



The American Association for the Advancement of Science

Voyages to strange new worlds

WASHINGTON, DC

This year's meeting of the AAAS looked at crop biology, the origin of heavy elements, how species raft around oceans and the problems of flying to Mars

SENDING PEOPLE to Mars is a daunting prospect. It would take astronauts at least nine months to get there, they might spend a year on the planet itself, and they would then spend another nine months on the journey home. During that time they would be exposed both to high radiation levels and to the increasingly irritating tics and habits of their fellow crew. It is hard to say which of these would be more likely to result in someone's death.

But though the scientific value of such a mission is questionable, as a propaganda stunt it would be unequalled. America's space agency, NASA, is therefore looking into ways of preserving both the physical and the mental health of putative Martian voyagers. And, at this year's meeting of the American Association for the Advancement of Science (AAAS), held in Washington, DC, several presentations described work towards that end.

One such effort is the NASA Twin Study, full results of which are to be published in the next few months. The AAAS meeting

was, however, given a taster.

The NASA Twin Study took advantage of identical-twin astronauts Mark and Scott Kelly. Scott was launched to the International Space Station in 2015 for a 12-month tour as station commander. Mark remained on Earth for the same period. Both men gave regular samples of blood, urine and so on for scientific analysis. Both also undertook batteries of physical and mental tests. Not knowing exactly what might change in the men's bodies, ten teams of researchers spread across America combed through the samples and results to track as many molecular, cognitive and physical changes as possible.

As Chris Mason of Weill Cornell Medical

College told the meeting, these teams found lots of surprises. For example, Scott's telomeres got longer during his sojourn in space. Telomeres are strands of DNA that cap the end of chromosomes in a cell's nucleus. They normally get shorter as that cell divides and ages.

Dr Mason then compared the operation of Scott's genes with those of his brother back on Earth. Genes in Scott's body associated with the immune system, he found, became highly active. This was also true of the cellular machinery associated with repairing DNA. "It's almost as if the body is in high alert," he said, which would not be surprising given the stresses of space flight. Another surprising observation was the presence of a lot of mitochondrial fragments in Scott's blood. Mitochondria are tiny structures within a cell which release energy from sugar. They tend to get into the bloodstream only when cells are damaged or dying of stress.

From Scott's point of view, the good news is that almost all of the thousands of changes catalogued in his body reverted to normal soon after he returned to Earth. This suggests that, for the most part, a healthy human body recovers well from the stress of space flight. But however detailed the Twin Study has been (and it was in fact the most detailed scientific portrait of human beings ever made) a sample size of two is still rather limited. In the coming years NASA is planning dozens more long- ►

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duration tests on people, including tracking astronauts heading to the moon in preparation for future trips to Mars.

When Scott returned from the space station, he said that "teamwork makes the dream work" when it comes to a successful mission in space. Cutesy. But it was an apt statement. Understanding how teams function, how they go wrong and how to prevent social problems will be a critical element of any successful mission to Mars.

Such a mission might involve half a dozen people, perhaps from different cultures, cooped up together for some three years in a space no bigger than a typical family home. There would be no emergency-escape strategy. One of the attempts being made to model these conditions is that of Noshir Contractor, a behavioural scientist at Northwestern University, in Illinois. As he told the meeting, he has been studying the dynamics of groups of people isolated for long periods in the Human Exploration Research Analogue, a facility at the Johnson Space Centre in Houston, Texas. Here, volunteers are locked away for up to 45 days at a time on mock space missions. They are poked and prodded, physiologically and psychologically, and monitored day and night.

Send in the clown

Something researchers have already learned from these experiments is that certain personality characteristics are essential to helping groups work well together. A good group needs a leader, a social secretary, a storyteller and a mixture of introverts and extroverts. Intriguingly, by far the most important role seems to be that of the clown. According to Jeffrey Johnson, an anthropologist at the University of Florida who has spent years examining relations between people in Antarctic crews overwintering at the South Pole, the clown is not only funny, he is also smart and knows each member of the group well enough to defuse most of the tensions that might arise during long periods of close contact. This sounds rather like the role of a jester in a royal court. The clown also acts as a bridge between different groups of people—in Antarctica the clowns linked scientists on the base with the tradesmen who also worked there. In groups that tended to fight most or to lose coherence, Dr Johnson found, there was usually no clown.

Even if a perfect, balanced group of astronauts is assembled for a Mars mission, however, things could still go awry. On December 28th 1973, for example, the three crew members of *Skylab*, an early American space station, decided to cut off contact with ground control and refused to do any of their assigned tasks—something they called a "work slowdown". Newspapers at the time referred to this incident as the first strike in space.

Dr Contractor's group wanted to understand what happened on *Skylab* and whether or not the crew's reaction could have been averted. They took transcripts of conversations that had occurred on *Skylab* over the many years it had hosted astronauts, and applied textual and network analysis to them to try to understand the nature of relations between the people who had been on the station.

The cause of the strike, they found, was that the crew's close ties with one another had become detrimental to their relationship with the team back on Earth. Crew members had started using a lot of negative words about their daily tasks. They complained bitterly to each other about their workload, but never shared these thoughts with those in ground control. The signal of problems was so clear in this analysis that Dr Contractor's team reckon they would have been able to see the strike coming a week before it happened.

