

FRONTIERS

THE NEWEST BREAKTHROUGHS IN SCIENCE AND TECHNOLOGY. BY DANIEL WEISS

Standing over a metre tall, emperor penguins are the largest species of penguin. These little princes and princesses still have a way to go before they grow into their feathers though.

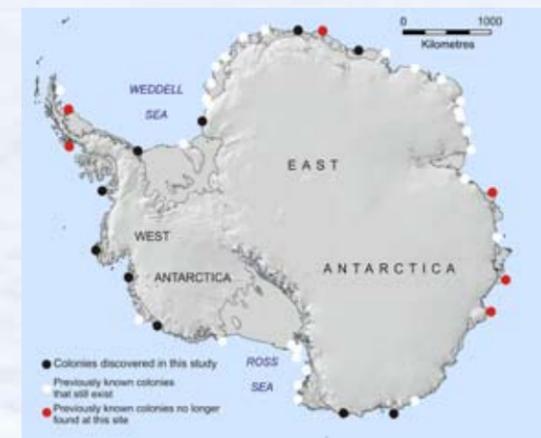
PENGUIN COUNT

High-resolution satellite imagery is helping scientists to complete the first thorough census of emperor penguins (*Aptenodytes forsteri*) in Antarctica. Previous estimates have been based on occasional serendipitous sightings, and a more precise enumeration will help determine how susceptible the birds are to climate change.

"There is a lot of concern that emperors may be vulnerable to loss of sea ice," says Dr Philip Trathan, a penguin ecologist with the British Antarctic Survey who is working on the census. "Having a good handle on

patterns of sea ice change and where the penguin population is distributed is going to be really important for understanding whether they are under any threat in the future. You couldn't do this without satellite imagery."

Each pixel in the images being used for the census represents just 60 centimetres by 60 centimetres on the ground, which means researchers can count the birds individually if they are standing on their own. If the penguins are huddling together, they appear as blobs, and statistical models can be used to determine how many birds fit in a blob of a given size. The census should be completed by the end of this year.



This map shows results from an earlier study co-authored by Trathan, which also used satellite images to locate breeding colonies.

PHOTO AND MAP: MINDEN PICTURES; BRITISH ANTARCTIC SURVEY

BREATHABLE COFFEE

Tired of slurping your coffee and chewing your chocolate? Now you can inhale them with **Le Whif**, a line of breathable food and beverages developed by Dr David Edwards, a professor of biomedical engineering at Harvard University in the United States.

Le Whif comes in lipstick-sized tubes. Just pop one open, stick it in your mouth, breathe in and ... taste. Edwards says that each puff is packed with flavour even though it contains less than a single calorie – plus a cup's worth of caffeine for the coffee version.

"We swallow quite a bit of what we eat without tasting it," he says. "With whiffing, you deliver to your mouth a small amount that is immediately dissolved on the tongue. You get a relatively big taste hit for a relatively small calorie hit."

In developing the breathable comestibles, Edwards drew on his experience with medical aerosols. Producing them involves transforming fresh ingredients into particles a few hundred microns in diameter – small enough to become airborne, but too large to enter the lungs.

In addition to coffee and chocolate, plans are afoot for a range of new flavours. "You can whif a lot of different foods – anything from cheese to mushrooms to steak," says Edwards.

Care to go out and breathe some dinner tonight?



