NATURE'S 10

Ten people who mattered this year.

Ricardo Galvão / Victoria Kaspi / Nenad Sestan / Sandra Díaz /
Jean-Jacques Muyembe Tamfum / Yohannes Haile-Selassie /
Wendy Rogers / Hongkui Deng / John Martinis / Greta Thunberg

Nature's 10 is the journal's annual list of ten people who mattered in science this year. They might have achieved amazing discoveries, brought attention to crucial issues, or even gained notoriety for controversial actions. Although not an award or a ranking, *Nature's 10* highlights individuals who had a role in some of the year's most significant moments in science.

Ricardo Galvão

Science defender

As chaos spiked in the Amazon, the physicist became a national hero by challenging Brazil's government.

By Jeff Tollefson

Ricardo Galvão nearly passed out when he heard the news and realized he was being targeted by his own president.

On 19 July, Brazil's leader, Jair Bolsonaro, lashed out against a report on deforestation by Galvão's team at the National Institute for Space Research (INPE) in São Paulo. The group's analysis had incited the president's wrath because it found a sharp spike in forest clearing in the Amazon. The president accused the scientists of lying about the data and suggested that Galvão – as head of the institute – might be in cahoots with environmentalists. The 72-year-old fusion physicist was stunned by the accusation. "My wife had to bring me a glass of water," he says.

Rather than rush to react, Galvão gave himself 12 hours to craft a response. After a nearly sleepless night, he spoke out in defence of INPE scientists. He also accused the president of cowardice and called for a face-to-face meeting – acts that he knew would lead to him losing his job. What he didn't know was that he would become a hero of sorts, hailed by his scientific colleagues as well as by strangers on the streets. A woman even stopped him on the subway in São Paulo to thank him for standing up to Bolsonaro and helping her to understand why preserving the Amazon matters.

"He lost his job because he took a very clear and strong position in defence of science – and against authoritarianism," says Paulo Artaxo, an atmospheric physicist and Galvão's colleague at the University of São Paulo. Artaxo sees worrisome parallels between Bolsonaro's government and the dictatorship that ruled Brazil between 1964 and 1985, including a tendency to attack any evidence that doesn't support its political goals. "We

need people like Galvão to stand up."

It wasn't Galvão's first run-in with the Bolsonaro administration. Officials had repeatedly questioned the accuracy of INPE's deforestation alerts, which use detailed analysis of satellite imagery.

This time, however, the president was attacking the integrity of scientists and one of Brazil's top scientific institutions. As expected, Galvão was dismissed two weeks after he defended INPE, just as the burning season kicked off in the Amazon. Farmers light fires as the last step in clearing the land for agriculture.

Brazil's reputation as an environmental leader has been deteriorating in recent years. The country had managed to curb deforestation by more than 80% between 2004 and 2012, but the aggressive environmental enforcement ended up sparking a political backlash and a rise in deforestation.

INPE's latest numbers, released on 18 November, show that an estimated 9,762 kilometres of land – an area larger than Puerto Rico – was cleared between August 2018 and July 2019. That is an increase of 30% over the previous year, and more than twice the area cleared in 2012. Scientists and conservationists charge that Bolsonaro's anti-environmental rhetoric has sent a signal to ranchers, farmers and land-grabbers that they can once again clear forest in the Amazon with impunity.

Galvão has since returned to his previous position at the University of São Paulo. He doesn't enjoy the limelight and was preparing to stop giving interviews and focus on his fusion research. After receiving messages from fellow scientists thanking him for speaking out, however, he realized that he has a responsibility to continue to advocate on behalf of science – and scientists – in the face of political pressure. "I'm just a humble old man who works in physics," Galvão says. "But I decided to go on for this reason."

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MICHAEL RUBIN FOR NATURE

Victoria Kaspi

Sky sleuth

An astrophysicist chased mysterious fast radio bursts with an innovative radio telescope.

By Alexandra Witze

In the past quarter of a century, Victoria Kaspi has used many of the world's top telescopes to make fundamental astronomy discoveries. But in 2017, she found herself helping to build one, screwing in hundreds of cables to connect the Canadian Hydrogen Intensity Mapping Experiment (CHIME) to powerful computers.