On a future mission to Mars, ground control would thus be well advised to have transcripts of conversations showing details of who talks to whom, how quickly people respond to each other and what the sentiment of each conversation is. Dr Contractor and his colleagues are creating algorithms that can crawl through these data and predict when there could be problems between members of the crew, or between the crew and the ground.

Predicting problems is just the start. Ground-control teams monitoring the flight could help with crew conflict near to Earth, but on a mission to Mars the astronauts will need to operate autonomously, given the large communications delays. NASA's engineers are therefore working on software that can be used to analyse data about a crew's behaviour in real time and provide a sort of digital counselling service, helping them find ways to mitigate any problems. "Good mental health on a mission is not the absence of conflict, but how you handle that conflict," said Thomas Williams, a specialist in human factors at the Johnson Space Centre.

All this detailed understanding of teams will have uses far beyond lengthy space missions, the researchers hope. Behavioural scientists are already trying to apply such "people analytics" to the understanding of sentiments within companies. They might, perhaps, replace performance surveys, monitor inclusion and diversity, identify high potential or put together dream teams for certain tasks.

Building a perfect team for a long mission to Mars will not be easy, says Dr Contractor, and there is much to learn yet. But if human beings are ever to travel to other parts of the solar system, then understanding the behaviour of those who will be crewing the hardware should make a successful voyage far more likely. ■

Nitrogen fertilisation

Fixed!

WASHINGTON, DC

A big obstacle to agricultural productivity may soon be overcome

PLANTS NEED nitrogen to make proteins and DNA. But though this element is abundant in the air, they have failed to evolve the biochemical apparatus needed to break up nitrogen molecules and combine the resulting atoms with other elements (a process called "fixing") in order to feed it into their biochemical pathways. Some bacteria have, however, managed this trick. And some plants, notably legumes, have worked out how to play host to these nitrogen-fixing bacteria by encouraging them to invade the cells of their roots, and by growing special root nodules to encourage such cohabitation.

At the moment, farmers overcome the inability of most crops to fix nitrogen either by crop rotation (planting fields with legumes every few years to refresh the soil with nitrogenous compounds) or by applying artificial fertiliser. But fertiliser, on which about half of the world's food production now relies, costs money and (a more modern worry) is manufactured using a lot of fossil fuel in the form of natural gas. It has therefore long been a dream of agricultural scientists to fit out cereal crops with their own bacteria-hosting nodules, or similar organs, so as to permit them to fix their own nitrogen.

Jean-Michel Ané of the University of Wisconsin-Madison is one of those working on this problem. He told the AAAS meet-



Dripping with promise

►ing of two approaches that he and his colleagues are following. One involves an evolutionary analysis of the way legumes became bacteria-friendly in the first place. The other is the identification of a type of symbiotic nitrogen-fixing that does not rely on root nodules.

The crucial insight behind the first of these approaches was the realisation that the association between legumes and bacteria is similar to a more widespread one between land plants and fungi. Most plants have fungal hyphae growing in their roots. Occasionally this is a parasitic relationship, but usually it is mutualistic. The plant feeds sugars and amino acids to the fungus. The fungus supplies the plant with water and minerals. Analysis of the genes involved in the plant side of this deal suggests that plant-fungal symbiosis goes back to the first land plants. The genes in question permit intimate association between fungal hyphae and plant cells, and the molecular pathways involved are similar to those that let nitrogen-fixing bacteria sit inside legume root cells.

Genetic tweaking

Dr Ané and his colleagues have also worked out the evolutionary origin of nodule formation. This is a result of mutations in genes that control the formation of lateral roots in legumes. What seems to have happened is that, about 60m years ago, relevant changes in the symbiosis genes and the root-formation genes came together in the ancestor of modern legumes. The team's mission is to recapitulate this fortuitous coincidence in other crops, by genetic tweaking. At the moment they are studying the effects of promising-looking tweaks on root cultures of poplar. They picked poplar as a model for their experiments because it has a well-understood genome and is fairly closely related to the legume family. Their ultimate target is rice—the third most widely grown crop in the world.

The most widely grown crop of all, though, is maize, and this cereal is the subject of the second approach Dr Ané and his colleagues are taking. Some years ago the properties of a strange form of maize, which is grown by farmers in the Sierra Mixe of Oaxaca state, in Mexico, were brought to the world's attention by Howard-Yana Shapiro, chief agricultural officer at Mars, an American confectionery company, and an adjunct professor of agriculture at the University of California, Davis.

