

366 DAYS: the year in science

BY RICHARD VAN NOORDEN

Two of the biggest breakthroughs of this leap year relied on breathtaking amounts of data. The ENCODE project has generated 15 terabytes of data over the past five years to uncover the functions of human DNA sequences; CERN has stored 26 petabytes of data this year alone from its Large Hadron Collider, as physicists worked to prove the existence of the Higgs boson. But data were a source of controversy as well as discovery. Arguments raged over whether information about a potentially dangerous flu virus should be published, for example, and funders, publishers and researchers discussed how to make raw data — as well as peer-reviewed research — more openly available. Meanwhile, high-profile cases of dubious or fraudulent results offered a reminder that above all else, findings need to be trustworthy.

THE HIGGS AT LAST Applause, relief, joy and tears: in July, the world's largest physics experiment officially discovered the Higgs boson. It took more than 500 trillion proton collisions at the Large Hadron Collider (LHC) at CERN, Europe's particle-physics lab near Geneva, before physicists could confidently announce that they had seen a new boson with a mass of around 125 gigaelectronvolts. Nearly 50 years ago, theorists including Peter Higgs had proposed that a Universe-filling quantum field imparts mass to some particles. The Higgs boson — the embodiment of that field — is looking disappointingly mundane so far, with no convincing hints of behaviour beyond that predicted by the standard model of particle physics. Nor has the LHC spotted evidence for the additional particles predicted by supersymmetry, a theory that would extend our understanding of the subatomic world and help to explain mysteries such as dark matter.

GOING TO EXTREMES In this Olympic year, science provided plenty of its own records. After two decades of drilling, a Russian team broke through 3.8 kilometres of Antarctic ice in February to reach Lake Vostok, a huge body of water isolated for millions of years. Early sample analysis has not found any signs of the life many scientists thought the lake might host. As *Nature* went to press, a British team hoping to reach Lake Ellsworth, one of the continent's other subglacial lakes, was battling technical problems with the high-pressure jet of hot water used to bore through the ice. Film director James Cameron, meanwhile, became the first person to dive solo to the deepest spot on the planet: the bottom of the Mariana Trench, almost 11 kilometres deep. Just as gripping — though less scientifically valuable — was skydiver Felix Baumgartner's jump from more than 39,000 metres above New Mexico, breaking the speed of sound and a height record held since 1960.

2012 in review



GRAHAM STUART/AFP/GETTY

Vindicated: Peter Higgs's prediction gained weight this year.

But not every record-beating attempt was successful. After six years of trying, the US\$3.5-billion US National Ignition Facility in California — the world's most powerful laser — failed to meet its target of achieving 'ignition', a fusion power milestone in which a small pellet of hydrogen isotopes blasted by the laser would generate as much fusion energy as the beams put in.

RETHINKING ENERGY Nations' energy policies are continuing to shift in the wake of last year's nuclear disaster in Fukushima, with Japan outlining options for a future almost free of nuclear energy. The country switched off its last operating nuclear reactor for maintenance work in May, and faced widespread public protests against turning any reactors back on — although it did manage to restart two in July. In Europe, stress tests of more than 140 reactors concluded that widespread safety

172 ▶ NUMBER OF PAPERS IN WHICH YOSHITAKA FUJII IS THOUGHT TO HAVE FABRICATED RESULTS

392.9 ▶ ATMOSPHERIC CONCENTRATION OF CARBON DIOXIDE (IN PARTS PER MILLION) — A RECORD HIGH



Superstorm Sandy ravaged New York in October.

upgrades are needed. The US Nuclear Regulatory Commission, meanwhile, granted a licence for a plant that uses lasers to enrich uranium for nuclear fuel, a technology that some fear could enable bomb-makers to covertly enrich uranium. Countries also continued to explore unconventional sources of gas and oil to keep the lights burning and cars on the road. The United States proposed rules for the booming shale-gas fracking industry, which has enabled the US electric-power industry to shift 10% of its generating capacity from coal to gas. According to the International Energy Agency, the United States is also on course to be the world's largest oil producer by 2020, and almost self-sufficient in energy by 2035. But there were reminders of the dangers of searching for new oil reserves. Shell was unable to begin its drilling programme in the Arctic sea after damage to drilling vessels, and BP was hit by US\$4 billion in criminal fines relating to the April 2010 Deepwater Horizon

oil accident in the Gulf of Mexico. The fledgling clean-energy industry had its own problems: lithium-battery maker A123 Systems of Waltham, Massachusetts, went bankrupt in October as the market for electric cars remained small.

