

2013 IN REVIEW

Shutdowns, lethal viruses, typhoons and meteorites — much of this year's science news seemed to come straight from the set of a Hollywood disaster movie. But there were plenty of feel-good moments, too. Space exploration hit a new high, cash poured in to investigate that most cryptic of human organs, the brain, and huge leaps were made in stem-cell therapies and the treatment of HIV. Here, captured in sound-bites, statistics and summaries, is everything you need to know about the science that mattered in 2013.

COSMIC MYSTERIES One of the year's most important cosmological results was an experimental no-show. The Large Underground Xenon (LUX, pictured) experiment at Sanford Underground Research Facility in Lead, South Dakota — 370 kilograms of liquid xenon almost 1.5 kilometres down in a gold mine — did not see any particles of elusive dark matter flying through Earth. But it put the tightest constraints yet on the mass of dark-matter particles, and their propensity to interact with visible matter. Theoretical physicist Matthew Strassler at Rutgers University in Piscataway, New Jersey, says a consensus is forming that hints of dark matter seen by earlier experiments in the past three years were probably just statistical fluctuations.

Whatever dark matter is, it makes up around 84% of the Universe's total matter, according to observations, released in March, of the Universe's cosmic microwave background (CMB) by the European Space Agency's Planck satellite. Planck's image (pictured) also strongly supports the hypothesis of inflation, in which the Universe is thought to have expanded rapidly after the Big Bang. A better probe of inflation might be provided through its predicted influence on how the polarization of CMB photons varies across the sky ('B-mode polarization'). That subtle signal has not been measured yet, but astronomers' hopes were raised by news of the first sighting of a related polarization signal, by the South Pole Telescope, in July. And another Antarctic telescope — the underground IceCube observatory — confirmed this year that the

high-energy neutrinos it has detected come from far away in the cosmos, hinting at a new world of neutrino astronomy.

SHUTDOWN! The slow decline of US federal support for research and development — spending is already down 16.3% since 2010 — reached a new nadir in October, when political brinkmanship led the government to shut down for 16 days. Grant money stopped flowing; work halted at major telescopes, US Antarctic bases and most federal laboratories; and key databases maintained by the government went offline. Many government researchers were declared 'non-essential' and barred by law from visiting their offices and laboratories, or even checking their official e-mail accounts. Since the shutdown's end, grant backlogs and missed deadlines have scrambled agency workloads.

Away from the deadlock in the United States, the European Union negotiated a path to a 2014–20 research budget of almost €80 billion (US\$110 billion), a 27% rise in real terms over the previous 2007–13 period. And funding in South Korea, China, Germany and Japan continued to increase (the United Kingdom and France saw little change). But Japan's largesse came with the clear understanding that its science investment would bring fast commercial pay-offs. Along similar lines, US Republican politicians are calling for the National Science Foundation to justify every grant it awards as being in the "national interest".

"WE WANT TO DO OUR JOB AND WE CAN'T, BECAUSE THE GOVERNMENT ISN'T DOING ITS JOB."

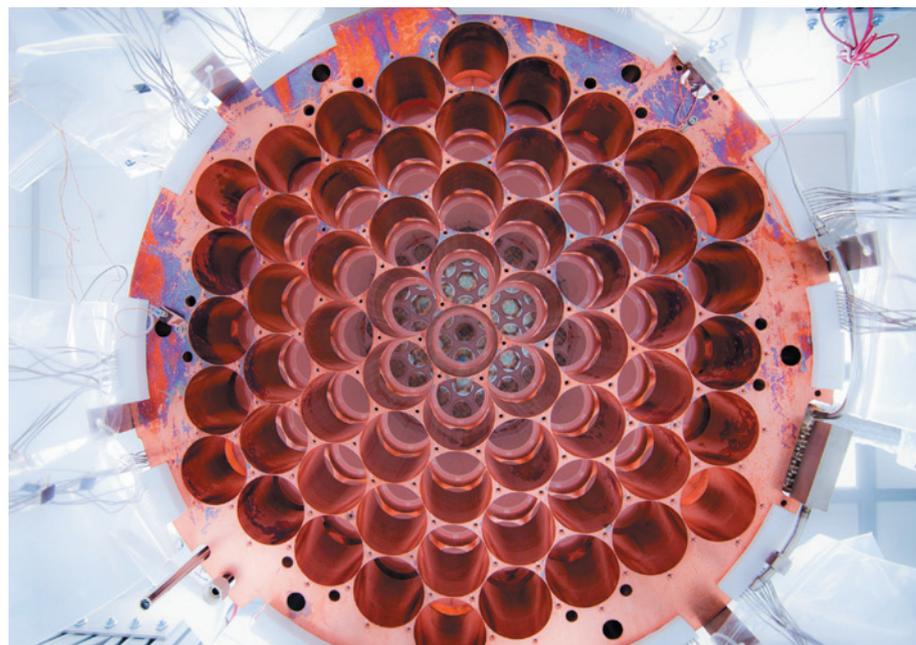
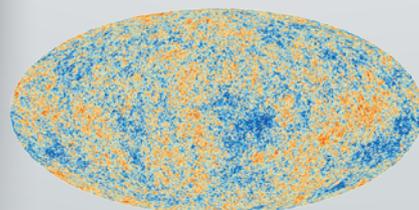
Boston University ecologist Robinson Fulweiler on the US government shutdown in October.



