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WEEKLY October 7 - 13, 2017

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LEARN ABOUT MARINE CONSERVATION

Enjoy the company of marine expert Jo Ruxton on board during the voyage. After a long career with conservation organisation WWF and the BBC Natural History Unit, Jo is currently leading the campaign to protect the world's oceans from plastic pollution. Quiz her on the science behind protecting oceanic ecosystems.

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Volume 236 No 3146

Analysis DNA tests put your genes up for sale **22**

On the cover

Leaders

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Analysis

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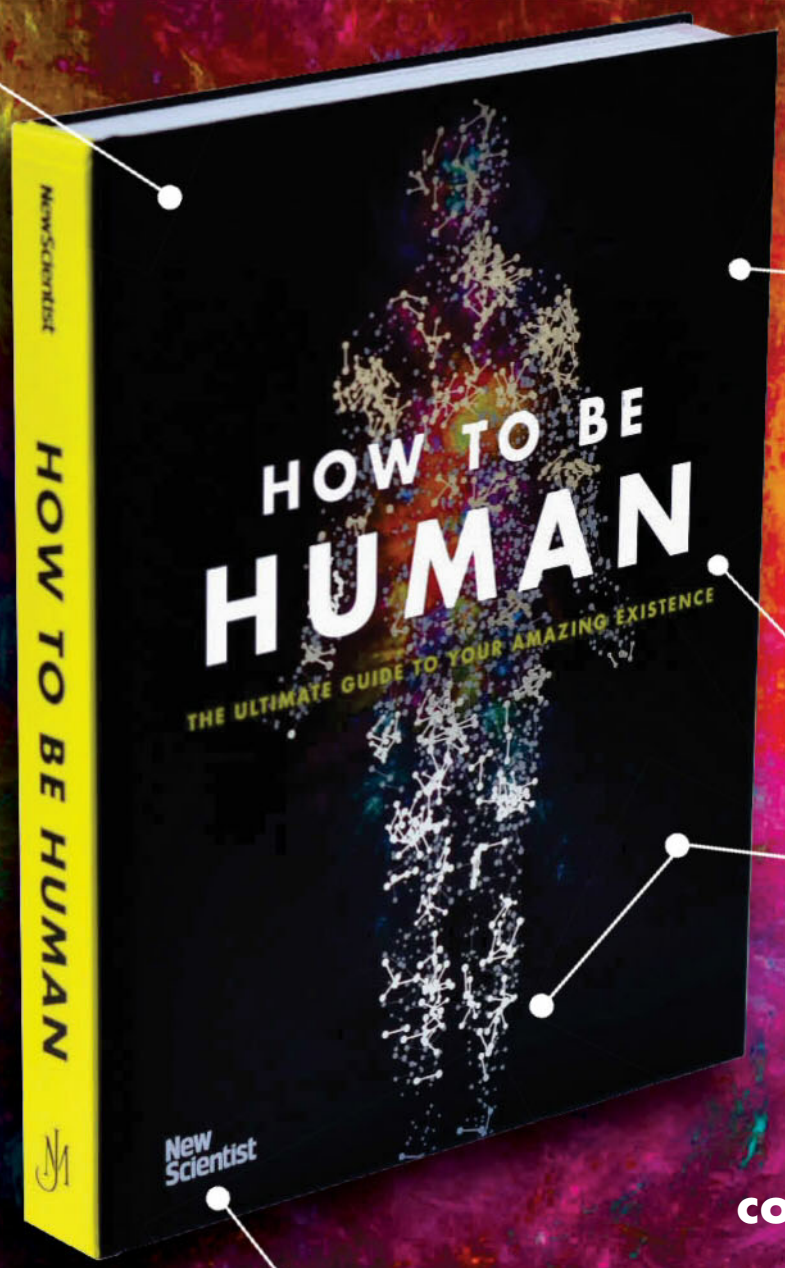
Culture

Regulars

Humanity will need the equivalent of 2 Earths to support itself by 2030.

People lying down solve anagrams in 10% less time than people standing up.



About 6 in 100 babies (mostly boys) are born with an extra nipple.

60% of us experience 'inner speech' where everyday thoughts take a back-and-forth conversational style.

We spend 50% of our lives daydreaming.

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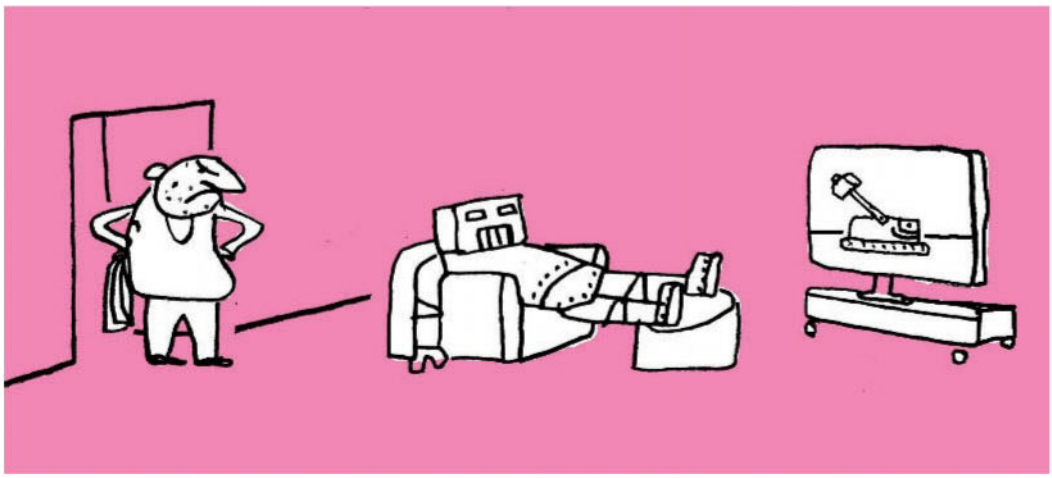


MODERN TOSS

More smarts needed

We still need humans to ensure AIs are up to the job

IT WAS supposed to be a meeting of minds – scientific, cultural and artificial. A recent closed-door colloquium held at a top British university brought together two dozen leading AI researchers and a group of illustrious humanities scholars to address philosophical questions raised by AI.

In the event, however, the two contingents struggled to find common ground. The engineers described their work in precise, dense terms, mostly skipping over its implications. The scholars, too, critiqued the descriptions rather than tackling the implications; some seemed affronted by the very idea of thinking machines.

That's a pity, because we really need fresh thinking on AI. Public discussion is dominated by scary stories about the elimination of human workers – or of humans, full stop. Meanwhile, machine learning applications are quietly becoming integral to our daily lives, with little consideration of the consequences (see page 28).

Those consequences are myriad, poorly understood, and evolving rapidly. AIs are now involved in many decisions that significantly affect our lives. But there is also growing evidence that they aren't necessarily ready to shoulder all the responsibilities they are being given.

Machine learning alone may be fine when it comes to optimising, say, your power usage. But in less clear-cut tasks, such as healthcare, the combination of human and machine can be more effective. Then there's the problem of "algorithmic bias" in AI decision-making (see page 10).

Artificial intelligence really has made great strides in recent years, so much so that initial awe at these machines' uncanny abilities is giving way to hucksterism. But for all their smarts, the machines can't tell us how we could best deploy them. For that, we need people willing to engage in a genuine meeting of minds. ■

Buyer beware

IF YOU'RE not paying for it, you're the product, as the saying goes. Use a "free" online service and you are paying with personal data. But when it comes to genomics, you both pay and are the product. Firms charge people who want to understand their genetics – sometimes on the basis of dubious science – but also the biotech companies that buy aggregated genetic data to shape their products (page 22).

Shouldn't donors get a cut? The firms argue there's no value in a single DNA sequence, but that research using the aggregated data could benefit everyone, and the tests incentivise donation. So we should let them get on with it.

This call to altruism doesn't stand up. We could donate our genomes to medicine through non-profit agencies – much as with organs. And recent test cases cast doubt that properly informed consent is being obtained. You might also wonder if the biotech firms will cut the price of any drugs that result, given that genome donations could slash their development costs.

So think carefully if you buy a DNA test. Is it worth paying the price only to become the product in turn? ■

RICARDO ARDUENGO/AFP/GETTY

Left without electricity

An island without power

PUERTO RICO is still literally powerless.