Sierra Mixe maize is a giant crop, standing five or six metres tall when fully grown. What intrigued Dr Shapiro, however, was that it needs neither fertiliser nor crop rotation to flourish. It also, he noticed, has a strange anatomy. It puts out aerial roots (see picture on previous page). These are a feature that plants such as mangroves

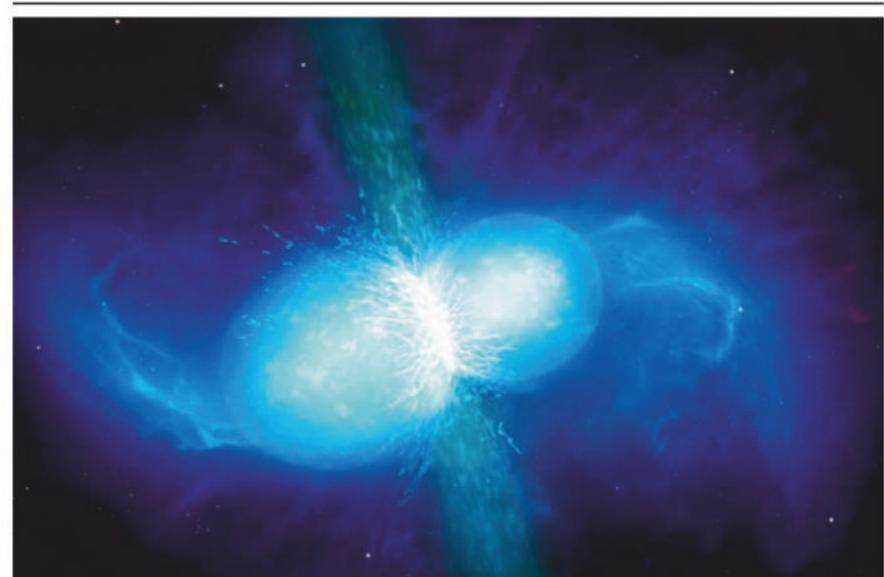
(which live in saline coastal areas) and epiphytic orchids (which cling onto trees and have no contact with the soil) use to collect water from the air. Such roots were, though, previously unknown on maize. Moreover, far from absorbing water when conditions are damp they actually ooze gel when it rains, and this gel drips off them onto the soil.

Analysis of the gel showed that it was fixing nitrogen. The aerial roots, in other words, are hosting nitrogen-fixing bacteria and using them to fertilise the surrounding soil. Hence the lack of need for fertiliser or crop rotation.

Six-metre-tall maize plants, even ones with the ability to fix nitrogen, are unlikely

to find favour with the intensive farmers of the rich world. But maize is maize, and Dr Ané, Dr Shapiro and their colleagues have managed to cross-breed aerial roots into more manageable plants, which are being tested experimentally. They have also, by searching old literature, found that gel-dripping aerial roots were reported on a strain of sorghum at a conference in India in 1984, though the matter was never followed up.

Dr Ané is now doing so. Though sorghum is not as dominant or as widely traded as maize or rice, it is still important. If any of these crops could be encouraged to fix nitrogen routinely, that would simplify and improve farmers' lives enormously. ■



How heavy elements are made

The ultimate nuclear reactor

WASHINGTON, DC

A lot of the periodic table came from the collision of neutron stars

LIVING THINGS are star stuff. Other than hydrogen, which comes from the Big Bang, which marked the birth of the universe, the familiar elements of which flesh is composed—carbon, oxygen, nitrogen and so on—were created by the energy-releasing process of nuclear fusion that powers stars. But fusion has its limits. The balance of forces inside an atomic nucleus means that creating an element heavier than iron (number 26 on the periodic table) consumes energy, rather than releasing it. Further up the table, beyond lead (number 82), nuclei tend to fall apart spontaneously. In other words, they become radioactive.

To synthesise elements heavier than

iron—and particularly those heavier than lead—therefore requires a lot of work. Some of this work happens in stellar explosions called supernovae. Calculations suggest, however, that even supernovae would be hard put to explain the abundance of the heaviest elements, including metals such as gold and platinum as well as radioactive ones like uranium. One hypothesis is that these elements are the products of collisions between ultradense objects called neutron stars. And, as Brian Metzger of Columbia University told the AAAS, that hypothesis has now been confirmed by data.

The neutron-star hypothesis of nucleosynthesis also depends on supernovae, but ►

► at one remove. Neutron stars are the collapsed leftovers of particular types of supernova involving stars with eight or more times the mass of the sun. During the course of such events the exploding star's core collapses, creating pressures so great that most of the electrons and protons of the atoms within are forced to merge, to create neutrons. The resulting object is therefore small (with a radius of around

10km) and has the same sort of density as an atomic nucleus. A sugar-cube-sized piece of it, in other words, would weigh as much as a mountain.

A single neutron star cannot create new elements. But two neutron stars orbiting each other might. The pair will gradually lose energy, in the form of low-power gravitational waves, and will come closer and closer together as a result. Eventually, they

will collide, creating an explosion called a kilonova that is accompanied by an enormous gravitational wave. This explosion throws neutrons in all directions.

On Earth one established way of making heavy elements from light ones is by neutron bombardment. In this process existing nuclei absorb neutrons, becoming heavier but also unstable. In the reverse of what happens when a neutron star is created, neutrons within the bombarded nuclei then spit out electrons and turn into protons. The upshot is a more massive nucleus, and one with more protons in it. More protons means a higher atomic number. The nucleus in question has thus been transformed into a heavier element.

