NATURE'S 10

Ten people who helped shape science in 2021.

Winnie Byanyima / Friederike Otto / Zhang Rongqiao / Timnit Gebru / Tulio de Oliveira / John Jumper / Victoria Tauli-Corpuz / Guillaume Cabanac / Meaghan Kall / Janet Woodcock

The *Nature*'s 10 list explores key developments in science this year and some of the people who played important parts in these milestones. Along with their colleagues, these individuals helped to make amazing discoveries and brought attention to crucial issues. *Nature*'s 10 is not an award or a ranking. The selection is compiled by *Nature*'s editors to highlight key events in science through the compelling stories of those involved.

Winnie Byanyima
Vaccine warrior

This UN leader knew that vaccine equity wouldn't happen without a fight.

By Amy Maxmen

Before vaccines for COVID-19 even existed, Winnie Byanyima knew that distributing them equitably would be a challenge. In early 2020, she was one of the few voices warning that low- and middle-income countries could not rely on donations alone to vaccinate their people. The only way to get life-saving shots to everyone, she argued, would be by helping as many companies as possible to manufacture them and by setting up systems of distribution to get them where they're needed.

That hasn't happened. Companies that developed coronavirus vaccines, such as Pfizer–BioNTech and Moderna, have held on tightly to the intellectual-property (IP) rights, and wealthy countries have snapped up most doses. Several nations are now distributing booster shots, whereas only about 6% of people in low-income countries have received a single dose. Byanyima expected this disparity because of her experience with the AIDS epidemic. In the early 2000s, life-saving drugs existed but were largely unavailable in her home country of Uganda.

She finds the profit models for some drugs and vaccines infuriating. "This idea that you can sell a life-saving health technology the way you sell a luxury handbag is not normal," says Byanyima, who leads UNAIDS, the United Nations agency heading the effort to end AIDS around the world. "We shouldn't normalize it, we shouldn't respect it and we should call it what it is: immoral, greedy and wrong." Byanyima co-founded the advocacy group the People's Vaccine Alliance to change that way of thinking. Its strategy has been to enlist powerful leaders by presenting them with carefully tailored arguments that highlight how supporting vaccine equity will further their own goals. "Governments are not saints, but they respond to people's demands."

This May, Byanyima and her colleagues celebrated an unexpected victory when the United States — historically a strident patent defender — threw its weight behind a proposal from South Africa and India to waive the IP protections surrounding COVID-19 vaccines in the hope of bolstering manufacturing capacity.

There is still much work to be done. Several countries and the European Union remain opposed to such a waiver, and the companies that own the IP have rejected requests to license their vaccine technologies and share the knowledge needed to produce them. The corporations defend their actions by saying that waivers would not change the situation and would undermine innovation.

Byanyima disagrees, and her frank statements on this and other matters of inequity have won her many admirers. "Some people will say inequality is bad," says John Nkengasong, director of the Africa Centres for Disease Control and Prevention. "But when Winnie talks about it, you feel there is a fire in her that comes from within."

Byanyima says it was this thirst for justice that caused her to leave her career in aeronautical engineering soon after the overthrow of Uganda's former authoritarian president Idi Amin. In 1981, she joined a guerilla movement fighting to restore democracy and human rights to Uganda. They prevailed, and by 1994, she was elected to Uganda's parliament. She was appointed head of UNAIDS in 2019, where she is putting equity at the centre of the programme's work around the world. Global-health-policy researcher Matthew Kavanagh took leave from a position at Georgetown University in Washington DC, to work for Byanyima because of the way she targets underlying inequalities that foster the spread of HIV. The same goes for COVID-19: "Winnie drove the conversation on vaccine equity, starting way before vaccines existed, and others have raced to catch up," Kavanagh says.

Byanyima is working to ensure that the fruits of science change lives. "Without political decisions to reduce inequality," she says, "we can't get anywhere."

"We shouldn't respect it and we should call it what it is: immoral, greedy and wrong."

ERICH BARTLEBAUGH/BUZZFEED NEWS/EYEVINE

Friederike Otto
Weather detective

As heatwaves, floods and droughts multiply, this researcher assesses whether humans bear some blame.

By Quirin Schiermeier

Friederike Otto has spent the past seven years studying extreme weather events, but even she was shocked when an extraordinary heatwave hit Canada and the US Pacific Northwest in July, shattering temperature records and killing hundreds of people.

Whenever extreme weather strikes these days, people immediately wonder whether climate change is to blame. This is exactly the kind of question that Otto and her collaborators in the World Weather Attribution (WWA) group try to answer quickly. Otto set up a video call with the WWA team and they planned a speedy research study. The team pored over meteorological data to gauge how big the heatwave was, studied climate records for the region and ran computer models to find out how much more likely this kind of heatwave has become, relative to a hypothetical world without climate change. The result: it would have been all but impossible for a heatwave of that magnitude to have happened in the region without human-induced climate change.

"Temperature records were broken by 5 °C in some places," Otto says. "That's immense."

Otto, a climate researcher at the Grantham Institute for Climate Change and the Environment in London, helped to set up the WWA in 2015 with the aim of rapidly analysing whether climate change plays a part in extreme heat, cold, downpours, drought and wildfire activity. She chairs the ad hoc group, which includes about a dozen climate modellers and statisticians.

Aside from the American Northwest heatwave this year, she and the group analysed the role of climate change in the devastating floods in July in Germany and Belgium, an April 'cold wave' in France, and the persistent drought in Madagascar.

