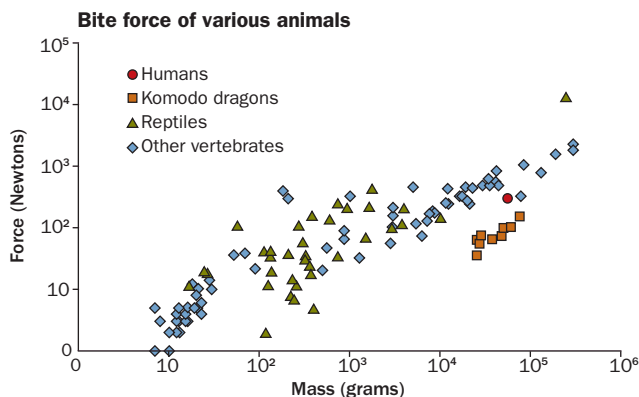
The (-est)

The largest virus known to science has been discovered lurking in seawater off the coast of Chile. Dubbed *Megavirus chilensis*, the beastie’s genetic blueprint is 6.5 percent larger than that of Mimivirus, the previous record holder, researchers led by Jean-Michel Claverie of Aix-Marseille University in France report in the Oct. 18 *Proceedings of the National Academy of Sciences*. *Megavirus* (shown) and *Mimivirus* look alike, both bearing hairlike extensions and a five-pronged gate through which the viruses expel genetic material into a host. The two big viruses appear to have many proteins and genes in common, similarities that suggest a shared, much more complex ancestor. — *Rachel Ehrenberg*



Science Stats | NASTY BITE

The Komodo dragon is known as a fearsome predator, but new data reveal that its bite is less powerful than a human’s. Instead, researchers say, the reptile relies on its muscular body to help it rip flesh apart. SOURCE: D. D’AMORE ET AL/PLOS ONE 2011



“ Not only are the receptors organized in patches, but the axis that best describes their organization is pleasantness. ”

— NOAM SOBEL, PAGE 14

Science & Society Valuing Facebook

Life Rodents like to hate their neighbors

Environment Thin year for Arctic ozone

Body & Brain Teens' IQs can change a lot

Molecules How a berry makes sour sweet

Atom & Cosmos Mercury's blue holes

Genes & Cells Black Death genetics

In the News

STORY ONE

Brain's genetic activity traced over life span

Dramatic changes from just after conception to old age

By Laura Sanders

Human brains all work pretty much the same, using roughly the same genes in the same way to build and maintain the infrastructure that makes people who they are, two new studies show. By charting the brain's genetic activity from before birth to old age, the studies also reveal that the brain continually remodels itself throughout life.

In addition to uncovering details of how the brain grows and ages, the results may help scientists better understand what goes awry in brain disorders such as schizophrenia and autism.

“The complexity is mind-numbing,” says neuroscientist Stephen Ginsberg of the Nathan Kline Institute and New York University Langone Medical Center, who wasn't involved in the studies. “It puts the brain in rarefied air.”

In the work, published in the Oct. 27 *Nature*, researchers focused not on DNA — virtually every cell's raw genetic material is identical — but on when, where and for how long each gene in the DNA is turned on over the course of a person's life. To do this, the researchers measured levels of mRNA, a molecule whose appearance marks one of the first steps in executing the orders contained



Brain biochemistry changes dramatically with age as different sets of genes are activated. Yet two new studies find remarkable consistency among individuals.

in a gene, in postmortem samples of donated brains that ranged in age from weeks after conception to old age.

Different patterns of mRNA levels distinguish the brain from a heart, for instance, and a human from a mouse, too, says Nenad Šestan of Yale University School of Medicine and coauthor of one of the studies. “Essentially, we carry the same genes as mice,” he says. “However, in us, these genes are up to something quite different.”

To see what human genes are up to in the brain, Šestan's team examined mRNA levels of different genes in 57 brains. The researchers divided the brain tissue up

by region, so they were also able to get an idea of genes' behavior in different parts of the brain. A parallel study, headed by Joel Kleinman of the National Institute of Mental Health in Bethesda, Md., studied 269 brains that also spanned the lifetime to look for gene behavior in a single region called the prefrontal cortex.

This approach allowed researchers to get access to the brain that had previously been impossible.

“One of the limitations in studying human brain development is that you cannot do experiments,” Šestan says. “It's very hard to understand when things happen.”

BRAIN: JUSTAV/SHUTTERSTOCK; BABY: GRAFFISSIMO/ISTOCKPHOTO; YOUNG GIRL: JOHNNYGREIG/ISTOCKPHOTO; MIDDLE-AGED WOMAN: LAFLOR/ISTOCKPHOTO; OLDER WOMAN: YURI ARGUROS/SHUTTERSTOCK



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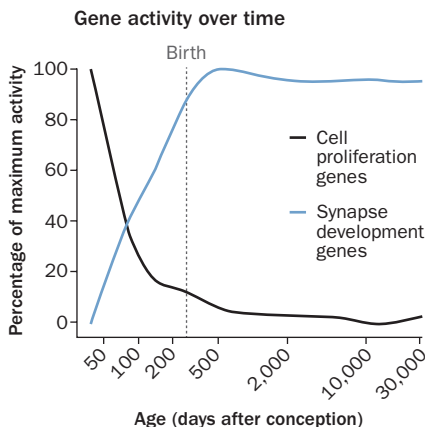
Both studies found lots of variation in gene behavior at different life stages, but one period stood out: The prenatal brain had massive changes in gene activity. Many genes pumped out big quantities of mRNA, and this production abruptly slowed after birth. “Prenatally, things are changing faster than they change at any other time,” says Carlo Colantuoni of the Lieber Institute for Brain Development at Johns Hopkins University Medical Center, coauthor on one paper. “Things are happening fast in there.”

Kleinman and his colleagues turned up a curious finding: Many of the genes that slow down right after birth show a surge of activity as a person gets older. “The biggest changes that are going on occur fetally,” he says. “And then they drop off until midlife, and then in the 50s to 70s, expression changes pick up again and become quite dramatic.”

Genes involved with building new brain cells were highly active early on, and then this activity quickly fell after birth. As these genes grew less active, genes involved in linking nerve cells became busier.

What's more, the differences in gene behavior between male and female brains were greatest at early stages

The growing brain In the neocortex, a part of the brain involved in higher mental function, genes that create new brain cells are highly active before birth. After birth, genes that connect these cells assume a larger role.



of development. Some of the genes found to be busier in male brains have been linked to schizophrenia, autism and other disorders that are known to affect males and females differently, the researchers report. These disease-associated genes are very active at the start of development and less so as a person ages, the researchers found, suggesting that something goes wrong very early in these conditions.

The scientists don't know exactly

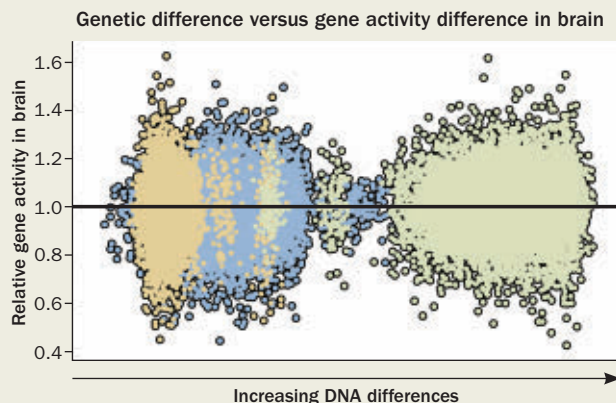
which cells are responsible for these gene behavior differences. Figuring out whether gene behavior changes in all kinds of cells in the brain — specialized neurons and glia cells, for instance — is the next step, says Ginsberg. “That's going to be really important, especially for neuropsychiatric disorders.”

Although gene behavior is incredibly dynamic, the results suggest that brains are more alike than different. Despite millions of differences in DNA, brains have a common biochemical shape, Kleinman says. Two people who have very different DNA makeup don't necessarily have very different gene behavior in the brain. “These individual genetic variations, they do matter — no question,” he says. But overall, genes behave similarly from person to person. “And that's a really cool thing. It means that we're much more alike than we are different.”

Many more studies are needed before scientists fully understand how the brain is built. But the work is a major step forward, says geneticist Christopher Mason of Weill Cornell Medical College in New York City. “This is extraordinary work,” he says. “This is the beginning of telling us what the whole brain looks like.” ■

Back Story | A BRAIN IS A BRAIN IS A BRAIN

The uniformity of gene activity in the brain is striking when seen in the context of overall human genetic diversity. Each dot on the graph at right represents a comparison between two people. On the horizontal axis is the total genetic difference between a pair. On the vertical axis is a measure of the difference in gene activity between the two in the brain's prefrontal cortex. The horizontal axis clearly reflects continent-level differences in ancestry — comparing an African-American's DNA with a Caucasian's (green dots) produces the biggest difference, while comparing DNA from a Caucasian with another Caucasian (yellow dots), or an African-American with an African-American (blue dots), produces less difference. But those differences disappear on the vertical axis, which shows variation in gene behavior, revealing that overall, human genetic diversity has no detectable influence on how the brain works. On average, the spread in



gene activity measured along the vertical axis is the same from the left side of the graph to the right. And there's no trend — across the graph, the average relative gene activity level between individuals (black line) is steady at 1.0.

FROM TOP: H.J. KANG ET AL./NATURE 2011; C. COLANTUONI ET AL./NATURE 2011



Yankee engraver pays for whiskey with Confederate coin. Big mistake.

In 1861, the U.S. Mint struck 10 million copper one-cent coins in Philadelphia.

Just nine blocks away, noted coin engraver Robert Lovett Jr. struck 12 one-cent coins—*for the Confederate States of America!*

He dreamt of glory—then feared the gallows

In 1861 the Civil War was just underway. When agents from the South approached Lovett and commissioned him to design a one-cent coin for the Confederacy, Lovett agreed - thinking that if the South won, he would go down in history.

After engraving the dies and striking the coins, Lovett quickly got cold feet. Thinking he could be hung for treason, he hid the dies and 11 of the one cent coins in his cellar.

The whole story might have ended there except for the last coin—*he kept it in his pocket!*

A drink makes history

In 1873 Lovett accidentally paid for a drink with the Confederate cent. He was soon discovered to be the engraver, and after confessing, he sold the dies and the cents.

Today an original 1861 Confederate cent is highly sought after—*one sold recently for more than \$70,000.*

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Waving cash wins over the masses

Pay strategy quickly mobilizes cross-country balloon posse

By Bruce Bower

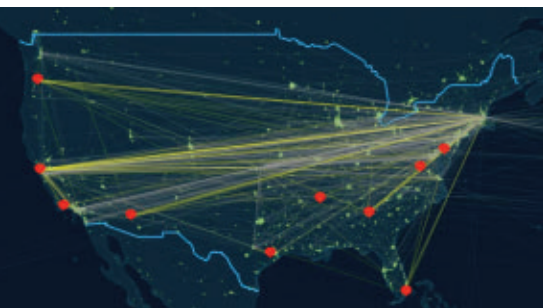
These days, bounty hunters aren't deputized, they're digitized: Online crowdsourcing strategies that induce masses of people to solve a task, such as locating far-flung items or alleviating world hunger, work best when financial incentives impel participants to enlist friends and acquaintances in the effort, a new study concludes.

In a competition to find 10 red weather balloons placed across the United States, MIT researchers used online social media and a simple reward system to recruit balloon-searchers in the 36 hours preceding the contest. The pay-based strategy garnered 4,400 volunteers who located all the balloons in a contest-winning eight hours, 52 minutes.

"Our incentive system offers monetary rewards, but perhaps more importantly it builds social capital between you and the people you recruit, who get an opportunity to participate in something interesting," says MIT computer scientist Alex Pentland. This strategy could boost the effectiveness of humanitarian and marketing campaigns, Pentland and colleagues conclude in the Oct. 28 *Science*.