This year, the efforts of Kaspi and dozens of other astronomers paid off. CHIME became the world's best hunter of fast radio bursts (FRBs) – mysterious flashes of radio energy that frequently pop off across the sky. CHIME, which is located in southern British Columbia, has spotted hundreds of bursts, many more than any other telescope. With it, astronomers hope to solve the puzzle of the signals' origin.

Kaspi, an astrophysicist at McGill University in Montreal, Canada, had a major role in giving CHIME its powerful FRB-detection capabilities. The telescope was originally designed to map hydrogen emission from distant galaxies, to answer questions about the early Universe. But as the project was coming together in the early 2010s, so, too, was the burgeoning field of FRBs, the first of which was discovered in 2007. In 2013, astronomers reported four more examples, confirming that the flashes were a real phenomenon that needed explaining.

"That moment to me was a watershed," says Kaspi. She had spent much of her career studying ultra-dense stellar remains known as neutron stars. But, suddenly, a new astrophysical mystery was emerging. Kaspi had been thinking about how CHIME could study fast-rotating neutron stars and realized the telescope's sensitivity and large field-of-view could be ideal for bagging FRBs – but only if it were upgraded. She telephoned Ingrid Stairs, an astronomer at the University of British Columbia in Vancouver, to chew over the idea. "And within a few months, she was leading this big proposal," says Stairs.

Kaspi worked with the cosmologists who

"At this point, it's like drinking from a fire hose, we have so much data."

dreamt up the telescope to request more money from its main funder, the Canada Foundation for Innovation in Ottawa, to hunt for FRBs. They wanted to add another instrument and enough computing power to enable the telescope to churn through data gathered 1,000 times per second at 16,000 different frequencies. "We all knew this was very risky," she says. "The telescope hadn't been built yet, and here we were proposing to add something onto something that didn't exist."

But Kaspi, who became principal investigator of the FRB part of CHIME, pulled it off. Her scientific chops helped win the funding; her personal connections enabled her to build a large and diverse team; and her political skills were essential in bringing together the original cosmologists and the new FRB hunters, says Matthew Bailes, an astronomer at Swinburne University of Technology in Melbourne, Australia.

Along the way, Kaspi has worked to develop the next generation of scientists, mindful of how challenging it can be to enter physics, especially for women. She won the nation's highest science prize, the Gerhard Herzberg Canada Gold Medal for Science and Engineering, in 2016 and used the Can\$1-million (US\$760,000) prize to hire students and postdocs for CHIME.

This year, she helped to land a US\$2.4-million grant from the Gordon and Betty Moore Foundation to explore building 'outrigger' telescopes. The outriggers would be sited some 1,000 kilometres away from CHIME and help in pinpointing FRBs. That would keep this inventive Canadian telescope at the forefront of astronomy.

"At this point, it's like drinking from a fire hose, we have so much data," Kaspi says. "Honestly, I'm blown away."

Nenad Sestan

Brain rebooter

“I realized it was something beyond our expectations.”

A neuroscientist revived disembodied pig brains and challenged definitions of life and death.

By Sara Reardon

Nenad Sestan was working in his office one afternoon in 2016, when he heard two of his lab members in a room across the hall giggling with excitement over a microscope. “I knew something was happening,” he says. “I realized it was something beyond our expectations.”

The researchers, at Yale School of Medicine in New Haven, Connecticut, had found electrical activity in brains taken from dead pigs. The team had painstakingly removed the organs shortly after death and infused them with oxygen and an ice-cold preservative, and in doing so, brought the brains at least partially back to life. With that shocking result, Sestan realized that what had started as a side project to find ways to better preserve brain tissue for research had morphed into a discovery that could redefine our understanding of life and death.

The excitement soon turned to concern, when the researchers thought they saw widespread, coordinated electrical activity – the type that can indicate consciousness. Sestan brought in a neurologist, who determined that the readout was actually an error, but the possibility had spooked them.

Sestan kept his cool and immediately did two things: he shut down the experiment

and contacted the US National Institutes of Health (NIH), which funds his research, as well as a Yale bioethicist. Over the next few months, experts pored over the potential ethical implications, such as whether the brains could become conscious and whether physicians needed to reconsider the definition of brain death.

Sestan had anticipated the ethical questions and adopted some safeguards. Before starting the experiments, the group had decided to anaesthetize the brains with blocker drugs to prevent neurons from firing in unison – a prerequisite for consciousness.