Curiosity's arrival on Mars was cause for celebration at NASA.

DATA ON DISPLAY Science, famously, self-corrects. By March, researchers had firmly scotched last year's suggestion that neutrinos might travel faster than light, and a number of experiments had refuted the 2010 claim that a bacterium can use arsenic in its DNA. But correction does not always come so quickly: when studies are hard to replicate, bias or error can linger for years. Anaesthesiologist Yoshitaka Fujii and nutrition researcher Eric Smart were both censured this year for decades of misconduct that had gone undetected until relatively recently, and psychology came in for particular criticism after a number of accusations of massaged data led to some high-profile resignations. Scientists worried more generally about the issue of irreproducible results and set up efforts such as the Reproducibility Initiative to get independent labs to replicate high-profile research. The idea that scientists should communicate and publish their data more openly also gained momentum. High-profile online open-access journals such as *eLife* and *PeerJ* launched, and the open-access movement made headway in Britain, where government and private research funders said in July that they would pay for papers to be made publicly accessible from April 2013.

THE ROVER HAS LANDED "It's the wheel! It's the wheel!" came the cry, as NASA scientists saw the first images of their Curiosity rover on the surface of Mars, where a hovering sky crane had gently deposited it. Since landing at Gale Crater in August, Curiosity has provided startling images and analysis of the Martian surface and atmosphere, but has not yet found any methane or organic molecules that might hint at

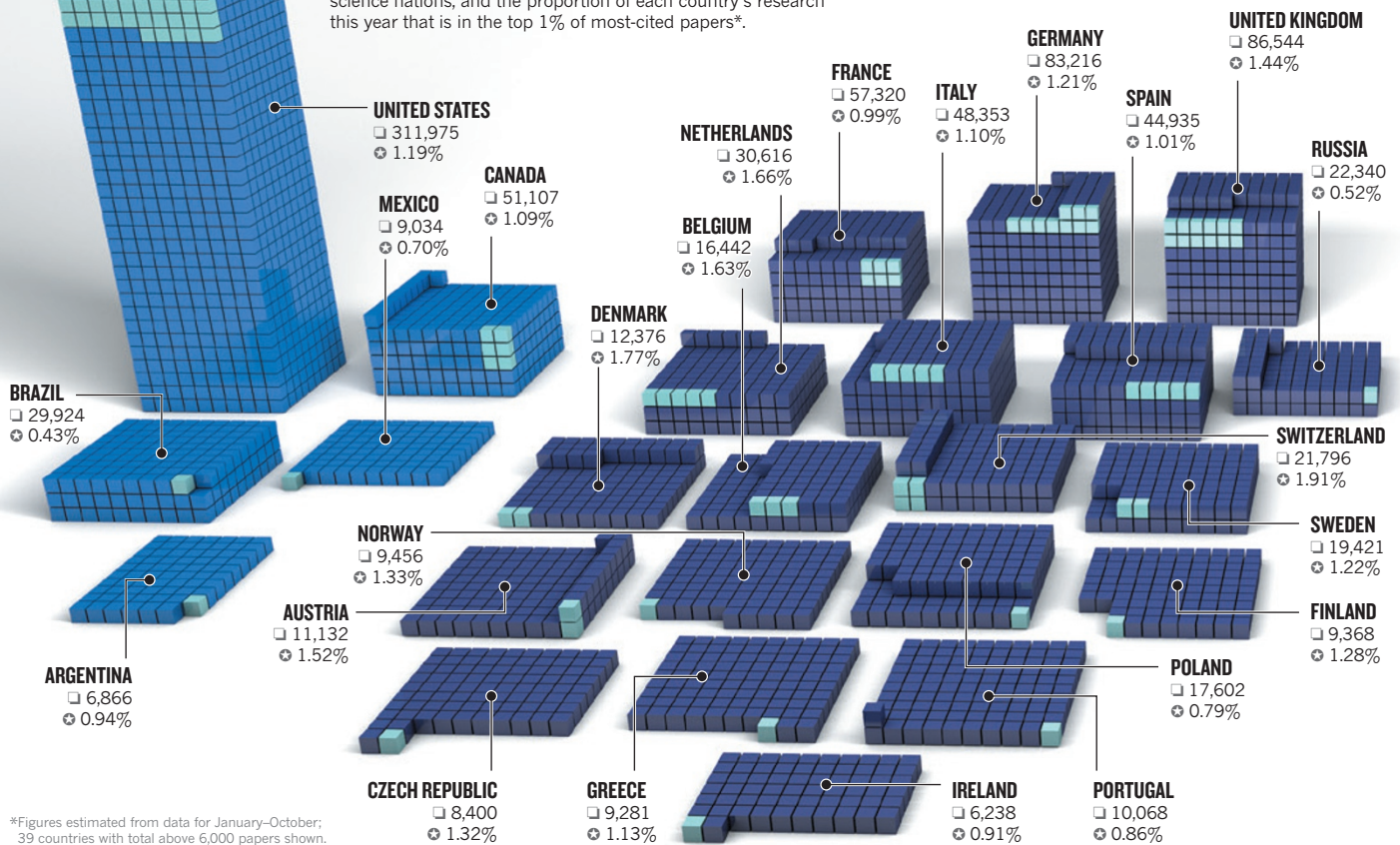
NATURE.COM
For an interactive
look at the year in
numbers:
go.nature.com/xrggmf

