THIS WEEK

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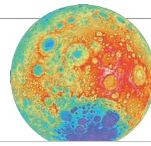


NEW MOON Lunar impact shows surprising surface ingredients **p.305**

A view from above

The world's latest carbon-monitoring satellite has advanced our understanding of how the planet functions. US politicians should take note.

When a rocket failure saw NASA's first carbon-monitoring satellite plunge into the ocean in 2009, it was a major blow for climate scientists. Space-based greenhouse-gas monitoring was a promising new frontier — and perhaps an eventual tool for monitoring international climate commitments. It took several years to get a replacement into space, but the Orbiting Carbon Observatory-2 (OCO-2) began taking measurements in 2014. The first major scientific results were published last week in *Science* (see go.nature.com/2yr8n6a), and there can be no doubt that the mission is delivering. No doubts, either, that the US government should launch a successor.

The results give an unprecedented insight into one of the most important planetary phenomena: El Niño, the subtle but massively influential gathering of warm waters in the tropical Pacific Ocean. The 2015–16 El Niño was a monster, changing weather patterns and driving the largest and longest coral-reef-bleaching event on record. Through it all, scientists used OCO-2 to watch carbon move through oceans and ecosystems.

The overall trend came as little surprise — a massive increase in global atmospheric carbon levels. Scientists have measured similar rises in carbon dioxide during past El Niños. But the precise mechanism was elusive. OCO-2 helped clarify the matter by producing detailed maps. Researchers saw an initial decrease in the amount of CO_2 coming out of the tropical Pacific Ocean, a dip later swamped by CO_2 originating from Africa, South America and southeast Asia as the event wore on.

Tracking carbon is just the first step. Those data feed into atmospheric models that can provide a more comprehensive explanation for the origin — and destination — of any given CO_2 molecule. Fortunately, sensors on board OCO-2 can assess the amount of photosynthesis using methods other than measuring carbon flux. They detect a photosynthesis-linked signal called solar-induced chlorophyll fluorescence, which gives an independent measure of how much CO_2 plants are taking up.

With this suite of tools, scientists have managed to paint a finer picture of how the 2015–16 El Niño affected individual regions. Heat and drought set the stage for the massive wildfires that ravaged Indonesia during the event, whereas drought-stricken trees in the Amazon rainforest took up less carbon than usual. In Africa, the higher temperatures probably boosted plant respiration. All three mechanisms for increasing atmospheric CO_2 have been proposed in the past, but it was a surprise to see all play out on different continents simultaneously.

Plenty of questions remain. The satellite measurements are not as precise as scientists would like, and they don't always align perfectly with data from the ground. And getting the models right is a never-ending challenge. It will be some time before satellites are able to provide the precision needed to quantify the natural carbon cycle, let alone to separate out human emissions with enough confidence to verify whether countries are meeting their obligations to cut greenhouse-gas emissions. But OCO-2 is further validation that the effort is worth pursuing.

US politicians should take note. President Donald Trump has proposed scrapping a follow-on mission, OCO-3, presumably because it falls under the rubric of climate — a topic that is anathema to this administration. That would be a self-defeating and damaging move. The bulk of the budget for OCO-3 — which was built from the spare parts of its predecessor — has already been spent; all that's left is the expense of launch and operation. Killing the mission now would waste time and money. But more importantly, as these latest studies show, humanity can learn from the measurements that it will make.

> ***"OCO-2 is an affirmation of climate science that everybody should be able to appreciate."***

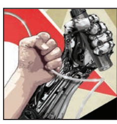
OCO-2 is an affirmation of climate science that everybody should be able to appreciate, regardless of political leanings. Trump might not like talking about climate. But surely his administration — and the lawmakers on Capitol Hill who will decide whether OCO-3 survives — cares about the weather.

El Niño has an impact on weather systems around the world. It raises the likelihood of heavy rainfall from California to the Gulf of Mexico, while increasing the chances of drought and extreme heat in areas farther north. El Niño and its opposite sister system La Niña factor heavily in longer-term seasonal forecasts, which can help governments prepare for fires like those tearing through California at the moment. The more we understand this system, the better we will be at forecasting changes in the weather, the climate — and the economy. A 2014 report from the International Monetary Fund argued that effects of El Niño should be taken into account when nations plan their finances. This has nothing to do with politics, and everything to do with understanding the world in which we live. ■

Computer future

Researchers should gather evidence to map how automation will change employment.

In 2014, the *Los Angeles Times* began beating its rivals to report earthquakes, using an algorithm to convert announcements from the US Geological Survey (USGS) to breaking news within a few minutes. This June, it announced that a magnitude-6.8 quake had shaken Santa Barbara, California. That was certainly news to the distinctly unshaken residents of Santa Barbara; the earthquake the newspaper was reporting on had actually happened in 1925. The paper's Quakebot had misinterpreted



THE FUTURE OF WORK
A *Nature* special issue

an update to the USGS seismic database and published its story online without anyone checking. The story was deleted and Santa Barbarans (and human journalists everywhere) could breathe a sigh of relief.

The tale encapsulates many of the issues that surround the intensifying debate about the roles of computers and humans in the workplace of the future — both the very near and the very far. Much of that debate places people and algorithms in direct competition. From lorry drivers threatened by self-driving vehicles to doctors who could be replaced by know-it-all diagnostic devices, many jobs as we know them could be done by artificial intelligence (AI) systems.

In an Editorial last year on the likely role and risks of AI in future society, *Nature* noted that even academic debate on the topic is polarized between sceptics and fanciful futurists (see *Nature* **532,** 413; 2016). In a special issue this week, we try to find and explore some middle ground, by bringing together and assessing the evidence on how automation will affect the future of work (see page 316).