Overall, the feat met with more excitement than concern. Sestan’s results suggested that oxygen deprivation, which can happen during a stroke or severe injury, was not as damaging to brain cells as previously thought. “It’s very important: something we overlooked, because nobody really thought that this was possible,” says Anna Devor, a biomedical engineer at Boston University in Massachusetts.

Once they were confident that the experiment was ethically sound, the researchers resumed their experiments. They submitted the work to *Nature*. But before the paper could be published, Sestan presented data at a public NIH neuroethics meeting and – despite his protests – the

story appeared in the press.

Sestan admits he was amused by some of the sensationalist headlines, dubbing his project ‘Frankenswine’ and ‘Aporkalypse’. But he was stung by suggestions that the researchers were engineering immortality, or maintaining a room full of living brains in jars. Neither he nor his team wanted to discuss the results until the paper was out, but as their inboxes filled with concerns and rants from animal-rights activists and futurists, Sestan became depressed. “We were really very worried,” he says. He felt that all they could do, however, was to hold off on correcting public misunderstandings until the peer-review process had run its course.

Since the paper was published in April (Z. Vrselja *Nature* **568**, 336–343; 2019), the team has been so busy fielding enquiries from the media and scientists that it hasn’t performed any further experiments. Sestan wants to focus on his original questions and explore, for instance, how long the brains can be maintained for, and whether the technology can preserve other organs for transplantation.

From now on, this strand of his research will be decided by committee. “We want to get outside opinion before we do anything,” he says. “When you explore uncharted territory, you have to be very, very thoughtful.”

Sandra Díaz

Biodiversity guardian

An ecologist and her colleagues assess Earth's ecosystems and call for drastic action.

By Ehsan Masood

On 4 May, Sandra Díaz and 144 other researchers had a stark message for the world. They had just finished the most exhaustive study ever of the world's biodiversity, and the news was worse than most researchers had imagined: one million species are heading for extinction because of human activities, and it will take drastic action to stop that. "The rate at which species are going extinct is at least tens to hundreds of times faster than it has been on average over the past ten million years," Díaz says. "Our safety net is stretched almost to breaking point."

Those alarming findings came from the Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services

(IPBES). Díaz, an ecologist at Argentina's National University of Córdoba, is one of the panel's three co-chairs. For most of the previous three years, she and her colleagues – anthropologist Eduardo Brondízio at Indiana University Bloomington and ecologist Josef Settele at the Helmholtz Centre for Environmental Research in Halle, Germany – coordinated the work of experts from 51 countries, meeting in physical

"We cannot live a fulfilling life, a life as we know it, without nature."

workshops and in virtual working groups, poring over 15,000 sources of information.

Their final report, which runs to 1,500 pages, says that nations will fail to meet most global targets in biodiversity and sustainable development unless they make massive changes, such as abandoning the idea that economies must grow constantly.

"We cannot live a fulfilling life, a life as we know it, without nature," Díaz says. And if economies continue to run in such a destructive way, a "new economic model is needed for nature and people", she says.

It's a blunt and, in some ways, radical message. But Díaz does not shy away from speaking out on important issues in science and policy. She challenged, for instance, what was once one of the central tenets in twentieth-century ecology: the idea that ecosystems and their benefits to humans – such as food, or climate regulation – depend heavily on having large numbers of species. Shahid Naeem, a researcher at Columbia University in New York City who studies the impacts of biodiversity loss, says that Díaz has led the charge in highlighting the value of what plants actually do – known as their functional traits.

This insight and others came to Díaz through years spent trudging through the fields of Africa, Asia, Europe and Latin America, collecting leaves, measuring their toughness, and assessing soil properties. It's a habit she developed growing up in central Argentina, when she would explore the Pampas grasslands while others took their afternoon rests. "I would escape the siesta to see plants and animals," she says. "Ever since I was an undergraduate, I knew I wanted to be a researcher."

Díaz has a second career now, beyond conservation science – influencing policy through her work with IPBES. She takes heart in how the panel's report is being adopted by many social and environmental movements, including Extinction Rebellion, that are pushing for stronger and more urgent action on the environment.

"We have been amazed at its reach," she says. "The report has come at the right moment." And despite its dark prognosis, Díaz refuses to be pessimistic about humankind's capacity to turn things around. "I have to be optimistic," she says, "because there is no Plan B".

Jean-Jacques Muyembe Tamfum

Ebola fighter

The co-discoverer of Ebola faces his tenth battle with the virus in the DRC – his toughest yet.