Hurricanes Irma and Maria trashed its electrical grid, leaving nearly 100 per cent of the island without power. Governor Ricardo Rosselló says it is a "humanitarian emergency".

The lack of power makes it hard to chill food and run air conditioning – and pumps that push water for drinking, bathing and toilets aren't working. The Puerto Rico Electric Power Authority can't restore power: it filed for bankruptcy in July.

The damage must first be assessed before knowing how long repairs will take, says the American Public Power Association (APPA). "We don't know if this is going to be a six-month situation, a five-month situation," says Mike Hyland, APPA's senior vice president of engineering.

Power was swiftly restored on the mainland US, but the situation in Puerto Rico is far worse, says Alexis Kwasinski at the University of Pittsburgh, Pennsylvania.

First, the damage is severe. Power grids have three parts: generation, transmission and distribution. Storms normally hit distribution, says Kwasinski. But Puerto Rico lost all three, unlike Texas and Florida, which just lost distribution.

"More importantly, those states didn't completely lose power," says Kwasinksi. "When the whole grid goes down and you have to begin again from nothing, it's much more complicated." This is called a black start. The challenge is that big power stations need electricity to start up, which requires generators.

Waves get Nobel

NOBEL season is here again. Two years after their discovery, gravitational waves have earned a Nobel prize for Rainer Weiss, Barry Barish and Kip Thorne, the three leaders of the LIGO/Virgo collaboration. The finding confirmed predictions made 100 years ago by Albert Einstein.

"It's wonderful, but I view this as recognition of around 1000 people who contributed"

Half of the $1.1 million physics prize – announced on Tuesday – went to Weiss, with the remainder shared equally between Barish and Thorne. "It's really wonderful, but I view this more as recognition of around 1000 people who contributed and a result of dedicated efforts over 40 years," said Weiss.

On Monday, the Nobel prize for physiology or medicine was awarded to Jeffrey C. Hall, Michael Rosbash and Michael W. Young for their work on the mechanisms controlling circadian rhythms: the internal clocks that organisms use to track the day-night cycle. Working on fruit flies, they identified genes that keep cellular time and help sync it to Earth's 24-hour days.

Given that circadian rhythms seem to control so many of our biological processes, these discoveries have profound implications for our understanding of disease and all-round well-being, says the Nobel committee. Chronic mismatches in circadian rhythm have been linked to many conditions, from cancer to depression.

And more waves

ANOTHER gravitational wave has been spotted, by the new Virgo detector in Italy. The sighting comes after rumours of a possible detection of neutron stars merging, but that isn't what was found.

On 14 August, Virgo and the two US detectors of the Laser Interferometer Gravitational-Wave Observatory (LIGO) observed ripples in space-time caused by two black holes hitting each other and merging.

This is the fourth ever gravitational wave detection. All have come from black hole pairs spiralling towards one another and colliding, their huge masses warping space-time as they merge. The latest observation comes from the second largest collision we have detected this way.

With Virgo up and running, scientists can triangulate the location of a signal. In this case, they have narrowed the regions of sky that could host the gravitational wave source by 10 times more than with LIGO alone. The black holes are about 1.8 billion light years from Earth.

JAN WOITAS / EPA/REX/SHUTTERSTOCK

Changing jobs, not taking them

Automation impact

ROBOTS may not be stealing our jobs after all – at least, not if you are German. An analysis of more than 20 years of labour automation in Germany found no evidence that robots caused job losses in the country as a whole.

Although plenty of reports are predicting that automation will bring job losses, the paper is only the second to look at how many jobs robots have already taken.

Co-author Jens Südekum at

Heinrich Heine University Düsseldorf estimates that automation stopped 275,000 manufacturing jobs being created between 1994 and 2014. However, this was offset by posts created in other sectors, particularly the service industry.

It's not all good news. Robots have tended to reduce wages for those in lower and medium-skilled manufacturing jobs, the study found. Südekum says it might be a good idea to ensure the benefits of automation are shared by all workers, for example by raising taxes on firms that replace workers with robots.

Unapproved graft

EXPERIMENTAL implants made at University College London were used on patients without approval, an inquiry has found.

The implants included an artificial windpipe, a synthetic tear duct and an arterial graft.

The inquiry was at the request of UCL, prompted by its relationship with Paolo Macchiarini, a surgeon who had been an honorary professor there. He has been at the centre of a scandal in which six of eight people who received synthetic windpipes died.

The inquiry highlighted several cases, including one involving a man in Iceland who had a trachea tumour. Macchiarini decided to remove the tumour and replace the affected segment of trachea with a synthetic graft provided by Alexander Seifalian, then at UCL.

The inquiry found that Seifalian's laboratory wasn't licensed to make clinical-grade devices and didn't request permission to use them in this way. But Seifalian says his job was to do the basic research. "The implantation was the job of the surgeon, who requires getting ethical approval and [regulatory] approval. This was not my job."

SpaceX aims big

ELON MUSK is dreaming big. On 29 September, he announced plans for a huge new SpaceX rocket that he says will go to Mars in 2022 and may even provide speedy trips around Earth.

The rocket, which Musk calls the BFR – the first and last letters stand for "big" and "rocket" – is smaller than the now-scrapped design he revealed last year, but still more powerful than any other rockets planned.

Musk said the BFR will replace all of SpaceX's other vehicles: the Falcon 9 and Falcon 9 Heavy rockets and the Dragon capsule. The BFR's first tasks will be satellite launches and bringing cargo and crew to the ISS. Then, Musk said, it will make its way to the moon.

The rocket will have 40 cabins that could each hold up to five or six people, along with a solar storm shelter and entertainment area. After the initial 2022 Mars mission, Musk plans to send four BFRs to the Red Planet in 2024. Two will be crewed; they will mine water and extract carbon dioxide from the atmosphere to make fuel for return missions.

Musk claimed the rockets might one day be used to shuttle passengers from New York City to Shanghai in 39 minutes.

Grass-fed beef is bad for climate

PRINCE CHARLES is wrong to support grass-fed beef. The idea that beef from cows on pastures is good for the environment, allowing us to eat as much as we want, doesn't add up.

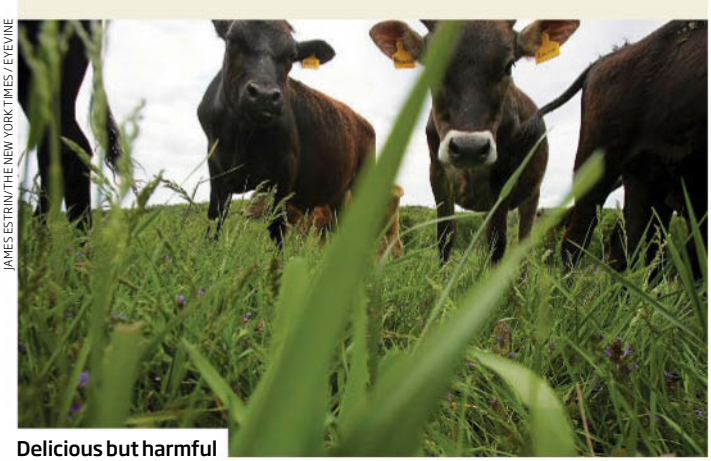
"Though it would be nice if the pro-grazers were right, they aren't," says Tara Garnett of the University of Oxford. "We cannot eat as much meat as we like and save the planet."

A typical cow releases 100 kilograms of methane a year, produced by the microorganisms in its gut, and there are about a billion cows worldwide. Since methane is a greenhouse gas, this exacerbates global warming. Also, destroying forests to feed cows emits greenhouse gases too.

But a counter-view has gained currency. Ecologist and livestock farmer Allan Savory claims pasture plants capture carbon from the air. Pastures should also reduce our need for food crops grown on land that releases carbon when ploughed.

Garnett and her team calculated how greenhouse gases flow through pastures. They found that carbon capture offsets at best 20 to 60 per cent of grazing emissions. "And the carbon capture stops after a few decades," says Garnett. "The cattle continue to belch methane." The findings are published in a report, *Grazed and Confused?*

"It asks, if we are to eat meat, is there a better way to grow it?" says Tim Benton at the University of Leeds, UK. "The answer is: not really."



JAMES ESTRIN/THE NEW YORK TIMES/EYEVINE

Delicious but harmful

60 SECONDS

Keys to secure email

After the 2016 Hillary Clinton campaign hacks, Google looked into new ways to secure online accounts. This month, high-profile Gmail users – politicians and others whose accounts are likely to attract attacks – will be offered physical security keys instead of two-factor authentication, which can be hackable in certain situations.