In a sense, this debate is nothing new. Technology and automation have been putting people out of jobs for hundreds of years, as historian Robert Allen discusses in a Comment on page 321. So have other factors — chiefly economic trends and globalization. But the spread of technology has also created new roles. In broad terms, as manufacturing jobs in the West have been transferred to low-wage economies elsewhere, politicians and economists have looked to tech to help fill the gap. These new industries, they argue, both need direct labour to develop them and create employment indirectly through the need for service and support. But will this trend continue? The true debate over the future of work is not whether computers will replace people in many jobs — they surely will — but whether they are team players. For how long will Quakebot and its descendants need a human supervisor?

Both sceptics and fanciful futurists will find something to agree and disagree with in the articles that follow. In a Comment on page 324, Yuval Noah Harari, historian and best-selling author of *Sapiens* (Harper, 2014) and *Homo Deus* (Harvill Secker, 2015), argues: "The challenges posed in the twenty-first century by the merger of infotech and biotech are arguably bigger than those thrown up by steam engines, railways, electricity and fossil fuels." He also offers reassurance about job prospects for some people, from a perhaps unlikely source. Each US military drone flying over Syria keeps 110 people in a job, he writes — 30 operators and 80 analysts to process the information it sends back. This is not an argument for more drones, the use of which is controversial. But, as Harari writes: "A careful study of the military job market might tell us a lot about potential future developments in the civilian economy."

Careful study, *Nature* naturally argues, is something that (human) scientists and other academics excel at. As the 2016 editorial put it, "it is crucial that progress in technology is matched by solid, well-funded research to anticipate the scenarios it could bring about", such as impacts on mental health and management, and how humans interact with robots. It's important, too, to study possible political and economic reforms that will allow those usurped by machinery to contribute to society.

"The true debate is not whether computers will replace people, but whether they are team players."

The Oxford Martin Programme on Technology and Employment at the University of Oxford, UK, is doing just this (see go.nature.com/2xxauvm). Oxford economist Ian Goldin offers his own thoughts on page 327.

Among the topics worthy of examination is the future fate of science and scientists. So far, the application of technology and automation to research has fuelled, and not felled, the need for human support. Indeed, fields such as bioinformatics exist only because of the work that computers generate for scientists. But as explored in a Careers Feature on page 419, science is not immune from the gig economy — short-term employment on specialist tasks such as writing a literature review or managing a database. The trend towards parcelling off and even publishing science as a series of steps rather than full papers could see demand for freelance services rise. (The breakdown of complex tasks into a series of simpler steps is, of course, also a proven path to automation.)

Still, browse 'help needed' adverts for scientific gigs and the future looks less rosy. As little as US$80 to perform a detailed meta-analysis of published studies? It's hardly worth even plugging in for that. ■

Bee seen

Flowers have evolved an ingenious way to attract pollinators.

The car maker Lexus announced a new paint job for its LC coupé this month, which it says will appeal to drivers who value the interaction of science and craftsmanship. The car is blue and the science it leans on is the optics of iridescence. Lexus says that it uses several layers of pigment to increase the amount of incoming light that reflects as blue. The finish, it claims, is "more blue" than anything seen before — and more time-consuming to apply. People who buy the model are unlikely to suffer that common psychological bias experienced by owners of a new car who suddenly notice other vehicles everywhere the same colour as theirs: at present, the company can make just two a day.

Lexus says that its new blue is based on the famous wings of the morpho butterfly. These contain no pigment, but look blue because of how the wing structure physically separates the various components of white light and reflects only certain wavelengths. The company could also have borrowed the idea from the (less PR friendly) tarantula spider, many species of which use the hairs on their legs and body to show off the same blue effect. In fact, such iridescence is fairly common in plants and animals — sometimes deliberate (the shimmer of the peacock tail) and sometimes less so (the same effect from a fresh cut of meat). It's why a blue-cooked steak really does look blue.

The effect is called structural colour (Lexus calls its paint Structural Blue). Blue is a common consequence of structural colour (natural blue pigments are rare), and this week a paper online in *Nature* explores its role in flowering plants (E. Moyroud *et al. Nature* http://dx.doi.org/10.1038/nature24285; 2017).

Fewer than 10% of the 280,000 species of flowering plant naturally produce blue petals. This presents a problem, because the bees on which many flowers rely for pollination struggle to see any colour other than blue. So how do these flowers attract the insects they need?

The new study shows that they use structural-colour techniques to generate an iridescent blue halo. From the tulip to the golden perennial sweet pea, a dozen different flowering plants of varying colours were found to have surface nanostructures that produced the optical effect. It's visible to the human eye, too, and best seen against dark-coloured petals.

In a series of tests with bumblebees (*Bombus terrestris*), the researchers demonstrate that the insects avoid artificial flowers made to have smooth surfaces that don't produce the blue ring. And they show how the insects see the halo more easily than we do, because bee vision can better distinguish the ultraviolet frequencies into which the structural-colour effect spreads. The findings are discussed in an accompanying News & Views article (D. D. Deheyn *Nature* http://dx.doi.org/10.1038/nature24155; 2017).

Lexus boasts that it took more than a decade to develop its new blue paint. It took the flowers a lot longer: their ability to generate the halo effect has evolved over millions of years, and perhaps emerged in each species independently. In both cases, the colour is best appreciated at first hand. Photographs do not do it justice. Take a stroll in the garden. And keep one eye on the road. ■