By Amy Maxmen

In 1976, Jean-Jacques Muyembe Tamfum travelled deep into the tropical forests of what is now the Democratic Republic of the Congo (DRC) to investigate an outbreak of an unidentified ailment that was swiftly killing people.

The young researcher realized that something was odd when he drew blood samples from those who were sick and the needle pricks wouldn't clot. Blood spilt over his bare hands. Nurses he worked beside were dying, and Muyembe began to worry. "I started taking my temperature every morning and every night," he says. Miraculously, he never fell ill from the virus, later named Ebola.

Now, 43 years after discovering the disease, Muyembe is leading the DRC's response to the most volatile outbreak of Ebola yet. Since August 2018, the epidemic has killed more than 2,200 people in the northeast of the country, a region already pummeled by a quarter of a century of conflict and political instability.

Muyembe – who took the helm of the response in July – brings deep experience to the effort, along with a dedication to

cutting-edge science. Beginning in 1995, he developed the key public-health measures still used to contain the virus. During a large outbreak in the DRC city of Kikwit, he realized that the most vital step was to converse with communities so that they trusted him and understood how to protect themselves. He found ways to bury the dead respectfully while minimizing the risk of infection. And he began investigations that would lead to the roll-out of effective Ebola drugs and vaccines. During this outbreak, he took blood from Ebola survivors and infused it into eight people who had been infected, in the hope that antibodies would quash the virus. Seven of the recipients survived.

Last month, a 680-person, controlled clinical trial led by his team showed a 90% survival rate for those treated with antibody-based drugs shortly after infection. One of the drugs, mAb114, is derived from an antibody from the blood of a survivor whom Muyembe recruited during the Kikwit outbreak. Nancy Sullivan, an immunologist at the US National Institutes of Health in Bethesda, Maryland, attributes the success to Muyembe's doggedness at the time. "His contribution was pivotal to show that you can do a trial in a chaotic outbreak," she says.

"He was there at the start and he is still there because he is so persistent."

In recent weeks, the number of new Ebola cases being recorded has dwindled – progress that Muyembe's colleagues attribute in part to his leadership. Yet, in a rushed call with *Nature* in late November, the Ebola veteran was worried. Violence had broken out in Beni, a city hit hard by the epidemic, and Ebola responders were on lockdown. But backing down has never been an option for Muyembe. David Heymann, an epidemiologist at the London School of Hygiene and Tropical Medicine, says: "He was there at the start and he is still there because he is so persistent."

After this outbreak eventually ends, Muyembe is determined to unravel one last puzzle before retirement. His team has been collecting animals from regions where the virus has spilt into people, in the hope of tracking how the disease moves between species. "I want to find the vector," he says.

Yohannes Haile-Selassie

Origin seeker

A palaeontologist shook up the human family tree with the discovery of a remarkably preserved 3.8-million-year-old skull.

By Nisha Gaiind

It was a pale, circular shape on the ground, about the width of a grapefruit, that caught the attention of Yohannes Haile-Selassie when he was investigating a site in the northern Ethiopian desert in February 2016. The object was jutting out of the parched earth just 3 metres away from a jawbone found by a goat herder a few hours earlier. “Before I picked it up, I said, ‘Oh my goodness, this is something.’”

The fossils together formed a remarkably complete early hominin skull, which Haile-Selassie’s team dated to 3.8 million years old. It belongs to a species called *Australopithecus anamensis* – the oldest and most elusive known human relative. That afternoon, the team celebrated their rare find with cold Cokes, beers and dancing.

The skull, known as ‘MRD’ and revealed to the world in August (Y. Haile-Selassie *et al. Nature* 573, 214–219; 2019), gave researchers their first look at the face of

“Before I picked it up, I said, ‘Oh my goodness, this is something.’”

this enigmatic ancient relative, which was previously known from just a few bone fragments. Palaeoanthropologists are impressed by the specimen, and some say it is rivalled only by Lucy, the 3.2-million-year-old skeleton fossil of the closely related species *Australopithecus afarensis*. “That’s a big thing to hear from our colleagues,” says Haile-Selassie, a palaeoanthropologist at the Cleveland Museum of Natural History in Ohio.