In effect, this is a small-scale version of what happens after a neutron-star collision. The liberated neutrons bombard any matter in the surrounding space, giving each of the atoms in that matter a large number of serial upgrades of their atomic numbers. The only problem with this theory was that until recently no one had seen a kilonova, and so it was not known for sure that they existed. As Dr Metzger described, that changed on August 17th 2017 when LIGO, a gravitational-wave detector in North America, made its first observation of a neutron-star collision. It took place a long time ago in a distant galaxy in a constellation called Hydra, but gravitational waves travel at the speed of light, which is finite, so there was a considerable delay in the arrival of the signal on Earth.

Precious knowledge

In the wake of the gravitational wave, optical telescopes looked to its source. That let astronomers collect spectra from the explosion and thus determine which elements were created. Kilonova GW170917, as the event was called, ejected material equivalent to 5% of the sun's mass. Among much else, this ejection produced gold (around ten Earth masses' worth) and platinum (50 Earth masses' worth).

Kilonovae are rare events, happening perhaps once every 10,000-100,000 years per galaxy. They would have been commoner in the past, when the short-lived, high-mass stars that create neutron stars were more abundant. Even so, elements with atomic numbers above 26, whether generated by supernovae or neutron stars, make up only 0.1% of the mass of atoms in the universe.

Future observations using LIGO (which is being upgraded) and forthcoming detectors in Japan and India will permit more refined analysis. It now, though, seems clear that, while human bodies are composed largely of star stuff, part of the jewellery they wear started life in a kilonova. And the scarcity of those precious metals, which makes them so desirable, is a direct consequence of the rarity of kilonovae. ■

Biogeography

The hitch-hiker's guide to the Pacific

WASHINGTON, DC

A long-term natural experiment hints at how species disperse

THAT SPECIES might spread overseas by hitching lifts on floating vegetation is an idea going back to Charles Darwin. It is a plausible thought, but hard to test. A test of sorts has, however, been made possible by the tsunami that struck the Pacific coast of Japan in 2011, in the wake of a submarine earthquake.

The incursion and regression of this tsunami dragged with it millions of pieces of debris, many of them buoyant. After a year or so some of the debris started arriving on the coast of North America—and it is arriving still. James Carlton, of Williams College, Connecticut, and his colleagues have been studying the living creatures on board pieces of it, and Dr Carlton gave a round-up of what they have so far found to an audience at the AAAS meeting in Washington.

Disappointingly for lovers of Darwin's vision of land animals moving from place to place on natural rafts, an intensive examination of 634 objects, ranging from a plastic bottle to a floating dock 20 metres long that had been ripped free of its moorings (see picture below) failed to reveal any terrestrial species. A lot of marine ones turned up, though, providing work for an army of 80 taxonomists wielding the latest genetic bar-

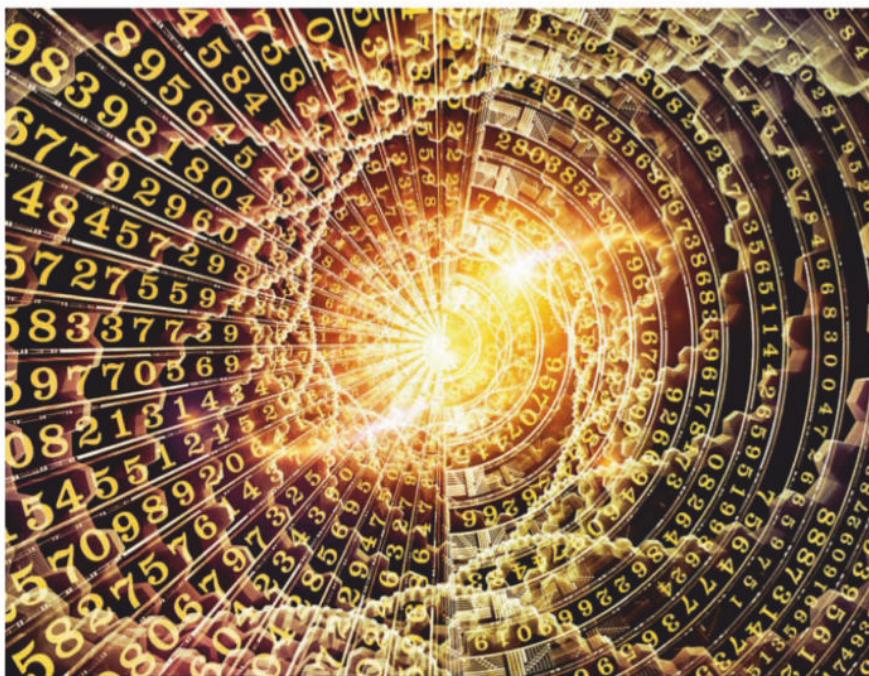
coding equipment.

The current species count is 379—mostly animals but also some seaweeds—of which two-thirds are alien to North American waters. The majority of the animals are invertebrates such as molluscs, polychaetes and bryozoa. But not all. A few fish made it across the Pacific, too. Indeed, some of the fishing boats that had been swept away by the wave supported veritable ecosystems.