1,640 ▶ NUMBER OF
GENOME-WIDE
DATA SETS IN
ENCODE

2,932 ▶ NUMBER OF AUTHORS ON THE
ATLAS COLLABORATION PAPER
THAT ANNOUNCED THE
DISCOVERY OF THE HIGGS

SCIENTIFIC PAPER TRAIL

Number of research papers published in 2012 by leading science nations, and the proportion of each country's research this year that is in the top 1% of most-cited papers*.



*Figures estimated from data for January–October; 39 countries with total above 6,000 papers shown.

the presence of life. Outside the Solar System, new planets swam into focus thanks to the eagle-eye of the Kepler space telescope, which has now racked up some 3,000 candidate new worlds. Earth-based scopes played a major part, too, discovering an Earth-sized exoplanet in our neighbouring star system, α Centauri, a mere 1.34 parsecs (4.4 light years) away. Among space successes, NASA's Dawn craft found evidence of water on the asteroid Vesta, and China sent its first female astronaut, Liu Yang, into orbit. But it was a private firm, not a government, that made the year's headline launch: in October, SpaceX sent its capsule Dragon on the first commercial resupply mission to the International Space Station. The craft has been so successful that the company, based in Hawthorne, California, is even considering a trip to Mars.

THE EARTH UNDER PRESSURE The summer's dramatic melt of sea ice in the Arctic set a record that exceeded the predictions of climate models, and the United States faced its most extensive drought in half a century. But for many east-coast Americans it was Superstorm Sandy, in late October, that came to embody the nebulous threat of global warming. The storm, which caused \$50 billion in damage, triggered discussion that focused more on how to adapt to increasingly likely weather extremes than how to prevent climate change. Global talks on the environment were overshadowed by economic concerns. At June's United Nations Earth Summit in Rio, developing countries argued against constraining their growth, and rich countries were reluctant to pledge more development aid. Similar political inertia hit climate talks in Doha in December, although delegates did agree to extend a weakened Kyoto Protocol to 2020. Individual countries did more: Mexico set legally binding emissions cuts in April, for example. In Brazil, the rate of deforestation in the Amazon fell to another record low this year, although in October the country passed

Lonesome George died in June.