Many digital crowdsourcing strategies have recently appeared. Paying people

An MIT team recruited an online network of 4,400 volunteers (white), some of whom (yellow) led to 10 weather balloons around the United States (red).



works for some tasks, as the MIT team found, but other tasks hinge on self-motivation that may get undermined by promises of money, says computer scientist Matthew Lease of the University of Texas at Austin. Wikipedia, for instance, parleys individuals' inherent interests and specialized knowledge into collective encyclopedia entries.

The goal of the 2009 balloon-hunting contest was to explore digital strategies for rapidly mobilizing people into intelligence-gathering networks. More than 50

groups entered the competition, which was sponsored the Pentagon's Defense Advanced Research Projects Agency.

Only MIT's team found all 10 balloons. To get the recruiting ball rolling, the researchers sent a link for the team's website to a few friends and several bloggers about 36 hours before the contest began. Portions of the \$40,000 winner's prize were promised to everyone who contributed to the search.

Second-place finishers from the Georgia Institute of Technology recruited 1,400 participants by offering to donate winnings to the American Red Cross. That team located nine balloons in nine hours.

Signs of a bubble in social sites

Facebook value estimate falls short of oft-cited figures

By Rachel Ehrenberg

Claims that Facebook is worth \$100 billion or even just \$65 billion grossly overvalue the company's future profit potential, say researchers who have done a simple calculation of the company's value. The econophysicists warn that inflated value estimates for sites such as Facebook, Zynga and Twitter are signs that a social networking financial bubble is gaining steam.

Didier Sornette and Peter Cauwels of the Swiss Federal Institute of Technology Zürich argue that determining the value of social networking sites is vastly simpler than with other companies, because there's a relatively direct link between the number of users and profit. The math boils down to a simple equation: the number of users times the profit per user. Examined that way, Facebook's value is probably in the neighborhood of \$15 billion to \$30 billion, the team reports online

October 6 at arXiv.org.

Figuring out the number of people with Facebook accounts was easy: The company reported reaching 750 million users in July.

Figuring out how much each user is worth was a little harder, because the company is private. Based on recent reports, the team calculated an average profit margin of 29 percent, yielding an estimated profit per user of \$1 per year.

Then the researchers plugged these numbers into some simple growth models. Assuming unlimited exponential growth quickly inflates the number of users beyond the world's population, which isn't very realistic.

So the team used a more moderate calculation that accounts for things that can be expected to slow Facebook's growth, such as future competition or limits to the expansion of Internet access in the developing world. That approach pegged Facebook's value at between \$15.3 billion and \$32.9 billion.

"It's a wonderfully robust result, and suggests that the market value for Facebook has been grossly overestimated," says Theodore Modis, a physicist and founder of Growth Dynamics, a strategic forecasting firm in Lugano, Switzerland.



Pole flips tied to plate tectonics

Continental clumps could lead to reversals in magnetic field

By **Alexandra Witze**

Continents moving over millions of years in the slow-motion geologic jigsaw puzzle known as plate tectonics could trigger the occasional swapping of the north and south magnetic poles.

Assumed to be caused by random fluctuations in the circulation of the molten iron core, the flips may actually be tied to what's going on at Earth's surface. At times when landmasses have bunched together on one side of the equator, the Earth's magnetic field has begun flipping soon thereafter, suggests a study to appear in *Geophysical Research Letters*.

"What we see clearly is that the surface positions of the continents are linked with the frequency of the reversals," says group member François Pétrélis, a geophysicist at the French research agency CNRS in Paris.

Other scientists aren't so sure, cautioning that more work needs to be done to confirm any such link.

Computer simulations have shown how molten iron in the spinning outer core can generate magnetic fields that spontaneously flip direction every so often, so that a compass that once pointed north would suddenly begin pointing south. The last reversal happened around 780,000 years ago. Before that there were periods with no flips for tens of millions of years, and others with lots of flips.

Curious about what drove these changes, Pétrélis and his colleagues mathematically probed the way liquid iron flows in the core. In earlier work, they found that if the flow is interrupted so that it no longer moves symmetrically with respect to the equator, the planet's magnetic field soon reverses.

Now the researchers have calculated where the continents sat at various points in the past, to see when they had equatorial symmetry. When the distribution of landmasses was lopsided, the team found, magnetic field flips followed soon

after. And when continents were more evenly arranged — such as between about 80 million and 120 million years ago, and again between 260 million and 310 million years ago — there were long stretches without geomagnetic field reversals.

But a third reversal-free period between around 460 million and 490 million years ago doesn't fit the proposed pattern, because the continents were bunched in the southern hemisphere then, says Trond Torsvik, a geophysicist at the University of Oslo. "I am not terribly convinced with their analysis," he says.

Pétrélis says scientists don't know enough about continental arrangements that far back to say anything conclusive about how they might have affected the magnetic field.

What would connect happenings at the surface and the core remains a mystery. One possibility is that the middle layer of the Earth, the mantle, can wiggle around separately from the Earth's overall turn, so that changes in the crust can be transmitted to the core. Testing this idea is not easy, though, as "it requires a very accurate description of what is going on in the mantle," Pétrélis says. ■

NEWS BRIEFS

Hot to a fault

Rocks that have the hots for each other could explain how some faults rupture during an earthquake. When two rocks rub together, the microscopic points where they touch can heat up and often melt in a fraction of a second, a new study finds. In small-scale laboratory tests, these flashes of heat lubricated pieces of granite and other materials sliding past each other, causing them to move in abrupt jerks. This heat may weaken faults such as the San Andreas and lead to sudden slippages, researchers at Brown University in Providence, R.I., report in the Oct. 14 *Science*.

— *Devin Powell*

Got oxygen?

The great burst of oxygen that flooded the atmosphere 2.45 billion years ago, setting the scene for oxygen-breathing creatures, may trace back to the first continents that emerged on the planet. Most volcanoes in Earth's early days lay underwater, spitting out gases containing little sulfur. French researchers now argue that when continents first appeared, changes in how gases dissolve in magma meant that volcanoes suddenly put a lot more sulfur into the air. Dissolving that sulfur in seawater could have triggered the chemistry that allowed oxygen to rise, the scientists write in the Oct. 13 *Nature*.

— *Alexandra Witze*

Methane meltdown — not

One global warming disaster scenario envisions underwater landslides releasing methane from beneath the seafloor to heat the planet even more. But geologists have let one such historical landslide off the hook for an abrupt warming that took place 8,200 years ago. The Storegga landslide, off the west coast of Norway, sent a tsunami smashing ashore as far away as Greenland. Alastair Dawson of the University of Aberdeen in Scotland and his colleagues checked the dates of the landslide and of spikes of methane in ice-core records, and say the two aren't close enough to be related. The work appears in the November issue of *The Holocene*. — *Alexandra Witze*

Life

“A similar pathway could potentially promote feelings of arousal in humans.” —BARRY DICKSON

Food odor makes male flies frisky

Courtship in a classic lab insect is driven by fruity aromas

By Nick Bascom

It's the smell of food that gets male fruit flies in the romantic mood, say researchers exploring the sexual habits of *Drosophila melanogaster*.

When trying to woo an attractive female, the sexually excited male fruit fly becomes a kind of troubadour, playing a love song with one wing as it waltzes behind its object of desire. But what exactly provokes this courtly behavior has been a mystery.

Research reported in the Oct. 13 *Nature* shows that disabling the gene for an olfactory protein called IR84a makes male flies less apt to perform their song and dance. Found amid nerve cells that spur reproductive activity in fruit flies, the protein is primarily stimulated by two aromas, phenylacetic acid and phenylacetaldehyde. Strangely, these aphrodisiacal odors are given off not by female flies, but by the fruit and plant tissues



Two compounds emitted by fruit inspire a male fruit fly (lower of the two flies) to shake his wings at a potential mate.

the flies eat and use for laying eggs.

Many insects become amorously inclined when they sense sex pheromones — natural biochemical perfumes — coming from a potential mate. Being turned on by the scent of food instead could provide an evolutionary advantage for a species whose newborn

spend several days eating and growing before leaving home. “Fruit fly larvae eat constantly, and they need a good supply of food to support this growth,” says Richard Benton of the Center for Integrative Genomics in Lausanne, Switzerland, who did the work with colleagues in Switzerland, France and England. Being sexually stimulated by food odors ensures that flies will couple near a nutrient source.

And it may not be just flies that get a rise from the essence of fruit. The same two sweet, honeylike aromas that drive flies wild are often used in perfumes, making Benton wonder if the scents have a similar effect on humans.

Though the aphrodisiacal effects of foods like chocolate and oysters boast more anecdotal hearsay than hard scientific evidence, researchers aren't totally willing to discount the possibility that some foods could inspire amorous impulses in people. “A similar pathway could potentially promote feelings of arousal in humans,” says Barry Dickson of the Research Institute of Molecular Pathology in Vienna. [f](#)

Enemies make great neighbors

Relocated kangaroo rats thrive when rivals move too

By Susan Milius

Even solitary beasts benefit when a new place has the same old jerks next door.

Endangered Stephens' kangaroo rats live by themselves most of the time in plots of California grassland that they defend from nearby members of their species. When conservationists moved animals to safer homes away from development, familiar rivals relocated together fared better than rats grouped with strangers, says conservation biologist Debra Shier of the San Diego Zoo

Institute for Conservation Research.

This boost may come from what's been called a “dear enemy effect,” Shier and institute colleague Ronald Swaisgood write online October 6 in *Conservation Biology*. Animals tend not to scrap as aggressively with familiar holders of neighboring territories as with complete strangers. The researchers noted that rats relocated along with their dear enemies spent less time fighting and more time foraging than others surrounded by unfamiliar neighbors.

“While the last 30 years have seen some spectacular species returns, there are many, often undocumented, failures,” says

Mark Stanley Price, chair of the International Union for Conservation of Nature's Task Force on Moving Plants and Animals for Conservation Purposes. The new work “should prove to be an exemplary milestone in translocation biology.”

Shier and Swaisgood took animals from three failing habitats, moving 99 of them to new, protected ground in 2008 and 2009. About half the relocated rats had their old neighbors nearby.

Survival was higher in the group moved with familiar foes. This group also had 24 times as many pups, in part because only three out of 20 females in the stranger group survived six months. [f](#)



Stephens' kangaroo rats relocated to a new habitat fared better when moved along with familiar enemies.

Environment

“It was significantly worse than anything we have ever seen.” — **GEIR BRAATHEN**

Arctic ozone loss at record levels

Northern ‘hole’ comparable to early losses over Antarctica

By Janet Raloff

Record ozone depletion over the Arctic early this year rivals what was observed in the Antarctic when holes in the protective atmospheric layer first appeared there during the 1980s.

The Arctic observation raises concerns that parts of the Northern Hemisphere might periodically begin experiencing harmful levels of ultraviolet radiation in early spring, an international team reports October 27 in *Nature*.

“It was significantly worse than anything we have ever seen,” says atmospheric chemist Geir Braathen of the World Meteorological Organization in Geneva, who was not involved in the new work. Typically, spring Arctic

ozone depletion has maxed out at a drop of between 20 and 30 percent, he says. “But in 2011, we had a loss of around 40 percent.”


In Antarctica, 70 percent of the ozone can disappear in springtime, Braathen says. In a 5- to 7-kilometer-thick band of the stratosphere, he says, ozone concentrations plummet to zero.

Arctic conditions have not gotten that bad, says Michelle Santee of NASA’s Jet Propulsion Laboratory in Pasadena, Calif., one of 29 authors of the *Nature* paper.

Most Arctic ozone accumulates between 14 and 21 kilometers up, where concentrations hover around 4.5 parts per million much of the year. But in late March, “there was an approximately

2-kilometer altitude region where ozone fell to around 0.7 ppm,” Santee says — “meaning the ozone was pretty much gone.”

It takes four things to destroy much of the stratosphere’s ozone: sunlight, very prolonged cold temperatures, a stable vortex of winds and the presence of special clouds that foster the transformation of benign chlorine molecules into ozone-vanquishing types. For the first time in the Arctic, all of these conditions aligned for months, says JPL atmospheric scientist and study coauthor Nathaniel Livesey.

Although prolonged cold spells in the stratosphere hit only every few years, those in recent winters have been increasingly extreme, says Ross Salawitch of the University of Maryland in College Park, and there’s some concern that a progressive warming at Earth’s surface is responsible. 