Otto earnt her PhD in the philosophy of science before turning to physics, and eventually to climate science. Like many researchers, she is sincerely worried about the impacts of climate change. "I'm into justice," she says. "And climate change is one of the biggest threats to justice."

Until a few years ago, scientists would have been hard pressed to answer with certainty whether climate change is to blame for specific extremes, and how much more (or less) likely they have become. Many scientists viewed attribution studies critically when the WWA made its first attempts to analyse extreme events — using just one or two climate models without evaluating whether these were able to reliably simulate the extreme in question.

This has changed entirely. Otto and her team — including her former co-chair, the Dutch climate modeller Geert Jan van Oldenborgh, who died this year after a long illness — have developed a strategy that uses climate simulations from as many as 50 models. This approach and the studies generated are now widely viewed as highly robust; they feature prominently in a report issued in August by the Intergovernmental Panel on Climate Change, a scientific committee established by the United Nations. It is now an "established fact", the panel said, that rising greenhouse-gas emissions have made some weather extremes — in particular, extreme heat — more frequent and more intense. Its report came out shortly before the 26th Conference of the Parties (COP26) to the global climate-change treaty, held last month in Glasgow, UK.

Attribution studies are more difficult in the global south, where reliable climate data are often lacking, and where local research capacities are limited. But these are some of the places most at risk from climate change and the extreme weather that it can spark. Otto hopes that lower-income countries will be able to strengthen their research in these areas in coming years, with support from wealthier countries.

"Attribution studies are really essential in terms of understanding human impacts of climate change," says Emily Boyd, a social scientist at Lund University in Sweden who studies climate adaptation and governance. "The science is shifting our mindsets — it allows us to think about the relation between climate and vulnerability in a completely new way."

Together with Boyd and legal scholars, Otto will study how vulnerable groups and countries might be able to capitalize on attribution studies. "The science", says Boyd, "has every potential to drive government action and promote climate justice."

Zhang Rongqiao
Mars explorer

This engineer leads China's first successful Mars mission, which reached the planet this year and landed a rover on its surface.

By Smriti Mallapaty

On 15 May, Zhang Rongqiao wiped tears from his eyes as China's Mars rover landed safely on the planet's sandy, auburn plains. "I was so overwhelmed," says Zhang, who coordinated the mission.

The touchdown marked the conclusion of a 475-million-kilometre journey full of peril for Zhang and the China National Space Administration, which had never before sent a successful mission to Mars.

The landing, says Zhang, gave him a taste of the old Chinese saying — it takes ten years to sharpen a good sword. China is only the second nation, after the United States, to place a rover on Mars, which is notorious for crushing the hopes of space agencies; nearly half of all missions to the planet have ended in failure.

China's team faced many unknowns in what Zhang calls "such a strange and complex environment". As chief designer, he is responsible for coordinating a team of tens of thousands who built and operate the Mars mission, named Tianwen-1. The project consists of an orbiter, a lander and the rover, called Zhurong. "The buck stops with him," says David Flannery, an astrobiologist at Queensland University of Technology in Brisbane, Australia.

The mission was one of three to arrive at Mars in 2021 — the others were NASA's Perseverance rover and an orbiter delivered by the United Arab Emirates. The success of China's mission has made a national hero of Zhang, who has appeared numerous times on state media, but rarely talks to the press outside China. He responded to

Nature's questions by e-mail.

Science took a back seat to Tianwen-1's primary goal, which was to develop and demonstrate China's prowess in deep-space missions that travel beyond the Moon. But Zhang says that getting rich and high-quality information from Mars was a key consideration of the design. And researchers say that the data generated by the rover's six scientific instruments, and another seven on the orbiter, will contribute to a better understanding of a previously unexplored patch of the planet.

Born in 1966 in the town of Anling, eastern China, Zhang studied engineering at Xidian University in Xi'an. He later completed a master's degree at the Chinese Academy of Space Technology in Beijing, and has worked on Earth-observation satellites.

Lu Pan, a planetary scientist at the University of Copenhagen, says that Zhang probably played a key part in the CNSA's decision to send an orbiter, lander and rover to Mars in one shipment — making China the first country to do so. Researchers also say that Zhang considered their input on

the choice of instruments and landing site, which will help to ensure that the mission generates as much research as possible.

"He encouraged scientists to participate in the mission to get more scientific output," says Wenzhe Fa, a planetary scientist at Peking University, Beijing, who is analysing radar data from the Mars mission.

Launched on 23 July 2020, Tianwen-1 arrived at the red planet in February, and dropped the lander and rover in May. The spacecraft settled on a vast impact crater named Utopia Planitia — selected mainly because it is flat and a relatively safe place to land. Since then, the rover has travelled more than 1,200 metres south, taking panoramic images as well as selfies that have been widely shared online.

In mid-September, Zhurong went into hibernation because the Sun got in the way of communications between Mars and the Earth, but it returned to work in late October. It is now heading towards a region that might once have been the coastline of an ancient ocean, where researchers will search for clues about the evolution of Mars.

The mission has produced limited science so far, but data collected by some instruments on the rover and orbiter have been shared with more than two dozen teams across the Chinese mainland, Hong Kong and Macau, says Fa, and results are seeping out. They expect to learn insights about the geology of the Utopia Planitia region and the fate of water on the planet.

For China's deep-space missions to take a big leap scientifically, the country will need to refocus towards advancing research rather than chiefly demonstrating engineering. That switch has already happened with China's lunar missions, says Pan. "These processes take time."