Free ride

Do you have an electric car? From next year, you may be able to start driving it for free in the UK. Energy companies will pay electric vehicle owners to charge or drain their car battery at certain times, as part of a scheme to help power grids manage supplies from clean energy sources. It could slash the overall cost of charging the battery to nothing.

Vitamin cuts asthma

Vitamin D supplements may lower the risk of asthma attacks. An analysis of 955 people found that taking the pills is linked to a 30 per cent lower incidence of asthma attacks requiring steroid treatment, and a halving in ones requiring hospitalisation (*The Lancet Respiratory Medicine*, DOI: 10.1016/S2213-2600(17)30346-6).

Dominica to be resilient

The hurricane-ravaged island of Dominica wants to transform itself into "the first climate-resilient nation of the climate change era". The island suffered extensive damage after being directly hit by Maria, a category 5 storm. The rebuilding programme mustn't recreate the same vulnerabilities, the prime minister said on 2 October.

We go back a long way

Our species is older than we thought. A genetic analysis of seven Stone Age and Iron Age people from Africa suggests that *Homo sapiens* was present at least 260,000 years ago, supporting recent fossil finds (*Science*, doi.org/cdtn).

CRISPR from head to toe

We're nearly ready to use gene editing to target many more diseases

Michael Le Page

THE race is on to edit our bodies to fight or prevent disease. Results from animal studies targeting the liver, muscles and brain suggest CRISPR genome-editing could revolutionise medicine, allowing us to treat or even cure a huge range of disorders.

This powerful technique for changing DNA was only developed five years ago, but around 20 trials in people have already begun or will soon. However, most of these involve removing cells from a person, editing their DNA, and putting them back into the body.

This approach is being used, for example, to alter immune cells to make them better at killing cancers. It's relatively easy to remove these cells, edit them, and return them to the body, but this isn't possible for most bodily tissues.

So being able to edit cells inside the body without removing them would allow us to treat

"Editing cells inside the body without removing them could be used to treat absolutely everything"

many more conditions – from genetic disorders to high cholesterol. Absolutely everything could be treated this way, says Irina Conboy of the University of California, Berkeley.

The challenge is delivering the CRISPR machinery to tissues inside the body. Editing genes with CRISPR requires at least two components: a protein that cuts DNA and a piece of RNA that guides it to the precise DNA site to make the cut. Proteins and RNAs are much larger than standard drugs and it's hard to get them inside cells. They don't usually survive in the bloodstream, either.

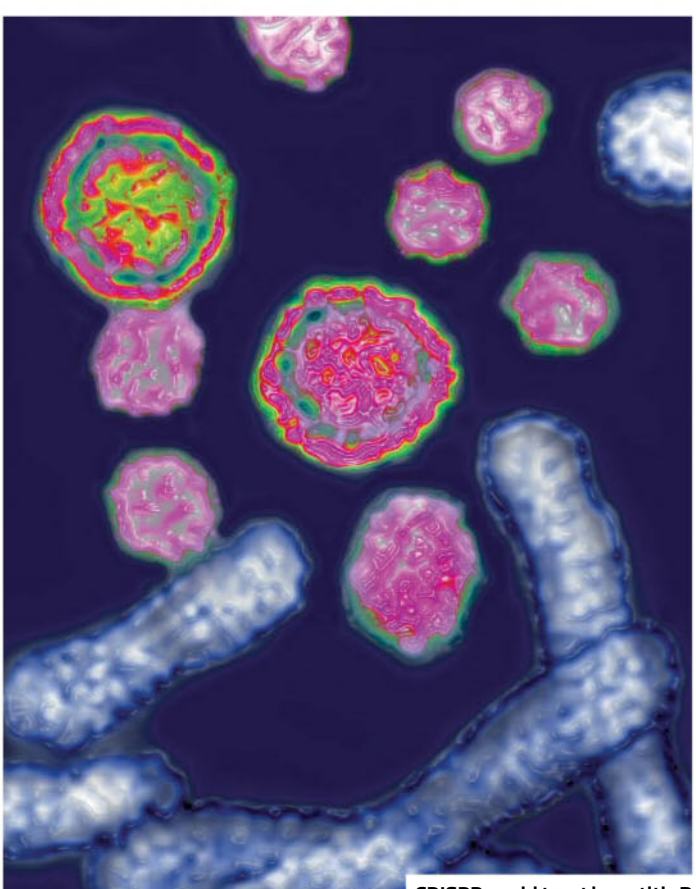
Intellia Therapeutics of Cambridge, Massachusetts, is using fatty particles to deliver the CRISPR components to livers. Last week, the company reported that, in mice, it managed to disable a gene in the liver involved in a rare genetic disease, with high efficiency and no signs of ill effects.

Intellia is also working on a cure for hepatitis B, which infects 250 million people worldwide. The virus can be difficult to eliminate because viral DNA can linger in liver cells. CRISPR can destroy this DNA.

However, targeting the liver is relatively easy, because anything injected into the blood is likely to reach the organ. Conboy's team has managed a more difficult feat: they have treated the muscle-wasting disease muscular dystrophy in mice by injecting gold nanoparticles carrying the CRISPR components into muscle (*Nature Biomedical Engineering*, doi.org/cdtb)

Amazingly efficient

Conboy's team was able to fix the faulty gene responsible. This only worked in 5 per cent of muscle cells, but it was enough to boost muscle strength in the mice.



JAMES CAVALLINI/SCIENCE PHOTO LIBRARY

CRISPR could treat hepatitis B

Conboy thinks the proportion of repaired cells could be increased by repeated injections.

"I think this delivery method is fantastic for certain applications," says Jeffrey Chamberlain at the University of Washington in Seattle. However, to treat disorders such as muscular dystrophy, muscles all around the body – including the heart – need to be edited. Chamberlain's team has successfully edited tissues around the body and treated muscular dystrophy in mice by injecting a virus carrying DNA coding for the CRISPR components.

But there is a big safety issue with viral delivery. When the DNA for the CRISPR cutting protein is inserted into cells, it keeps on making the protein for weeks, raising the risk of DNA also being cut in the wrong places.

Already, though, Nicole Déglon of Lausanne University Hospital in Switzerland and her colleagues have developed a way to prevent the cutting protein lingering. Their "kamikaze" CRISPR system not only disables the target gene, it also disables the gene for the cutting protein after a short delay. Last month, her team showed this reduced unwanted effects in a mouse study targeting the gene that causes Huntington's disease.

What's more, they managed to disable the gene in 65 per cent of cells in the key area of the animals' brains. "I was amazed to see how efficient it was," says Déglon.

Altogether, it's looking like CRISPR's potential for treating some of our most difficult diseases may soon be realised. It's impossible to say how soon these techniques will start being trialled in humans, says Déglon. But the field is advancing so rapidly that it may not be that long. "It's going faster and faster," she says. ■

Methane blasts liquefied Mars ice for ages

BURPS of methane flowing into young Mars's atmosphere might have allowed liquid water to persist through the planet's later dry periods. Rovers and orbiters have found evidence of rivers there 3 billion years ago, suggesting things warmed up enough to stop ice forming, sometimes for a million years.

To discover how this happened, Edwin Kite at the University of Chicago and his team simulated the behaviour of deposits of methane ice on Mars. "It's basically ice that you can set on fire. You can flick a lighter at it, and get a flame," Kite says.

The team found that methane, a potent greenhouse gas, could have been set free when the tilt of Mars's axis changed wildly over time because of Jupiter's tug on its orbit. The change in tilt would expose the ice deposits to sunlight for longer, melting them and freeing methane (*Nature Geoscience*, doi.org/cds8).

The timing and duration of extreme-tilt events matches the duration and rarity of lake-forming climates in Mars's history. What's more, boosting methane in the atmosphere by just 1 per cent would warm the planet enough to melt water ice, provided Mars also had a blanket of carbon dioxide, Kite says.

But Mars may not have had as much CO_2 as we thought. Thomas Bristow at NASA's Ames Research Center and his colleagues recently found a dearth of carbonate minerals – a sign of captured CO_2 – in rocks studied by the Curiosity rover inside Gale crater.

So was Mars indeed low on CO_2, or was the gas somehow cut off from the crater, which was probably once a lakebed? That's an open question, but "if Tom's right, I'm wrong", Kite says.