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It knows what you're watching

Brain-scan method can
re-create what viewer sees

By Laura Sanders

Researchers have just wrapped production on a special movie of the mind that stars a brain scanner, a sophisticated computer program and millions of YouTube videos. By monitoring the brains of people watching movies and then re-creating what the people saw, the new release has tiptoed closer to technology that can read minds by decoding mental activities, researchers report in the Oct. 11 *Current Biology*.

In the study, researchers led by Jack Gallant of the University of California, Berkeley used a type of brain scan called functional MRI to record neural activity in three people (who were all coauthors on the paper) as they watched hours of Hollywood movie trailers. Brain signals were fed into a computer program that learned how each person's visual system responded to scenes in the movies. Once the computer program had a good handle on the brains' responses, the researchers went backward and attempted to re-create what people were watching solely on the basis of brain signals.

It worked. The technique roughly reproduced movie clips that showed a red bird swooping across the scene, elephants marching across the desert and Steve Martin's hilarious antics.

The reproductions reflected only visual details such as the red of a feather, shape of a face and motion of an airplane — not the viewers' full emotional reactions to the films.

One of the main reasons the method worked was that scientists have a deep understanding of the visual system, Gallant says, an understanding that's lacking for most other mental tasks. As researchers learn more about how the


brain dreams, thinks or even feels emotions, other cognitive processes could be revealed by reading brain signals, he says.

Until now, such technology has been successful at decoding only stationary objects — such as an image of a chair — from brain activity. fMRI detects sluggish blood flow changes in the brain, signals that are usually too slow to capture the activity that accompanies watching a fast-paced movie. To get around this limitation, the researchers fed the slow fMRI signals through a complex program that filled the gaps in the data to approximate the rapid chain of events as nerve cells in the visual system detect a moving scene.

Estimating these quick brain changes from slow data was key to the technique's success, Gallant says. "Here, we're modeling in way, way more detail

than anyone has ever done before."

Guided by these lightning-quick predictions, the computer program then cobbled together scenes from a library made of millions of one-second snippets from YouTube videos. When Gallant and his team averaged the program's top 100 predictions, the result was a blurry clip eerily similar to what had been watched.

Scientists will probably attempt other brain decoding feats soon, says neuroscientist James Haxby of Dartmouth College. "I'm sure people are going to try to do imagination," he says. "We'll calibrate someone's brain somehow, and say, 'OK, I'd like you to imagine an ocean beach scene or imagine looking at your mother's face.' And then we'll say, 'Imagine whatever you want to, and we're going to try to guess what you're looking at.'" 

Teenage years can warp the brain

Striking changes are possible in IQ and neuroanatomy

By Laura Sanders


A person's IQ can nosedive and climb sky-high during adolescence, while corresponding brain regions wax and wane in bulk, researchers report online October 19 in *Nature*. The study suggests that the IQ number given to a child is not immutable, as many researchers believe, says neuroscientist Richard Haier of the University of California, Irvine, who was not involved in the research.

Back in 2004, Cathy Price of the Wellcome Trust Centre for Neuroimaging at University College London and colleagues tested the IQs of 33 healthy boys and girls who were, on average, 14 years old. While the teens were in the lab, structural MRI brain scans measured particular brain regions.

About four years later, Price and her team invited the teenagers back. Overall, IQ scores held steady: Average IQs were 112 in 2004 and 113 four years later. But

when zooming in on individual teens, the researchers found that about a third had meaningful changes in IQ, and a handful showed dizzying climbs or plunges.

One person's IQ score plunged 18 points, enough to demote that person from genius status to merely above average. The retest also turned up an IQ gain of 21 points, which would elevate a below-average person to above average. Some people who scored high the first time around scored even higher later, and some low scorers scored even lower.

The IQ changes were accompanied by changes in the brains' gray matter, which includes nerve cells. Boosts in verbal IQ came along with denser gray matter in the left motor cortex, a part of the brain that's involved in speaking. And boosts in performance IQ, which measures abilities such as understanding pictures, were accompanied by denser gray matter in the anterior cerebellum, a part of the brain important for movement. 

245 U.S. measles
incidence in
per 100,000 1960

11.2 U.S. measles
incidence in
per 100,000 1990

0.01 U.S. measles
incidence in
per 100,000 2007

Measles spikes in U.S. and Canada

Countries report the highest numbers since the mid-1990s

By Nathan Seppa

Measles, a preventable disease that has been largely vanquished in the United States, continues to show up sporadically in the population as unvaccinated people traveling to other countries unwittingly bring back infections. New data reported on October 22 show that 2011 has been a bad year for this kind of spread, with the highest number of U.S. measles cases since 1996.

Other data indicate that many U.S. pediatricians are doing their best to keep these cases away from their patients, turning away families that refuse to have their children vaccinated — whether against measles or other diseases.

There have been 214 measles cases in the United States so far this year, says epidemiologist Huong McLean of the Centers for Disease Control and Prevention in Atlanta. Of these patients, 68 were hospitalized and 12 developed pneumonia. Roughly 86 percent of people who contracted measles were either unvaccinated or had unknown vaccination status, the CDC data show.

The measles influx has been highly sporadic, with 73 different people bringing in an infection, McLean says. Most were U.S. residents visiting Europe. “They’re having a big year in Europe, and we’re feeling the effects here,” she says, noting that Europe has reported 28,000 cases of measles in 2011 so far, many in France.

In Canada, Quebec province has had 759 cases, says Gaston De Serres, a physician and epidemiologist at Laval University in Quebec City. The 2011 toll in Canada as a whole is now 783, the highest since 1995.

The spotty measles outbreaks are a

far cry from the pre-vaccination days in the 1960s, when the United States could expect hundreds of thousands of infections and thousands of people hospitalized. But the numbers are notable compared with the past decade, which has typically seen no more than a few dozen measles cases annually in the United States.

“They’re having a big year in Europe, and we’re feeling the effects here.”

HUONG MCLEAN

When a measles outbreak is reported, standard public health measures are mobilized to limit the spread. For example, in Utah this spring, 184 people were quarantined when an unvaccinated student returned home from Europe with measles and

nine people became ill, according to epidemiologist Karyn Leniek of the Utah Department of Health in Salt Lake City.

At the clinical practice level, some doctors are taking a preemptive approach. Physicians Chris Harrison and Tom Tryon of the University of Missouri in Kansas City presented data on October 21 from a survey in nine states of more than 900 pediatricians. Of those, 21 percent stopped accepting appointments from families that refused to have their children vaccinated. In Minnesota that rate was only 1 percent, but in Iowa it was around 38 percent, Tryon says.

“There is a misperception regarding vaccines,” says Saad Omer, an epidemiologist at Emory University in Atlanta who has studied the vaccine refusal issue. Many younger parents, he says, “are coming of age in an era where they don’t see these diseases. But they hear of real or perceived adverse events from vaccinations.”

Resolving doubts about vaccination will require physicians to communicate with and counsel their patients, he says. “This issue is not going to go away on its own.” ■

MEETING NOTES

Bacteria, bacteria everywhere

The quality of hand-washing in restrooms isn’t up to par, epidemiologist Lennox Archibald of the University of Florida in Gainesville reported on October 21. A sampling of common surfaces and handles in public restrooms revealed substantial amounts of well-known bacterial culprits such as *Staphylococcus aureus* and *Escherichia coli*. Archibald’s team took swabs from four airplane restrooms and 18 restrooms in U.S. restaurants, offices, libraries, hotels and other public establishments, noting that many microbe-laden surfaces were those typically touched after hand-washing. “I don’t want the public to get paranoid,” Archibald said. “But I think in the current era of [methicillin-resistant *S. aureus*] and community-acquired infections, you just need to wash your hands carefully.” —Nathan Seppa

C. diff vaccine progresses

An experimental vaccine against the bacterium *Clostridium difficile* has cleared an early hurdle. The vaccine is designed to boost a person’s ability to produce antibodies against two toxins, dubbed A and B, made by *C. difficile*. The toxins cause colitis with fever, diarrhea and cramps. Researchers gave 72 adults three injections of the vaccine over 56 days in low, medium or high doses. Another 24 volunteers got placebo shots. Blood drawn six months after the last shot showed that nearly all vaccinated people developed an antibody response against toxin A; more than half did against toxin B, reported Ginamarie Foglia of Sanofi Pasteur on October 21. —Nathan Seppa

Molecules



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Nose divvies up smell sensors

Scent detector segregation suggests innate preferences

By Nick Bascom

Like birds of a feather, nasal molecules that respond to pleasant smells flock together, keeping their distance from sensor molecules that pick up unpleasant smells.

Sensor molecules, or receptors, appear to be organized according to the pleasantness (or unpleasantness) of the odors they sense, a new study finds. Locations in the nose that respond strongly to one fragrant (or putrid) aroma will respond strongly to other delectable (or repul-

sive) smells, Noam Sobel of the Weizmann Institute of Science in Rehovot, Israel, and colleagues report online September 25 in *Nature Neuroscience*.

The researchers inserted electrodes into 16 people's noses and then showered the volunteers with six different scents. Because certain odors provoked stronger responses at different locations in the nose, the research team was able to confirm previous evidence suggesting a variegated nasal receptor surface.

"We're not the first to find that," says Sobel. But he and his colleagues have added an important new wrinkle. "Not only are the receptors organized in patches, but the axis that best describes their organization is pleasantness."

This discovery sheds new light on a relatively poorly studied sensory organ. Compared with the eyes or ears,

scientists don't know much about how the nose works.

"It's interesting to see that the perceptual space would reflect itself on the peripheral level," says Mats Olsson of the Human Olfaction Research Group at the Karolinska Institute in Stockholm. Even more interesting, these results "may reflect an inherent pleasantness preference system" in the nose, he says.

An innate attraction to sugary smells and repulsion to acrid odors may have conferred an evolutionary advantage by helping newborn babies seek out the food sources they needed for survival.

With a clear physical map of nasal receptors — which is a potential outcome of this research, says Sobel — scientists can target the regions that respond to unpleasant smells, even blocking odors from binding on the receptor level.

Miracle fruit produces an acid trip

Berry turns on tongue's sweet sensors to low-pH flavors

By Rachel Ehrenberg

Scientists have finally explained how a little red berry makes just about anything, from the sourest lemon to the bitterest beer, taste as sweet as honey. A protein found in the fruit tickles the tongue's sweet-sensing machinery, its effects intensifying in the presence of acidic flavors like citrus and carbonated drinks.

Researchers and foodies alike have long known the effects of the miracle fruit (*Richadella dulcifica*). At flavor-tripping parties, guests will pop a berry then chew, chew and chew some more, letting the masticated fruit linger on the tongue. Then the sampling begins: Guinness tastes like a chocolate shake, Tabasco loses its sting and pickles lack their mouth-pinching tang. Lemons and limes gush with sweetness.



A protein in a berry known as miracle fruit stimulates the tongue's sweet sensors under acidic conditions, new research shows.

It hasn't been clear exactly how miracle fruit's active ingredient, a protein called miraculin, confers its sweetness. Now scientists in Japan and France report that miraculin's interaction with the tongue's sweet sensors depends on the acidity of the local environment. At a pH of 4.8 (water is neutral with a pH close to 7), the sweet-tasting cells respond twice as vigorously to miraculin as they

do at a less acidic pH of 5.7. At pH levels of 6.7 and higher, the protein seems to slightly shift shape, blocking the sweet sensors but not activating them. This explains why under certain conditions sweet foods may taste less flavorful after eating the berry, researchers led by Keiko Abe of the University of Tokyo report in the Oct. 4 *Proceedings of the National Academy of Sciences*.

In general, proteins — think of a nice rib eye — aren't known for tasting sweet. Plants usually pack their fruits with sugars to please the palates of animals so the critters will gobble up and distribute the seeds inside. But, in a trick of nature, some plants use protein instead of sugar to deliver a sweet punch, says sensory biologist Paul Breslin of Rutgers University in New Brunswick, N.J.