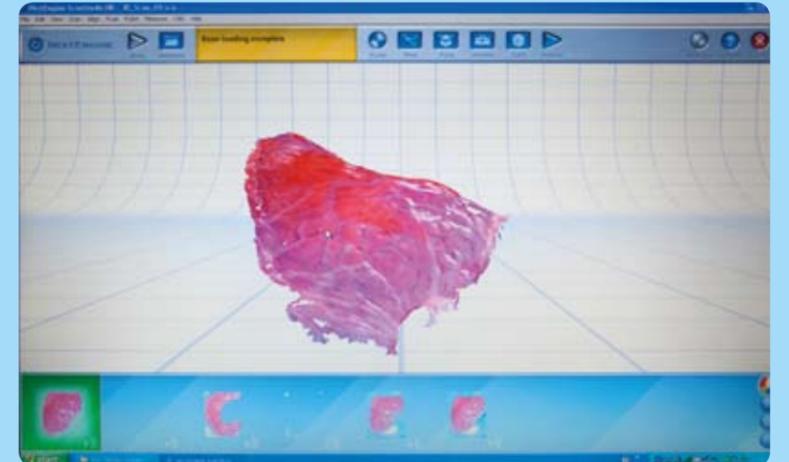
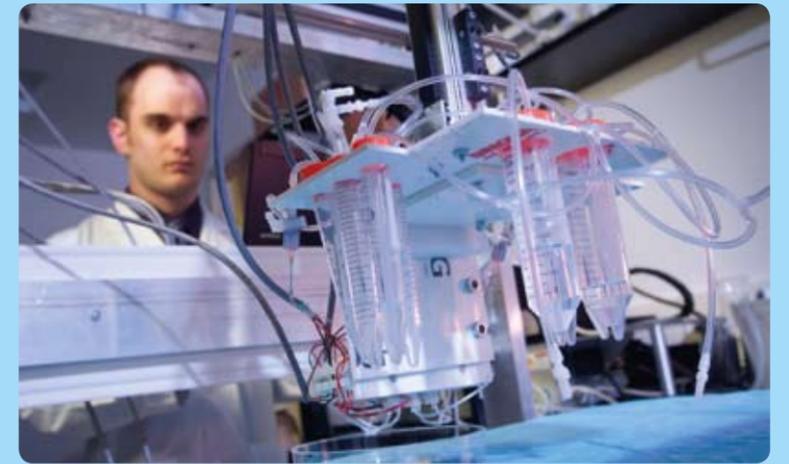
PHOTOS: PHASE ONE PHOTOGRAPHY (BREATHABLE COFFEE); PEEPOO (DISPOSABLE TOILET); CAMERAPHOTO ARTE, VENICE (SUPERSIZED SUPPER); WFSU SCHOOL OF MEDICINE (SKIN PRINTER)

DISPOSABLE TOILET

A biodegradable plastic bag called the Peepoo could make life much easier for the hundreds of millions of urban slum dwellers who lack access to a toilet. The bag, designed by Swedish architect and professor Anders Wilhelmson, serves as a single-use toilet that can be used anywhere. "It is almost like flush and forget," says Wilhelmson. "When you knot it, the smell is gone even more quickly than from a toilet."

The bag features a layer of foil that can be used as a glove to shuttle waste into the bag without contaminating the fingers. Once the bag is closed off by knotting up the opening, urea crystals inside break down waste into pathogen-free fertiliser that can be used to help grow food. "You not only get the toilet, you also get an asset," says Wilhelmson, who envisions a system in which Peepoo users can exchange their waste-filled bags for mobile phone credits.

The Peepoo has been well received in tests by residents of Nairobi, Kenya, and Mymensingh, Bangladesh, and will be more widely available in these areas and elsewhere soon. Daily production is currently limited to a few thousand bags, though by January 2011 this should ramp up to half a million. By 2014, Wilhelmson expects the unsubsidised price per bag to fall to a few cents.



SKIN PRINTER

A new device modelled after an inkjet printer which sprays skin cells directly onto burn wounds could foster more rapid and complete healing than conventional treatments such as skin grafts. The device, developed by researchers at Wake Forest University in the US state of North Carolina, has so far been tested only on mice, but results have been promising. "Mice with wounds similar to burn wounds healed in three weeks," says Dr Anthony Atala, director of the Wake Forest Institute for Regenerative Medicine. "Animals without the treatment took five weeks to heal."

To prepare for the treatment, pieces of skin harvested from the patient or drawn from a donor bank are dissolved, divided by cell type and then grown in the lab. The precise contours of the wound are programmed into a computer, and then the printer sprays skin cells onto it in layers. "We are reproducing the architectural organisation of the skin," says Atala.

The research has received funding from the US military, which is interested in finding better ways to treat soldiers injured on the battlefield. The technique could also be used to treat wounds other than burns, such as skin ulcers in diabetes patients.

SUPERSIZED SUPPER

With the increasing popularity of fast food and skyrocketing rates of obesity in the last few decades, it seems that people have been consuming larger and larger meals. But a new study finds evidence in artistic depictions of Jesus Christ's Last Supper that appetites have been increasing for far longer. Analysis of 52 such depictions from the last 1,000 years found that on average, food portion size had increased by 69 percent.

Dr Brian Wansink, director of the Cornell University Food and Brand Lab in the United States, chose to study depictions of the Last Supper because food is almost always present in them but is never the primary focus. "Artists include whatever they are most accustomed to in a similar dinner," he says. "It's sort of a food Rorschach test." To compare different depictions, Wansink used computer-imaging tools to adjust for the angle at which food was rendered and then calculated the ratio between its size and the size of people's heads. He argues that his findings document a case of art imitating life. "During this period, there's an increasing amount of wealth and [thus] an increased availability and affordability of food," he says.



