

365 DAYS: 2011 in review

BY RICHARD VAN NOORDEN

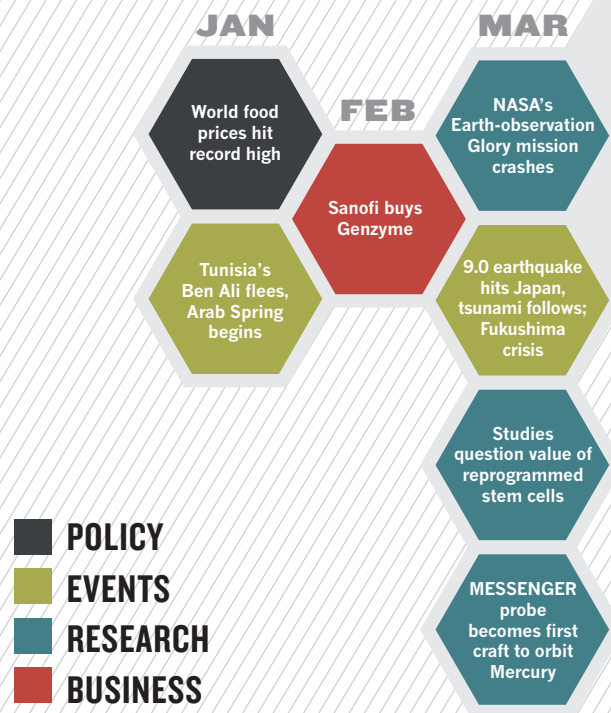
For science — as for politics and economics — 2011 was a year of upheaval, the effects of which will reverberate for decades. The United States lost three venerable symbols of its scientific might: the space-shuttle programme, the Tevatron particle collider and blockbuster profits from the world's best-selling drug all came to an end. But the year also saw stirrings of science's future: hopes that research might blossom following the Arab Spring; cheap vaccines rolling out in Africa; and the first fruits of genome sequencing being used in the clinic. All this was overshadowed by the triple trauma of Japan's devastating earthquake, tsunami and nuclear meltdown, and a continual chipping away at science funding as nations struggled with the financial crisis.

THE STEM-CELL ROLLER COASTER It has been an emotional year for advocates and opponents of embryonic stem (ES) cell research. In July, there was relief when a federal judge dismissed a lawsuit seeking to halt US government funding of research using human ES cells. But in October, the European Court of Justice banned patents based on human ES cells, although the ruling's impact on European science remains unclear. And November brought a shock when the first company to test a human ES-cell product in patients — Geron of Menlo Park, California — bailed out of the field. Back in the lab, ES cells in a dish were coaxed into forming complex three-dimensional tissues, including a retina and a pituitary gland. Scientists also managed to create a human ES-cell line by using cloning technology on a human egg — the only catch being that the cells contained an extra set of chromosomes. Meanwhile, scientists' early love affair with induced pluripotent stem (iPS) cells gave way to a more nuanced assessment of their abilities. In the first half of the year, a string of worrying research papers showed that the reprogrammed adult cells can trigger adverse immune reactions in mice and may contain genetic abnormalities. But other studies demonstrated potential benefits: iPS cells derived from patients can be used to study their diseases in a dish, with published examples including a rare condition linked to accelerated ageing and neurological disorders such as schizophrenia.

R. HAHN/FERMILAB



Powered down: the Tevatron collider was turned off for good in September.



THE YEAR IN BRIEF

PUZZLING OVER PARTICLES What a cliff-hanger. After gathering evidence from around 420 trillion proton-proton collisions in the Large Hadron Collider at CERN, Europe's particle-physics lab near Geneva, physicists announced in December that they still couldn't confidently state whether or not the Higgs boson exists — although they did identify its most likely hiding place, at a mass of around 125 gigaelectronvolts. That mystery joined another messy plot thread: the astonishing claim that neutrinos can travel faster than light. In September, a team at the OPERA experiment — a neutrino detector at the Gran Sasso National Laboratory near L'Aquila, Italy — claimed to see a beam of neutrinos make the 730-kilometre journey from CERN 60 nanoseconds quicker than light could have managed, apparently breaking the cosmic speed limit. Although physicists have tried to poke holes in the result, no one has so far spotted an obvious flaw, leaving a world on tenterhooks as independent experiments attempt to replicate the finding. The mysteries continued with dark matter, as a flurry of results from astrophysical experiments provided a welter of contradictory and confusing signals. But at least one story came to a definite conclusion this year: after more than 25 years spent colliding particles, the massive Tevatron accelerator at Fermilab in Batavia, Illinois, was switched off for good.