While miraculin packs a sweet wallop, the U.S. Food and Drug Administration hasn't approved the protein's use in food. And since it is a protein, it probably would fall apart if heated, making it a poor candidate for baked goods anyway, says Breslin. For now, it must make do being the limelight of parties.

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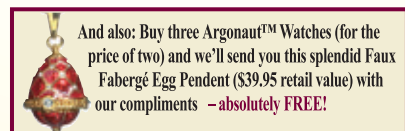
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Humans

Stone Age paint shop discovered

Finds suggest advanced manufacturing knowledge

By Bruce Bower

People concocted a colorful pigment of their imagination around 100,000 years ago. In a cave hugging what's now South Africa's coast, Stone Age humans stirred up a recipe for a red-hued paint that they stored in abalone shells and possibly used to decorate themselves or their belongings.

In a technological advance impressive for its time, these hardy foragers worked out a system for collecting components of a pigmented compound, producing the substance and storing it.

"Recovery of these toolkits shows that *Homo sapiens* at Blombos Cave 100,000 years ago had an elementary knowledge of chemistry and an ability to make long-term plans," says archaeologist Christopher Henshilwood of the University of Bergen in Norway. Abalone-shell paint holders found at the site represent the oldest known containers, he says.

Henshilwood and his colleagues excavated a pair of ancient toolkits. Pieces of ocher, soft rock containing iron oxides, were rubbed on stone slabs to produce a red powder that was mixed in a predesignated order with ocher chips, heated and crushed animal bone that acted as a binder, charcoal fragments, quartz grains and an unknown liquid, the team reports in the Oct. 14 *Science*.

Each toolkit consisted of several stone tools, some stained with red ocher, lying above and below an abalone shell partly coated with a red mixture. An animal bone with a red-tinged, spatula-shaped end found next to one shell probably served as a paint stirrer and utensil for dabbing paint on people or objects.

It's possible that this ancient substance was a glue used to attach wooden handles to stone tools, but the researchers found no signs of any sticky, gumlike substance in the mixture's remnants.

"It's tough to tell what they did with the stuff," says anthropologist Sally McBrearty of the University of Connecticut in Storrs. "I would call it paint." Whatever the Blombos toolkits were used to make, she says, they imply that



This abalone shell uncovered in Blombos Cave held paint made 100,000 years ago by southern Africans in a series of chemically distinct steps.

people of that time carefully planned out how to gather various ingredients that were mixed in a specific sequence to produce a compound.

Soil layers containing the toolkits included only a few stone implements and little food waste, indicating that paint making occurred over perhaps a couple of days before the cave was abandoned.

Although researchers need to test the effectiveness of the ancient Blombos recipe as a paint or some other product, says archaeologist Lyn Wadley of the University of the Witwatersrand in Johannesburg, "making compounds of any kind implies complex cognition."

Comparably sophisticated thinking characterized European Neandertals, who heated birch bark at high temperatures to make an adhesive for tool handles more than 100,000 years ago, says Stanford University anthropologist Richard Klein. [f](#)



Incas not always hostile

Contrary to their reputation as warmongers, South America's Inca rulers used a range of largely nonviolent takeover tactics, say anthropologists Valerie Andrushko of Southern Connecticut State University in New Haven and Elva Torres of the National Institute of Culture in Cuzco, Peru. Head injuries suggestive of warfare—such as the one the man at left sustained above his left eye during Inca rule—appear on only a small proportion of skeletons previously excavated at Inca-controlled sites located near Cuzco, the researchers report online September 30 in the *American Journal of Physical Anthropology*. From 600 to 1000, before the Inca came to power, only one of 36 individuals in the sample suffered war-related head injuries. During the Inca heyday, from 1400 to 1532, war injuries affected 17 of 219 individuals—7.8 percent of the total. Despite this increased rate, such injuries remained sporadic, Andrushko says, indicating that the Inca had a long history of nonviolent takeovers. —Bruce Bower [f](#)



Black holes offer new cosmic ruler

Active galactic nuclei may help measure extreme distances

By Nadia Drake

Astronomers have a new gadget in their cosmic toolbox capable of measuring distances to very faraway objects. The method uses active galactic nuclei, the bright, violent regions at the centers of galaxies, to gauge distances farther than existing cosmic yardsticks can reach.

Such a range finder is crucial for understanding how space, time and matter behave at cosmic scales and could help solve mysteries such as the nature of the dark energy believed to be accelerating the expansion of the universe.

For four decades, astronomers have tried to turn active galactic nuclei into cosmic mile markers. Now, scientists at the University of Copenhagen's Dark Cosmology Centre and their collaborators think they've worked it out. The brightness of an active nucleus is tightly related to the radius of a region of hot gases surrounding a central black hole. Knowing that radius, scientists can predict how intrinsically bright the nucleus should be. They then compare that value with how bright it appears, which depends on distance. Objects whose properties can be used to determine their intrinsic brightness are known as "standard candles."

"It's the radius-luminosity relationship that allows us to assume that these active galactic nuclei are standard candles," says Kelly Denney, a coauthor of the study, to appear in the *Astrophysical Journal*.

The stable of standard candles already houses phenomena known as type Ia supernovas and Cepheid variable stars, which have predictable luminosities but are good for measuring distances only to objects present when the universe was nearly 4 billion years old. Active galactic nuclei would extend that capability to objects at distances corresponding to when the universe was only 1.5 billion years old.

"Right now we rely so much on supernovas, it would be really nice to have independent verification of cosmological parameters," says astrophysicist Bradley Peterson of Ohio State University. "I'm really excited about this result."

A technique called reverberation mapping measures how long it takes photons kicked out of a black hole's immediate neighborhood to reappear after they've traversed the hot, gassy maelstrom surrounding the black hole. Because light travels at a constant speed, astronomers can determine the gassy region's radius. Then, the luminosity of the active galactic nucleus can be calculated.

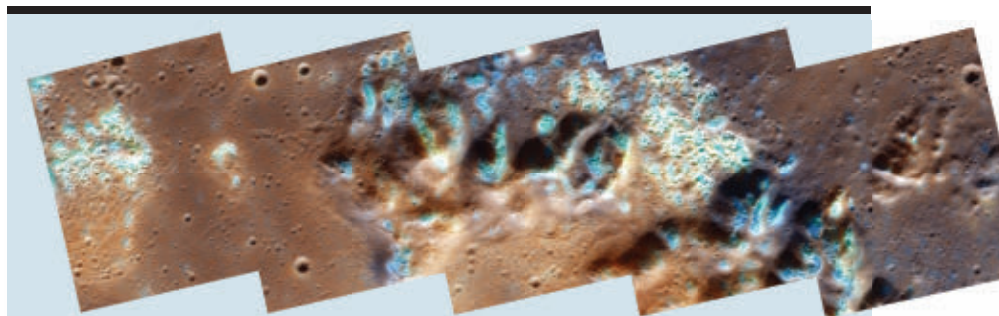
Until now, tightening the relationship between radius and luminosity has been tricky. Among other reasons, starlight from a host galaxy contaminated the

brightness measurements of its active nucleus. But the team had data from astrophysicist Misty Bentz of Georgia State University that corrected for the effects of the starlight, plus Denney's own precise measurements of radii.

"I think this paper is really clever," Bentz says. "But it needs a few improvements before it can be comparable to supernovas and stuff like that."

Peterson says the method will probably take a decade to catch on. But the team is optimistic that active galactic nuclei will become an accepted distance measure, since they are more numerous and more easily observable than existing standard candles.

"It could end up being one very large rung on the distance ladder," Bentz says. "It would put everything on the same scale, instead of using one thing to calibrate something else that's used to calibrate something else.... There's less potential for something to go wrong." ■



Mercury's puzzling pits

Hot and heavy little Mercury is warming to NASA's MESSENGER probe and revealing true planetary colors—such as the bizarre blue landforms (shown in enhanced color) tucked inside impact craters on the planet's surface. David Blewett of the Johns Hopkins University Applied Physics Laboratory in Laurel, Md., and colleagues report these puzzling scarlike pits in the Sept. 30 *Science*. The pits resemble sunken Swiss cheese holes—smooth, rimless depressions several meters to a few kilometers across. Irregularly shaped, the clustered hollows don't look purely volcanic but make some areas appear as though the planet's innards are leaking away, just what scientists speculate might be happening. They propose that impacts exposed unstable material from Mercury's interior to the planet's harsh surface. Whether baked off by the sun, blasted away by the solar wind, blown skyward by volcanoes or simply burped out, the stuff disappeared, leaving these pits behind. —Nadia Drake

Plague bug wasn't all that fierce

DNA analysis suggests living conditions fed Black Death

By Nick Bascom

Using methods that seem inspired by *Frankenstein* and *Jurassic Park*, scientists have analyzed the DNA of the ancient microbe responsible for the Black Death, the plague that killed half of Europe's population between 1347 and 1351.

An international team plucked bits of the bacterium *Yersinia pestis* from the teeth of four plague victims whose skeletons were excavated from London's East Smithfield cemetery in the 1980s. DNA analysis of those samples revealed that the medieval microbe has nearly the same genetic code as modern strains of the bacterium. The scientists found no evidence that genetic mutations helped the 14th century strain of *Y. pestis* notch such a massive death toll.

"As to why this killed so many people across Europe in 1348, there is no particular smoking gun," says geneticist Hendrik Poinar of McMaster University in Ontario, Canada, a member of the international team of anthropologists and evolutionary geneticists who published their findings October 27 in *Nature*.

Instead, a variety of nongenetic factors that are difficult to control probably helped the infectious disease spread and made it more lethal. "The climate was beginning to dip," says Poinar. "It got very cold, very wet, very quickly."

More rain meant less food for people who were already poorly nourished. Crowded cities also played host to millions of rats, which provided the fleas that carry *Y. pestis* a warm — and mobile — home. Weakened by hunger and stressful living conditions, medieval Europeans' immune systems weren't prepared to fight off the pathogen.

Though genetically similar to its ancestor, the modern strain of *Y. pestis* sticks almost exclusively to rodents and has trouble jumping from human to



Plague victims exhumed from East Smithfield cemetery by Museum of London Archaeology yielded samples of *Yersinia pestis* for genetic analysis.

human. Antibiotics and other advances of modern medicine may have eliminated the need for a pied piper, but in the age of the bird flu and other animal-carried diseases, puzzling out why humans proved so susceptible to the ancient strain of *Y. pestis* is still important, researchers say.

Reconstructing genetic information about pathogens such as *Y. pestis* will play an important role in revealing the character of other kinds of infectious diseases, says historian Samuel Cohn of the University of Glasgow in Scotland. He notes, however, that understanding how a particular disease affects people takes more than knowledge of its microbial cause. "A disease is a relationship between a pathogen and its host, and that relationship changes over time," he says.

Poinar says his team's method of analyzing ancient DNA may help public officials stave off future pandemics by helping predict how a life-threatening microbe will interact with the human immune system, treatments and even other microbes. ■

NEWS BRIEFS

Yogurt doesn't shift microbes

Eating yogurt doesn't produce lasting changes in the mix of microbes that live in the human intestine. That's the finding from a new study in which identical twins ate yogurt twice a day for four months. But Jeffrey I. Gordon of Washington University in St. Louis and colleagues found that yogurt did change the way microbes in the twins' and in mice's intestines used carbohydrates. Yogurt microbes boosted the ability of intestinal bacteria to break down complex carbohydrates found in fruits, vegetables and other foods, the researchers report in the Oct. 26 *Science Translational Medicine*. Many people eat yogurt in an attempt to change the mix of microbes in their intestines, but the new study suggests yogurt's benefits take a different form and last for only a short time.

—Tina Hesman Saey

Cancer protein's real shield

Scientists studying a protein that protects against breast cancer have been concentrating on the wrong end of the molecule. Reena Shakya of Columbia University and colleagues report that the function of what was thought to be the business end of the BRCA1 protein is dispensable. The front end of the protein, known as the RING domain, does perform the protein's enzyme activities. But experiments in mice show that the protein's tail end, which contains repeated amino acids that interact with DNA repair machinery, is what's important for guarding against tumors, the team reports in the Oct. 28 *Science*.