FISH FRAUD

Do you know what you are eating? Researchers at New York City's American Museum of Natural History and Columbia University used DNA barcoding, a method in which specific points on a sample's mitochondrial DNA are compared with established reference points for a range of species, to identify fish in sushi served in 31 restaurants across the United States.

More than half of the establishments either misrepresented or could not identify the species of fish they used in tuna sushi. Five out of nine samples of white tuna turned out to be escolar, a fish unrelated to tuna whose sale is banned in Japan and Italy because it can cause diarrhoea and vomiting. And almost a third of the samples were heavily overfished bluefin tuna, though fewer than half of these were identified as bluefin on the menu. (Southern bluefin is critically endangered and Northern bluefin has been recommended for a trade ban.)

"A piece of tuna sushi has the potential to be an endangered species, a fraud or a health hazard," write the study's authors in the journal *PLoS ONE*. As reported, all three of these scenarios were uncovered during research. The team hopes that the DNA barcoding tests can one day be performed with a portable device as small as a mobile phone. Until then, you might want to stick to the salmon roll.



HEAT-SENSING GENE

A gene closely related to those that allow humans to sense spicy heat when eating wasabi and chilli peppers has been found to explain how certain snakes "see" their prey in the dark. Scientists have long known that snakes such as vipers, boas and pythons sense heat through an opening in the face called the pit organ, but its precise workings were a mystery until the discovery by researchers at the University of California, San Francisco, in the United States.

The researchers studied unusually large clumps of nerve cells in the snakes' brains that receive information from the pit organs and found that the TRPA1 gene was 400 times more active in these cells than in cells from other parts of their

bodies. When cells from these clumps were removed and heated, they became active starting at 28°C, slightly below the body temperature of prey such as mice. Some had conjectured that the pit organs sensed heat via infrared vision, but the results make clear that they sense it directly. No word yet on whether they can sense a chilli from afar.



WINGS OF DESIRE

Some birds woo with plumage, others with song. The male club-winged manakin (*Machaeropterus deliciosus*) gets the girls by shaking its wings faster than any other known bird.

Dr Kimberly Bostwick, an ornithologist at Cornell University in the United States, has studied the birds for over a decade. She scrutinised high-speed video of male manakins making their courting call and determined that they shake their wings 107 times per second.

Close examination of museum specimens revealed that the tip of one feather is thickened while an adjacent feather has seven ridges. When the bird shakes its wing, the thick tip slides over the ridges to produce a violin-like call. "They've ramped up and modified everything to transform their wings from a flying instrument to a musical instrument," Bostwick says.

The birds most likely sacrifice flying efficiency for musical virtuosity, but Bostwick says they aren't likely to suffer for it since they stick to a very limited range at specific elevations in the Andes.

PHOTOS: PHOTO RESEARCHERS AND JUAN CARLOS MUNOZ / NATUREPL.COM (DINO DEMISE); TIM LAMAN (WINGS OF DESIRE); GETTY IMAGES (FISH FRAUD); JULIUS LAB, UCSF AND TEXAS A&M UNIVERSITY-KINGSVILLE, NATURAL TOXINS RESEARCH CENTER (HEAT-SENSING GENE)



DINO DEMISE

What caused the dinosaurs to go extinct? For several decades, the primary suspect has been an enormous meteorite that landed in Chicxulub, Mexico, some 65.5 million years ago. However, alternate explanations including volcanic eruptions and multiple meteorite impacts have been proposed as well, so a group of researchers from around the world undertook an exhaustive review of the evidence. Their study, recently published in the journal *Science*, concluded that the culprit was indeed a single meteorite.

The 41 researchers examined 350 different points around the globe where residue from the Chicxulub impact has been found, all of which coincided with the mass extinction of the non-avian dinosaurs and many other species. The impact of the 10-kilometre-wide meteorite was so great, they say, that it caused rapid heating as well as massive earthquakes, tsunamis and landslides. In the longer term, atmospheric debris caused acid rain, global cooling and darkness, halting photosynthesis and disrupting the food chain.

"If you look at what an asteroid of that size would do to the atmosphere, you can make a compelling argument that most of the death and dying would have happened in the first year or so," says study co-author Dr Kirk Johnson, chief curator of the Denver Museum of Nature and Science in the United States.