The real research riches for China, says Flannery, will come later — with the next round of planetary missions. China plans to launch sample-return missions to the asteroid Kamo'oalewa in 2024, and to Mars before 2030. And it has its sights set on Jupiter, too.

Tianwen-1 has also given China's nascent field of planetary science a boost, say researchers.

"A new generation of scientists is being created right now with this mission," says Flannery.

Timnit Gebru
AI ethics leader

After losing her job at Google, an artificial-intelligence pioneer founded an independent institute to raise questions about ethics in technology.

By Holly Else

Timnit Gebru, a researcher who studies the ethics of artificial intelligence (AI), says her past year has been — in a word — horrible. Last December, she lost her job at Google after a row over the tech giant's vetting of her work. The highly publicized ousting shocked scientists, including some in the firm, and thousands of researchers rallied to support her, amplifying her concerns around anti-Black discrimination in AI, and around the harms that the technology can cause to marginalized groups in society.

Now, Gebru has forged her own path. On 2 December this year, exactly 12 months after her split with Google, she launched a research institute to study AI independently of big tech companies. The events of the past year, she says, reflect a growing realization that the faults of AI should not be framed as technical problems: they are a symptom of the flawed environment in which the technology is developed.

Born in Ethiopia to parents from Eritrea, Gebru fled the region during a time of war as a teenager and eventually arrived in the United States as a refugee. During her PhD at Stanford University in California, she co-founded a 'Black in AI' group with computer scientist Rediet Abebe. And while working at Microsoft, she and computer scientist Joy Buolamwini reported that facial-recognition software performed less well at identifying the gender of people who were not white men — a finding that drew more attention to bias in AI.

Gebru joined Google in 2018, where she co-led the firm's ethical AI team with Margaret Mitchell. The pair had a reputation for creating a supportive environment for Black and brown researchers at the firm, where 1.6% of researchers (now 1.8%) were Black women. Their team studied the potential harms of AI, helped Google product teams to think through societal risks of their technologies and supported workforce diversity and inclusion.

But in late 2020, a dispute flared about a paper Gebru had authored with Mitchell and external academics. It critiqued the environmental impacts and potential biases of large language models — AI software that generates fluent prose and that Google uses in search engines. Gebru was told that internal reviewers at the firm wanted her to withdraw the paper from a conference that she'd submitted it to, or to remove Google-affiliated authors; when she asked for details about who had suggested this — and e-mailed colleagues saying that Google was silencing marginalized voices — she found herself without a job. Google says it accepted her resignation; Gebru says that she was fired, as she had only threatened to resign. (Google didn't respond to *Nature*'s request for comment for this article.)

Gebru tweeted about the split, and the company faced a storm of protest. Almost 7,000 researchers and engineers, including more than 2,600 from Google, signed a petition in December 2020 calling for an overhaul of the company's research integrity. In February, the firm fired Gebru's colleague Mitchell after she searched for incidents of discrimination against Gebru in her company e-mail. Two other Google employees left the company outraged at Gebru's treatment, and several groups that support minority researchers in AI ended sponsorship agreements with Google.

Gebru says that what happened to her was a display of disrespect to her and her work that amounts to misogynoir — anti-Black sexism. "They would never do what they did

"Google had a problem with me speaking up about discrimination."

to me to someone else," she says. "Google had a problem with me speaking up about discrimination."

Meredith Whittaker, who researches the social implications of AI at New York University, says that it suddenly became clear to those on the outside that Google's commitment to ethics "was only paper thin".

Reverberations from the firing were powerful because Gebru has such a high-profile voice, says Luke Stark, a researcher who studies the social impacts of AI at Western University in Ontario, Canada. "It was immediately obvious that this was censorship," he says. The firing also brought into focus AI research's dependency on corporate money, and how academics have become so entangled in it, Whittaker adds.

Gebru says that she has long had ideas about creating her own institute to build a positive model of how AI work should be done. Those dreams came to fruition after she applied for grants and won US$3.7 million in funding from several philanthropic organizations. The Distributed Artificial Intelligence Research Institute — a remote interdisciplinary centre — will develop AI models and applications that do not depend on the large data sets and computing power that the big tech companies hold.

The organization has two advisory board members and two research fellows (including Gebru), and expects to hire more people soon. "Her institute is not going to shy away from the reality of things," says Deborah Raji, who has collaborated with Gebru on AI ethics and works at the non-profit Internet foundation Mozilla. "It's going to be a great landing spot for people who want to ask these questions and don't have somewhere to do it. She's going to define the field in ways people don't appreciate. It is going to be amazing."

Tulio de Oliveira
Variant tracker

A bioinformatician in South Africa helped to identify troubling variants of the coronavirus SARS-CoV-2.

By Linda Nordling

On 25 November, Tulio de Oliveira announced the discovery of a new variant of SARS-CoV-2. Omicron, detected in samples from Botswana, South Africa and Hong Kong, had a Swiss Army knife of mutations that de Oliveira and other leading scientists feared might help it to evade immunity from previous infection or vaccinations.

For de Oliveira, director of South Africa's KwaZulu-Natal Research Innovation and Sequencing Platform (KRISP), it was eerily reminiscent of the previous year, when his team had discovered another SARS-CoV-2 variant of concern in South African samples. Beta, as that variant became known, led foreign governments to curb travel to and from South Africa many months after its discovery. Both variants were spotted after doctors and laboratory workers flagged unexpected rises in infections in areas that had already been hit hard by COVID-19.