—Tina Hesman Saey

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Astronaut journey to Mars requires new age nibbles

By Alexandra Witze

Even an Iron Chef couldn't master what a food-centric cadre of NASA scientists do every day: Devise tasty, healthy meals for astronauts to take into low-Earth orbit and beyond — perhaps even to Mars.

Feeding people in space is harder than it sounds. Meals have to contain enough nutrients to keep the human body functioning in near-zero gravity. Slicing, dicing and stir-frying are impossible because ingredients float around. And now that NASA has set its sights on manned trips to Mars, packaged food has to last longer than ever to keep dinner from spoiling (*SN Online*: 7/26/10).

Fortunately, new research reveals how to make long-lasting space chow both possible and palatable. Plant scientists are testing new methods to farm crops in orbit, so that astronauts could snack on space-grown salad. Engineers are inventing new ways to package food to keep it fresh for up to five years.

Soon, NASA hopes to have a menu plan that would put Bobby Flay to shame.

Space food was born in August 1961, when cosmonaut Gherman Titov nibbled a few crackers while orbiting Earth. Seven months later U.S. astronaut John Glenn sucked applesauce from an aluminum tube on his way around the planet, even though NASA had no idea what it would do to his body. Later, Mercury astronauts flew with toothpastelike tubes and compressed cubes of nutrition.

“We learned that no one really wanted to eat that,” says Maya Cooper, a food scientist at Lockheed Martin in Houston

who works with NASA's Johnson Space Center. “As the crew came back, so did the meal-in-a-pill,” she said in August in Denver at a meeting of the American Chemical Society.

Astronauts aren't supposed to diet, so NASA began giving them tastier options. Apollo flights got hot water and bowls that could be used in space, opening up the possibilities of soups and gravies. By the 1970s, astronauts aboard the Skylab space station had their own refrigerator and freezer, which they could break into for filet mignon, lobster and other treats to reheat — the only time Americans in space have had such a luxury. Shuttle and later space station astronauts dined on thermostabilized foods that didn't require refrigeration.

But elaborate, packaged meals weigh a lot and create a lot of trash — not the streamlined approach NASA wants for long space voyages. Six astronauts eating 3,000 calories a day for three years, the length of a Mars mission, adds up to 20 tons of prepared food that would need to be launched, Cooper says.

So she and other scientists are exploring menus that combine packaged food with vegetables grown in space, known

Space eats

Lettuce and chard are among crops tested at NASA's Kennedy Space Center in Florida for future space gardens.



as “bioregenerative” crops because they generate oxygen as well as food.

Cosmic greenhouse

Cosmonauts have been growing food aboard Soviet and Russian spacecraft for decades, notes flavor chemist and space journalist Neil Da Costa. Their orbiting greenhouses have provided scallions and other greenery to accompany national foods such as borscht and quail eggs. The Russian segment of the International Space Station has a tiny garden, or “salad machine,” providing a few fresh vegetables to the crew.

American research into space crops has waxed and waned with available funding over the years, says Raymond Wheeler, a plant physiologist at NASA’s Kennedy Space Center in Florida. Early work focused on growing algae to produce oxygen and remove carbon dioxide from the craft. By the 1980s, scientists started to look more at growing food crops; in 1988 researchers at Kennedy set up a chamber with a tightly closed atmosphere to mimic a space growing environment, where they churned out wheat, potatoes and other major crops in a 20-square-meter garden. But yields were surprisingly low.

Today, Wheeler and his colleagues grow hydroponic test crops, from radishes to lettuce to cherry tomatoes, in smaller-scale greenhouses at Kennedy. Along with reducing trash and launch mass requirements, such crops would give astronauts a little diet variety and psychological lift. “It would add colors and textures and flavors and antioxidants — a combination of things that might be better than just straight vitamin supplements,” Wheeler says.

By tweaking the environmental conditions, the researchers are figuring out how best to get things growing. And as any gardener who tends crops in a closet knows, lighting is a key to success. LED lights use little energy and provide focused light in a narrow spectrum that is ideal for space crops, Wheeler has found. Experiments at Kennedy show that plants need a blue LED light, since blue light helps them orient themselves, combined with red



Packaged foods such as this shrimp fried rice get high marks for taste, but weight makes them costly to launch.

light to stimulate chlorophyll production. Adding a little green light naturalizes the appearance to human eyes, which would let astronaut farmers better assess whether a plant is sickly.

Growing crops in Florida is one thing; growing them in weightlessness is another. Fluids behave differently in near-zero gravity: The way the nutrient liquid bathes the roots changes, as does the way that the plant takes up the fluid. In a mock-up space habitat in Arizona, Wheeler’s team has been testing a system developed by ORBITEC, in Madison, Wis., that uses a “rooting pillow” with capillary action to wick moisture through roots.

In September, the team finished two weeks of successfully growing lettuce, mizuna greens, radishes and other plants brought from Kennedy. Next year, the researchers plan to tend the crops for a longer time and use more full-color light to better assess plant health and growth.

To hit the right balance between space-grown and Earth-made foods, Cooper and colleagues have fashioned three possible space menus: one relying mainly on bioregenerative crops, one with packaged foods and one with a combination of the two. The goal is to get the right calorie count and nutrition into foods that astronauts will actually eat. So far, her team has found that many of NASA’s packaged foods have more nutrition than thought, but with low caloric density because they contain so much water.

Cooper suspects that astronauts will continue to eat mainly packaged foods supplemented with crops they grow

themselves. But packaging becomes a problem on long trips. Plastics, foils and other existing space food wraps aren’t designed to keep goods fresher for longer than the 18 months NASA currently requires; a Mars voyage would need a five-year approval.

The long haul

One idea for long-term packaging is to improve the vacuum seal so that less oxygen is trapped within, where it can make the food break down and turn mushy. Another is to improve the packaging itself. For instance, NASA scientists are testing how cereal, peanuts and cottonseed oil do over years when wrapped in different plastic and foil materials. So far, a combination of plastic laminate coated with aluminum oxide works best, Cooper’s team reported in March in the *Journal of Food Science*.

Other work explores whether the natural freezer of deep space could be an obvious place to tuck frozen meals. Cooper’s team is testing how space food packets hold up in an ultracold freezer at -80° Celsius. One worry: The packaging might simply shatter from the cold over time.

Of course, even the best-preserved food isn’t worth much if the astronauts get tired of eating it. Routine space menus can cycle through the same set of meals every 10 days for months on end. “That’s a long time to eat the same stuff, especially if there’s a dish in there you don’t like,” Cooper says.

Witness the last-ditch creative cookery of the “Mars500” crew, six people in Moscow who have been living in an enclosed space for 520 days, simulating the psychological confinement of astronauts traveling to Mars. As they’ve become bored with cupboard offerings, the crew members have been fashioning some unusual dishes. A recent experiment: “pizzas” made out of onion crackers, canned fish and the occasional slice of Chinese bamboo. ■

Explore more

■ Mars500 website: www.esa.int/SPECIALS/Mars500

Darwin's Tongues



Languages, like genes, can tell evolutionary tales

By Bruce Bower

Talk is cheap, but scientific value lurks in all that gab. Words cascading out of countless flapping gums contain secrets about the evolution of language that a new breed of researchers plan to expose with statistical tools borrowed from genetics.

For more than a century, traditional linguists have spent much of their time doing fieldwork — listening to native speakers to pick up on words with similar sounds, such as *mother* in English and *madre* in Spanish, and comparing how various tongues arrange subjects, verbs, objects and other grammatical elements into sentences. Such information has allowed investigators to group related languages into families and reconstruct ancestral forms of talk. But linguists generally agree that their methods can revive languages from no more than 10,000 years ago. Borrowing of words and grammar by speakers of neighboring languages, the researchers say, erases evolutionary signals from before that time.

Now a small contingent of researchers, many of them evolutionary biologists who typically have nothing to do with linguistics, are looking at language from in front of their computers, using mathematical techniques imported from the study of DNA to wring scenarios of language evolution out of huge amounts of comparative speech data.

These data analyzers assume that words and other language units change systematically as they are passed from one generation to the next, much the way genes do. Charles Darwin similarly argued in 1871 that languages, like biological species, have evolved into a series of related forms.

And in the same way that geneticists use computerized statistical approaches to put together humankind's family tree from the DNA of living people and a

few long-dead individuals, these newcomers can generate family trees, called phylogenies, for languages. From existing data on numbers of speech sounds and types of grammatical structure, these phylogenies can point to ancient root languages and trace a path to today's tongues.

The new approach is making a splash — some would say a splatter — among mainstream linguists, who haven't exactly been anxiously waiting for advice from the fossils-and-genes crowd.

One recent study upends the traditional view that ancient languages did not evolve neatly, one into another and so on, arguing that modern tongues indeed contain telltale marks of how past languages moved across continents. Other results question the influential idea that grammar everywhere reflects innate properties of the human mind. Both investigations have appeared in high-profile science journals, drawing unprecedented publicity for explorations of speech sounds and word orders.

“Linguists spin a bit of a story with case studies of individual languages,” says evolutionary biologist Russell Gray of the University of Auckland in New Zealand, a pioneer of the phylogenetic analysis of speech. “Statistical methods can now be used to examine languages rigorously and on a global scale.”

Traditional language studies are still vital, he says, because they provide

the massive amounts of speech and grammatical information needed for statistical breakdowns.

Talk of ages

Auckland's Quentin Atkinson, a psychologist and colleague of Gray's, stands in the eye of the phylogenetic storm. In a controversial paper in the April 15 *Science*, Atkinson concluded that because African languages have greater numbers of speech sounds than others, language probably originated in Africa. A parallel argument from evolutionary biology holds that greater numbers of DNA alterations in African populations reflect humankind's African roots.

Atkinson's study grew out of observations by other researchers that the number of sounds, or phonemes, employed in words declines as populations shrink and increases as populations enlarge. A succession of smaller and smaller groups migrating away from a larger founding population should thus lose more and more phonemes with increasing distance from the point of origin, Atkinson reasoned. Settlers of new lands could come up with their own phonemic twists but would have less time to build up the big inventories of speech sounds found in larger, well-established populations.

Using vowel, consonant and tone inventories from 504 languages, obtained from an online database, Atkinson evaluated all possible

Heritable words A new breed of researchers are studying the evolution of language the same way that biologists study the evolution of species. A number of parallel features (some highlighted below) exist between these two seemingly disparate fields.

Biological evolution	Language evolution
Discrete heritable units such as nucleotides and genes	Discrete heritable units such as words and sounds
Biological mechanisms of replication	Teaching, learning and imitation
Natural selection	Social selection and trends
Genetic mutations	Innovation: mistakes, sound changes, slang
Homology: traits similar due to common origin	Cognates: words related via an ancestral language
Horizontal gene transfer	Borrowing
Fossils	Ancient texts
Extinction	Language death



SOURCE: M. PAGEL/NATURE REVIEWS GENETICS 2009

OPPOSITE PAGE: DAN PAGE; THIS PAGE, FROM TOP: MARK GILLOW/ISTOCKPHOTO; AIRSPEED/ISTOCKPHOTO

geographic origins of language, from Africa to South America, for signs of progressively declining phoneme frequencies as languages got farther away from a given source. Southwestern Africa emerged as the strongest candidate for an area where language got its start.

This pattern held after accounting for additional factors that alter phoneme numbers, such as word and phoneme borrowing among neighbors. “Languages apparently expanded out of Africa, with a loss of phonemic diversity along the way,” Atkinson says.

Global phoneme patterns say nothing about when Africans started talking, but other evidence does, he says. Seashell necklaces, engraved pigment chunks and other signs of symbolic cultural behavior (*SN*: 8/13/11, p. 22) date to between 160,000 and 80,000 years ago in Africa, a period when languages like those today must have first been spoken. Language expansions to other continents coincided with estimated migration times of genetic lineages out of Africa, Atkinson suggests.