US workers came out in force against the shutdown.

13.82
billion years

AGE OF UNIVERSE AS ESTABLISHED BY THE PLANCK MISSION'S PICTURE OF COSMIC MICROWAVE BACKGROUND (BELOW).



The Large Underground Xenon dark-matter experiment, deep in a mine in South Dakota.

JAE C. HONG/AP

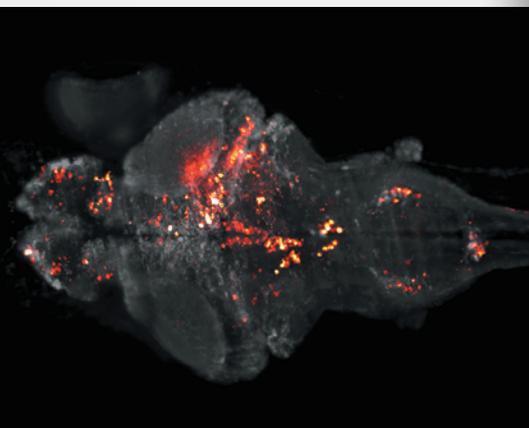
PLANCK: ESA/PLANCK COLLABORATION; LUX: CARLOS H. FAHAM

310 km h⁻¹

WIND SPEED OF TYPHOON HAIYAN, ONE OF THE STRONGEST ON RECORD.

400

CO₂ ATMOSPHERIC CONCENTRATION IN PARTS PER MILLION MEASURED AT THE MAUNA LOA VOLCANO IN HAWAII.



Individual neurons flash red in the brain of a larval zebrafish.



Typhoon Haiyan was snapped from the International Space Station as it raced across parts of Asia.

KAREN L. NYBERG/NASA

WAVERING ATMOSPHERE Apart from a landmark treaty to cut mercury emissions, signed by more than 90 nations so far, large environmental agreements were low on the political agenda this year. But no one expected to see nations actually regress. Japan renounced any near-term commitment to cut carbon emissions, Canada withdrew from the United Nations convention to combat desertification and the Australian government, elected in September, decided to scrap climate-change agencies and carbon taxes. At least the European Union agreed to end overfishing, reducing catch limits to a level that scientists say is sustainable.

In May, the atmospheric concentration of carbon dioxide temporarily surpassed 400 parts per million for probably the first time in human history. It was no surprise when the Intergovernmental Panel on Climate Change warned in its latest report, published in September, that climate change “unprecedented over decades to millennia” is altering natural environments in ways that could affect billions of people. Typhoon Haiyan’s record-breaking wind speeds demonstrated the destructive forces that the atmosphere can unleash — although the jury is out on whether and how much global warming contributed (see page 361).

There were small signs of promise: emissions fell modestly in recent years in the United States and the European Union, and global renewable power generation reached around 5,000 terawatt hours — exceeding the total estimated electricity consumption of China.

In research, the focus was on the apparent slowdown in the rise of global average temperatures over the past 15 years or so. A study published in August supported the idea that the ‘missing’ heat is being stored in the deep ocean and that surface warming will resume soon. But a November study suggests that the apparent

hiatus is a mere statistical artefact produced by incomplete coverage of Arctic regions in global temperature data sets. Stay tuned.

DECADE OF THE BRAIN US neuroscientists were excited and confused in equal measure this April when President Barack Obama unveiled the BRAIN Initiative — the field’s equivalent of a Moon shot programme. Those feelings are still running high: what started life as a brain-mapping proposal has rapidly mutated into a more general effort to jump-start new technologies for deciphering the brain, albeit one that lacks clear vision and funding goals. Together with the European Union’s €1-billion (US\$1.3-billion) decadal project to simulate the human brain with supercomputers, announced in January, Obama’s project reflects neuroscience’s gradual shift away from molecular and cellular studies towards research on how networks of neurons produce thoughts, memories and actions. “It’s starting to become possible to do the kinds of detailed, mechanistic analyses of larger circuits that were unimaginable ten years ago,” says Eve Marder, a neuroscientist at Brandeis University in Waltham, Massachusetts.

