



VICTOR MORIYAMA/NT/REDUX/EYVINE

Large areas of Brazil's Amazon rainforest were burnt to clear space for cattle ranching.

# 2019 IN REVIEW

A year marked by climate protests, political uncertainty and debate over the ethics of gene editing in human embryos proved challenging for science. But researchers also celebrated some exciting firsts – a quantum computer that can outperform its classical counterparts, a photo of a black hole and samples gathered from an asteroid.

**T**his year, astronomers glimpsed the blackness of a black hole for the first time ever. In April, the international Event Horizon Telescope collaboration unveiled perhaps the most memorable picture of 2019: the first direct image of a black hole and its event horizon (see page 354). To produce it, researchers coaxed a network of radio telescopes to take simultaneous readings from around Earth.

In a year that marked the 50th anniversary of the Apollo Moon landings, lunar exploration was high on the agendas of space agencies. In January, China's Chang'e-4 probe became

the first spacecraft to land safely on the lunar far side. Its rover, Yutu-2, continues to roll across the dusty soils of Von Kármán crater. Other attempts to explore the Moon were not so successful. In April, an Israeli-led effort to put the first private spacecraft onto the Moon ended in a crash landing. The same thing happened to India's Vikram lander in September, although the orbiting part of that mission – known as Chandrayaan-2 – is still circling the Moon as planned.

Ongoing Mars missions returned a host of results. The French-built seismometer on NASA's InSight lander detected the first-ever

'marsquakes'. Roughly 600 kilometres away, NASA's Curiosity rover sniffed record-high levels of methane gas in the Martian atmosphere in June – a mystery that scientists have yet to explain, especially because the methane vanished in days. In February, NASA officially bid farewell to its most stalwart Mars rover, Opportunity.

In the farther reaches of the Solar System, Japan's Hayabusa2 probe collected a sample from the surface of the asteroid Ryugu in February. Then, in July, it dropped a small pellet onto the asteroid and blasted its surface, before descending to gather some of

the freshly exposed material. Hayabusa2 will return its samples to Earth next year. Far beyond Pluto, NASA's New Horizons spacecraft passed a 35-kilometre-long object known as Arrokoth. Its bizarre shape, resembling two pancakes stuck together, gave humanity our closest glimpse yet at an icy, primordial world.

This year even brought a visitor from beyond the Solar System. The interstellar Comet 2I/Borisov whizzed past the Sun earlier this month. It is only the second object known to have visited our Solar System from another one, following 2017's 'Oumuamua.

## Heated debate

Back on Earth, it was another tough year for the environment. Up to one million plant and animal species now face extinction owing to habitat destruction and climate change, warned a report by the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services, a panel backed by the United Nations. And the Intergovernmental Panel on Climate Change (IPCC) called for drastic efforts to curb demand for agricultural land, including people shifting towards a plant-based diet, in a special report. Without such action, the IPCC said, governments will fall short of their collective goals under the 2015 Paris climate accord, in which nations agreed to limit global warming to no more than 2°C above pre-industrial levels.

But political trends seemed to move in the opposite direction. In Brazil, the populist President Jair Bolsonaro took the helm in January with a fiery anti-environmental agenda. He slashed federal funding for science, and in July accused his own government's scientists of lying about a spike in deforestation in the Amazon. In the United States, President Donald Trump continued his efforts to dismantle environmental regulations. In June, the US Environmental Protection Agency (EPA) finalized a plan to relax limits on greenhouse-gas emissions from power plants. In August, the EPA followed up with a proposal to freeze fuel-efficiency standards for automobiles, and the president announced in September that the agency would revoke a long-standing waiver allowing California to set its own limits on carbon emissions from cars and trucks. And in November, the administration began the official process of pulling the United States out of the Paris agreement.