Unsound speech

Many traditional linguists view Atkinson’s analysis as a strange, wayward statistical creature. Language, like people, may have flowered in Africa and spread from there, they say, but Atkinson’s proposed phonemic highway misleadingly races over language’s long and winding road. Too many factors affect how speech sounds get added and subtracted from contemporary languages to enable reliable evolutionary reconstructions, these linguists assert.

“Nothing of what’s known about language acquisition or change suggests that either fewer or more phonemes will

appear as people move around,” says linguist Lyle Campbell of the University of Hawaii at Manoa. Languages lose and acquire sounds for many reasons, including cultural adaptations to new habitats and conquest by foreigners.

Others suspect Atkinson’s analytical approach could be fruitful if informed by more sophisticated assumptions about how languages change. “I think many linguists would praise Atkinson’s contribution if it weren’t for the fact that his conclusions are so outlandish and contrary to linguistic intuition,” says linguist Michael Cysouw of Ludwig Maximilians University Munich in Germany.

One problem lies in Atkinson’s focus on frequencies of only one linguistic element, phonemes, to retrace language evolution. “That could be compared to tracking the history of vertebrates by counting the number of bones in their skeletons,” Cysouw says.

The database of phonemes consulted by Atkinson incorrectly gives greater weight to vowels and tones than to consonants, inflating the estimated number of speech sounds in western Africa where people speak languages that include clicks, Cysouw adds. In an analysis of a linguistic database corrected for such issues, he and his colleagues find the most phoneme-heavy tongues in North America. Languages of West Africa, New Guinea and Australia contain the fewest sounds.

Using this database, Cysouw’s team repeated Atkinson’s technique and found two separate geographic origins for language, one in East Africa and another in West Asia’s Caucasus region, with a large swath of the Middle East and South Africa also possible. Crucially, Cysouw’s analysis suggests that none of

these regions contain phoneme-rich languages that stand out as having far more speech sounds than any of the others.

Linguist Florian Jaeger of the University of Rochester in New York agrees with Cysouw’s criticisms. Many languages that Atkinson folds into his analysis belong to families that don’t display declining phoneme numbers among speakers located at increasing distances from Africa, Jaeger says. Statistical tests conducted by Jaeger and colleagues find that only three of the nine largest language families that Atkinson examined behave according to his hypothesis. The other five language families consist of tongues that gain phonemes with increasing distance from West Africa or show no geographic patterns in phoneme numbers, Jaeger’s team reports in an upcoming *Linguistic Typology*.

All in the families

Similar disagreements swirl around another phylogenetic study, published in the May 5 *Nature*. That paper challenges a long-standing linguistic consensus that universal patterns exist in the ways that languages assemble words into sentences, reflecting innate grammatical rules or predispositions in the human mind. Grammatical standards instead develop in distinctive ways from one language family to another, indicating that cultural forces have orchestrated language evolution, say evolutionary linguist Michael Dunn of the Max Planck Institute for Psycholinguistics in Nijmegen, the Netherlands, and his colleagues.

“We don’t find any evidence for a universal structure in language,” says Gray, a coauthor of the paper.

Dunn and Gray’s findings run counter to MIT linguist Noam Chomsky’s position that a small set of innate rules for putting words together limits how languages can change. The new investigation also defies an influential idea, championed by the late Stanford University linguist Joseph Greenberg, that certain structural patterns appear in all languages.

Researchers inspired by Greenberg propose, for example, that languages

Linguistic roots

By analyzing sound diversity, a researcher has pegged southwestern Africa as the source of all language. Shading shows how diversity decreases as distance from the source increases. Other analyses dispute that researcher’s finding.



in which verbs come before objects tend to use prepositions, as in “The man (subject) put (verb) the dog (object) in (preposition) a canoe.” Languages in which verbs follow objects tend to use postpositions, as in “The man (subject) the dog (object) put (verb) the canoe in (postposition).”

Using eight word-order features, Dunn and Gray’s team statistically reconstructed evolutionary trees of languages from four major families: Austronesian, Bantu, Indo-European and Uto-Aztecan. These families contain about one-third of the world’s roughly 7,000 languages.

The team found that languages within each family, but not languages across families, formed branching patterns with related sentence structures. Pairs of word-order features, such as a particular arrangement of numerals and nouns or of nouns and adjectives, almost always occurred together within single language families.

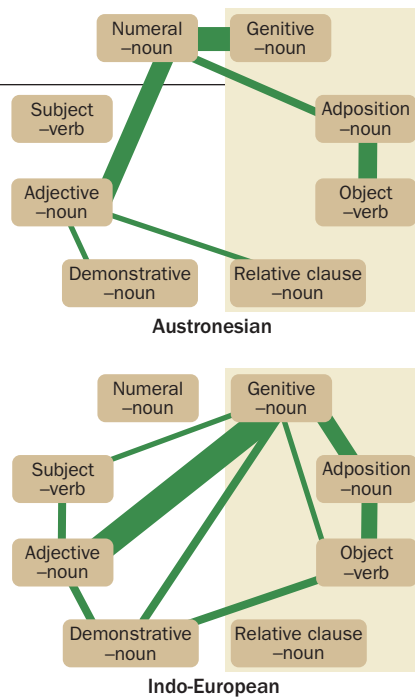
If universal properties of the human mind provide a framework for speech, then word-order patterns should have shown commonalities across language families. But this work suggests that speakers of, say, Indo-European and Austronesian languages — heirs of distinctive cultural traditions — take vastly different routes to ordering various types of words in sentences.

“This finding indicates that different cultures come up with their own, quite sensible word-order rules,” says evolutionary biologist Mark Pagel of the University of Reading in England, a pioneer of phylogenetic studies of language.

Borrowing of words and grammatical styles can cloud lines of descent, but Dunn’s analysis accounts for such non-evolutionary factors while ferreting out systematic word-order changes over time, Pagel says. “What makes phylogenetic findings so extraordinary is that, despite lots of uncertainty, we still see that language gets transmitted in evolutionary ways,” he says.

Universal kickback

Many linguists think that what makes Dunn’s phylogenetic study



No universals A study looking at how different word-order features depend on one another (line thickness indicates connection strength) suggests that Austronesian and Indo-European language families follow different word-order rules. Among four features expected to be strongly correlated (shaded background), only one link showed up in both families.

so extraordinary is a cavalier, data-challenged dismissal of the bedrock notion that talk everywhere shares common properties. Other work indicates that languages around the world pick from a limited menu of possible word-order choices, says MIT linguist David Pesetsky. Language families can’t opt for off-menu, one-of-a-kind word sequences, he says.

Consider verb-second positioning, in which the second word or group of related words in a main clause is always a verb. A verb-second structure appears in the following Dutch sentences: “I read this book yesterday,” “Yesterday read I this book” and “This book read I yesterday.” Among Germanic languages, which include Dutch, only English lacks a structure that always puts the verb second. (English speakers, for example, could say, “Yesterday I read this book,” a verb-third positioning.) Researchers have now identified verb-second tongues in West Africa and Brazil.

Languages everywhere can easily pop into a verb-second framework, Pesetsky proposes. Other verb placements

sometimes appear, as in English, but the menu of alternatives is limited; no languages that always put the verb third or second from the end have been found.

Sketchy and unreliable descriptions of many languages, including those in major families, also undermine Dunn’s work, in Pesetsky’s view. Word orders shift in some languages depending on the situation, another poorly understood phenomenon. “Languages are complex beasts,” Pesetsky says. “Even the best-studied ones have secrets.”

Furthermore, word-order changes occur so infrequently in documented languages that Dunn’s study could have lacked enough statistical power to identify word-order patterns shared by two or more language families, contend linguist William Croft of the University of New Mexico in Albuquerque and his colleagues, including Jaeger, also in an upcoming *Linguistic Typology*. Several other critiques of phylogenetic studies are set to appear in the journal.

Although many traditional linguists have so far greeted phylogenetic findings with the academic equivalent of a Bronx cheer — a derisive act with a grammar all its own — those with a statistical background suspect that the techniques those studies use have a future.

Many difficulties remain in constructing sophisticated scenarios of language change that can be tested with phylogenetic methods, Cysouw says, but it’s not an impossible goal.

Pagel is more hopeful: Statistical methods for testing models of DNA evolution with voluminous amounts of genetic data revolutionized molecular genetics more than 20 years ago and will do the same to linguistics. “Some linguists are very skeptical,” he says, “but others see that this approach has a ring of truth.”

Pagel knows, though, that it’s one thing to walk the statistical walk. It’s quite another to talk the linguistic talk, at least in a dialect that makes sense to most language researchers. ■

Explore more

■ Russell Gray’s language evolution site: bit.ly/SN_language

A spitting image of health

How saliva can help doctors diagnose disease

By Susan Gaidos

Rinse and spit. Someday soon, doctors may join dentists in issuing these simple instructions. And before leaving the office, you might know whether you're at risk for oral cancer. Additional tests on that same ptui may reveal whether you show signs of certain other cancers or diseases such as diabetes and Alzheimer's.

Saliva — the frothy fluid that helps clean the mouth, digest food and fight tooth decay — carries many of the same proteins and other molecules found in blood and urine. Scientists have long been interested in mining a person's mix of these compounds for clues to diagnosing diseases. Three years ago, these efforts got a boost when researchers completed a preliminary master list of the proteins found in spit — 1,166 of them.

Since then, scientists have nearly doubled the length of the protein list, while identifying changes in the salivary protein profile that are linked to disease. Other labs are delving into genetic material found in human saliva, looking for

variations in gene activity that might signal disease risk.

Already, studies show that diseases such as breast cancer, type 2 diabetes and Alzheimer's leave specific and identifiable signatures in saliva. Such biomarkers have also been found for Sjögren syndrome, an autoimmune condition that affects production of tears and saliva. And proteins known to be related to heart activity, including a handful whose levels are elevated during a heart attack, have also shown up in spittle.

Such findings — combined with the fact that saliva is quick, easy and painless to collect — may make spit the body fluid of choice to get an inside view of health, says David Wong, a dental expert at the University of California, Los Angeles who helped lead efforts to catalog spit's proteins. "As a screening test, saliva is a late-comer," Wong says. "But it's catching up. The science is maturing and developing."

Currently, most medical diagnoses are based on blood samples. That's because serum, the clear part of blood, contains high amounts of proteins,

genetic material and other molecules of interest. A bevy of studies have linked certain genes and proteins found in blood to specific diseases. But drawing blood requires trained clinicians and special equipment to handle and store the samples. Blood tests also mean frightening needles and long waits for test results.

Spit collection, on the other hand, is simple, if not glamorous. To get a sample, patients just drool into a vial or swipe a swab across their gums. Efforts are now under way to develop real-time detectors to diagnose disease from just a few drops of the spitter. Such test kits could be used in a dental office or emergency room and be carried onboard emergency response vehicles.

"The concept is that there are going to be various devices and capabilities that doctors, nurses and dentists — or patients themselves — can use to monitor health," Wong says.

To make that happen, researchers are working to validate the biomarkers they've already discovered and to test tools that can be used on the fly.

What's in there

Saliva is mostly water, but its fluid content doesn't come from the cola or the coffee that you drink. Instead, it comes from three major salivary glands located on the bottom of the mouth and sides of the cheeks, as well as smaller glands elsewhere in the mouth and throat. Within these glands, networks of capillaries surround the ducts that carry saliva to the mouth. As blood filters through the capillaries, specialized cells take up water, proteins and other molecules. This chemical brew gets mixed with the fluid produced by the glands, creating spit.

In 2004, Wong's team at UCLA, along with groups at the University of California, San Francisco and the Scripps Research Institute in La Jolla, received funding from the National Institute of Dental and Craniofacial Research to find out what is in saliva. The list of ingredients includes more than 2,200 proteins, collectively called the "salivary proteome."

About two-thirds of the proteins come from the salivary glands themselves. Some serve as protectors, Wong says, warding off microbes and other invaders that come into contact with the mouth. Other gland-produced proteins work to digest food, heal wounds or control the teeming hordes of bacteria residing in the mouth.

The remaining proteins come from

other parts of the body, such as the liver, muscles or heart, and filter in through the blood. Though these proteins probably serve no specific role in the mouth, researchers can pick up on them to find out what's going on in other parts of the body.