Among the technical advances helping to make these dreams reality this year was a calcium-sensing dye that researchers used to capture the first images of nerve cells firing in an entire vertebrate brain — that of a transparent zebrafish larva (pictured). Efforts to map the brain’s architecture got a big boost from CLARITY, a chemical treatment that turns opaque tissue clear and can expose neural circuits without the need for tedious brain slicing. Conventional neuroanatomy approaches also paid off with the completion of BigBrain, the first fine-scale, three-dimensional atlas of a human brain. And the introduction of false memories in mice by using light to stimulate

MISHA B. AHRENS AND PHILIPP J. KELLER

genetically modified neurons in the hippocampus suggested that the ability to precisely manipulate neural signals is not that far away.

VANQUISHING VIRUSES The crippling paralytic disease poliomyelitis is now endemic in only three countries, but 2013 offered a reminder that the path to eradication will not be smooth. Although the virus's geographical range in two of the endemic nations, Pakistan and Nigeria, was reduced, efforts to make further progress faced serious opposition, with assassinations of polio-vaccine workers in both countries. No new cases were seen in the third endemic area of southern Afghanistan. But the virus continues to cause sporadic outbreaks elsewhere, with more than 180 cases reported in Somalia. A polio outbreak also began in war-torn Syria, and wild poliovirus persisted in southern Israel, leading to mass vaccinations across the Middle East to try to

stop the virus becoming entrenched in the region.

This year also saw the emergence of a new foe: the H7N9 avian influenza virus. An April flare-up in China was quickly brought under control after live bird markets were shut down in the main cities affected (see page 362); the toll stands at 143 lab-confirmed cases and 45 deaths. Scientists are watching closely for any winter resurgence — a job made harder because the virus does not cause visible disease in poultry, and its reservoir species are not yet known. There has been less success in subduing the 'MERS' coronavirus, first reported in September 2012 (see 'A tale of two viruses'). A steady stream of cases has followed — 185 lab-confirmed or suspected, with 74 deaths by 12 December — most in Saudi Arabia, but also more widely in the Middle East and Europe. Researchers have criticized Saudi Arabia's lack of progress in tracking down routes of infection and animal sources — and the case count looks set to rise.

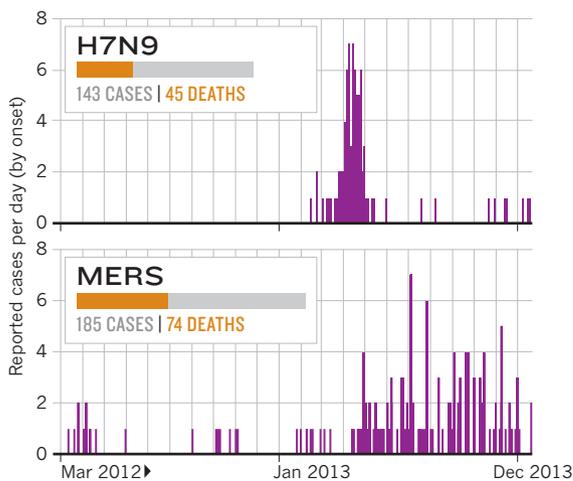
NOORULLAH SHIRZADA/AFP/GETTY



An Afghan health worker gives polio vaccine in an immunization drive earlier this year.

A TALE OF TWO VIRUSES

The outbreak of H7N9 avian flu virus was speedily controlled once live bird markets were identified as the route of transmission to humans. But the route for the MERS coronavirus remains elusive, and so a steady stream of new cases continues.



SOURCE: ANDREW RAMBAUT/WHO

69 years

TIME TAKEN FOR AN EXPERIMENT TO CATCH THE FALL OF A DROP OF TAR PITCH ON CAMERA (A DROP FORMS ONCE EVERY 7–13 YEARS).

-94°C

THE COLDEST TEMPERATURE EVER RECORDED ON EARTH. NASA SATELLITES PINPOINTED THE LOW IN ANTARCTICA, WHERE THE PREVIOUS RECORD OF -89.2°C WAS MEASURED IN 1983.

US \$13.6 billion

THE YEAR'S LARGEST SCIENCE BUSINESS DEAL SAW THERMO FISHER SCIENTIFIC OF WALTHAM, MASSACHUSETTS, BUY BIOTECH-EQUIPMENT MANUFACTURER LIFE TECHNOLOGIES OF CARLSBAD, CALIFORNIA.