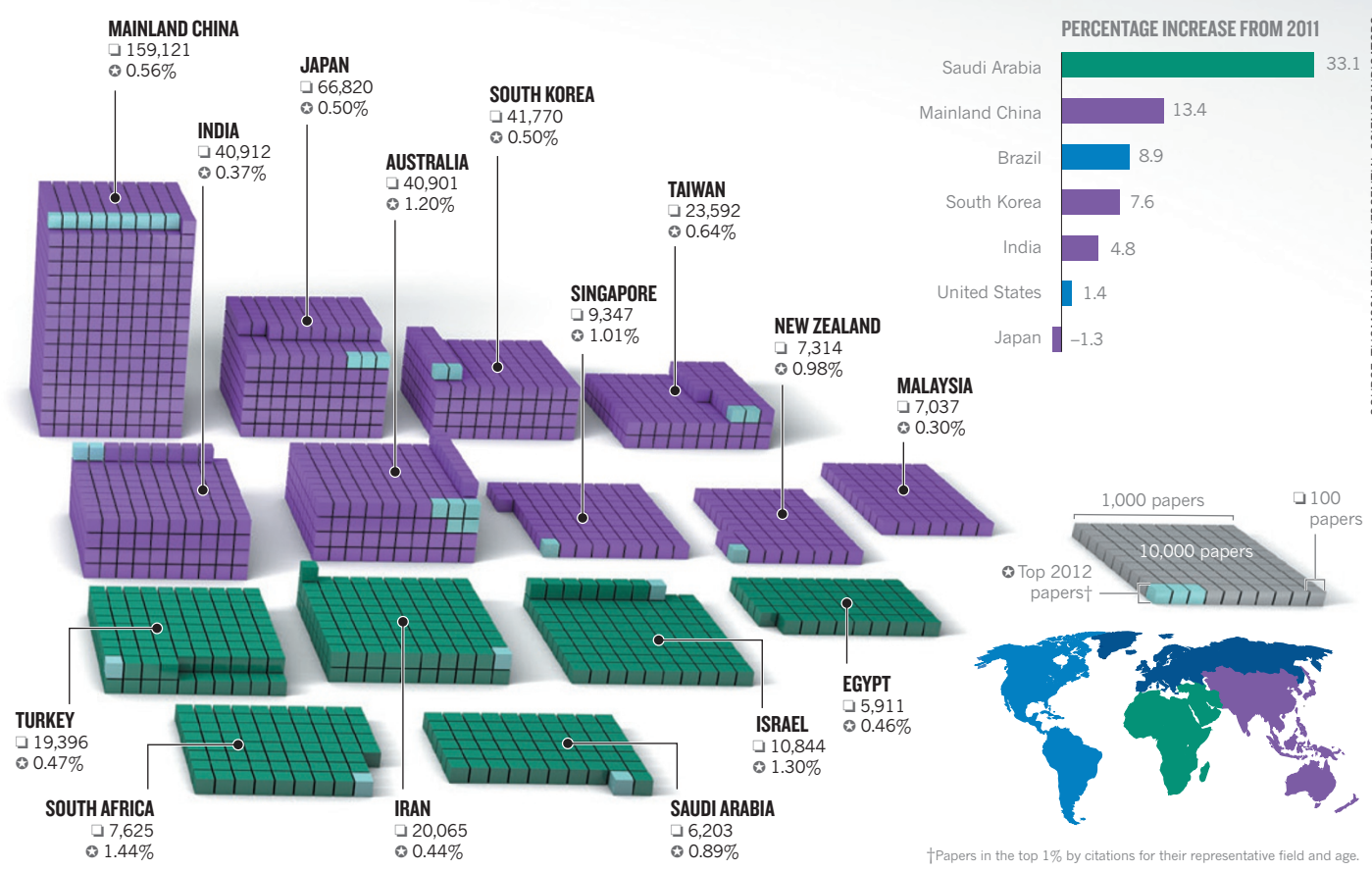


a controversial act that may weaken protection for forests. In June, Australia unveiled plans for the world's largest network of marine reserves — but proposals for international protection of three large areas in the waters around Antarctica were knocked back in November. And in the Galapagos Islands, the death in June of the iconic giant tortoise Lonesome George — the last of his subspecies — called attention to the plight of endangered species around the world.

SCIENTISTS SPEAK OUT Many researchers prefer to keep their heads down when scientific controversies blow up, but they can certainly put up a fight when whole fields or scientific values are threatened. In May, UK scientists spoke up for the value of their work on genetically modified (GM) wheat when an anti-GM campaign group, Take The Flour Back, threatened to destroy it. And in October, researchers across the world reacted with dismay when an Italian court sentenced a group of experts to jail for six years, for allegedly playing down seismic risks before the devastating earthquake in L'Aquila in 2009. Critics warned that the precedent might make scientists reluctant to offer expert opinions for fear of prosecution or reprisals. But scientists have been quieter about other challenges: slowly but surely, animal-rights activists have this year restricted the transport of lab animals by a large number of cargo carriers, without facing effective opposition.