With that in mind, Timothy Griffin, a biochemist at the University of Minnesota's Twin Cities campus, is looking to see how saliva proteins differ between healthy people and those with cancer. Studies have shown that saliva in patients with cancer may contain unexpected proteins. Other times, a protein may change in its abundance, showing up in fewer or greater numbers as the illness progresses, or it might get chemically modified, changing in shape or function.

Protein changes associated with a particular disease can serve as biomarkers for that disease, Griffin says. For the last three years, his group has been working to suss out protein biomarkers for oral cancer, collecting saliva samples not only from patients already diagnosed with the disease, but also from people who face an elevated risk, such as those with an oral lesion in a precancerous state.

Griffin says the idea is to identify subtle shifts in the molecular makeup of saliva that signal the transformation from a pre-malignant state to full-blown cancer.

Last year, his group reported in *PLoS ONE* that changes in the abundance of two proteins — myosin and actin — occur during this transformation. The scientists are now gathering more samples to see if the differences hold true for large numbers of people.

Such early markers are crucial in diseases such as oral cancer, where progression occurs in only a small percentage of cases, Griffin says. "Doctors could continue to watch a premalignant lesion to see if it's at risk for transformation, and know when to intervene."

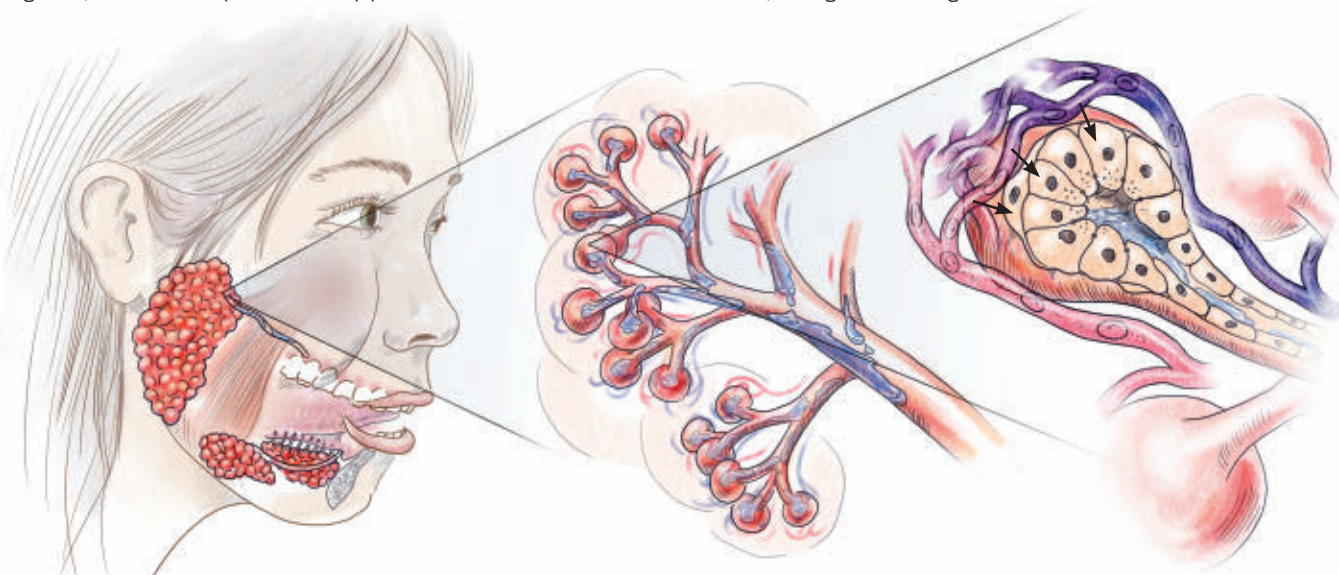
88%
Proportion of dentists willing to take saliva samples

56%
Proportion willing to take blood samples

Beyond the mouth

Griffin's group is also looking at ways to better analyze saliva proteins that originate outside of the mouth to see what's going on elsewhere in the body. The problem is, proteins that originate outside the mouth appear in saliva in quantities so small that searching for them becomes the equivalent of looking for a needle in a wet, stringy haystack.

Saliva's source Glands on the bottom of the mouth and sides of the cheeks make saliva and empty it into the mouth via ducts. Within the glands, networks of capillaries take up proteins and other molecules from the blood, adding them to the gland-derived fluid.



In a study published in March in the *Journal of Proteome Research*, Griffin and colleagues used a technology called dynamic range compression, or DRC, to sort through the content of saliva samples collected from women who had breast cancer, looking for low-abundance proteins associated with the disease.

DRC employs various biomolecules to bind to the different proteins found in saliva. Proteins that bind remain in the sample, and those that don't are washed away. Because proteins appearing in high numbers quickly saturate their binding baits, a large number are removed from the sample. Low-abundance proteins, though, bind fully to the bait and remain in the sample, boosting their proportion in the contents to be analyzed.

In the study, Griffin's group collected saliva samples from 10 healthy women and 10 women with metastatic breast cancer. A portion of the samples from each group were left untreated and analyzed for their protein content; the rest were analyzed using DRC. The researchers identified twice as many different low-abundance proteins in the DRC-treated samples.

Among those proteins, Griffin's group found a handful of biomarkers known from blood to be associated with metastatic breast cancer. "We knew that there were proteins in the blood that are diagnostic of these breast cancer patients," he says. "But we wanted to see if we could see them in saliva."

Griffin says the study serves as a proof of principle that saliva tests can detect proteins that change as a result



A dollop of saliva on a chip like this one can be analyzed for disease-related proteins by a portable detector.

of cancers in parts of the body besides the mouth. Such tests might someday be paired with other diagnostic measures, such as mammograms, to monitor women at high risk of breast cancer.

Saliva-based tests also hold promise as a screening tool for hard-to-diagnose diseases such as Alzheimer's. Last year, scientists at the Neurodegenerative Diseases Biomedical Research Center in Madrid, Spain, found increased levels of a protein known to form the toxic brain plaques associated with Alzheimer's in the saliva of Alzheimer's patients. The protein may help diagnose the disease at early stages, when therapies are more effective, the team noted in *BMC Neurology*.

Wong's lab is looking past proteins to ask what else in spit can be diagnostic. In recent years, the group has studied distinct bits of the genetic material messenger RNA in saliva. By focusing on this material, which carries the blueprints for protein synthesis, the scientists hope

to determine when and where genes are turned on or off in various types of cells and tissues, and then relate this information to disease. So far, results show mRNA signatures for pancreatic cancer and breast cancer, as well as oral cancer and Sjögren syndrome.

Wong's team is also looking at ways to diagnose disease by picking up on changes in the presence of microbial organisms that invaded the mouth.

"Not every disease will reflect itself through the proteins, and not every disease will reflect itself through RNA," Wong says. "If you want to look for biomarkers, the more targets you look at the better off you'll be finding those targets that will be of interest."

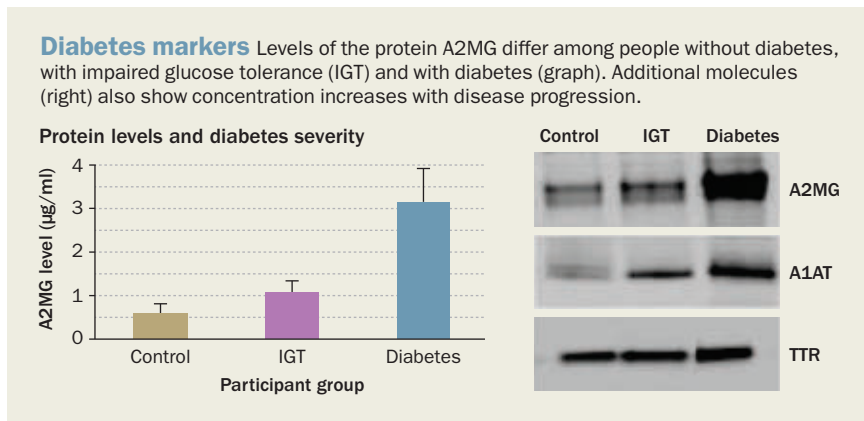
Tools of the trade

With numerous signatures of disease now under study, scientists are working to develop instruments to detect and analyze the molecules found in saliva.

Wong's group has designed a desktop device capable of simultaneously analyzing the protein and mRNA content of a sample within minutes. In a clinical trial, the device successfully detected both levels of interleukin-8, a protein associated with tumor growth and cell movement in numerous cancers, and levels of the mRNA that carries the blueprints for that protein. The study compared spit samples from 28 patients who had oral cancer with samples from 28 healthy people. Scientists could correctly identify patients with oral cancer based on elevated levels of these two biomarkers with 90 percent accuracy, findings published in 2009 in *Clinical Cancer Research* showed.

A dentist himself, Wong says that in the future dental offices might be equipped with such diagnostic devices, making dentists primary health-care providers. When patients come into a dentist's office, in addition to getting a teeth cleaning or denture adjustment, they could be evaluated for diseases such as osteoporosis or cancer, he says. No needle pricks or embarrassing urine cups needed.

Other groups are developing devices that can be used on the go. Chemist John



FROM TOP: RICE UNIV.; P. RAO ET AL./JOURNAL OF PROTEOME RESEARCH 2009

McDevitt of Rice University in Houston has developed a device, called a biotometer, that analyzes saliva samples, as well as other body fluids, on board emergency vehicles. Like programmers developing apps for an iPhone, McDevitt's team has individual test cards customized for specific health conditions. Each card can look for multiple biomarkers associated with that condition.

The battery-operated analyzer weighs in at just under five kilograms, making it light enough to transport from place to place. Working like an ATM machine, the device reads information on the disposable test cards inserted into it. Each card contains a series of wells packed with tiny detection beads that act as microsponges to collect the biomarkers of interest.

McDevitt and his colleagues are already using the device to analyze spit samples to find out whether patients with chest pain are suffering a heart attack. A drop of saliva obtained from a gum swab goes onto the appropriate test card and is placed in the analyzer. If the saliva sample contains troponin T, a protein characteristic of a heart attack (it is released into the blood when heart cells die), the detection beads will emit a fluorescent color. The analyzer spots that color glow in the beads and indicates that the patient is indeed experiencing a heart attack.

McDevitt says he hopes saliva-based tests can detect heart attacks faster and more accurately than traditional methods. Of the millions of patients who visit emergency rooms with chest pain each year, only about half of those suffering a heart attack are immediately diagnosed using the electrocardiogram. The others must undergo additional testing, which can take anywhere from 90 minutes to several hours to process.

With the biotometer, clinicians could make a diagnosis within minutes instead of hours, McDevitt says.

The device is now being tested in a clinical trial in Houston, directed by Baylor College of Medicine cardiologists, to see how spit samples work in conjunction with the EKG to diagnose cardiac arrest patients. A second study

Digging in

That frothy fluid in your mouth holds all kinds of clues to the body's happenings.

Drug use Saliva can reveal drug use, whether for therapy or recreation.

Hormones Commercial test kits gauge estrogen, testosterone and cortisol levels from saliva.

HIV The U.S. Food and Drug Administration has approved a test that looks in oral fluid for antibodies known to be present in people with HIV infections.

Age A recent study suggests that genetic clues in spit can pinpoint age to within five years.

Cancer Messenger RNA signatures for breast and pancreatic cancer have turned up in saliva.

Heart disease The protein troponin T in spit may pinpoint people having heart attacks.

is in progress on emergency vehicles in San Antonio.

Within spitting distance

Currently being manufactured by Force Diagnostics, a biotechnology firm in Chicago, McDevitt's device will be made available for real-world applications within the next few months. The first units will be deployed for blood-based testing, targeting HIV infection in Africa. A 12-minute field test will replace a two-hour lab version, McDevitt says.

Initial applications for spit-based tests using the biotometer and other devices may appear within two to three years. Oral disease and gum disease tests will probably come online first. Widespread screening for conditions such as pancreatic cancer, breast cancer or heart attack may occur within five years.

These developments and other findings from various labs are laying the groundwork for a dramatic change in disease treatment, McDevitt says, allowing clinicians to move from reactive to preventive medicine.