One, for example, had what Dr Carlton described as a "tide pool" in its stern. This contained a population of barred knifejaws, a species of black-and-white-striped reef fish. Another was home to 20 yellowtail amberjacks.

The knifejaws, in particular, are interesting because they are local to the northwest Pacific. Since the arrival of the tsunami debris, however, a group of them has been found in Monterey Bay, California—an area which is intensively studied because of a nearby marine-biology laboratory. Whether this new knifejaw population will prosper remains to be seen. But even if it has only a transient existence its establishment suggests that, even if land animals have difficulty making the crossing, for marine creatures Darwin was correct.





The tyranny of metrics

Every step you take

In a world where everything is quantified, power will accrue to whoever is keeping score

M EASUREMENTS PERVERSE life and society. Infants are weighed the moment they blink into the world. Pupils are graded. Schools are judged on their students' performance, universities on graduates' job prospects. Companies monitor the productivity of employees while CEOs watch the share price. Countries tabulate their GDP, credit-rating agencies assess their economies, investors eye bond yields. The modern world relies on such data. It would cease to function without them.

The numbers are proliferating. As ever-greater swathes of human activity are subsumed by the digital revolution, so they too can be calibrated. Uber riders earn stars for their back-seat behaviour. Social-media posts attract "likes". Users of dating sites are assigned desirability scores. Apple's iPhones tell their owners how many hours they have spent peering into their screens. Wristbands measure footsteps; apps can track sleep patterns and sex. As recently as the start of this decade, people who voluntarily observed themselves in this way had a cultish name, the "quantified-self movement". That urge is now the premise of one of Apple's latest products, a watch that keeps tabs on the wearer's heart rate.

If everything people do and every step

The Metric Society. By Steffen Mau. Translated by Sharon Howe. Polity; 200 pages; \$22.95 and £15.99

they take is tracked, they lose the freedom to act independently of such oversight, writes Steffen Mau, a German sociologist, in "The Metric Society". Published in German in 2017 and now in Sharon Howe's English translation, Mr Mau's book is a wide-ranging tour through rankings and ratings, stars and points, charts and graphs. When these technologies become embedded in society, he argues, life is reduced to checkboxes. Faith in experts is replaced by devotion to figures. Meanwhile, power is transferred from individuals to those who create and maintain the scoring systems. These in turn can be gamed and their purposes perverted.

The numbers game

Take the World Bank's annual comparison of business regulations around the world. One country stood out in its latest ranking: China, which had languished in 78th place the previous year, jumped to 46th. India seemed to have improved, too, rising 23 spots, to 77th. Those remarkable ascents

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have less to do with the ease of doing business in those places than with their governments' determination to achieve good grades. Some 40 people work in a Chinese government unit dedicated to improving its World Bank score; perhaps 200 toil in India's. At least 60 countries have teams that focus on the index. Conversely, a change in methodology can lead to precipitous falls. In 2016 Chile's performance slumped after one such rejig, which some attributed to political machinations.

These days, though, it is not only technocrats who have cause to fret about skewed metrics. Consider the role played by misinformation on Facebook in the American presidential election of 2016. For a relatively small sum of money by the standards of American political campaigns—about \$1.25m a month—Russian propaganda reached 126m people. How did the Kremlin get such a bang for its buck? "They tracked the size of the online US audiences reached through posts, different types of engagement with the posts (such as likes, comments, and reposts), changes in audience size, and other metrics," according to an indictment by Robert Mueller, the special counsel investigating Russian interference in the vote.

The algorithms that power Facebook's news feed are opaque, but it doesn't take a state-backed operation to work out part of the method. From around 2013, media companies across the world began to pander to Facebook's tastes, turning out increasingly emotional pieces to entice readers to click on links. Publishers monitored emerging trends using an online service called CrowdTangle (later bought by Face- ➤

► book); they tracked traffic to their own websites using Chartbeat, another measurement tool. Some rewarded staff on the basis of these numbers. Some websites cynically exploited touchy issues of social justice to bring in traffic from Facebook.

It became a self-fulfilling prophecy. A piece would appear on a website, attract attention from others through Facebook, be re-written and re-posted on Facebook, and soon it was all over the internet, morphing into a genuine news event. At the same time readers were being tracked by Facebook, CrowdTangle, Chartbeat and dozens of other outfits as they idly clicked entertaining-looking links. The position of the cursor, the amount of time spent on the page, the depth to which they scrolled—all were recorded, analysed, packaged and sold. Did these articles fulfil the basic journalistic function of informing their readers? Or, on the contrary, did readers' clicks determine what was written? To judge from the hysterical, hyperpartisan tone of much of the ensuing coverage, it was the clicks.

If such techniques can change how countries design regulatory regimes and what the media publish, the direct effects on individuals are even greater. "In the age of the metric society," writes Mr Mau, "individuals constitute bundles of data in which their personal worth is encoded." When different sources of data are linked together, it becomes possible to paint an eerily complete picture of a person, and to predict with some accuracy both their net worth and their future behaviour.