Activists around the world responded to government intransigence with protests, including September's Global Climate Strike. Galvanized by youth climate activist Greta Thunberg (see page 372), millions of people in 150 countries took to the streets to demand stronger action. In October, youth leaders filed a pair of lawsuits against the state of Alaska and Canada's federal government, arguing that they are violating their rights by encouraging the use of fossil fuels. The lawsuits are part of a larger trend in climate litigation, including



Climate-change protestors gather at a demonstration in Cape Town, South Africa.

a major case pending in the Netherlands. In May, the Dutch supreme court heard the government's appeal against a lawsuit brought by the Urgenda Foundation, a citizens' climate organization that successfully argued in the lower courts that the Dutch government must do more to combat climate change. If the supreme court rules in Urgenda's favour, the government will be unable to appeal further.

## Pushing biological boundaries

It was a year of testing biological and ethical limits in the laboratory. US researchers revived the brains of pigs four hours after their heads had been severed, by pumping in a nutrient- and oxygen-rich liquid to mimic blood (see page 365). The trick triggered sugar consumption and other metabolic functions, suggesting that the brains were still working. The researchers did not attempt to restore consciousness, however – they added chemicals to stop neurons

from firing before the experiments started.

In another out-of-body experiment, scientists grew monkey embryos in a dish for nearly three weeks – longer than primate embryos have ever been grown in the laboratory before. The feat raises the question of whether lab-grown human embryos should be allowed to develop beyond 14 days, a restriction imposed in most countries. In September, a US research team provided a possible circumvention of the 14-day limit by growing a human embryo from stem cells. The 'artificial embryo' seemed to mimic the early development of a real human embryo. Whether it should be permissible to grow artificial embryos to later stages is an ongoing ethical debate.

Japan continued its dominance in the clinical use of induced pluripotent stem cells – adult cells that are reprogrammed into an embryonic-like state. In September, a Japanese group used these stem cells to make sheets of corneal cells that could be transplanted into a woman whose eyesight was failing. In the past decade, Japanese physicians have used iPS cells to treat Parkinson's disease and another eye condition, and this year a group was granted approval to use them cells as a therapy for spinal-cord injury. However, the jury is still out on whether any of these treatments is effective.

## Culture shock

Investigations into harassment and workplace culture and ethics have continued at research institutions around the world. Staff at Germany's Max Planck Society reported that gender-based discrimination and bullying are regular occurrences, in a massive employee survey that drew more than 9,000 responses.

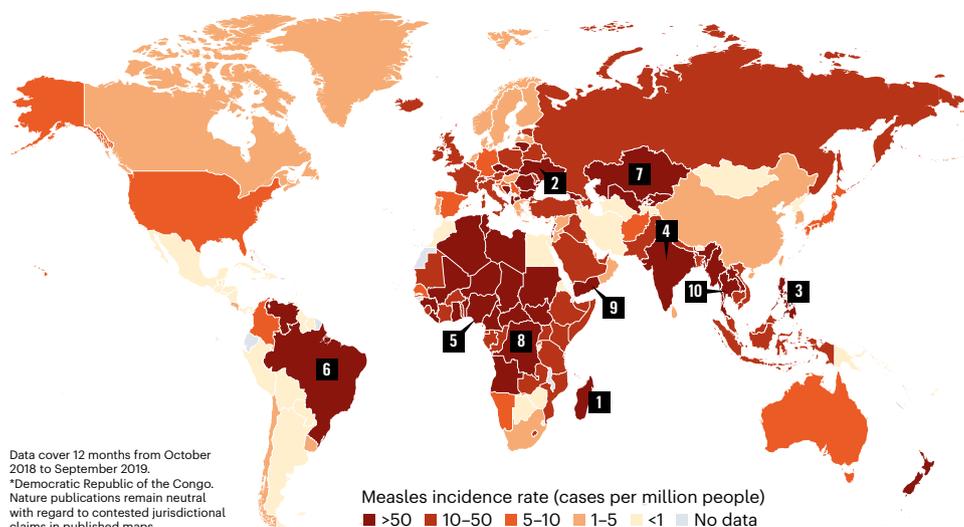
In Australia, 50% of female scientists who responded to a national poll said they faced harassment at work. And in August, the University of Adelaide suspended Alan Cooper,



NASA's Curiosity continued to explore Mars.