The researchers rejected the argument that volcanic eruptions in India around the same time could have altered the climate enough to cause the extinctions. Likewise, they found no convincing evidence that multiple meteorite impacts were necessary to cause the die-off.



● 30 percent: Estimated portion of food wasted in the United States.

● 20 million: No. of overweight children under age five worldwide (2005).

● 11.13 kilograms: Chocolate consumed per person per year in Germany (2004).

● 12 kilograms: Coffee consumed per person per year in Finland (2007).

HIGH-SPEED TRAINING

China staked its claim to high-speed rail supremacy at the end of December when it launched service on the world's fastest train line. The Harmony Express covers the 968

kilometres between Wuhan and Guangzhou in less than three hours, for an average speed of 350 kilometres per hour. The previous speed champion, the French TGV, averages 278 kilometres per hour, while Japan's Shinkansen "bullet" trains plod along at a mere 243 kilometres per hour.

The key to the new line's record-breaking performance is that every stretch of track was engineered for speed, including 468 kilometres over bridges and 177 kilometres through tunnels. In addition, the route is entirely dedicated to high-speed traffic, which means no waiting



behind dawdling locals. "In terms of technology, there is no secret formula," says Dr Rongfang Liu, a rail expert at New Jersey Institute of Technology in the United States. "The technology closely resembles that of the Shinkansen."

The line, which cost a reported US\$17 billion and took four years to build, is the first link in what will soon be the world's largest high-speed train network. China's Ministry of Railways plans to complete 16,000 kilometres of high-speed lines by 2020, and the Wuhan-Guangzhou line will be extended north to Beijing and south to Hong Kong by 2015.

UNDERSEA ROBOT, RIP

ABE, one of the first autonomous undersea robots, was lost off southern Chile in early March. The robot had reached a depth of 3,000 metres when its transponders ceased communication. The intense underwater pressure most likely caused its demise by imploding the glass spheres it used for buoyancy.

The Autonomous Benthic Explorer, ABE's name in full, was designed and built at Woods Hole Oceanographic Institution in the US state of Massachusetts and first launched in 1995. It quickly impressed scientists by producing maps of the sea floor at resolutions higher than previously possible. Since 2004, it had specialised in exploring hydrothermal vents.

"ABE could go anywhere, track down new hydrothermal fields and photograph animals nobody had ever seen before in parts of the ocean nobody had ever explored," says Dr Chris German, a Woods Hole senior scientist who was on the Chile expedition.

On that fateful dive, its 222nd, ABE was attempting to locate and photograph yet another hydrothermal vent. It had been called out of semi-retirement because a newer robot was on another mission.



PHOTOS: DAN FORNARI / WOODS HOLE OCEANOGRAPHIC INSTITUTION (UNDERSEA ROBOT, RIP); ESA / NASA / JPL (VOLCANIC VENUS); STR / AFP / GETTY IMAGES (HIGH-SPEED TRAINING); R. STANLEY WILLIAMS / HP LABS (MEMORY BOOST); CORBIS (TELESCOPIC SITE)

VOLCANIC VENUS

Scientists have detected evidence of recent lava flows on the surface of Venus, suggesting that the planet is one of a small number of bodies in our solar system with active volcanoes. Other members of the volcano club include Earth, possibly Mars and Io, a moon of Jupiter.

"We estimate the flows to be younger than 2.5 million years and probably much younger, about 250,000 years or less, indicating that Venus is actively resurfacing," write the scientists, led by Dr Sue Smrekar of NASA's Jet Propulsion Laboratory, in the journal *Science*.

Venus has around 1,000 impact craters, a relatively small number, and scientists have long suspected that lava flows are responsible for covering other craters. In the early 1990s, NASA's Magellan spacecraft detected gravitational anomalies in a number of areas that suggested volcanic activity but placed no time constraints on when it last occurred.

The most recent evidence is drawn from the European Space Agency's Venus Express mission, which gathered data on the amount of infrared radiation emitted at three points of suspected volcanic activity. All three locations registered as unusually bright, suggesting that they were covered with fresh lava flows that have yet to be weathered by the harsh Venusian atmosphere.

This image of a circuit with 17 memristors – each of which comprises two layers of titanium dioxide sandwiched between two wires – was captured by an atomic force microscope.