This is already the case in car insurance, where some drivers voluntarily attach devices to their vehicles that transmit reports to their insurers. American health insurers reduce premiums for non-smokers and exercise fanatics. All-round surveillance is coming to the workplace, too. In 2015 BP gave 25,000 fitness trackers to staff as part of a health-insurance scheme. The next year the *Daily Telegraph*, a British newspaper, installed heat- and motion-sensors under employees' desks. (They were removed after protests.) Elsewhere, scorekeepers have begun to appraise people in the round. In China, for example, Zhima Credit, a popular private service, measures "personal characteristics", "online behaviour" and "interpersonal relationships", among other things. A high rating entitles people to a fast-track visa for Singapore.

For good drivers, hard workers, athletes and the financially prudent, all this might seem an unalloyed good. For everyone else—and few people tick every virtuous box—the metric society may prove a means for faraway data overlords to capture power and entrench inequality in the guise of efficiency. It risks descending into a 21st-century dystopia that is almost as bleak, in its impersonal way, as those imagined in the darkest novels of the 20th. ■

Be afraid

The end of normal

The Uninhabitable Earth: Life After Warming. By David Wallace-Wells. Tim Duggan Books; 320 pages; \$27. Allen Lane; £20

CLIMATE CHANGE is a devilish problem for humanity: at once urgent and slow-moving, immediate and distant, real and abstract. It is a conundrum for writers, too. Relegating it to a human-interest story—a Bangladeshi displaced by rising sea levels, say—downplays its civilisation-wide significance; sticking to scary forecasts—zoom climate refugees by 2050, the UN warns—diminishes its visceral relevance. That may be why, for all its existential gravity, the subject has yet to produce a great work of literature. It lends itself instead to dystopian science-fiction, or to compendiums of scary science facts, sometimes derided as "climate porn". The latest in that genre, "The Uninhabitable Earth" by David Wallace-Wells, is unabashedly pornographic. It is also riveting.

Mr Wallace-Wells, an editor at *New York* magazine, freely admits that he is not an environmentalist. He has never willingly gone camping, and rarely recycles. Nor is he an environmental reporter. He is a voyeur, seduced at first by stories that appeared allegorical—Arctic scientists trapped by melting ice on an island inhabited by polar bears, or a Russian boy killed by anthrax from a reindeer carcass uncovered by thawing permafrost.



The unbearable hotness of being

Yet, as the author makes starkly clear, global warming is no parable. Far from being a problem only for future generations, it is wreaking havoc now. Five of the 20 worst fires in California's history blazed in 2017; the deadliest incinerated the town of Paradise last year. Floods are becoming wetter, droughts drier and hurricanes fiercer. Such calamities, Mr Wallace-Wells notes, are not the "new normal"; they mark "the end of normal", as climate change tips Earth beyond the conditions that allowed humans to evolve in the first place. And that is with barely 1°C of man-made warming since the industrial revolution.

Things will get much worse. The world is on course to become at least 3°C hotter than in pre-industrial times. Within a few decades, this could mean that temperatures in Mecca render the *haj* physically impossible for many of the 2m Muslims who make the pilgrimage each year. With a rise of 7°C—plausible if humanity remains wedded to fossil fuels—swathes of Earth's equatorial band would become uninhabitable. Even if warming did not exceed 2°C, as stipulated in the Paris climate agreement of 2015, rising seas may engulf \$1tn-worth of American property.

"Numbers can numb," Mr Wallace-Wells writes. Yet like fellow climate-porn addicts, he cannot resist piling statistic on dismal statistic. In the hands of a lesser writer, this litany of woe might have degenerated into one of the dry treatises on which he draws. But whereas his chapters—on the impacts of extreme weather, sea levels, human health, economic consequences and so on—echo reports by the Intergovernmental Panel on Climate Change, his elegant, accessible prose does not.

He has a point when he says that exercising caution over warning signs is tantamount to complacency. Occasionally, however, he could exercise a bit more of it himself. For example, he acknowledges that humans are an adaptive species, then cites projections of lives lost to heatwaves, air pollution and the like, which typically do not factor in adaptation measures.

He nevertheless gets the big things right. His insistence that electing leaders with climate-friendly policies matters immeasurably more than forgoing a plastic straw in your cocktail is surely correct. Yet he is perversely optimistic: because humans are responsible for the problem, they must be capable of undoing at least some of it, he thinks. If Americans' carbon footprints matched those of average Europeans, the United States would emit less than half as much carbon as it does.

The book does not dwell on the policies that might achieve such outcomes; it is more expository than prescriptive. Some readers will find Mr Wallace-Wells's outline of possible futures alarmist. He is indeed alarmed. You should be, too. ■

Troublesome frontiers

Walking the line

The Border: The Legacy of a Century of Anglo-Irish Politics. By Diarmaid Ferriter. Profile Books; 192 pages; £12.99

WHENEVER AN INTER-STATE border is inserted into a hitherto seamless terrain, the consequences will range from the farcical to the tragic, and many will be unexpected. It matters a lot whether the border is hard or soft. A key point is not merely how strictly it is policed, but whether sharp differences in tax and regulations create incentives for smuggling. Those are some of the lessons of Diarmaid Ferriter's timely historical essay on the 310-mile (500km) boundary that came into existence on the island of Ireland in 1922, when 26 of its counties formed the new Irish state, while six stayed in the United Kingdom.