De Oliveira knew that by reporting yet another concerning variant, he ran the risk of incurring fresh sanctions, which would economically penalize countries in southern Africa. But he also knew it was the right thing to do. "The way that one stops a pandemic is by quick action," says the Brazilian-born bioinformatician. "Wait and see has not been a good option."

The rapid identification of both Beta and Omicron in southern Africa reinforces the importance of having disease surveillance spread evenly around the world, says Jeremy Farrar, director of the biomedical research charity Wellcome, based in London. "If an imbalance continues, then where disease surveillance is limited, we risk new variants of COVID-19 — or even new diseases entirely — cropping up and spreading unchecked," he says.

The COVID-19 pandemic isn't the first time that genomic sequencing has been used to trace outbreaks in Africa; scientists used it in the Ebola outbreak in West Africa from 2014 to 2016. KRISP, created in 2017 with de Oliveira at the helm, has tracked pathogens behind diseases including dengue and Zika, and more common scourges such as AIDS and tuberculosis. But never before have so many different samples of the same virus been sequenced in such a short period of time — both in Africa and around the world.

De Oliveira's work has also influenced policymaking. KRISP's way of working combines cutting-edge molecular technology with close links to doctors and nurses on the front line, to inform policy in real time. For example, their mapping of an early hospital outbreak of COVID-19 resulted in guidelines for ward layouts to prevent the virus from spreading in hospitals. "Tulio has done an incredible job pioneering a new way of science responding to epidemics," says Christian Happi, a molecular biologist who heads the African Centre of Excellence for Genomics of Infectious Diseases at Redeemer's University in Ede, Nigeria.

In December, de Oliveira moved permanently to Stellenbosch, outside Cape Town, South Africa, where he has been setting up the Centre for Epidemic Research, Response and Innovation (CERI) since July (he will keep his position at KRISP). The centre will work to control epidemics in Africa and the global south, and will house Africa's largest sequencing facility. The coronavirus pandemic has fuelled these investments, but the momentum is already spilling over into surveillance on other diseases, says de Oliveira. "The main thing we have shown the world is that these things can be done in developing countries."

Not that those countries have been rewarded for it — quite the opposite. De Oliveira says he was extremely disappointed when rich countries imposed travel bans on southern Africa simply because the country had the scientific skill to discover new variants. The scapegoating of South Africa "was almost a smokescreen for the vaccine hoarding, and for rich countries losing control of the pandemic", says de Oliveira. "Of course I expected more."

De Oliveira's role in announcing two variants of concern has given him a reputation for delivering bad news. When the Omicron announcement brought fresh travel bans, some South Africans, including politicians, queried de Oliveira's right to make such pronouncements. Some people even view the genomic-surveillance community as the enemy. But, he says: "We are not the enemies, we are the opposite."

ROGAN WARD FOR NATURE

John Jumper
Protein predictor

A team led by this AI researcher released a tool that is transforming biology

By Ewen Callaway

What would it mean if determining the structure of almost any protein — all of its intricate folds, pockets and catalytic surfaces — were as simple as performing a web search? John Jumper and his colleagues at DeepMind in London attempted to answer that question earlier this year with the public release of AlphaFold, which uses artificial intelligence (AI) to predict protein structures with stunning accuracy.

“It is going to change the face of modern biology,” says Tobin Sosnick, a biophysicist at the University of Chicago, Illinois, and one of Jumper's former PhD advisers. “There's going to be a before and after 2021, when people ask, ‘What is structural biology?’”

AlphaFold's development was a process of destruction and rebirth. In 2018, the team working on it jolted the small community of scientists interested in protein-structure prediction. At a biennial competition called CASP (short for Critical Assessment of Structure Prediction), an early version of AlphaFold outperformed all other computational tools for determining a protein's shape from its sequence.

But despite the win, AlphaFold didn't generate predictions with fine enough detail, says Jumper, who was co-leader of the team at the time. Efforts to improve its performance hit a wall. So the researchers decided to start from scratch. “You had to throw away everything,” says Pushmeet Kohli, head of AI for Science at DeepMind, a subsidiary of Alphabet, Google's parent company. Jumper had a key role in the decision to start afresh, says Kohli, and stuck with it, even when early versions of ‘AlphaFold2’ performed much worse than its predecessor. “He's not afraid of taking on new directions.”

Jumper has a history of changing tack. He started a PhD in condensed-matter physics at the University of Cambridge, UK, but decided it wasn't the right research topic. So he left with a master's degree and wound up working on computer simulations of proteins at a private research group run by a physicist-turned-hedge-fund-manager. “I didn't know what a protein was when I showed up,” says Jumper.

He next embarked on a chemistry PhD programme, in which he used machine learning to study protein dynamics. Applying AI to a scientific problem was “really magical”, says Jumper. But he wanted stability. So, he applied for jobs in finance as well as at commercial AI laboratories. During an interview with DeepMind, the company revealed its plans to tackle protein-structure prediction, and Jumper was intrigued. “I probably would have left science, if not for DeepMind,” Jumper notes.

The first iteration of AlphaFold was based on a neural network that predicted the distance between parts of a target protein, an approach that other teams were also taking. Jumper wanted AlphaFold to deliver predictions that scientists could have confidence in, necessitating a complete overhaul of the underlying neural network.