We should know more once the ExoMars Trace Gas Orbiter analyses the Martian atmosphere next year. A detection of previously unseen methane could lend heft to the idea that the gas warmed ancient Mars.
Rebecca Boyle ■


ANGELO GANDOLFI/NATUREPL.COM

Whistle while you work

Dolphins that help us fish also have an odd accent

ALL bottlenose dolphins whistle, but those that work with humans have a distinctive way of doing it. This unusual calling style may help them recognise each other.

In the seas off Laguna, Brazil, fishers stand in a line in waist-deep water or wait in canoes while, farther out, bottlenose dolphins chase shoals of mullet to the shore. The fishers can't see the fish in the murky water, so they wait for the dolphins to give a signal – like an abrupt dive or tail slap – before casting their nets.

This cooperation between dolphins and humans is rare. In most places, fishers see dolphins as competitors, or simply as unexpected by-catch. The only other known cooperative species is the Irrawaddy dolphin, which helps fishers in Myanmar.

The Laguna dolphins have been working with fishers since at least the late 19th century, presumably because it benefits both parties. Fishers catch larger fish in greater numbers when they operate in tandem with dolphins.

"Dolphins likely reap similar benefits," says Mauricio Cantor of the Federal University of Santa Catarina in Brazil. It might be easy for them to gobble up fish disoriented by the nets, for example.

But only some of the Laguna dolphins, alone or in small groups, cooperate with humans. What's more, in a study published in 2012, Cantor showed that the cooperative dolphins are partly segregated from their non-cooperative peers.

To explore the differences between helpful and unhelpful dolphins, Cantor and his colleagues recorded the sounds made by both types while they foraged either on their own or with people.

"It's as if the dolphins speak the same language but cooperative ones use their own 'expressions'"

Surprisingly, the whistles of cooperative dolphins were different from those of non-cooperative ones, even when foraging alone.

For instance, cooperative dolphins used fewer ascending whistles. They also tended to use shorter, higher-pitched whistles with more inflections (*Ethology*, doi.org/cds3).

Dolphins from different regions often whistle differently, Cantor says, but "it is much less common to find such acoustic differences among dolphins of the same population that inhabit such a small area".

Since cooperative dolphins also whistle differently when foraging solo, the researchers don't think these calls carry specific messages about fishing with people. Instead, the whistles may be a way for dolphins to label themselves as members of a particular social group, Cantor says.

Alternatively, the dolphins may be using dialect or slang. Cantor says it is "as if they speak the same language but use some 'expressions' that are exclusive to their social community".

Dolphins also use clicks to communicate during feeding, says Elena Papale of the Italian National Research Council. Researchers will need to examine clicks as well as whistles to better understand the animals' communication styles.

Bottlenose dolphins in the Bahamas are known to cooperate with spotted dolphins. A 2015 study found that the two species spent around 15 per cent of their time together, and sometimes worked together to catch food or even drive off rivals.

However, it remains unclear whether these bottlenose dolphins also use unusual whistles when communicating.
Elizabeth Preston ■

NEW YORK TIMES/REDUX/EYEVINE

Why are we here again?

A flaw in the pre-crime system

Matt Reynolds

PREDICTIVE policing that aims to work out when and where a crime will take place promises a future of data-driven law enforcement. But a flaw found in the design of the software used suggests that instead of fixing biases in policing, predictive algorithms are to blame for a whole new set of problems.

Pre-crime tech is catching on in the US. PredPol – a market-leading system – is already used by police departments in places such as California, Florida and Maryland. Their hope is that such systems will bring down crime rates while simultaneously reducing human bias in policing.

But when researchers in the US examined how PredPol predicts crime, they found something disturbing. Their study suggests that the software merely sparks a "feedback loop" that leads to officers being repeatedly sent to certain neighbourhoods – typically ones with a high number of racial minorities – regardless of the true crime rate in that area (arxiv.org/abs/1706.09847).

The problem stems from the logic that PredPol uses to decide where officers should be sent. If an officer is sent to a neighbourhood and then makes an arrest, the software takes this as indicating a good chance of more crimes in that area in future.

What this means, says Matt Kusner at the Alan Turing Institute in London, is that the PredPol system seems to be learning from arrest rates – which are higher in areas where there are more police – rather than from underlying crime rates.

"A 'feedback loop' in software leads to officers being repeatedly sent to certain neighbourhoods"

"That's how dangerous feedback loops are," says Joshua Loftus at New York University, who wasn't involved in the study. Although these loops are only part of how PredPol makes its predictions, he says they may explain why predictive policing algorithms have sometimes seemed to recreate exactly the kind of racial biases their creators say they overcome.

To better understand how the system comes to its conclusions, the study team created a simplified mathematical model of the PredPol software. The algorithm chooses how to distribute a certain number of officers between two locations. If more are sent to one location, they tend to make more arrests there. The team found that this feeds back into the system and leads it to send even more officers to that same place.

That means the software ends up overestimating the crime rate in one neighbourhood, without taking into account the possibility that more crime is observed there simply because more officers have been sent there – like a computerised version of confirmation bias.

There might be a way to stop the feedback loop. The authors also modelled a different system, in which the algorithm only sent more officers to a neighbourhood if the area's crime rate was higher than expected. This led it to distribute officers in a way that much more closely matched the true crime rate.

Loftus says that many more problems need to be solved before policing algorithms can be truly called fair. "Human decisions affect every aspect of the design of the system," he says. The algorithm could be thrown off if officers are more likely to arrest racial minorities, for example. ■

A truly universal remote

NO NEED to dig out the remote, your coffee cup will do. You could soon use everyday objects to control your television thanks to a system that uses a webcam to recognise your movements.

To set up the Matchpoint system, created by Christopher Clarke at Lancaster University, UK, icons representing various functions, such as volume or changing channels, pop up one at a time on your TV screen.

When prompted, you draw a circle in the air with your object of choice to transform it into a remote control. You could then move a coffee cup laterally to coincide with an on-screen slider control, for example, to adjust the volume.

Such systems are typically trained to identify objects or people. However, differences between individuals or a change of position can interfere with recognition and cause them to fail. Because Matchpoint can quickly detect any object's shape from its circular movement, it can recognise an object regardless of its orientation.

Clarke also chose a circular motion because it is hard to make by accident, which should cut down instances of unintentionally giving commands.

This technique would be handy when your hands are occupied with something else, says Chris Harrison at Carnegie Mellon University in Pittsburgh, Pennsylvania, who researches human-computer interaction. "For making dinner in the kitchen, this could be very useful."

Medical professionals have also expressed an interest. Surgeons sometimes have to access information on a screen during surgery, for example. "They wouldn't have to put the tools down and touch anything, which would be unhygienic," says Clarke.

The concept will be demonstrated at the UIST2017 conference in Quebec City in Canada this month.

Sandrine Ceurstemont ■

How our sleeping brain stores away memories

AT LAST, we've seen how the brain stores memories when we sleep. By scanning slumbering people, researchers have watched how the "trace" of a memory moves from one region of the brain to another.

"The initial memory trace kind of disappears, and at the same time, another emerges," says Shahab Vahdat at Stanford University in California. It is the first time memories have been observed being filed away in humans during sleep, he says.

Vahdat and his colleagues did this by finding people who were able to fall asleep in the confined, noisy space of an fMRI scanner, which is no easy undertaking. "We screened more than 50 people in a mock scanner, and only 13 made it through to the study," says Vahdat.

The team then taught this group of volunteers to press a set of keys in a specific sequence – in the same way that a pianist might learn to play a tune. It took each person between about 10 and 20 minutes to master a sequence involving five presses. "They had to learn to play it as quickly and as accurately as possible," says Vahdat.

Once they had learned the sequence, each volunteer put on a cap of EEG electrodes to monitor the electrical activity of their brain, and entered an fMRI scanner – which detects which regions of the brain are active.

The team saw a specific pattern of brain activity while the volunteers performed the key-pressing task. Once they had stopped, this pattern kept replaying, as if each person was subconsciously revising what they had learned.

The volunteers were then asked to go to sleep, while the team monitored each of them for two-and-a-half hours. At first, the pattern of brain activity continued to replay in the outer region of the brain called the cortex, which is involved in higher thought.