Haile-Selassie is considered one of the field’s most talented fossil finders. Many treasures have surfaced from his project in Woranso-Mille, a region scattered with hominin fossils from the Pliocene, a key

period in the evolution of the genus *Homo* and its close relative *Australopithecus* between 5.3 million and 2.6 million years ago. He is also one of a crop of Ethiopian palaeoanthropologists who lead major scientific projects in their homeland – a big shift from a generation ago, when foreigners oversaw most of the research in this fossil-rich nation.

When Haile-Selassie was doing his PhD in the mid-1990s, his potential was clear and he had a knack for both laboratory and fieldwork, says Tim White, a palaeoanthropologist at the University of California, Berkeley, and Haile-Selassie’s PhD adviser. Fieldwork in remote areas is extremely difficult, says White, but Haile-Selassie has nailed it: organizing people, equipment, vehicles and permits, and all using multiple languages. “It’s not luck that Yohannes put these people in Ethiopia in this place, with all the right specialists to work on a problem.”

MRD is important in part because it is from a time period that was literally empty in terms of the fossil record, says Haile-Selassie. And it shook up the oldest branches of the hominin evolutionary tree. Researchers previously thought that Lucy’s species had evolved from *A. anamensis* – in a ‘classic’ case of direct evolution from one species to another, says Fred Spoor, a palaeontologist at the Natural History Museum in London. But Haile-Selassie and his colleagues argued that the skull’s features, together with the reanalysis of some existing fossils that it allowed, suggest that early hominin evolution was much messier, and that *A. anamensis* and *A. afarensis* overlapped for at least 100,000 years. It’s also vanishingly rare to find such an intact specimen. “The MRD find is an iconic cranium,” says White.

Not everyone agrees with the evolutionary shake-up that Haile-Selassie’s group has proposed. The team is still studying the cranium for more clues about its place in prehistory, and Haile-Selassie hopes to revisit the discovery site to enrich the picture. “Hopefully the rest of the skeleton might be there, who knows,” he says.

Of all his discoveries, MRD is number one, says Haile-Selassie. As a daily reminder, the moniker now features on his car’s number plate.

Wendy Rogers

Transplant ethicist

An academic revealed ethical failures in China's studies on organ transplants.

By David Cyranoski

For two decades, controversy has swirled around the origin of some livers, hearts and kidneys used for organ transplants in China. First, the government denied that organs had been taken from prisoners; then, it admitted it. It now says the practice has been banned since 2015, and that organs all come from volunteers. But researchers have questioned that, too.

Wendy Rogers, a bioethicist at Macquarie University in Sydney, Australia, found a new way to prise open the issue: examining research publications by Chinese transplant doctors. Her team's investigation, published in February (W. Rogers *et al. BMJ Open* 9, e024473; 2019), triggered more than two dozen retractions of reports of transplants, after doctors couldn't prove that donors gave consent. "If you think about what's really happening, it's unbearable," Rogers says.

The retractions help to place the practice among the world's major bioethical scandals, says Yves Moreau, a computational biologist at the Catholic University of Leuven in Belgium — and show how seriously scientists and publishers should take research ethics.

Rogers's shift from academic to activist

started at a 2015 conference that screened a documentary, *Hard to Believe*, discussing forced organ donations from political prisoners. Rogers had studied Australia's transplant system, and was shocked by what was going on in China. In 2016, she became the unpaid chair of the international advisory committee of the International Coalition to End Transplant Abuse in China (ETAC), a non-profit advocacy group in Sydney. Following an anonymous lead, she investigated a 2016 paper in *Liver International*, in which she found the documentation of donors lacking; the paper was retracted in 2017.

Rogers knew there must be many more problematic papers. She worked over nights and weekends with a team of researchers and volunteers to sift through thousands of papers. They found more than 400 that Rogers's team concluded had probably used organs from prisoners and didn't make their source clear. Those papers, published between 2001 and 2017, reported more than 85,000 transplants. The team spotlighted 17 journals that had published 5 or more papers. Two reacted. *PLoS ONE* retracted 19 of the 21 papers on Rogers's list; an investigation into the other two is ongoing. *Transplantation* retracted seven: five of six on Rogers's list and

two it identified on its own. The retraction notices say that the authors didn't respond or couldn't give satisfactory explanations.

Joerg Heber, editor-in-chief of *PLoS ONE*, says he is grateful to Rogers's team. His journal has now strengthened its reporting requirements for transplantation papers. For the journals that haven't responded, Rogers says, "I really urge them to take this seriously."