A decade later, as part of an "economic war" between the two countries, Britain imposed a 40% duty on Irish livestock, and cross-border cattle-smuggling became virtually uncontrollable. The beasts were herded over the frontier by boat and truck and on foot at all hours of the night. The illicit drovers sometimes had to contend with somewhat harder criminals who, posing as policemen or customs officers, seized their animals and made off into the darkness. In the same year, Ireland slapped duties on coats, underwear, shoes, frocks, bread, jam and chocolate, prompting contraband in the other direction.

In such situations, the law quickly becomes an ass. In the 1970s, when contraceptives were still banned in the Irish republic, a family-planning campaigner went south with 40,000 condoms in his station wagon; his insistence that they were all "for personal use" was met with good-humoured banter by an Irish police patrol. Nor did the economic and regulatory nonsense stop when Britain and Ireland became partners in the European club in 1973. For a while, the vagaries of agricultural subsidies from Brussels made it worthwhile to spirit the same cow or pig backwards and forwards across the line many times.

But the border had its unfunny side, too. Life became pretty hellish for people living nearby during the Troubles, whether or not they were directly involved in the war between British security forces, which included many local recruits, and Irish republicans. Many of the 200-plus roads that linked rural communities were declared "unapproved" and partially destroyed; travelling on those that were still open

meant coping with queues, checkpoints and searches.

After studying recently unclassified files, Mr Ferriter notes that politicians on both sides of the frontier responded to this tragicomic situation with dishonesty. Irish luminaries such as Eamon de Valera both abhorred partition and found it quite convenient. It enabled old-time nationalists of his hue to fashion the new state using a Gaelic, Catholic ethos without having to worry about northern Protestants, whose heritage was different. Meanwhile London's politicians, whatever their public commitment to keeping Northern Ireland in the union, often let slip their hunch that Irish partition might not last for ever. Winston Churchill, the book recalls, was no ex-

ception. During the second world war, he was positively keen to trade Irish unification for access to Ireland's ports or, better still, Irish entry into the war. It was de Valera who balked.

Now that the border's hardness or softness has become the biggest single problem in Britain's exit from the European Union, further oddities may be in store. On the face of things, right-wing British Tories and hard-line Ulster Unionists seem determined to maintain the inter-Irish border, even if that means stiffening it a bit. But that will only make a lot of people in both parts of Ireland, and some in Britain too, even more determined to remove the boundary altogether before this strange animal reaches its centenary. ■



American food

Roux the day

A beloved Louisiana dish is a stew of culture and history

GUMBO IS A stew, usually served over rice. On that Louisianian cooks can agree. After that, things become contentious. Should roux, a fat-and-flour mixture, form the foundation of gumbo? Usually, but not always. And what sort of fat? These days most chefs prefer vegetable oil or butter; in colonial Louisiana, the fat of choice was bear lard. What is the right thickener—okra, filé powder (pounded sassafras roots, a Choctaw contribution) or neither? Most believe the dish should never contain fin-fish, but it can accommodate almost anything else: chicken, sausage, shellfish and, in harder times, rabbit, squirrel, whelk and smoked raccoon. There are as many ways to cook gumbo as there are people who make it.

Gumbo Life: Tales from the Roux Bayou. By Ken Wells. W.W. Norton; 288 pages; \$26.95 and £18.99

Its origins are disputed. They are partly African: *ki-ngombo* is the word for "okra" in several West African languages, and gumbo is a close cousin to the okra soups served across that region, whence most enslaved people in Louisiana came. But it also betrays Native American and European influences; cooks across Louisiana and beyond claim to have invented it. In this way, gumbo embodies the cultural confluence that makes New Orleans and its environs unique—more tropical, French and African than anywhere else in America. ■

► As Ken Wells writes in his delightful book, southern Louisiana is “the last redoubt of southern Europe in America and like the continental French, Spanish and Italians, our people don’t eat to live, they live to eat.” In no other part of America does food play such a central cultural role. Nowhere else between Maine and San Diego can people of all means eat as consistently well (superior boudin, a delicious, heavily spiced sausage made of pork, offal and rice, is sold at petrol stations). But, as anyone lucky enough to be invited to dinner by a Cajun or Creole friend knows, the best food, and in particular the best gumbo, is found in private homes.

Mr Wells takes readers into dozens of kitchens, none rendered more lovingly than his mother’s. Bonnie Toups grew up in southern Louisiana and left school when she was 12—both because her family, like many others, was desperately poor and because, in early-20th-century Louisiana, speaking French in the classroom was forbidden. She married an Arkansan (no culinary rivalry there), and they brought up their children on a sugar plantation in the bayou. In her daily efforts to feed a large, boisterous family she routinely conjured up “something that flies so close to love that it must be love itself.” Her gumbo is classic: chicken, smoked sausage, filé powder stirred in at the end.