The second version of AlphaFold dominated CASP again in late 2020, this time by an even wider margin. Furthermore, nearly two-thirds of its predictions were on a par with experimentally determined structures. For Jumper, however, the most rewarding chapter in AlphaFold's story came in July. He and his team released the network's underlying code, as well as predicted structures for almost all proteins in humans and 20 other model organisms — 250,000 structures in total — together with the European Molecular Biology Laboratory's European Bioinformatics Institute in Hinxton, UK. They plan to release the structures of nearly half of all known proteins — totalling 130 million structures — next year.

Jumper's team regularly hears from other researchers who now use AlphaFold. One of the projects he was most excited about was a map of the nuclear pore complex, a gargantuan molecular machine that is a gatekeeper to the genomes of eukaryotic cells. The work combined AlphaFold's structures and other predictions with experimental structures comprising the complex, which consists of more than 1,000 individual protein chains.

For Jumper, such applications are the highest compliment. “To see the amount to which AlphaFold has changed the work of experimentalists has been really, really incredible,” he says. “The dream is to do something really useful.”
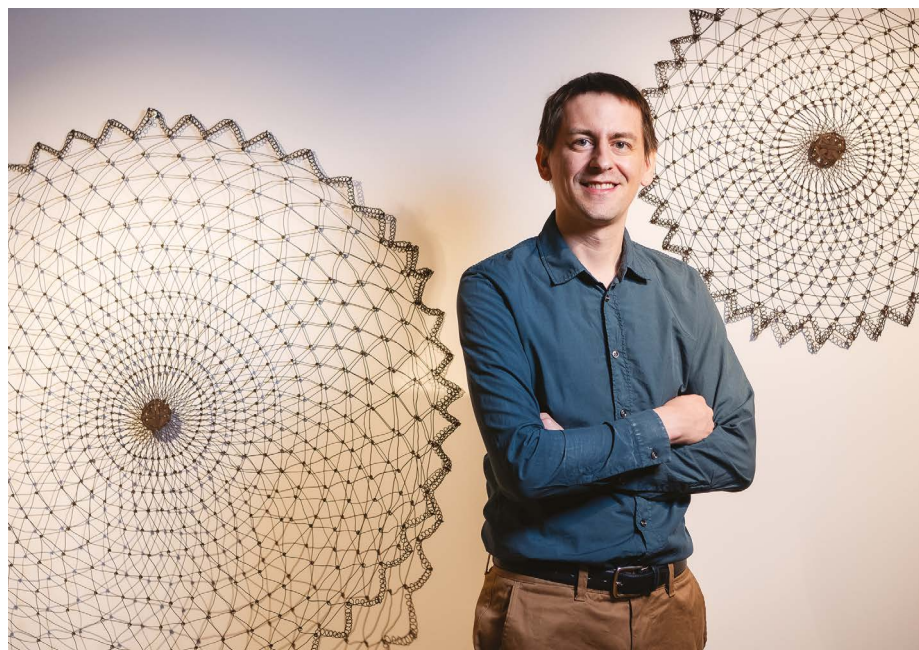
Victoria Tauli-Corpuz
Indigenous defender

A former revolutionary helped Indigenous peoples to gain international recognition for protecting biodiversity and the climate.

By Jeff Tollefson

As the United Nations climate summit COP26 kicked off in Glasgow, UK, several wealthy nations and more than a dozen philanthropic organizations stepped up with an unprecedented commitment. They pledged to provide US$1.7 billion to help Indigenous peoples around the world to preserve forests, protect biodiversity and prevent global warming by keeping carbon locked up in plants and soils.

It was a watershed moment for Indigenous groups, and much of the credit goes to decades of work by Victoria Tauli-Corpuz, an Indigenous leader from the Philippines who served for six years as the UN special rapporteur on the rights of Indigenous peoples.

Tauli-Corpuz has spent years criss-crossing the globe to convince governments, environmentalists and philanthropic foundations that Indigenous peoples are the best stewards of forests and other hotspots of biodiversity — something that has recently been backed up by scientific literature.

"The world caught up with her, and also science caught up with her," says David Kaimowitz, an economist at the Food and Agriculture Organization of the UN in Rome. Kaimowitz says that it has really only been in the past five or ten years that peer-reviewed literature has provided data showing that Indigenous lands serve as protective buffers against environmentally harmful activities such as mining, dams and deforestation (see A. Blackman *et al. Proc. Natl Acad. Sci. USA* **114**, 4123–4128; 2017). Having grown up in an Igorot village without electricity in the mountains of the Philippines, Tauli-Corpuz

learnt that lesson earlier than most. When the regime of former president Ferdinand Marcos sought to log her people's forests and install a hydroelectric dam in their river in the 1970s, she joined the opposition.

"We defeated the dam, and the logging stopped," says Tauli-Corpuz, who is the founder and executive director of the Tebtebba Foundation in Baguio City, the Philippines.

She realized that the fates of Indigenous peoples and the world's forests are inextricably intertwined. As she worked her way through the UN bureaucracy over the course of 35 years, Tauli-Corpuz became a forceful critic of what she calls "fortress conservation" — a model that presumes that nature can be preserved only if walled off from humanity. "The conservation mindset has to be changed," she says, because the forests that hold much of Earth's biodiversity and carbon are also home to the world's Indigenous populations. "People live in these forests, and we should be working with them." In recent years, with the help of satellite imagery, scientists have come to the same conclusion. Like national parks and other protected areas, Indigenous territories are less prone to deforestation, mining and dams than neighbouring lands.