THE CHELYABINSK METEOR

19 km s⁻¹

INITIAL SPEED OF METEOR
IN EARTH'S ATMOSPHERE.

12,000

METRIC TONNES, MASS
OF METEOR WHEN IT
ENTERED THE ATMOSPHERE.

500 kt

TNT ENERGY EQUIVALENT
OF RESULTING FIREBALL —
ABOUT 30 TIMES THAT OF
HIROSHIMA ATOMIC BOMB.

“WE WERE LUCKY.”

Astronomer Peter Jenniskens,
on the fact that no one was
killed when the Chelyabinsk
meteor hit Earth.



1908

LAST TIME SUCH A LARGE
OBJECT HIT EARTH.



A large piece of the Chelyabinsk meteorite is raised from the bed of Lake Chebarkul in Russia.

ANTON MELNIKOV/REUTERS/CORBIS

THE FINAL FRONTIER The planet-hunting spacecraft Kepler will be remembered for the tantalizing results it produced before going kaput in May: it located more than 3,500 possible extrasolar planets (see page 360). But when a second of Kepler's metal reaction wheels stopped spinning, scientists had to give up their dream of an extended mission for the NASA craft. Other space missions fared better. China, working towards constructing its second space station, saw three astronauts dock with an orbiting laboratory module. NASA's Curiosity rover continued to trundle along on Mars, notching up more than 4.5 kilometres on its odometer on the way to its ultimate mountain destination. As if that weren't enough for the red planet, both India and the United States launched Mars orbiters in November. And by December, China became only the third country ever to send a rover to the Moon.

NASA's Voyager spacecraft left them all in the dust. After a journey of 36 years and 19 billion kilometres, the Voyager 1 probe finally crossed the boundary into interstellar space. The actual transition took place in August 2012, but not until this year were project scientists confident enough to announce the final exit into the void between the stars. Next stop for Voyager 1: drifting past a star in the constellation Camelopardalis, about 40,000 years from now.

GENE PATENTS Nearly 20 years of US patenting practice was turned on its head in June, when the Supreme Court ruled that naturally occurring human genes could not be patented (see page 359). The aftershocks of that decision are only now being felt. The case, brought against medical diagnostics company Myriad Genetics, challenged the validity of patents on two cancer-related genes, *BRCA1*

and *BRCA2*, used to protect the company's proprietary tests for breast-cancer susceptibility. Shortly after the Supreme Court's decision was announced, several companies launched competing *BRCA1/2* tests at lower prices. But Myriad, of Salt Lake City, Utah, has already sued six of the firms, arguing that it holds other patents that protect the tests. The effects of the ruling have extended further. In October, a federal court judge cited the Myriad decision in overturning patents held by Sequenom of San Diego, California, on fetal DNA circulating in the blood of pregnant women, which the firm used in some of its prenatal screens. And lawyers report that US patent examiners are rejecting more patents than before on naturally occurring products such as genes and cells.

OPENING UP SCIENCE The drive to make science publications and data more open continued at a rapid clip this year. In February, the United States declared that the results of government-funded research must be made publicly accessible (rather than kept behind paywalls), but researchers have 12 months after publication to comply. By contrast, the United Kingdom wants articles to be made free immediately, although the next few years will see the country use a mixture of the two strategies. (One study found that half of all research papers published in 2011 can already be read for free somewhere on the Internet — the majority not at their publisher's website.) A rumbling undercurrent in the debate concerns the costs of this change, and exactly how much supposedly 'open' research can be reused.

Meanwhile, geneticists founded a global alliance to encourage wider sharing of data on DNA sequences and clinical information. In medical research, the UK government began a shake-up that could see patient medical

records shared with scientists. And regulatory bodies renewed their efforts to throw open the vaults of data from clinical trials. The European Medicines Agency led the push, but has been stalled by lawsuits from drug firms trying to prevent the release of some of their trial data.

PROGRESS ON HIV Prevention, treatment, cure: the three prongs of HIV research have begun to seem increasingly like part of the same mission. In March, researchers reported that very early antiretroviral therapy had cured an infant of HIV (see page 360), following a January study that found early therapy helps to keep the immune system intact. That prompted the World Health Organization to recommend that treatment begin earlier than previously proposed. But the barrier to cures is still formidable. In July, doctors said that stem-cell transplants had apparently cured two men of HIV — but by December, they revealed the virus had returned. Vaccinologists were buoyed by new structures of a key HIV protein; by the first study to track the development of a broadly neutralizing antibody in a human; and by the demonstration that vaccines based on these antibodies can protect monkeys against the virus. “The past year has been perhaps the most revealing thus far about HIV’s secrets,” says Bruce Walker of Harvard Medical School in Boston, Massachusetts.