BATTERED REPUTATIONS No year is free of scientific scandal, but 2011 saw some particularly high-profile cases. In October, prominent psychologist Diederik Stapel was fired by Tilburg University in the Netherlands after an investigation committee found extensive fraud in his work (see page 441). Three months earlier, evolutionary psychologist Marc Hauser resigned from Harvard University following last year's misconduct findings, but while the US Office of Research Integrity continues to investigate the case, exact details of what he did remain remarkably scant. The scandal involving cancer geneticist Anil Potti, who resigned from Duke University in Durham, North Carolina, in 2010, reached new



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heights in September, when patients enrolled in clinical trials based on his science brought a lawsuit against the university and the scientists involved, claiming that they had been harmed. And November saw the dramatic arrest and brief jailing of Judy Mikovits, prominent for her work (now partially retracted) linking chronic fatigue syndrome to a virus.

ARAB AWAKENING Elated scientists joined jubilant revellers throughout Egypt on 11 February, when Hosni Mubarak resigned after 30 years as the nation's president. He stepped down a few weeks after popular uprisings forced out Tunisian President Zine al-Abidine Ben Ali. With dictators ousted, many researchers remain optimistic that the Arab Spring's new freedoms will lead to progress in science, education and democracy. But by the time Libya's ruler, Muammar Gaddafi, was killed in October, it was increasingly clear that change would be slow in coming — and would depend heavily on those who take power. One immediate effect of the revolutions was to throw archaeology into turmoil: foreign archaeologists had to leave both Libya and Egypt, and Egypt's Supreme Council of Antiquities was left paralysed after its controversial but charismatic leader, Zahi Hawass, was forced to leave office in July.

A DRYING DRUG PIPELINE The world's best-selling drug, Lipitor (atorvastatin), racked up more than US\$100 billion in sales for its maker Pfizer over the past 14 years. But that golden age ended when the patent expired on 30 November, and with more blockbuster drugs soon to lose their patent protection, a familiar question loomed: why is research producing fewer profitable drugs to take their place? All the usual coping

strategies were in evidence this year: companies slashed research budgets, and forged external collaborations with academia and with other firms. Most notably, in February, Sanofi struck a \$20-billion deal to acquire the pioneering biotechnology firm Genzyme of Cambridge, Massachusetts. But some innovative treatments brightened the picture: boceprevir and telaprevir were the first two in an anticipated wave of hepatitis C drugs to win approval. They were joined by belimumab, the first drug approved to treat lupus in half a century, and vemurafenib, a treatment for advanced melanoma, which extended the small family of cancer drugs targeted at patients with a particular genetic profile.

A fundamental breakthrough came from researchers led by Brian Kobilka at Stanford University in California. They captured the crystal structure of a key player on the surface of cells — the G-protein-coupled receptor — locked in an embrace with its protein partner. Between one-third and one-half of all drugs target these receptors, so understanding how they work could give industrial research and development a much-needed boost.

SCIENTISTS UNDER PRESSURE In a year in which some scientific societies came under fire for shifting their human-rights work away from traditional campaigning on

behalf of oppressed researchers, there were many examples of scientists who needed that support. In Iran, for instance, physics student Omid Kokabee was jailed and charged with spying; and in France, French-Algerian physicist Adlène Hicheur began his third year in jail without having faced trial. In the United States, the administration of President Barack Obama did make progress on a much-vaunted effort to draft

2,326

NUMBER OF CANDIDATE EXTRASOLAR PLANETS IDENTIFIED BY NASA'S KEPLER SPACE TELESCOPE; 207 ARE ABOUT THE SIZE OF EARTH.

B. INGALLS/NASA



The end of the space-shuttle programme: *Atlantis* landed on 21 July.

policies on scientific integrity, a response to charges of censorship under his predecessor George W. Bush. The policies would give scientists at US government agencies more freedom to discuss their work (see page 425).

BRAVE NEW WORLDS After 30 years and 135 missions, the space-shuttle era is over. *Atlantis* touched down for the final time on 21 July, leaving NASA reliant on Russian Soyuz capsules to get astronauts off the planet. The space agency also struggled to contain the spiralling costs — \$8.7 billion and rising — of the James Webb Space Telescope, whose funding was narrowly saved amid budget cuts. Although NASA's Glory probe, to measure solar output, crashed on take-off in March, other robotic craft soared. The Curiosity rover is en route to Mars, and the Juno probe is heading for Jupiter. The MESSENGER spacecraft entered orbit around Mercury, and the Dawn mission did likewise around Vesta in the asteroid belt. Closer to home, Aquarius began to measure the saltiness of Earth's oceans from orbit. Meanwhile, China