## MEASLES ON THE RISE

The number of measles cases being reported to the World Health Organization continued to climb in 2019. Provisional data released in November show that severe outbreaks are ongoing in several countries, including Madagascar, Ukraine, the Philippines and Brazil.



Data cover 12 months from October 2018 to September 2019.  
\*Democratic Republic of the Congo.  
Nature publications remain neutral with regard to contested jurisdictional claims in published maps.

### Top 10 countries by reported cases

1. Madagascar	151,032
2. Ukraine	78,708
3. Philippines	49,419
4. India	36,251
5. Nigeria	27,954
6. Brazil	18,927
7. Kazakhstan	10,696
8. DRC*	9,245
9. Yemen	9,156
10. Thailand	7,738

SOURCE: WHO

head of the prestigious Australian Centre for Ancient DNA, after an inquiry into the ‘culture’ at the centre, and amid accusations from some co-workers that he had bullied them. The university has not given a reason for the suspension and told *Nature* that he is still suspended and that “the process in relation to him remains underway”.

In the United States, the National Institutes of Health announced for the first time how many of its grant recipients had been disciplined as a result of sexual-harassment investigations in the previous year. The agency said in February that it had replaced 14 principal investigators in 2018, and banned 14 people from participating in its peer-review panels. Meanwhile, the US National Academy of Sciences approved a policy to expel members found guilty of sexual harassment. And the Massachusetts Institute of Technology (MIT) in Cambridge is investigating its links to disgraced and deceased financier Jeffrey Epstein. Epstein had donated about US\$800,000 to the university, MIT says.

### Quantum wonders

Physicists reached a long-awaited milestone in quantum computing. In October, a team at Google reported in *Nature* that it had used a quantum computer to perform a calculation that would be practically impossible for a classical machine, even a state-of-the-art supercomputer. The calculation itself – checking the outputs from a quantum random-number generator – is of limited practical use, but the feat is a step towards future applications of quantum computers, which range from designing new materials to codebreaking.

Another Google unit, the London-based artificial-intelligence (AI) powerhouse DeepMind, made headlines when it showed that its programs had mastered the multiplayer online videogame *StarCraft II*. And for the first

time, an AI bot beat human champions at multiplayer poker. Although AIs that can beat the best human players at chess or Go – as DeepMind’s AlphaGo did in 2016 – are impressive, many in the field consider multiplayer games to be better analogues of real-life challenges for machine learning, such as fraud detection or self-driving cars.

Earlier in the year, molecular-scale transistors came into view when chemists made the first-ever ring-shaped molecule of pure carbon by using an atomic-force microscope to manipulate individual molecules.

### Embryo edits

As 2019 began, the world was still reeling from the announcement that Chinese scientist He Jiankui had produced the world’s first gene-edited babies. He used the CRISPR–Cas9 system to alter the gene *CCR5*, which encodes a protein that HIV uses to enter cells, in an attempt to give twin girls resistance to the

virus. In January, the Southern University of Science and Technology in Shenzhen fired He, after a Chinese health-ministry probe found that he had violated national regulations forbidding the use of gene editing for reproductive purposes. In March, the health ministry issued further draft regulations that included severe penalties for those who break rules regarding gene editing in humans. That month, an advisory committee to the World Health Organization called for the creation of a global registry of human gene-editing studies, and opposed the clinical use of heritable gene editing in people.

But then, in June, another scientist with ambitions to produce gene-edited babies spoke up. Russian molecular biologist Denis Rebrikov told *Nature* that he was considering implanting gene-edited embryos into women (see page 372). Most recently, he expressed interest in repairing a mutation linked to deafness, and said that he had started experiments to investigate. But he also said that he will wait until Russian regulatory authorities grant permission before implanting gene-edited embryos.