ELKE MEITZEL/MILLENNIUM IMAGES, UK

Rest well to remember

When the volunteers entered non-REM sleep – known as the stage when we have relatively mundane dreams – the pattern started to fade in the cortex, but a similar pattern of activity started in the putamen, a region deep within the brain (*eLife*, doi.org/cdsz). "The memory trace evolved during sleep," says Vahdat.

His team thinks that movement-related memories are transferred to deeper brain regions for long-term storage. This chimes with the hypothesis that the brain's cortex must free up space so that it can continue to learn new information, says Christoph Nissen at University Psychiatric Services in Bern, Switzerland.

Non-REM sleep happens within a few hours of dozing off, says Vahdat. If you're hoping for some night-time learning, it's important to make sure that those first few hours are uninterrupted, he says.

Nissen hopes a better understanding of how memories are consolidated during sleep could lead to treatments for people with insomnia and similar sleep disorders. Such individuals tend to be treated with drugs that send them to sleep, but Nissen has found that this sleep doesn't seem to be as good at consolidating memories as natural sleep. **Jessica Hamzelou** ■

New York's mice are evolving to eat a city diet

THERE are always better restaurants in the city, and that could be making the town mice of New York genetically distinct from their country cousins.

Stephen Harris at the State University of New York and Jason Munshi-South of Fordham University in New York City caught 48 white-footed mice (*Peromyscus leucopus*) from three New York parks and three nearby rural areas. The mice are native to this part of North America, so the pair wanted to find out whether some had begun to evolve for city living.

They examined the mice's RNA to see if the rural and urban populations expressed different genes. Ultimately, they homed in on 19 single nucleotide polymorphisms (SNPs): places in the genome where a single letter varies from mouse to mouse (*bioRxiv*, doi.org/cdr8).

Several SNPs were in genes associated with digestion and other metabolic processes. One highlighted gene was used to produce omega-3 and omega-6 fatty acids. A version of this gene appears to have been selected for in humans as we moved from hunter-gathering to agriculture.

The work is "at the forefront of biology", says Jonathan Richardson at Providence College in Rhode Island.

The survey also highlighted genes linked to non-alcoholic fatty liver disease, which may result from having to process a lot of fatty acids. This could be due to a diet rich in fast foods. "The first thing that we thought of was the 'cheeseburger hypothesis': urban mice subsidising their diet on human food waste," says Harris. If so, the mice may be like "Pizza Rat", a New York rodent videoed carrying a whole slice of pizza.

"The first thing we thought of was the 'cheeseburger hypothesis': urban mice eating human food waste"

In line with this, city mice had larger livers with more scar tissue, says Harris, who was at the City University of New York when most of the work was done. However, the sample size was too small to be sure.

Besides, New York offers other foods, like seeds, nuts and berries in its parks. Such resources are more plentiful than in rural areas, where there is more competition from other species. Chris Baraniuk ■

Google aims for quantum's reign

Mark Kim

GOOGLE has come up with a strategy for demonstrating quantum supremacy, the claim that quantum computers can perform tasks that no current computers can. While it's widely assumed that we will eventually reach quantum supremacy, nobody has done it yet because current quantum computers can only run a few specialised algorithms.

The plan is based on simulating coin flips. An ordinary computer does this by storing two numbers and choosing one of them at random for each flip. To simulate 50 coin tosses, it selects 50 times in a row. This is simple with regular coins, but if the coins behave like particles obeying the laws of quantum mechanics, things get more complicated.

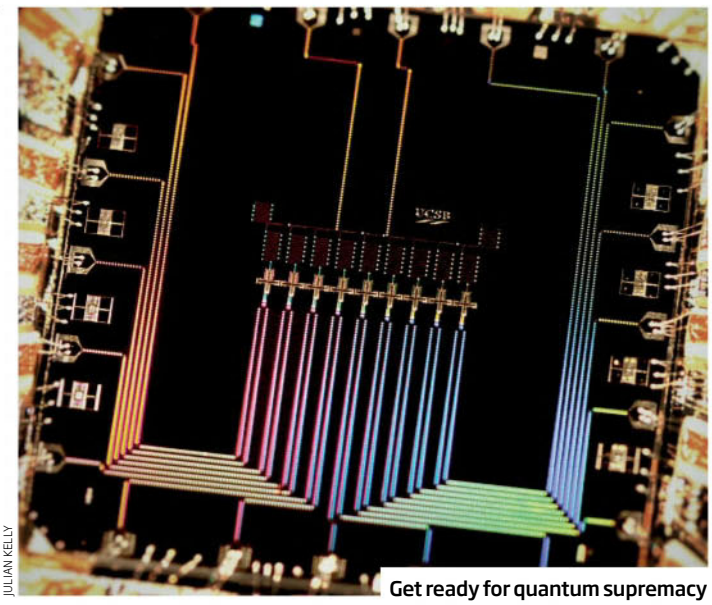
In that case, we cannot know whether any individual coin turned up heads or tails without knowing about all the other coins, a phenomenon known as quantum entanglement. The problem of simulating coin tosses with quantum entanglement is called quantum sampling.

Computers work sequentially, so they cannot choose 50 numbers at the same time. For this reason, the Google group argues, quantum sampling would require storing all possible configurations of all 50 coin tosses, so that all of the coins can be thrown simultaneously.

Since one bit – the building block of classical computers – can only store one of two states, heads or tails, covering all possible configurations for 50 coins takes hundreds of terabytes of storage.

This is where quantum computers come in. They are based on qubits, which can be in two states at the same time. This makes it possible to store the probability distribution of all the configurations at once using a single qubit for each coin. This led the Google group to suggest quantum sampling would be easy for a quantum computer.

In the proposal, the team demonstrates quantum sampling up to nine coins with high accuracy using a 9-qubit quantum computer. "If similar error rates are achievable in future devices with around 50 qubits, we will be able to explore quantum dynamics that are inaccessible otherwise," the proposal states. This way, quantum computers of the near future can be used to study physics, a huge step up from their infancy when they couldn't do anything practical.



JULIAN KELLY

Get ready for quantum supremacy

The only remaining task is to build a 50-qubit computer. And the team just might be able to. "The Google group has such a strong record that if they say they're going to do it, people pay attention," says Scott Aaronson at the University of Texas in Austin.

Not everyone is convinced quantum sampling is the right problem to tackle, though. "It is unclear whether what they claim to show is quantum supremacy," says Itay Hen at the University of Southern California. "You have to prove that classical computers can't do it." Proof that this kind of simulation can't be done on a classical computer may not come anytime soon, but many concepts in this field are accepted as true without formal proof.

"We know almost certainly there's not going to be a fast classical algorithm" that solves quantum sampling problems, says Aaronson. If there isn't, and Google manages to put its plan in motion, it may finally be a hint that quantum computers really are better than regular ones. ■

'Invasive' snake was a unique species all along

ON AN island off West Africa lives a venomous snake. It was thought to be an introduced species and plans were afoot to wipe it out. Now it turns out to be a species unique to the island, one that should be conserved.

Known as the cobra-preta, the snake is found on São Tomé in the Gulf of Guinea. Local people have a saying about it: *homem mordido, homem perdido*, or "man bitten, man lost".

The snake was thought to be the forest cobra (*Naja melanoleuca*), a black snake with a white collar found in mainland Africa. Colonial farmers supposedly brought it to São Tomé to control rats. Luis Ceríaco of Villanova University in Pennsylvania found this odd. "Why would you introduce the deadliest snake in Africa to an island?"

Ceríaco found an account of a 1506 visit to São Tomé by a Portuguese explorer, who wrote of a black snake "so venomous that when it bites a man, his eyes will explode out of the head and he will die". That was clearly the cobra-preta, Ceríaco says, albeit depicted with eye-popping hyperbole.

Ceríaco found that cobra-pretas were often larger than forest cobras and that scales on their underside had less white. Genetic analysis confirmed the cobra-preta as a new species, *Naja peroescobari* (*Zootaxa*, doi.org/cdrz).

"It's pretty incredible," says Ceríaco. "It's like discovering a new crocodile."

The timing was lucky, says Ceríaco.

"An explorer told of a snake so venomous that when it bites a man, his eyes will explode out of his head"

São Tomé is ever more conservation-conscious and the cobra-preta could have been earmarked for eradication, since it did not appear to be native.

"I think it says a lot that the type specimen, which is considered the gold standard in taxonomic research, is a snake that was chopped in half by a local resident," says Rayna Bell of the Smithsonian Institution in Washington DC. "Clearing up the misconception that the cobra-preta doesn't belong on São Tomé will be an important first step towards conserving these unique snakes."