THE HUMAN ENCYCLOPAEDIA Little more than 1% of the human genome's 3 billion letters of DNA — just 20,000 genes — code for proteins. But vast regions of non-coding sequences still have a vital function, affecting the way the genome is packaged, regulated and read in different cell types. In September, a consortium of some 440 scientists released 30 papers from the ENCODE project (the Encyclopedia of DNA Elements), estimating that at least 20% of the genome can influence gene expression. Other ambitious projects to crunch big biological data included the first results from an effort to map the circuit wiring of the entire mouse brain, and a project to

SOURCE: THOMSON REUTERS/ESSENTIAL SCIENCE INDICATORS



track gene activity in some 900 anatomical parts of the human brain. At the cellular level, the flexibility of stem cells continued to astonish. US researchers found stem cells in women's ovaries that seem to be able to produce new eggs, contradicting the dogma that women are born with their life's supply of gametes. And Japanese scientists showed how to coax stem cells from mice into becoming viable eggs. Fertilized and transplanted back into foster mother mice, they produced healthy offspring.

VIRAL STRIFE Two papers showing how mutated versions of the highly pathogenic H5N1 avian influenza virus can transmit between ferrets sparked international strife and a bitter intragovernmental feud in the United States. Some feared that disseminating the recipe for a mammalian-transmissible H5N1 would aid terrorists or increase the likelihood of an accidental release. And at the end of 2011, the US National Science Advisory Board for Biosecurity (NSABB) recommended that the papers be published only in redacted form. But others said that censoring the studies would fly in the face of the scientific ideal of open communication, and shut down potentially life-saving research. The NSABB reversed its position in March, and the papers were published in May and June. But the controversy continued: politicians lambasted the US government for acting too hastily in approving publication, while some scientists chided it for taking too long to reach a final decision. Government regulators are now considering tightening the restrictions for work on such viruses. While the details are being hashed out, a 'voluntary' moratorium on similar research has been in effect since January, angering some scientists who are anxious to get back to work.

AGE OF AUSTERITY As rich nations scaled back their public spending, research funding was also cut — although not in every country. Canada slashed spending on the environment and shut down a string of research programmes, including the renowned Experimental Lakes Area, a collection of 58 remote freshwater lakes in Ontario used to study pollutants for more than 40 years. Spain's 2013 budget proposal would reduce research funds for a fourth consecutive year, and follows a 25%

cut in 2012. In the United States, scientists spent most of the year worrying about the 'sequester,' an across-the-board budget cut that may take effect early next year, although some cuts were made in this election year too: NASA's planetary scientists held a cake sale to highlight their field's dwindling support. Talks on the enormous 2014–20 European budget — including a proposed €80 billion (US\$104 billion) for research under the Horizon 2020 programme — broke down in November and will restart in 2013. Even India scaled down its historic funding growth to more cautious inflation-level increases for 2012–13. But it wasn't all bad news: China's central government boosted its spending on science by nearly 12.5%; France's 2013 austerity budget still found room to boost science cash by 2.2%; Germany channelled more federal funding to universities (creating a large health-sciences institute in Berlin); and the US biotech sector saw the glimmers of a revival from public-market investors.

PHARMA'S FUTURE The US Food and Drug Administration approved two weight-loss drugs — Belviq (lorcaserin) and Qsymia (phentermine plus topiramate) — this year, the first since 1999. The agency also gave a green light to Truvada, the first drug designed to prevent HIV infection. But two monoclonal antibodies designed to fight Alzheimer's disease, bapineuzumab and solanezumab, failed keenly awaited clinical trials — although solanezumab may have slowed cognitive decline in some cases. Researchers think that preventing Alzheimer's at an earlier stage could be a more promising strategy, and hope to set up pre-emptive trials in 2013. Among significant business moves, California-based sequencing company Complete Genomics went to China's BGI for \$118 million, despite competition from Illumina; biotech giant Amgen said that it would buy deCODE Genetics for \$415 million; Bristol-Myers Squibb and AstraZeneca paid US\$5.3 billion to acquire biotech firm Amylin; and GlaxoSmithKline got Human Genome Sciences in a deal worth US\$3.6 billion. Pharmaceutical companies also paid a record amount in malpractice fines in the United States this year. ■

Additional reporting by Brendan Maher