That idea gained traction this year. Indigenous rights were recognized during the virtual UN Convention on Biological Diversity in October, and received unprecedented attention at the world conservation congress in Marseilles, France, in September. Indigenous groups attended the latter as members for the first time and successfully pushed for a motion that called on governments to protect 80% of
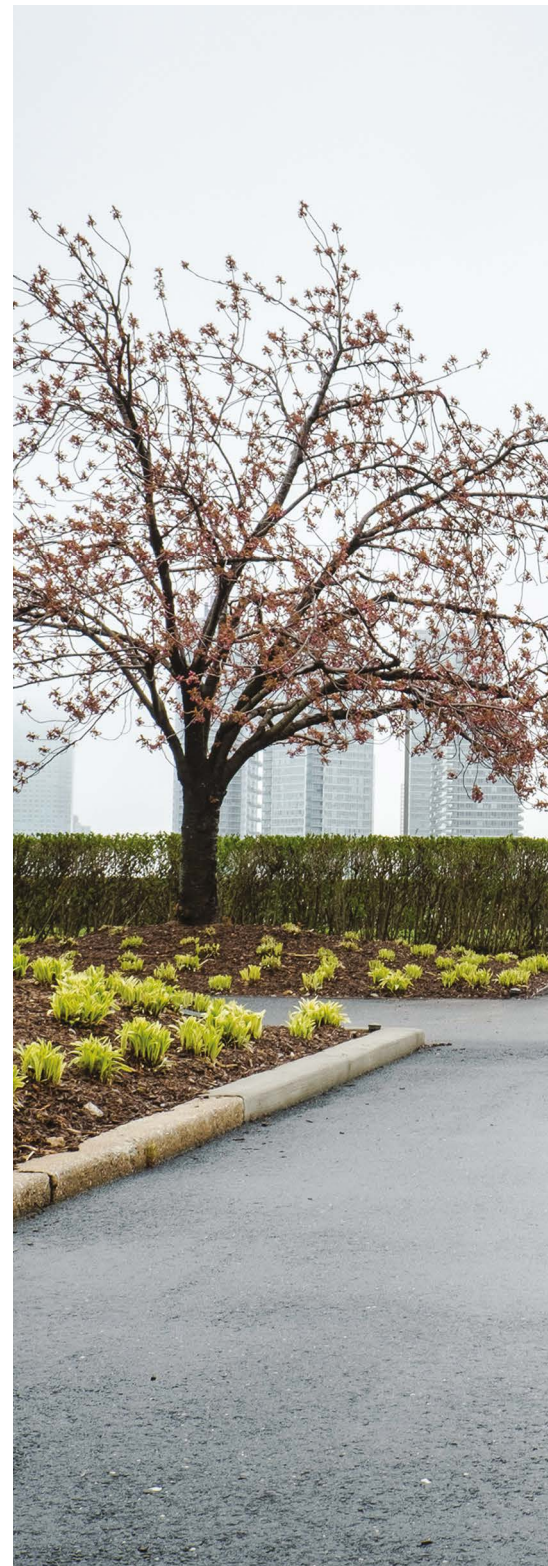
"The conservation mindset has to be changed."

the Amazon by 2025. And for the first time, governments and donors stepped up at COP26 with real funding commitments.

Activism came naturally for Tauli-Corpuz. After studying nursing at university, she returned home to help organize community health programmes, while also promoting resistance against the regime and the proposed dam and logging – activities that ultimately resulted in a military raid on her home in 1980.

In 1985, Tauli-Corpuz received an invitation to join a UN panel in Geneva, Switzerland, investigating Indigenous rights. It took nearly a quarter of a century and plenty of travel, but Tauli-Corpuz saw the effort through. In September 2007, the UN General Assembly in New York City adopted a landmark declaration that recognized, for the first time, the collective rights of Indigenous peoples. Tauli-Corpuz then carried that effort forwards under the UN climate convention, ultimately helping to garner recognition of Indigenous rights in the 2015 Paris agreement. At the COP26 summit, Indigenous rights were once again recognized in an agreement governing international partnerships and carbon markets.

From 2014 to 2020, as the UN special rapporteur, Tauli-Corpuz travelled the world, holding meetings with Indigenous communities to talk about the challenges they are facing on the ground. In one influential 2016 report to the UN, she shone a light on how the creation and enforcement of conventional protected areas such as national parks and nature reserves has often impinged on the rights and land claims of Indigenous communities (see www.undocs.org/A/71/229).

Now back at her foundation, Tauli-Corpuz continues to work with Indigenous communities around the world, helping them to understand their rights and gain the title to their traditional lands. She is also helping Indigenous communities to bolster their own governance systems, which will be crucial as they seek to propose projects and access the newly committed international funds.

"It's really about helping the Indigenous peoples empower themselves," she says. "Hopefully, we can strengthen their capacity to do what they need to do."

ANNIE LING/*THE NEW YORK TIMES*/REDUX/EYEVINE

Guillaume Cabanac
Deception sleuth

This computer scientist helped to uncover a new kind of fabricated paper.

By Diana Kwon

Underground creepy crawly state. Bosom malignancy. Sun oriented force. These might sound like expressions from a work of fiction, but they are actually strange translations, pulled from the scholarly literature, of scientific terms — ant colony, breast cancer and solar energy, respectively. Guillaume Cabanac, a computer scientist at the University of Toulouse, France, spots such bizarre phrases in academic papers every day.