ETAC approached Geoffrey Nice, a lawyer with experience prosecuting war criminals in The Hague, the Netherlands, to write about what was happening. Nice suggested an international panel, which he chaired and to which Rogers gave evidence. The panel also considered a paper published this year that questioned data from China's organ donation programme (M. P. Robertson *et al. BMC Med. Ethics* 20, 79; 2019).

In June, the panel concluded that people imprisoned for their religious or political views had been killed for their organs in China, and that the practice probably continues. That report and Rogers's work were both met with silence from China. Rogers is not optimistic that China will ever be fully transparent about its transplants, but the scrutiny might stop any forced harvesting of organs, she says.

Hongkui Deng

CRISPR translator

A Chinese scientist shows that CRISPR gene editing can be used safely in adults with HIV.

By David Cyranoski

The CRISPR–Cas9 gene-editing system was developed less than a decade ago, and it is already showing up in the clinic. This year marked what many consider the first published report of its use in a person. The study came from the laboratory of Hongkui Deng at Peking University in Beijing, and showed how CRISPR gene editing can create a potentially limitless supply of immune cells that are impervious to infection by HIV.

The approach was designed to recapitulate the success with the ‘Berlin patient’, Timothy Ray Brown. In 2008, Brown became the first person known to be cleared of the virus, thanks to a bone-marrow transplant he received as part of a treatment for leukaemia. His doctors had intentionally sought a donor with a genetic mutation that disables CCR5, a protein that HIV uses to infect immune cells. They wiped out Brown’s immune system,

then replenished it with the donor cells, and the virus disappeared.

But the protective mutation found in Brown’s bone-marrow donor is rare, and it is practically non-existent in China. So Deng, who was part of one of the teams that discovered CCR5’s importance in HIV in the 1990s, decided to try editing the gene instead. He took immunologically matched blood-forming stem cells from the bone marrow of a donor, edited them with CRISPR–Cas9 and then transplanted them into a person with leukaemia and HIV. “We are hoping for an exact mimicry of the Berlin patient,” he says.

But for safety’s sake, and because the type of cell used is difficult to edit, Deng used a mixture of cells for the transplant; only about 18% had been modified. The patient’s HIV infection remained (L. Xu *et al.* *N. Engl. J. Med.* **381**, 1240–1247; 2019). Deng says the work showed how CRISPR–Cas9 edited cells could be part of a bone-marrow transplant

and not cause adverse events. Some edited cells remain in the patient’s blood today, almost two years later. “We were most interested in persistence,” he says. “That is the major result of the paper.”

But according to Fyodor Urnov, a biologist at the University of California, Berkeley, who also is trying to push CRISPR into the clinic, the failure to successfully treat HIV was indicative of a rush to translate the technology. Previous experiments had shown that the clinical benefits achieved through other gene-editing methods, such as zinc-finger nucleases, depend on the efficiency of the editing process. The treatment couldn’t possibly work with such a low percentage of edited cells, Urnov says, and Deng and his team should have known that. “Their work will stand as an example of how not to do this,” he says.

Deng defends the experiment, and hopes in the short term to transplant a higher proportion of gene-edited cells. He also wants to develop methods for reprogramming cells into pluripotent stem cells, which are easier to edit, and then convert them into blood-forming stem cells for transplant. “That would be perfect,” says Deng.

John Martinis

Quantum builder

“It was clear to me that this was a great idea and that it would be wonderful to work on it.”

A physicist led Google’s first demonstration of a quantum computer that could outperform conventional machines.

By Elizabeth Gibney

When John Martinis was a graduate student in the mid-1980s, he went to a lecture that set the course of his scientific life. The famous physicist Richard Feynman discussed the idea of using particles’ quantum characteristics to make computers that could do things that are impossible on conventional machines. “It was clear to me that this was a great idea and that it would be wonderful to work on it,” Martinis says.

In October, Martinis took a big step towards Feynman’s dream. He led the work of a group of researchers at Google who announced that they had demonstrated a first: a quantum computer that could carry out a calculation faster than the best conventional computer. “Doing this experiment was the culmination of my career,” says Martinis.

The physicist, who works both at Google and at the University of California, Santa Barbara, has spent 17 years honing the hardware that underpins the firm’s quantum computer, named Sycamore. At its heart are tiny superconducting loops known as qubits, quantum systems that seem to exist in multiple states until they are observed. Physicists have long theorized that harnessing interactions between qubits could enable computers to excel at certain calculations, such as probing otherwise unsearchable databases and cracking conventional encryption.