The author’s affinity for his home region never curdles into chauvinism; he happily admits that decent gumbo can be found in San Francisco, New York and Chicago. But he is clear about the reason why: because so many people have left the bayous. The mill that employed his father closed. The public lands where he learned to hunt and fish have been parcelled out to private owners and sequestered behind “No Trespassing” signs. Every year around 15,000 acres of marshlands—the pantry that generations of rural cooks drew upon—vanish, because of subsidence, a rising sea level and the impacts of flood protection and the oil-and-gas industry.

Yet the book’s tone is more affectionate than elegiac. What lingers in the memory is less the food itself than the warm descriptions of the people who cook it. Gumbo is an inherently social dish; it is rarely made for fewer than a dozen diners, and even more rarely, in your correspondent’s experience, prepared without a crowd. It will include whatever ingredients the chef can defend adding.

Not long ago Brett Anderson, the restaurant critic for the *New Orleans Times-Picayune* (one of journalism’s most enviable jobs), opined on gumbo created by an Indian-born chef that contains delicious additions such as Kashmiri chilli powder and curry leaves; and on another made with smoked chicken and Thai curry. Gumbo, like America, contains multitudes. ■



The power of speech

Do not think of a white bear

BERLIN

A speaker turns lectures into a performance art

A BEARDED SWEDE in a three-piece suit stands at a lectern. Spotlit, Erik Bünger tells his listeners about an exchange between Ludwig Wittgenstein and Bertrand Russell in 1911. According to Wittgenstein, Russell could not say with certainty that there was no rhinoceros in his study. Mr Bünger (pictured) says he is not interested in who was right, but in why Wittgenstein chose a rhinoceros. “There was certainly an elephant in the room,” he concludes. “And that elephant was a rhinoceros.”

Laughter ripples through the audience at Video Art at Midnight (VAM), a monthly event at Berlin’s beautiful Babylon cinema. A series of video artists, including luminaries such as Wolfgang Tillmans, have shown work at VAM in the decade since its inception. Mr Bünger instead offers a lecture performance. In the 40 minutes of “The Elephant Who Was A Rhinoceros”, he leads the auditorium through a series of connections. The spectral rhinoceros turns into a metaphorical elephant, which becomes a white bear, which (Mr Bünger says) will flash in listeners’ minds when they are told not to think about it. A cultural history of language takes in Adam’s naming of the animals in the Garden of Eden, cave paintings and the invention of the alphabet. Invent the letter A, Mr Bünger says, and you see the devil and his horns.

Gradually the amusement is muted as listeners begin to question what he is doing—and, indeed, what they are doing. To begin with, they “can follow everything, feel surprise and even laugh,” says Renia Vagkopoulou, Mr Bünger’s wife, who has seen all his performance works many times. At some point, things become more

complex, as people are forced to interrogate their responses. “Some even get a little shocked. What starts as a theoretical exercise becomes more and more personal.”

By getting the audience to grapple with its own role, Mr Bünger’s work fits into an established artistic tradition, says Manuel Olveira, an expert in the lecture form and director of MUSAC, a contemporary-art gallery in León, Spain. He cites John Cage’s “Event” of 1952 (which incorporated a talk on Buddhism), Dan Graham’s “Performer/Audience/Mirror” of 1975 (in which the artist narrated his own movements and observations), and Andrea Fraser’s “Museum Highlights” of 1989 (in which she posed as a guide to the Philadelphia Museum of Art). Like Mr Bünger, each raised questions about how knowledge is produced and disseminated. “Lecture performance is a vibrant category within the wider performance medium,” says Adela Yawitz, a Berlin-based curator, mentioning several other practitioners. The form is fluid, she notes: performances can be live or taped, discrete or combined with other media.

Performance art is not the only means by which lectures have broken free from formal education. Internet streaming has led to the rise of TED talks, which attract billions of clicks a year, as well as boosting the audience for stand-up comedy. Mr Bünger admits to being inspired by comics such as Larry David and Louis CK, and concedes that, at first sight, his art may seem reminiscent of formats such as TED. But at a deeper level, he insists, “my lecture performance is the absolute antithesis of TED”. He sees short video talks as “vehicles of pure solutionism”: hard questions reduced to slick formulae. For him, lecture performance lays bare the imbalance of power between lecturer and listener, and highlights the alchemy of language.

His previous work evoked similar themes. “A Lecture on Schizophonia” (2009–2011) explored the impact of recorded speech. “The Third Man” (2010) dealt with the aura of song, roping in ABBA and Kylie Minogue. “The Girl Who Never Was” (2014) tells the serpentine story of a child whose voice was once thought to have been captured on a primitive audio recording, but who turned out not to have existed. “I’m placing a voice in the heads of my listeners,” Mr Bünger explains of that piece. “Most will see the girl in their mind’s eyes—she will come to exist.”

Human speech, maintains Mr Bünger, “refuses to follow the binary logic” of truth and falsehood or past and present. It is more slippery and magical than that. When the lights go on in the Babylon cinema, the magic seems to have worked. “Now, whenever you see an A, you will see something else,” chuckles Mats Birgert, one half of the video-art duo Birgert and Bergström. “That’s what art is about.” ■