This year, Cabanac and his colleagues found these tortured phrases, as they call them, in thousands of papers. A handful have been retracted; publishers are investigating many more. Cabanac has built a website to keep track of the mushrooming problem. "They found this whole new hornet's nest of articles that appear to be completely fake," says Elisabeth Bik, a research-integrity analyst in California.

Weeding out these problems is related to Cabanac's day job: he specializes in analysing the scholarly literature, and now devotes around two hours a day to finding tortured phrases. Some people might find them funny, but Cabanac takes the problem seriously. "This shouldn't be happening," he says.

Cabanac's hunt for gibberish papers began in 2015, when he started collaborating with Cyril Labbé, a computer scientist at the University of Grenoble Alpes in France. Labbé had developed a program to spot gibberish computer-science papers automatically generated using SCIgen, a

piece of software created initially as a joke. Labbé's work led journals to withdraw more than 120 manuscripts. Cabanac helped to update Labbé's program to find papers only partially written by SCIgen, and to locate them using Dimensions, a search engine for scholarly literature. This year, they reported finding hundreds more papers containing nonsense text, published in journals and conference proceedings and as preprints.

To raise awareness, Cabanac and his colleagues e-mailed publishers and posted their findings on social media and on PubPeer, a post-publication peer-review site. Cabanac also created the Problematic Paper Screener, a website for flagging and reporting questionable manuscripts. "He gets frustrated about fake papers," Labbé says. "He's really willing to do whatever it takes to prevent these things from happening."

The SCIgen work led Alexander Magazinov, a software engineer at the multinational technology firm Yandex, headquartered in Moscow, to contact Labbé and Cabanac. Magazinov asked whether SCIgen might be behind oddly paraphrased versions of scientific concepts he'd noticed in papers, such as "colossal information" for "big data". Together, the three located the terms in hundreds of papers, which they reported in July. Digging deeper, they suggested that machine-paraphrasing tools might have been used to create them.

"I think these tortured phrases indicate a failure of peer review," says Jennifer Byrne, a cancer researcher at the University of Sydney in Australia, with whom Cabanac has worked on other scientific-integrity projects. "Surely, somebody who was conscious during the peer-review process would have seen that that's not really right."

By now, Cabanac and colleagues — along with volunteers from the PubPeer community — have pinpointed nearly 400 tortured phrases in more than 2,000 papers, including ones in journals from well-known publishers such as Elsevier and Springer Nature (*Nature*'s news team is editorially independent of its publisher). Each such phrase first has to be spotted by a person; a search algorithm then runs on Dimensions' index to find papers that include it. Cabanac and a host of helpers manually scan each of these articles to weed out false positives. Eventually, Cabanac would like to develop a program that can identify tortured phrases automatically.

Cabanac hopes that his work will help to decontaminate the scientific literature. But he knows that will not be easy. "I'm afraid of new techniques that would help scammers publish papers containing errors that would be less detectable," he says. "It's a whack-a-mole game. We need to be prepared."

ONES TO WATCH 2022

Chikwe Ihekweazu
WHO Hub for Pandemic and Epidemic Intelligence
This epidemiologist will direct the surveillance hub and gather data on the COVID-19 pandemic and other outbreaks.

Jane Rigby
NASA Goddard Space Flight Center
As project scientist for operations for the soon-to-be-launched James Webb Space Telescope, this astrophysicist will help to orchestrate what discoveries are made.

Love Dalén
Swedish Museum of Natural History
This geneticist has sequenced the oldest DNA on record — 1.65 million years old, from a mammoth — and is now going after more genetic remains.

FRÉDÉRIC SCHEIBER FOR NATURE

Meaghan Kall
COVID communicator

A government epidemiologist went against norms to tweet explanations of UK coronavirus data.

By Richard Van Noorden

On the afternoon of 8 January, Meaghan Kall, a UK government epidemiologist, helped to put the finishing touches to a technical briefing document about a concerning SARS-CoV-2 variant spreading in southeast England. Then, about half an hour after the report was published, she tried something new: she posted a Twitter thread breaking down its key points.

Kall had seen increasing disquiet and confusion about the coronavirus variants online, and wanted to explain publicly what the government data showed. She hadn't asked permission from her bosses at Public Health England (PHE) — an agency tasked with responding to health threats, now succeeded by the UK Health Security Agency. "I just did it," she says. But she soon got an audience. UK researchers chimed in with questions; so did a US philosopher and an Argentinian programmer.

It was the first of a series of accessible, rapid explainers from Kall on dozens of the agency's coronavirus briefings. Through her tweets — prepared and posted around her day job — she became a human face for a government team that has provided many early answers to burning questions about COVID-19 in 2021.

Thanks to its early roll-out of vaccines, well-equipped genomics laboratories and unified National Health Service (NHS), the United Kingdom was quick to produce high-quality data on the coronavirus, from the spread of new variants to the effectiveness of vaccines. "PHE's data have been absolutely invaluable and have been used by the whole world to understand many key aspects of COVID-19," says Marm Kilpatrick, an infectious-disease researcher at the University of California, Santa Cruz.

UK researchers did a better job communicating these data than other countries with early vaccine roll-outs. Scientists from Israel, for instance, often shared initial data on social media only as pictures, making it hard to extract data, and in Hebrew, making the results difficult for an international audience to understand, says Ben Cowling, an epidemiologist at the University of Hong Kong.