As part of the heart attack trial, for example, his group is collecting information on protein changes associated with the risk of future heart attacks. Current diagnostic methods can't easily detect the earliest stages of cardiac disease, he says, so the findings open up the possibility of using the biomarkers in saliva, or other body fluids, to detect health risks months or years before they become full-blown problems.

"I think we actually have a way to do

it," McDevitt says. "We're seeing this in our trials right now."

His optimism is supported by a study published in the Oct. 25 *Journal of the American College of Cardiology*. It showed that adjusting therapy to control levels of the protein NT-proBNP in the blood of heart patients could lower the rates of arrhythmias, stroke and heart attack. NT-proBNP is a known marker of cardiac distress, and is already detectable in spit. Because spit tests are cheaper and easier to administer than blood tests, clinicians might someday use them to monitor such patients.

But first, saliva-based biomarkers have to undergo vigorous tests to prove their reliability. That will require large-scale trials involving thousands of patients. Such trials are already evaluating markers associated with oral cancer, heart attack and Sjögren syndrome.

Obtaining scientific credibility is not the only hurdle to making saliva tests a clinical reality. If scientists can't address some social stigmas, they may as well be spitting into the wind.

Spit doesn't seem to have the respect of other body fluids, Wong says. "To say 'I spit on your grave' is considered a very negative statement."

He hopes the saliva-based medical tests will help others see the value of this slippery fluid. ■

Explore more

■ D.T. Wong. "Salivary diagnostics." *American Scientist*. January-February 2008.

World in the Balance

Robert Crease

There's more to the meter than a metal stick. Crease, a physicist and philosopher, traces the rise of the metric system, telling a colorful tale of global conquest driven by kings, revolutionaries, polyglots and privateers — and ultimately scientists looking for rulers that could outlast any physical object.

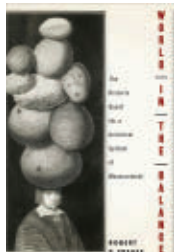
The French Revolution, argues Crease, set the stage for the first worldwide system of measurement. Spurred by calls for equality, France adopted standards for the meter and kilogram, which unlike previous systems were based not on royal body parts but on bits of metal.

Spread by wars and international commerce, these units would annihilate local ways of doing business. The Chinese ditched units of length based on the width of a knuckle, and brass figurines used to weigh gold dust in Africa became historic relics.

The story of standard units was shaped not only by sweeping forces

but by random quirks of history. The United States might already have adopted the metric system, suggests Crease, were it not for the kidnapping and death of an 18th century European emissary carrying an early set of metric standards.

As the tale moves into the 20th century, scientists link measurements not



to physical objects, but to unchanging aspects of the universe itself. The meter, for instance, is now simply the distance light travels in 1/299,792,458 of a second.

Only the kilogram defies this dream; it's still tied to a lump of metal in France. But Crease's book is well-timed. In October the keepers of today's standards met to rethink the unit of mass — the last hurdle in their quest for a truly universal system of measurement. — *Devin Powell*

W. W. Norton & Co., 2011, 317 p., \$26.95

The Most Human Human

Brian Christian

As anyone struggling to navigate a tangled web of automated customer service knows, most computers have a long way to go before they can impersonate a human. In this engaging and thought-provoking book, Christian describes his efforts to keep machines in their place.

The chapters follow Christian's preparations for a competition in which artificial intelligence programs try to pass as human — a form of a test proposed by Alan Turing in 1950. Turing said that a machine could be considered to “think” when it could convince human judges they're talking with another person. Each year computers get a little closer when they compete against humans in the Loebner Prize's “Most Human Computer” contest.

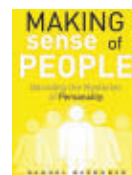


But an equally important prize is at stake, Christian says. The humans competing against the computers also vie for the “Most Human Human Award,” which in one case went to the most “moody, irritable and obnoxious” contestant.

Upon learning that the machines came close to out-humaning the humans in 2008, “a steely voice inside me rose up seemingly out of nowhere,” Christian writes. “*Not on my watch.*” Although the book is anchored by Christian's quest to defeat the machines, it often veers off on whimsical detours. For instance, Christian muses that the original “computers” were people — usually women who performed calculations. But today, “it is the *human* math whiz that is ‘like a computer.’”

A background in computer science, philosophy and poetry serves Christian well. His prose is cogent and quick, heartfelt and thoughtful. In other words, supremely human. — *Laura Sanders*

Doubleday, 2011, 320 p., \$27.95



Making Sense of People

Samuel Barondes

A psychiatrist describes how findings in personality research can be used in everyday life to understand others and improve relationships. *FT Press, 2011, 230 p., \$25.99*



The Best American Science and Nature Writing 2011

Mary Roach, ed.

Relive or discover non-fiction science writing from the last year on topics from captive orcas to organ selling. *Houghton Mifflin Harcourt, 2011, 384 p., \$14.95*



Fascinating Mathematical People

Donald J. Albers and Gerald L. Alexanderson, eds.

Interviews reveal people who have shaped mathematics, like “mathematician” Arthur Benjamin and Harold Bacon, who taught calculus to an Alcatraz prisoner. *Princeton Univ. Press, 2011, 328 p., \$35*



Better Than Human

Allen Buchanan

A philosopher examines biomedical enhancement — from improving memory to increasing stamina — and approaches to its future applications. *Oxford Univ. Press, 2011, 199 p., \$21.95*



Genentech

Sally Smith Hughes

A genetic engineering company's meteoric rise illustrates the development of the

biotech industry. *Univ. of Chicago Press, 2011, 213 p., \$25*

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Defining the human species

Having read “Humans benefited by interbreeding” (*SN*: 10/8/11, p. 13), I wonder if I have missed what, to me, seems a major change in the definition of “species.” I was taught that the attempted crossbreeding of animals of two different species could result in either no offspring or sterile offspring.

If modern humans carry genetic information from Neandertal and Denisovan ancestors, stemming from successful interbreeding that resulted in fertile offspring, why aren’t the Neandertals and Denisovans considered to be merely of a different race or breed rather than of a different species?

Alice Grover, Southbury, Conn.

Some anthropologists regard Neandertals as a subspecies of Homo sapiens and see the genetic evidence of limited interbreeding as supporting that view, but those anthropologists are in the minority these days. The majority of researchers today argue that Neandertals and Denisovans were separate species that managed to interbreed successfully with H. sapiens a small number of times. Biologists have a difficult time distinguishing between living species of primates and other animals in hybrid zones, where much interbreeding occurs, so debate about ancient hominid interbreeding — and about how to define a species — will probably continue. — Bruce Bower


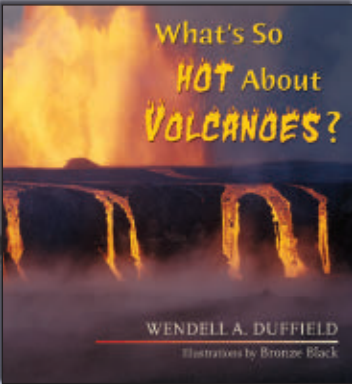
Chimps aren’t chumps

Regarding “Chimp has an ear for talk” (*SN*: 8/13/11, p. 16): Humankind has assumed all other living creatures are stupider than us. And yet experiment after experiment finds “higher cognitive skills” in other animals. We know that trees “talk” chemically, crows use tools, ants draw maps with pheromones. What an enormous change it would be if we adopted the far less arrogant presumption that all creatures possess in some manner the abilities *H. sapiens* does.

Scott Reuman, Nederland, Colo.

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

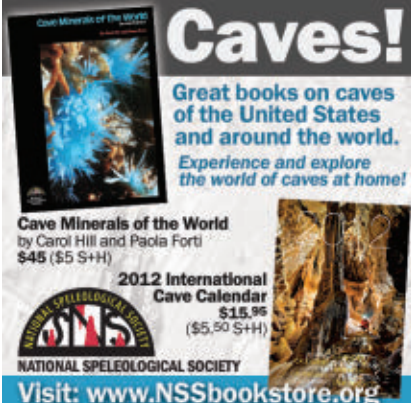
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From the Archive



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Recent estimates suggest the number of breeding pairs of peregrine falcons in the United States and Canada now exceeds 4,000.

UPDATE

Cornell project brings peregrines back to the eastern United States

No bird was more harmed by the overuse of DDT than America's peregrine falcon. One of the most voracious and skilled raptors, the long-winged, gray and white peregrine received concentrated doses of pesticides from its prey, and the eggshells of its chicks began thinning dangerously during the 1940's. Finally, the species vanished entirely from the eastern United States.

Now a team of ornithologists at Cornell University is trying to reestablish the eastern peregrine population, while uncovering secrets of the shy predator's behavior, physiology and breeding habits. Cornell's famous hawk barn, which can accommodate 90 large birds, is being converted into an artificial breeding ground for the falcons, earning it the local nickname Peregrine Palace. The National Science Foundation and the private Peregrine Fund support the work. Cornell professor Thomas J. Cade is project director.

Until very recently, breeding falcons in captivity was considered so difficult that few falconers would have believed regeneration of a lost population, or even supplying enough birds for sport, could be accomplished [through] breeding. But 20 young peregrines were hatched and reared at Cornell this year from three fertile pairs, and more are coming. — *John H. Douglas*

Peregrines made comeback, doing just fine today

By 1975, Cornell researchers had bred enough peregrine falcons in captivity to begin releasing them into the wild, where they could rebuild populations eradicated by DDT. Peregrine Fund researchers, field assistants and volunteers made the young birds new homes on cliffs and platforms built high above the ground. These human helpers monitored the falcons' progress and provided fresh meat until they could make it on their own.

The early days weren't easy, especially for caretakers who watched their baby birds being picked off by great horned owls or golden eagles. But supplementing wild nesting sites with releases in urban environments, where natural predators were scarce, proved promising.

Over the next two decades, the Peregrine Fund and other organizations released more than 6,000 peregrines throughout the United States and Canada. 1980 marked a turning point for the falcons, with the first natural reproduction east of the Mississippi River in more than 20 years. By the late 1990s, when major release efforts had waned, the number of nesting pairs in the whole of the United States and Canada had increased from 159 to 1,650. And in 1999, peregrines were

taken off of the endangered species list in the United States.

The peregrine falcon's recovery will probably go down in history as one of conservation's greatest success stories. Government officials, scientists and citizens came together to ensure that these birds' masked faces and high-dive displays would be around for future generations to appreciate. Today, there are more than 4,000 breeding pairs of peregrine falcons living throughout the United States and Canada.

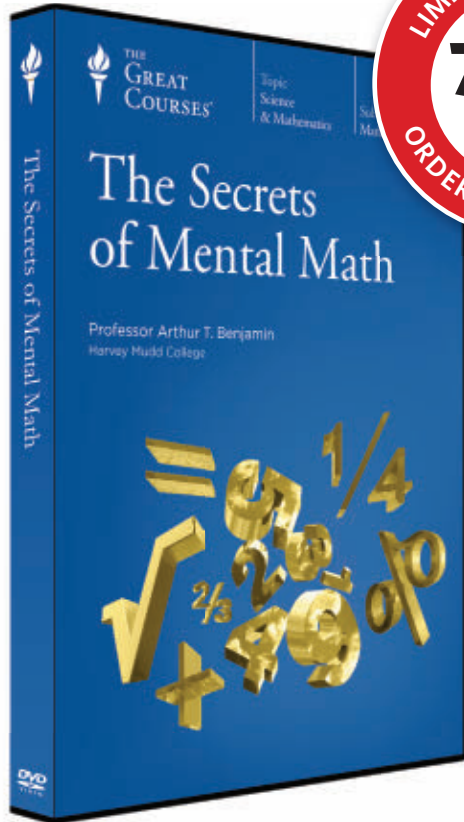
The Peregrine Fund closed its Cornell facility and is now headquartered in Boise, Idaho, where it continues to monitor potential threats to peregrines, such as last year's Gulf oil spill. Conservationists with the group have also turned their attention to other endangered birds, including aplomado falcons and California condors. — *Elizabeth Quill*

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