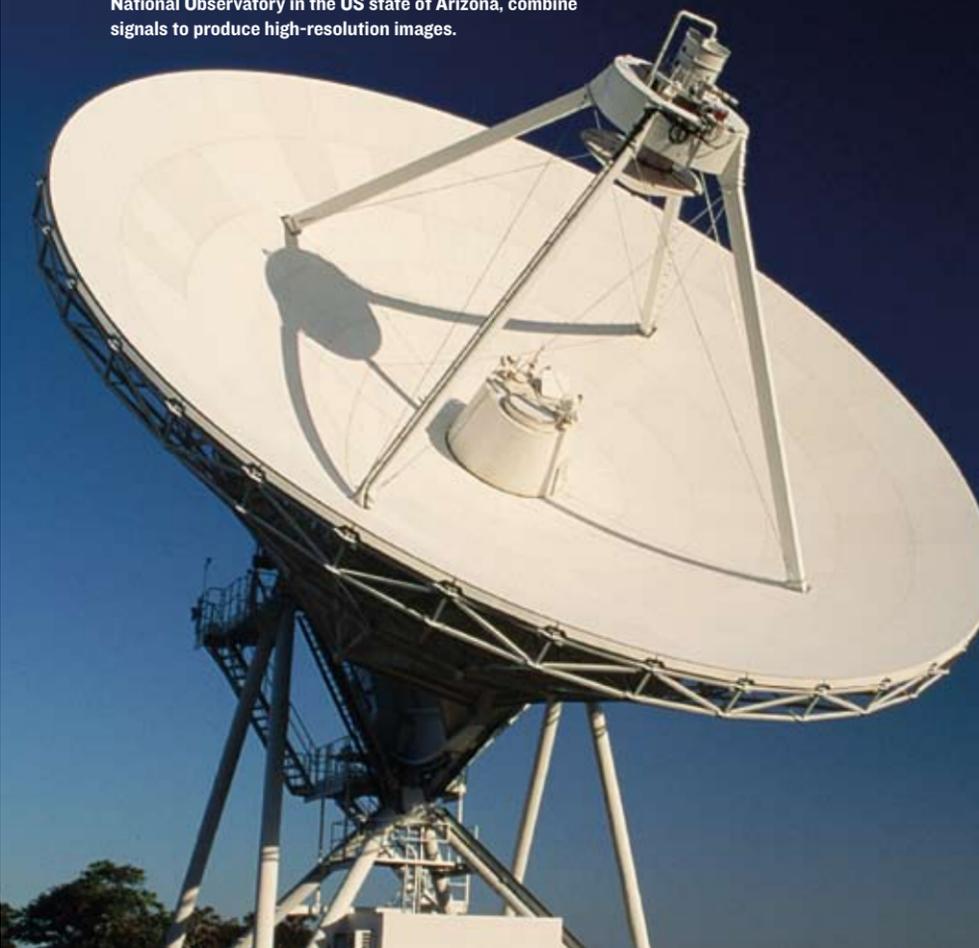
MEMORY BOOST

Imagine computers with vastly increased memory, speed and efficiency. This could be made possible by a new type of circuit – based on elements called memristors – being developed at Hewlett-Packard (HP). In the near term, researchers hope to produce memristor-based circuits as a competitor to flash memory.

While flash stores information by lodging electrons in tiny capacitors, memristors (memory resistors) do so by changing their resistance based on how much voltage passes through them. Since memristors can be made far smaller than capacitors and can be stacked in multiple layers far more easily, they have the potential for much higher memory density. "In about three years, we will be able to store twice as much information in the same area as flash will be able to in three years," says Dr Stan Williams, a senior fellow at HP Labs. The target at that point is 20 gigabytes per square centimetre.

Since memristors don't require mass storage of electrons, Williams adds, they are far less power-hungry and prone to memory loss than flash.

Radio telescopes worldwide, such as this one at Kitt Peak National Observatory in the US state of Arizona, combine signals to produce high-resolution images.



TELESCOPIC SITE

Cerro Armazones, a 3,060-metre mountain in Chile's Atacama Desert, was recently selected as the future site of the European Extremely Large Telescope (E-ELT). With a primary mirror 42 metres in diameter, the E-ELT will be the world's largest optical/infrared telescope. Construction is scheduled to start early next year and to be completed by 2018 at an estimated cost of a billion euros (US\$1.2 billion).

The chosen location boasts excellent conditions for astronomical observation. High above most clouds, it enjoys more than 320 clear nights per year. Its extreme desert aridity means minimal interference with light waves, especially in the infrared spectrum. In addition, the Chilean government has pledged to limit light pollution in the area, already scant since the nearest town is 120 kilometres away.