While debate rages around genome editing in the clinic, researchers have continued to improve on the technology. In October, a team led by chemical biologist David Liu of the Broad Institute of MIT and Harvard in Cambridge, Massachusetts, unveiled a method called prime editing. Early results suggest that this alternative tool could be more precise and accurate than standard CRISPR–Cas9 editing, which might ease some of the concerns about the safety of using gene editing in humans.

### Indecisive leadership

In the United Kingdom, universities have stockpiled supplies as the country reached the brink of a no-deal Brexit this year, only for



Google’s Sycamore quantum processor.

GOOGLE/REUTERS

its government to extend the deadline for leaving the European Union three times. Neither prime minister Theresa May nor her successor Boris Johnson managed to secure the backing of Parliament for a Brexit deal, and the ongoing uncertainty continues to worry scientists. To strengthen the country's science base, Johnson's government – which was re-elected on 12 December and now plans to exit the EU through the deal Johnson negotiated – promised to double government funding for research and development to £18 billion (US\$24 billion) a year by 2025, and to introduce a visa scheme that is more favourable to researchers.

In the United States, several science agencies started the year in suspended animation – caught up in a partial government shutdown that lasted a record-setting 35 days. NASA and the National Science Foundation (NSF) were among the agencies forced to halt most activities. Lawmakers did not resolve the impasse until late January.

Amid the chaos, the US Senate confirmed meteorologist Kelvin Droegemeier to serve as President Donald Trump's science adviser and lead the White House Office of Science and Technology Policy. Trump had gone nearly two years without a science adviser. Droegemeier quickly became a key player in the push to root out undue foreign influence in US science. Since 2018, the National Institutes of Health has investigated at least 180 scientists for failing to declare ties to foreign governments; many of the researchers are Chinese American, prompting fears that they were being unfairly targeted because of their ethnicity. Meanwhile, the Department of Energy and the NSF moved to bar their employees from participating in foreign talent-recruitment programmes.

Australia, too, has cracked down on foreign interference. In August, the government announced plans for an expert committee to



Health workers grappled with an Ebola outbreak in the Democratic Republic of the Congo.

respond to cyberattacks, intellectual-property theft and other strikes against universities by foreign governments or groups.

Elsewhere, scientists have found themselves caught up in civil unrest. In Hong Kong, violent clashes between police and protesters disrupted teaching and research on three university campuses (see page 383). And Chile had to pull out of hosting the United Nations COP25 climate summit because of safety concerns caused by massive protests against economic inequality in Santiago. The December talks were eventually held in Madrid.

### A picture of health

An ongoing Ebola outbreak in the eastern Democratic Republic of the Congo (DRC) flared throughout the year, and has killed more than 2,200 people since it began in August 2018.

This is the second-worst Ebola epidemic yet in terms of deaths, and is the most complicated to address, owing to ongoing conflict in the region (see page 367). Ebola responders have been attacked by armed groups, and widespread mistrust of government officials and aid workers causes many residents to avoid treatment centres. In July, the World Health Organization declared the outbreak a “public health emergency of international concern” – its highest alert level.

Despite the chaos, researchers managed to conduct the first large, controlled trial of four experimental Ebola drugs. They found that two antibody-based therapies cured 90% of people who sought treatment in the early stages of the disease. And health workers have given more than 256,000 people in the eastern DRC a new Ebola vaccine manufactured by the pharmaceutical company Merck. In November, the vaccine became the first in the world to gain approval by a medicines agency.

In the United States, an outbreak of lung injuries in users of electronic cigarettes has killed more than 50 people and hospitalized more than 2,000, sending researchers and public-health officials scrambling to find the cause.

And in March, a person with HIV (whose identity hasn't been disclosed) was declared free of the virus after a stem-cell transplant swapped their white blood cells with HIV-resistant versions. They are only the second patient to have been successfully treated using this method after the ‘Berlin patient’, Timothy Ray Brown, was reported free of both HIV and leukaemia in 2009.

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UK Prime Minister Boris Johnson pledged to raise spending on research and development.