A team of more than 70 scientists and engineers showed that, for a specific challenge – calculating the spread of outputs from a kind of quantum random-number generator – Sycamore could do in 200 seconds what they estimated would take the best supercomputer 10,000 years (although others argued that it would need only days).

The feat relied on improved hardware that lowered error rates and connected qubits in new ways. Some physicists debated

the significance of the landmark, and the task has limited practical application. But Martinis says the experiment’s importance lies in demonstrating something fundamental: that physicists’ understanding of quantum interactions – learnt on small quantum systems – remains true at larger scales and complexity. “That’s really good news,” he says.

Hartmut Neven, who leads Google’s Quantum Artificial Intelligence laboratory, says that Martinis used to be a mountain

climber, and that he applies that same careful, deliberate approach to building hardware, in which every sequence of moves must be thought out in advance. “John’s idea of a relaxing Sunday is to go into the lab and solder something together,” he says. “Life and work aren’t really separated.”

Martinis has many more ideas he’s hoping to pursue. His future priorities include making better quantum chips – including mastering methods to correct for errors caused by noise – and opening up Sycamore for use by outside researchers on a cloud system, to see whether there are useful algorithms that it could run. One idea is a method to verify that supposedly random numbers are truly random. “Physicists like me don’t retire,” he says with a smile. “We have lots of things to do.”

ONES TO WATCH 2020

António Guterres

Secretary-general, United Nations

This Portuguese diplomat has pushed for aggressive action on global warming, and that advocacy could prove crucial as nations meet in 2020 to update their pledges under the 2015 Paris climate agreement.

Denis Rebrikov

Kulakov National Medical Research Center for Obstetrics, Gynecology and Perinatology, Moscow

There has been an international outcry over this biologist's plans to start producing gene-edited babies, pending approval from the Russian government.

Geng Meiyu

Shanghai Institute of Materia Medica, China

This researcher and her team discovered a compound that has been approved in China to treat Alzheimer's disease, but sceptics have questioned its efficacy and many await more definitive trials.

Mariya Gabriel

European Commissioner for Innovation, Research, Culture, Education and Youth

The European Union's next spending plan for research and innovation, known as Horizon Europe, will take shape under the leadership of this Bulgarian political scientist.

Markus Rex

Alfred Wegener Institute, Germany

This atmospheric scientist is leading the €140-million (US\$155-million) MOSAiC expedition, in which a German ship frozen into Arctic ice for a year will collect data about polar conditions.

Greta Thunberg Climate catalyst

A Swedish teenager brought climate science to the fore as she channelled her generation's rage.

By Quirin Schiermeier

At a US congressional hearing on climate change in September, Greta Thunberg slid a slim bundle of papers across the table towards lawmakers. It was a special report from the Intergovernmental Panel on Climate Change, predicting dire consequences as the world warms. "I don't want you to listen to me, I want you to listen to the scientists," she told the legislators. "I want you to unite behind the science and I want you to take real action."

Scientists have spent decades warning about climate change, but they couldn't galvanize global attention the way that Thunberg did this year. The Swedish 16-year-old has outshone them – and many are cheering her along.

"Some may wonder why a teenage girl should get more credit and attention for publicly lamenting a well-known dilemma than most climate researchers get for years of hard work and effort," says Sonia Seneviratne, a climate scientist at the Swiss Federal Institute of Technology in Zurich. But Thunberg is candid and her outrage

unvarnished, and that is powerful, says Seneviratne. "As scientists, we normally don't dare to express the truth in such heartfelt simplicity."

Many researchers hail Thunberg in particular for focusing attention on climate change and its catastrophic impacts. What she has achieved should motivate climate researchers to carry on with their science despite slow political action, says Seneviratne.

"Greta has inspired scientists along with activists and policymakers," says Angela Ledford Anderson, director of the Climate and Energy programme at the Union of Concerned Scientists in Washington DC. In July, German Chancellor Angela Merkel announced sweeping measures to reduce carbon emissions, and acknowledged that the protests Thunberg ignited "drove us to act".

But perhaps Thunberg's biggest influence will be on the next generation of scientists, Anderson says. "Her mobilization of young people shows the rising generation expects science to inform policy," she says, "and may inspire many to become scientists themselves."

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