With so much misinformation and confusion about what data such as these can mean, public-health agencies struggled to get their messages across. Kall stepped into

"One of my main aims is really just to try and make sure people are empowered."

this breach. "Meaghan has been a wonderful source of hot-off-the-presses information and has done a fantastic job in breaking down the reports," says Kilpatrick.

Dozens of scientists have emerged as communication stars on Twitter during the pandemic, but Kall's position is unusual. "As a civil servant, I have limited scope to speak my truth," she tweeted in September. In more than 6,000 tweets this year, she also shared photos of her rapid coronavirus tests when her family had to isolate, and invited people who were worried about COVID-19 vaccines to message her privately. Her tweeting was neither forbidden nor encouraged by her bosses, she says, although some colleagues have been personally supportive.

Kall thinks her public communication has aided trust in UK government data. "My favourite responses are the people who say, 'I didn't really have a lot of faith in PHE, I didn't really trust it, until I started following your Twitter feed,'" she says.

Before COVID-19, Kall spent a decade monitoring HIV infections for UK government agencies. She says that her work with people with HIV — she was writing up her PhD on a national survey of those living with the virus when COVID-19 struck — gave her experience in understanding people's sometimes opposing views, as did her upbringing in a small, conservative town in Michigan.

Kall's most popular tweets have criticized the UK coronavirus response, which included the controversial privatization of most of its testing and contact tracing. In November, she wrote: "I still think it was a huge oversight that our NHS sexual-health advisers, who are professional contact tracers, were never drafted in or consulted on Test and Trace." Asked — with a press officer watching — about how much freedom she has to tweet, she says that she's never been told what to say or been reprimanded, but she carefully chooses the issues that she feels strongly about.

Kall says putting together her Twitter threads cuts into her personal life — it takes her an hour or so to prepare each briefing breakdown, in addition to responding to questions — and colleagues ask her how she keeps going. "One of my main aims", she says, "is really just to try and make sure people are empowered, and have agency to understand the data to make their own decisions, from a reliable source."

Janet Woodcock
Drug chief

This career administrator led the US's premier drug agency through a challenging year.

By Heidi Ledford

Only days after Joe Biden became US president this January, he appointed Janet Woodcock as acting commissioner of the US Food and Drug Administration (FDA). Soon, the letters came flooding in. Some were in her favour: one signed by 82 rare-disease patient-advocacy organizations praised her leadership and her focus on integrating patient voices in drug-approval decisions.

Others were less laudatory: 31 advocacy organizations urged the secretary of the US Department of Health and Human Services to keep Woodcock's time at the helm of the FDA brief. "Dr Woodcock presided over one of the worst regulatory agency failures in US history," they wrote, laying partial responsibility for the country's raging opioid crisis at her feet. The debates over her would continue through a tumultuous year at the top of the agency.

Woodcock, a former medical doctor, spent most of her 35-year career at the FDA running the Center for Drug Evaluation and Research, which is responsible for

ensuring that drugs are safe and effective before they are approved for the US market. Woodcock helped to modernize the centre's drug-evaluation process, ushering in advanced clinical-trial designs and pathways to drug approval that are coupled with sophisticated diagnostic tests. She also oversaw the development of a bigger role for patients and their advocates in the approval process. In January, there was speculation that President Biden might nominate her to stay on as commissioner.

By June, however, that prospect dimmed after a controversial FDA decision to approve the drug aducanumab for treatment of Alzheimer's disease. The drug, developed by Biogen in Cambridge, Massachusetts, had been shown to reduce tangled amyloid-β proteins in the brains of people with the disease. But it did not seem to improve cognitive function or symptoms.

A panel of external advisers to the FDA voted against the approval, but the agency made the unusual decision to ignore the recommendation. Michael

Carome, director of health research at the consumer advocacy group Public Citizen in Washington DC, says it was a pivotal moment: the agency had approved a drug that could be taken by millions, without solid evidence that it helps people. "It was one of the worst decisions the agency has ever made," says Carome.

Woodcock declined to comment for this article, but an FDA spokesperson said that she was not involved in the aducanumab approval. Even so, as acting head of the agency, she bore some responsibility, says Aaron Kesselheim, a physician who also studies drug regulation at Harvard Medical School in Boston, Massachusetts. Kesselheim served on the FDA advisory panel and, along with two others, resigned in protest over the decision. Woodcock has long advocated a close relationship between industry and the FDA, raising concerns among some consumer groups and academic scientists.

Kesselheim quit to call attention to what he worried might be an emerging trend at the agency: "My hope is that this kind of bad decision-making doesn't metastasize."

The agency faced more controversy in the summer, when the White House announced that the country would soon administer booster vaccines for COVID-19. The FDA had not yet issued a decision on the boosters, and Biden's announcement was seen as not only premature, but also antithetical to his promise to put science and evidence at the centre of decision-making. Woodcock, along with several other US public-health officials, endorsed the plan but said that it was subject to regulatory approval.

The episode caused a disturbance at the FDA, and two key vaccine evaluators resigned in protest.

In November, Biden nominated cardiologist Robert Califf, a former FDA commissioner, to return to lead the agency. But Woodcock's legacy will go beyond her year at the FDA's helm, says Kesselheim.

Despite his critiques, he says, "I think the FDA makes the right decision most of the time, and continues to serve as a gold standard for drug regulation around the world." Woodcock, he adds, "deserves some recognition for the way the FDA has evolved with the times".

Correction
The profile on Timnit Gebru incorrectly referred to Ethiopia's 1998 conflict with Eritrea as a civil war.