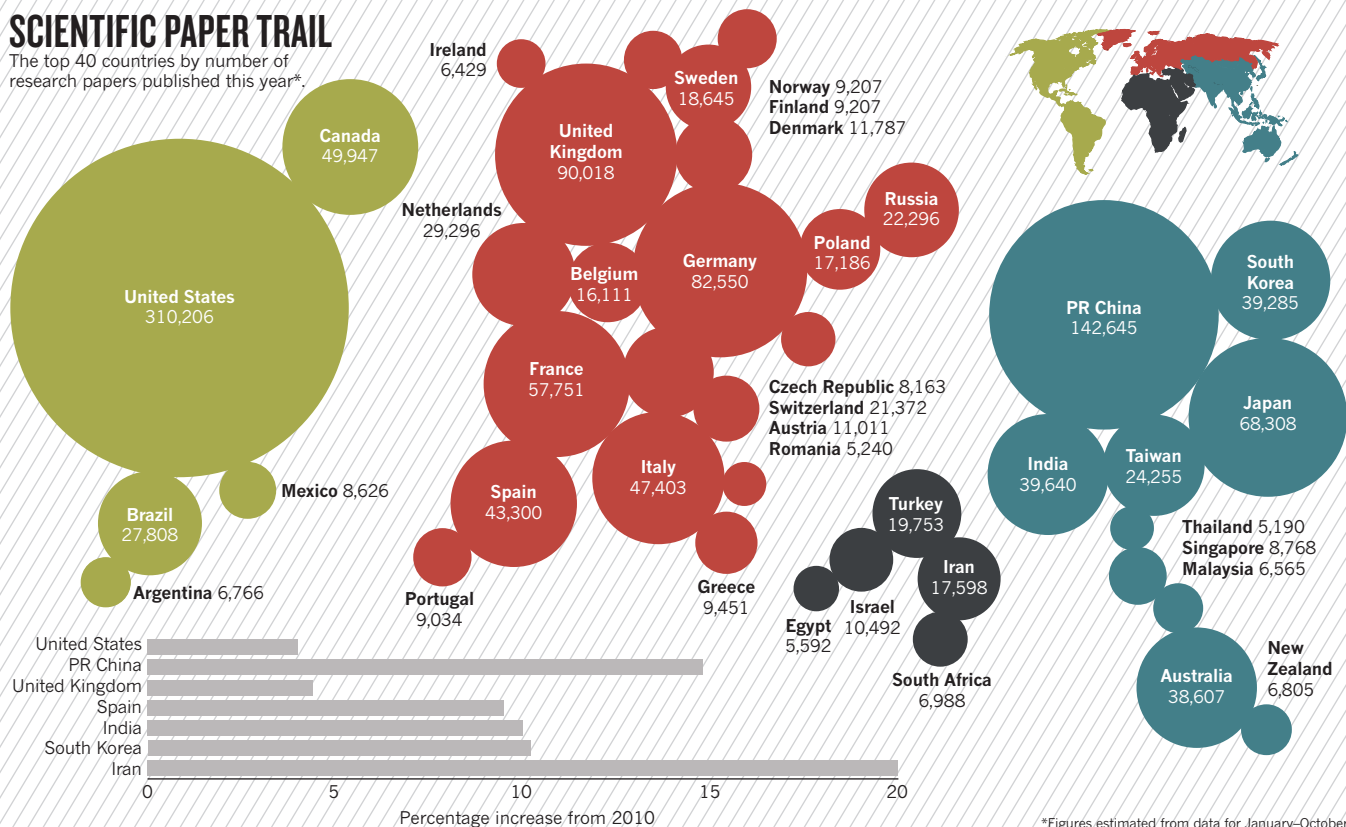
bolstered its growing power in space, achieving its first space docking, and Russia tasted failure with its botched Mars mission, Phobos-Grunt. Europe finally lofted the first satellites of its Galileo navigation system into orbit. But the most thrilling space research was the flood of data on new extrasolar planets emerging from NASA's Kepler mission and from ground-based telescopes. So far, more than 700 new worlds have been identified — although none is quite Earth's twin.

SEQUENCING: CHEAP AS CHIPS Care for a fish-and-chip genome? The cod and the potato were among the many organisms unravelled by sequencing machines this year, but the most fascinating genomes were those that revealed humanity's past. The first complete genome of an Aboriginal Australian offered clues that pioneers left Africa for the south more than 60,000 years ago, and the genome of the Black Death pathogen *Yersinia pestis*, recovered from victims' teeth, shed light on how the disease laid waste to Europe in the fourteenth century. Bacterial outbreaks nowadays can be sequenced as they happen — as shown by the rapid identification of the *Escherichia coli* strain that wreaked havoc in northern Europe in the spring. That feat was achieved in three days by one of a new wave of chip-based sequencers, which manufacturers say will provide genomes for less than \$1,000. Yet for all their promise, some makers of small and large sequencing devices announced miserable profits in the year's third quarter, after biologists, fearful of falling research funding, held off buying new equipment. Instead, sequencing companies are eyeing up new markets in biomedicine, promoting the use of genetic tests and whole-genome sequencing to diagnose clinical diseases, which is starting to have life-changing effects.