Sean Mowbray ■

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How we got our folded brains?

Clare Wilson

OUR braininess may have evolved thanks to gene changes that made our brain cells less sticky.

The cortex is the thin, highly folded outer layer of our brains and it is home to some of our most sophisticated mental abilities, such as planning, language and complex thoughts.

Around three millimetres thick, this layer is folded into an intricate pattern of ridges and valleys, which allows the cortex to be large, but still fit into a relatively small space. Many larger mammals, such as primates, dolphins and horses, have various patterns of folds in their cortex, but folds are rarer in smaller animals like mice.

So far, we have only identified a few genetic mutations that contributed to the evolution of the human brain, including ones that boosted the number of cells in the cortex. One theory about how the cortex came to be folded is that it buckled as the layer of cells expanded.

Daniel del Toro at the Max Planck Institute of Neurobiology in Munich, Germany, and colleagues wondered if some of the genetic changes in our brain's evolution might have been about more than just an increasing number of cells. They investigated the genes for two molecules – FLRT1 and FLRT3 – which make developing brain cells stick to each other more.

Human brain cells produce only a small amount of these compounds, while mice brain cells make lots. Del Toro's team created mice embryos that lacked functioning *FLRT1* and *FLRT3* genes, which meant their cortex cells were only loosely attached to each other, like those of humans.

When the genetically altered mice were born and grew into adults, they had more folded brains. This finding was presented at the Cortex Evolution and Development conference in Copenhagen, Denmark, last month. But it is still unclear if these mice are smarter – that is what the team plans to study next.

Why would less sticky brain cells lead to a folded cortex? As a human fetus develops, new brain cells are produced in the middle of the head, and then move outwards until they reach the surface and become the cortex. Del Toro speculates that the stickier cells in normal mice might make the cortex layer too rigid to deform into wrinkles. "Imagine a line of people running together holding hands," he says. "At the end, they all arrive at the same time."

The looser bonding of human brain cells might also allow them to migrate at different speeds and so form more complex structures within the cortex, says del Toro.

"If brain cells are less sticky, they may form more complex structures within the cortex"

But it is too soon to conclude that this was a key change in our evolutionary history, says Todd Preuss at the Yerkes National Primate Research Center of Emory University, Georgia, because the study only compared humans and mice. "It would be interesting to see what these genes are doing in other primates and mammals." ■

ZEPHYR/SCIENCE PHOTO LIBRARY

Non-stick brain

Earth may have had life earlier than thought

LIFE may have begun on Earth hundreds of millions of years earlier than thought, say two studies published this week. But both papers are already proving controversial.

Ben Pearce of McMaster University in Hamilton, Canada, and his colleagues simulated conditions on early Earth to find out how readily key molecules of life could have formed. They focused on RNA, a cousin of DNA widely thought to have formed the first life. Many of the building blocks of RNA are found in asteroids, so Pearce and his team calculated how much could have been carried to Earth's ponds. They concluded that RNA could have formed just a handful of years after major impacts, implying that life began very early in Earth's history (*PNAS*, doi.org/cdtm).

This argument does not stand up, says John Sutherland of the MRC Laboratory of Molecular Biology in Cambridge, UK. The team assumed the first step in making RNA is to link smaller molecules called nucleobases and ribose, but this was shown not to work years ago. "These authors are still assuming the old model," he says.

A second study claims to have found the oldest firm evidence of life. It dates back 3.95 billion years, half a billion years after Earth formed.

Tsuyoshi Komiya of the University of Tokyo and his colleagues studied the forms of carbon in rocks in Labrador, Canada. The samples Komiya looked at had little of the isotope carbon-13 (*Nature*, doi.org/cdqn). Organisms prefer carbon-12, so their remains contain little carbon-13. The team claims this is evidence that life was present.

"There are many ways in which abiotic processes can produce such an imbalance, so to conclude that it is evidence for life is simply not justified," says Sutherland.

Chemical reactions in the Fischer-Tropsch process can show a similar carbon bias. Komiya assumed these weren't responsible, because they need hydrogen. But if there was water and carbon monoxide in the air, and hot iron from meteorite impacts, says Sutherland, "hydrogen can easily be generated". Michael Marshall ■

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No GPS, no pilot, no problem

Sandrine Ceurstemont

TALK about a deep dive. A drone that can switch between flying and rolling along could soon be exploring inaccessible underground caves and mines without human help.

Above ground, drones can navigate autonomously using GPS, but these satellite signals don't penetrate deep underground, meaning robot spelunkers normally require human pilots.

Ahmed AlNomany and his colleagues at Swedish company Inkonova are working on an alternative. "It's complicated because we are trying to invent another way of positioning using bits and pieces of technologies," says AlNomany.

Giving the drone a view of its surroundings is the first step. Using laser scanners and a technique called SLAM, which calculates the distance between the drone and nearby objects, it will build up a map of the area around it. And it can do this fast.

The company recently used its manually operated drone, TILT Ranger, to map an underground mine in Mali using SLAM. In just 10 minutes, the team was able to virtually reconstruct a section of the mine with a volume of roughly 30,000 cubic metres – about a third the size of London's Royal Albert Hall. "It's not a big challenge to capture such zones quickly," says AlNomany.

Now the firm's new autonomous drone can combine its map with input from sensors, such as an accelerometer, to help position itself and move without GPS. So far, during preliminary tests, it has been able to stabilise itself on its own in the air.

When it encounters unusually shaped space, it has a backup. Equipped with wheels, the drone can move along the ground and tilt to fly or roll at an angle if needed. "If it is near a wall, the drone will adapt to it and climb it instead of flying," says AlNomany.

INKONOVA

Finds its own way

Adriano Mazzini at the University of Oslo in Norway thinks automated drones are now the ideal choice to explore dangerous environments. "Relatively lightweight and high-performing tools can now be added to them," he says.

Mazzini recently sent a drone over the erupting Lusi mud volcano in Java, Indonesia, to sample gas, water and mud – something that would have been unthinkable just a few years ago.

Inkonova's drones are of interest for other GPS-deprived environments too. The company was recently contacted to map a decommissioned nuclear power plant, which has thick walls that block any satellite signal from helping drones navigate.

However, the mission was aborted after concerns were raised that the drone's propellers could disperse potentially radioactive dust inside. "We didn't pursue it further, but we would like to adapt TILT Ranger for this purpose," says AlNomany. ■

Extreme gusts of space gas fed big black holes

MIGHTY winds may explain how black holes can get big fast. These cosmic behemoths take a long time to grow, so we don't expect to see many supermassive ones in the early universe. Any that existed would have grown from smaller "seed" black holes that somehow got very massive very quickly after the big bang.

But astronomers keep finding more supermassive black holes in the early universe, from which light is only now reaching us. That makes it unlikely that they all grew as most modern ones do – by slowly devouring dust and gas.

Shingo Hirano at the University of Texas at Austin and his colleagues simulated conditions in the early cosmos to figure out how the seed holes might be born.

In their model, a halo of dark matter was blasted by supersonic gas streams in the chaos of the big bang. The dark matter's gravity captured some of the gas, forming a dense cloud. Normally, such a cloud would fragment, collapsing in several places and turning into many stars.

But the team found that turbulence introduced by the streaming motion delayed this.

Eventually, this meant the gas cloud got big enough to collapse in on itself, rapidly building a star thousands of times more massive than the sun. That object ended up as a black hole 2 billion times the mass of the sun, and it did so less than 800 million years after the big bang – much faster than the way black holes grow today (*Science*, doi.org/cdtd).