STEM-CELL SUCCESS A decade ago, a huge fanfare greeted South Korean researcher Woo Suk Hwang’s claim — later proved fraudulent — to have created stem cells from cloned human embryos. This spring, the feat was accomplished for real, by researchers at Oregon Health and Science University in Beaverton. Yet it stoked much less excitement.

When Hwang was faking his results, hopes were high for therapeutic cloning: creating embryonic stem cells specifically matched to patients (see page 362). But few now think that cloning will be widely needed (although Oregon group leader Shoukhrat Mitalipov is working on clinical applications). This is not just because of concerns over destroying embryos, but also because the same end might be achieved using induced pluripotent stem (iPS) cells, reprogrammed from human adult cells. This year, a Japanese pilot study began

recruiting people with the eye disease macular degeneration — the plan is to transplant sheets of retinal epithelial cells, derived from iPS cells, into their eyes. And in November, Japan approved a regenerative-medicine law to speed up approval for iPS-cell and related therapies.

Meanwhile, clinics offering unapproved stem-cell therapies continue to play cat and mouse with regulators. This year, Italy’s health minister at first sanctioned a previously banned and unproven treatment for terminally ill patients (based on reinjecting stem cells from bone marrow), then offered money for a clinical trial — before reversing course on the advice of its scientific committee. In a final twist, the committee was ruled unlawfully biased — leaving the issue in limbo (see page 331).

IDENTITY PUZZLES In a year studded with revelations about spying and snooping, the question of what can be gleaned about identity from supposedly anonymized DNA data became an issue in genetics. In January, computational biologist Yaniv Erlich at the Whitehead Institute for Biomedical Research in Cambridge, Massachusetts, revealed how DNA in databases could be cross-referenced with public data to identify research participants. The ‘genome hacker’ followed this feat by creating a family tree of 13 million individuals going back to the fifteenth century from online genealogy sites.

DNA analysis continued to uncover clues to human ancestry. The 24,000-year-old remains of a Siberian boy suggested that up to one-third of Native American ancestry can be traced back to Europe, for example. Moving tens of thousands of years further back, examination of the Neanderthal and Denisovan genome sequences revealed large amounts of interbreeding between those human-like groups, as well as with modern humans and another unknown archaic population. And in another mystery, a 1.8-million-year-old fossil skull suggested that three separate hominin species may in fact be one. ■

Written by Richard Van Noorden, Jeff Tollefson, Erika Check Hayden, Lauren Morello, Helen Shen, Declan Butler, Heidi Ledford, Alexandra Witze, Eugenie Samuel Reich, Quirin Schiermeier & David Cyranoski



Five skulls found in Dmanisi, Georgia, suggest that varying hominin fossils may not be different species.

QUOTABLES

“IT’LL BE DIFFICULT TO COMPETE WITH THE READY AVAILABILITY AND VERY CHEAP COSTS OF HUMAN POOP.”

Tom Moore, a physician in Wichita, Kansas, on efforts to create synthetic pills of faecal bacteria, for curing gut infections.

“ARE WE THERE YET? YES, WE ARE.”

Space physicist Ed Stone confirms that the Voyager 1 spacecraft has finally crossed the boundary into interstellar space.



“MOST OF US HAVE LITTLE SENSE OF SOCIAL RESPONSIBILITY.”

Phillip Rogaway, a computer scientist at the University of California, Davis, who has sworn not to accept funding from the US National Security Agency and is critical of other researchers’ silence.

“IT JUST SEEMS LIKE A GRATUITOUS KILLING OF A MOSQUITO WITH A SLEDGEHAMMER.”

Genome policy analyst Misha Angrist, after the US Food and Drug Administration asked personal genetics firm 23andMe to stop marketing its products.

“I HAVE NEVER SEEN SO MANY PHYSICISTS FROM CERN SO WELL DRESSED BEFORE.”

Fabiola Gianotti of CERN on the lavish ceremony for the US\$3-million physics awards sponsored by Internet billionaire Yuri Milner.

TEST YOUR KNOWLEDGE

Q: THE OLDEST ANCIENT GENOME ON RECORD WAS PUBLISHED THIS YEAR, BUT WAS IT HORSE OR HOMININ?

Find out how much you can recall about the year in science with Nature’s end-of-year quiz

go.nature.com/izlxfn

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