CUTS, CUTS, CUTS We've had the stimulus: now prepare for austerity. As governments pondered where and when to slash budgets, scientists once again rallied to make the case for funding basic research. After the United States narrowly avoided a government shutdown in April, most of its federal science agencies saw modest funding increases

SCIENTIFIC PAPER TRAIL

The top 40 countries by number of research papers published this year*.



*Figures estimated from data for January–October

SOURCE: THOMSON REUTERS/WEB OF KNOWLEDGE



Fallout: inspectors take stock of the damage to Fukushima Daiichi.

3.5×10^{16} bq

AMOUNT OF THE RADIOACTIVE ISOTOPE CAESIUM-137 RELEASED BY THE FUKUSHIMA DAIICHI POWER PLANT — ABOUT HALF THAT RELEASED FROM CHERNOBYL.

GI. VERLINI/AREA

proposed for 2012 — but the prospect of across-the-board cuts looms over 2013. In the United Kingdom, cuts to facilities made in 2010 began to bite as researchers lost funds for buildings and major equipment, although some of the cash was dribbled back in concessions through the year. In Spain, the Prince Felipe Research Centre, a flagship biomedical-research facility in Valencia, was forced into severe cutbacks, and the San Raffaele Scientific Institute in Milan, Italy, is accepting a rescue package backed by the Vatican after running up a debt of US\$1.5 billion. Non-governmental organizations also suffered: the Global Fund to Fight AIDS, Tuberculosis and Malaria said that it would not fund new grants until 2014 because of budget cutbacks. The dizzying growth of China's economy, however, meant that its science budget expanded by 12.5% this year. And the European Commission was clearly feeling optimistic when it requested €80 billion (US\$104 billion) for research under the Horizon 2020 proposals unveiled in November.

IN THE SHADOW OF FUKUSHIMA Even Japan, the nation best prepared for a tsunami, was overwhelmed by the monster waves that struck the coast of Sendai on 11 March, following a magnitude-9.0 earthquake. Tens of thousands of people died, and hundreds of thousands were displaced. But it was the meltdown of three tsunami-damaged reactors at the Fukushima Daiichi nuclear plant — the worst nuclear disaster since Chernobyl — that soon gripped the world's attention. Fortunately, wind carried much of the radioactivity out to sea. It took nine months before the reactors could be declared safely in cold shutdown; and it will take decades and hundreds of billions of dollars to clean up the plant. Unsurprisingly, energy policy in Japan — and in Germany, Italy and Switzerland — has turned abruptly against nuclear power. So where will the world find its low-carbon energy? Many countries are banking on recently discovered reserves of natural gas locked up in shale, accessible thanks to 'fracking', in which rock is fractured with high-pressure fluids. But concerns that the process pollutes air and water sparked vociferous protests in the United States and a ban in France. Solar power went through turmoil too, as slow demand for solar panels, oversupply of products and materials, and widespread subsidy cuts bit deep into the industry's profits. Several companies

declared bankruptcy — including high-profile US start-up firm Solyndra of Fremont, California. The good news for consumers, however, is that solar-power modules are rapidly getting cheaper.

LIVING IN THE ANTHROPOCENE The world's population passed 7 billion this year, and our carbon emissions carried on rising too. Little wonder that geologists gathered in May to discuss whether human impact on the planet deserved recognition through the declaration of a new geological epoch: the Anthropocene. The year's main climate-change conference in Durban, South Africa, ended with a last-minute agreement to work towards a global treaty to set emissions-reduction targets, bolstering political progress that included Australia instituting a carbon tax and a record low for deforestation in the Brazilian Amazon. For the 3.4 billion people surviving on less than \$2 a day, getting enough food and avoiding disease are more urgent priorities. And it is not getting any easier: after droughts and oil-price hikes, the cost of food staples reached a record high in February and dropped only slightly through the year. Help from the GAVI Alliance, however, came in the form of a new pneumococcal vaccine rolled out widely in February, and a rotavirus-vaccination programme to target childhood diarrhoea in Africa. In October, interim results from a huge phase III clinical trial of the RTS,S malaria vaccine candidate showed disappointing efficacy and no effect on mortality. But there was promising news in HIV: one trial showed that treating infected people with antiretroviral drugs early helped to prevent them spreading the virus, and two others suggested that giving antiretrovirals to healthy people reduced their chances of becoming infected. ■