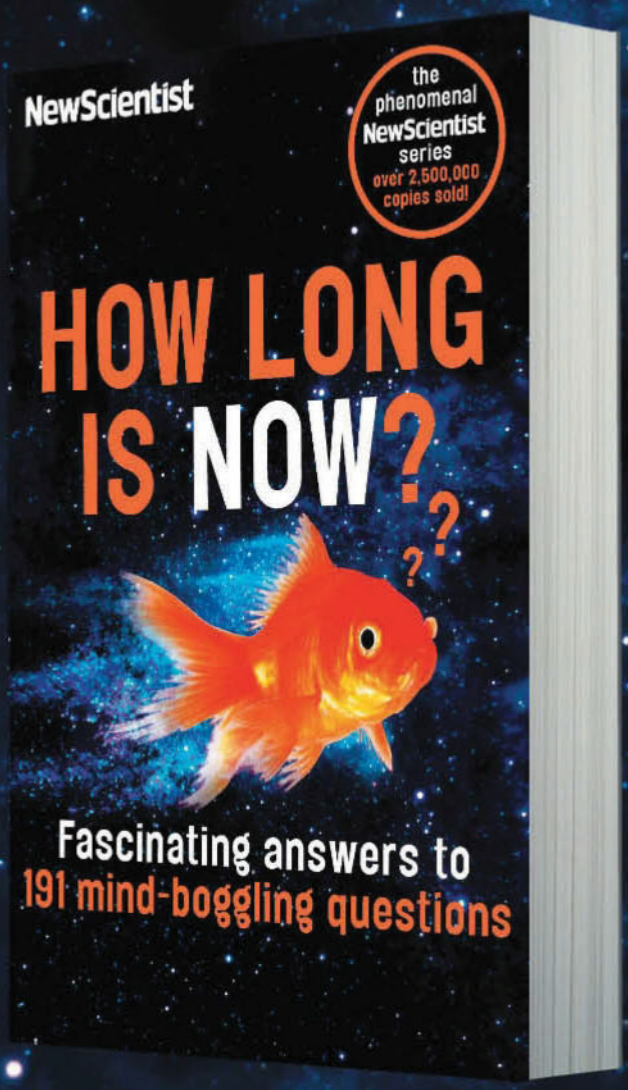
"Their massive seed black holes form extremely early on – much earlier than discussed in most other works," says Zoltán Haiman at Columbia University in New York.

"Supermassive black holes in the early cosmos are too young to grow like modern ones do – by eating gas"

The earlier these seeds formed, the harder it will be to observe them directly. Luckily, the next generation of space telescopes may be able to see deep enough into the distant universe – and thus further back in time – to find black hole seeds and help confirm theories of how they got started.

"The formation of seed black holes is one of the most important outstanding questions in supermassive black hole research," says Jenny Greene at Princeton University. "It will be very exciting to directly test models like this one with the upcoming James Webb Space Telescope." Leah Crane ■

WHY ARE DOGS' NOSES WET?



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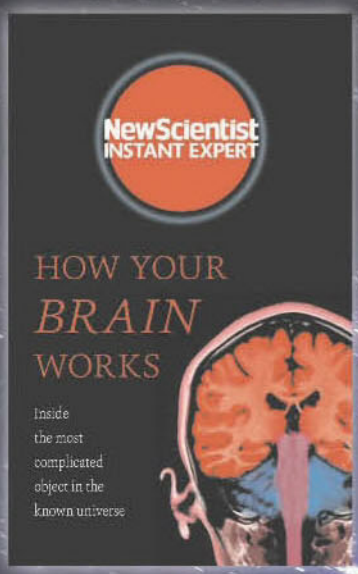

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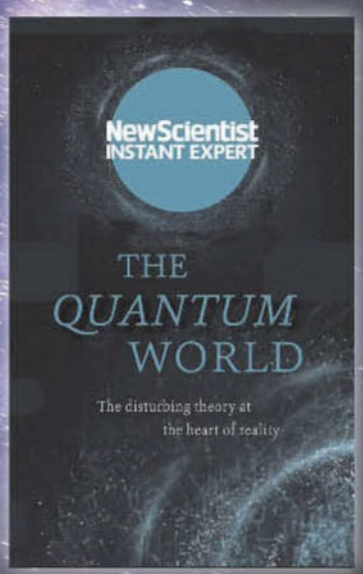

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PETER VERHOOG, BUITEN-BEELD/FLPA

Packs of killer penguins harry fish then pick them off

BIRDS of a feather fish together – if they're African penguins. They catch more food using less energy.

African penguins were believed to forage in groups, but nobody had ever seen them hunt underwater. To find out how they catch fish like schools of sardines, Alistair McInnes of Nelson Mandela University, South Africa, and colleagues fitted cameras to 12 birds.

Often the penguins chased single fish, but sometimes they teamed up. Groups of penguins were seen herding schools of fish towards the surface, corralling them into a "bait ball". Any fish trying to escape were easy prey.

The researchers calculated how efficient the penguins were by dividing the number of fish caught by time spent foraging. When hunting a school of fish as a group, they were 2.7 times as efficient as when they attacked on their own (*Royal Society Open Science*, doi.org/cdmz).

"This study provides the first evidence that penguins are actively interacting with other individuals to enhance hunting efficiency," says Yuuki Watanabe at the National Institute of Polar Research, Japan.

African penguins are endangered – the wild population has fallen by over 60 per cent since the 1970s. This decline may make it harder for the remaining penguins to get enough food, says McInnes. "If they benefit from group foraging and there are less birds at sea, it's harder to find other penguins to [join] them when they're foraging."

Antidepressant helps mice burn belly fat

EXCESS belly fat is linked to a host of chronic diseases, but it gets harder to lose it as we get older. Now it seems that inflammation of immune cells may be to blame, and drugs can help fight this and burn off belly flab.

There's evidence that immune cells called macrophages in belly fat become inflamed as we get older. So Christina Cammel of the Yale School of Medicine and her team isolated macrophages from the fat tissue of young and old mice, and sequenced the DNA from these cells.

The genomes of the aged macrophages expressed more genes that hinder a group of molecules that spread signals between nerve cells, called catecholamines.

"We found macrophages in belly fat interfere with signals in a way that's new to us," says Cammel.

When the team used the antidepressant drug clorgyline to boost catecholamine signalling, older mice became more able to burn off the fat around their middle (*Nature*, doi.org/cdmw).

But we don't know yet if people taking this drug see the same effect on their waistlines. It may be tricky to find out, says Cammel, because the drug seems to change appetite in people.

Energy from evaporating water

EVAPORATING water could supply a vast amount of clean electricity – if we can harness it.

Evaporation from US lakes and dams – excluding the Great Lakes – could provide 2.85 million megawatt-hours of electricity a year, says Ozgur Sahin of Columbia University, New York, and his team. That is equivalent to two-thirds of US electricity generation in 2015 (*Nature Communications*, doi.org/cdm3).

Sahin has made prototype evaporation engines using tape coated with bacterial spores. The spores curl as they dry, shortening the tape. "They work like a muscle," he says. This force could be used to generate electricity.

"The question is whether there is any practical way to capture that energy," says Ken Caldeira of the Carnegie Institution for Science in Stanford, California. Then, the engines would have to be mass-produced.

Japanese species floated to the US

HUNDREDS of marine animals crossed the Pacific Ocean from Japan to the US. They hitched rides on debris swept up by the Tohoku earthquake and tsunami of 2011.

A total of 289 species have been documented arriving this way, including fish, mussels, sea slugs, sea stars, crabs and sponges – all native to Japanese waters. Some fish survived years in water-filled boats. They include banded knifejaws and yellowtail amberjacks, up to 60 centimetres long (*Science*, doi.org/cdr6).

"It's the biggest rafting event ever aboard anthropogenic material," says James Carlton of Williams College, Connecticut . It shows potentially invasive species can travel far aboard human-made materials that degrade slowly.

Fake clouds show how rain can start

A LAB-MADE cloud has thrown light on a mysterious rain-creating phenomenon. It could explain how a single cold droplet or ice shard can trigger abrupt rain or snowfall.

Prasanth Prabhakaran at the Max Planck Institute for Dynamics and Self-Organization in Germany used chemical stand-ins to create artificial clouds. Helium took the part of nitrogen and the other gases in the atmosphere, while sulphur hexafluoride played the role of water. The cloud was created in a box with a heated bottom and a top that was 4°C cooler.

Some sulphur hexafluoride formed a pool at the bottom of the box, and some evaporated into the helium gas above. Drops of sulphur hexafluoride condensed on the ceiling of the box and dropped back down through the gaseous cloud.

Because the drops had formed on the cooled top of the box, they were colder than the surrounding gas. As a drop fell, it cooled the area around it. That caused "microdroplets" to form in its wake, just as condensation forms (*Physical Review Letters*, doi.org/cdk8).

This could help explain some abrupt rainstorms. Microdroplets produced in this way in real clouds could merge until they are big enough to fall as a raindrop, or be swept into an updraft and then create microdroplets of their own.

BRIANAJACKSON/GETTY

Antibiotic plan may stop spread of resistance

THE world is losing its antibiotics, as bacteria increasingly become resistant. Use of these drugs in farming promotes the evolution of resistance, but it has been unclear what countries should do to cut back. Now there is an achievable three-point plan to reduce this type of use by 80 per cent.

First, Ramanan Laxminarayan of the Center for Disease Dynamics, Economics and Policy in Washington DC and his colleagues calculate that if rich countries and China cap their use of antibiotics in farming at the global average, overall use in that sector should be 60 per cent lower in 2030.

Second, if by 2030 everyone eats only 165 grams of animal protein a day – the expected EU average – the team calculates that antibiotic consumption by livestock would be 22 per cent lower than current predictions.

And lastly, the team estimates that a tax on veterinary antibiotics of half the price of the drug would cut global consumption by nearly a third. "This is not only doable, but urgently needed," says Laxminarayan.

Enacting all three measures in sequence would cut antibiotic use on farms by 80 per cent, the team predicts (*Science*, DOI: 10.1126/science.aao1495).

The effect this would have on resistant infections in people is difficult to forecast, because resistance arises in both farm animals and people. But a modelling study earlier this year found that if antibiotics on farms are not limited, simply restricting the use of drugs in people will do little to cut resistance.

Lab-grown cells cure anaemia

CELL transplants have been used to cure anaemia in mice.

Millions of people worldwide have chronic kidney disease. The kidneys make erythropoietin (EPO), a hormone that triggers the production of red blood cells, so people whose kidneys degenerate can develop anaemia – not having enough haemoglobin-rich red blood cells to carry oxygen around the body.

EPO can be made commercially to treat anaemia, but it is expensive and needs to be given by regular transfusions.

Now a team has used stem cells from human cord blood to make cells that produce EPO. Four weeks after transplanting these cells into the kidney cavities of mice with a form of kidney anaemia, the treated animals had blood EPO levels 20 times higher than those in controls (*Science Translational Medicine*, doi.org/cdmx).

"Just one transplant of the human EPO-producing cells treated kidney anaemia in mice, keeping their haemoglobin levels in the normal range for the remaining 7-month lifespan of the animals," says Kenji Osafune of Kyoto University in Japan, who led the team.

JASON DORFMAN, MIT CSAIL

Shiny plastic suits add to robot skills

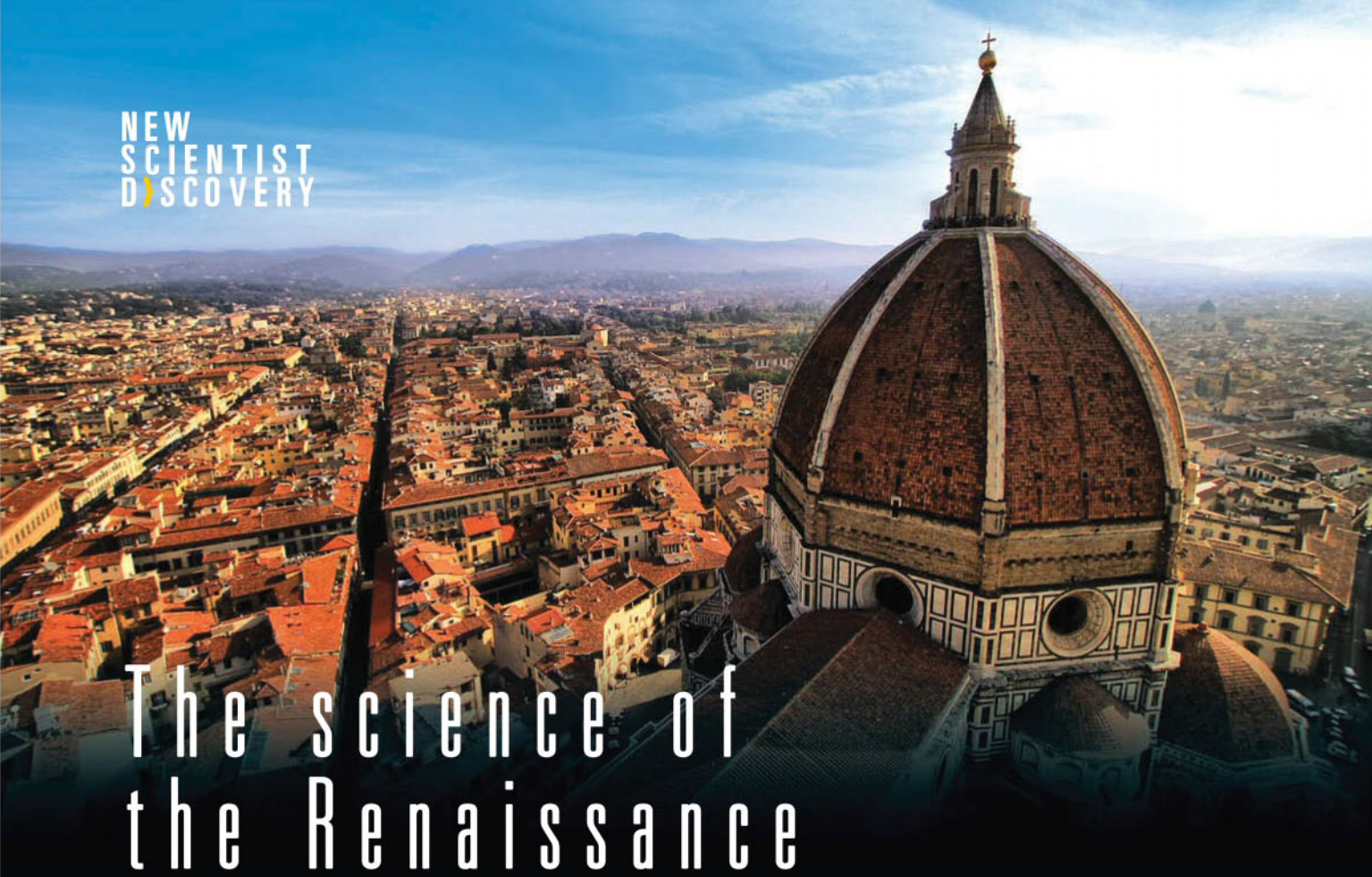
IT'S a pint-sized Transformer. A robot named Primer can don tailor-made outfits to tackle challenges like walking, rolling, sailing and gliding.

Each outfit starts as a simple sheet of plastic. Once the robot rolls onto it, heat is applied to make the sheet fold, forming an exoskeleton – a bit like origami assembling itself. Lines cut into the plastic create the folds, with the depth of each cut determining the angle of fold.

One exoskeleton lets Primer roll, meaning it can move twice as fast as without the suit. Another is boat-shaped, letting the robot float and carry nearly twice its weight. There's even a glider-shaped one that allows it to soar when falling from a height (*Science Robotics*, doi.org/cdnh).

The system was created by Daniela Rus at the Massachusetts Institute of Technology and her colleagues. "Robots like this could become mini surgeons, squished into a pill that you swallow," Rus says – Primer is only a couple of centimetres in size.

Once the robot has finished with an exoskeleton, it can ditch it by dipping itself in water, causing the suit to unfurl.



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DNA tests put your genes on sale

Firms that sell home genome tests are gathering valuable data that they sell on to drug developers. Should you be getting a cut, asks **Jessica Hamzelou**

YOUR DNA determines many aspects of who you are, and an increasing number of companies are claiming they can decode it for you. But they may be getting more out of it than you do.

Some tests that reveal genetic trivia sell for as little as $29, although typical prices are between $100 and $200 if you want more detail, with similar costs outside the US.

But the companies selling these kits stand to gain a good deal more. Their vast, growing databases of genetic information are hugely valuable to researchers and pharmaceutical companies. Flogging this data, or mining it for drug discovery, could be where the big profits lie. So should these firms be paying you, rather than charging for what might ultimately be little more than a conversation starter?

The tests on offer generally fall into three categories. Some firms provide insights into your ancestry from a saliva sample. They search your DNA for genetic variants known to be common in certain parts of the world, now and in the past.

For example, Living DNA, which is based in the UK, uses this information to suggest where your ancestors might have lived, both in recent times and thousands of years ago.

Other companies like 23andMe offer health information, looking for genetic variants that might put someone or their children at risk of disease, as well as more trivial factoids, such as how well you can handle your alcohol. In 2013, the firm was banned from selling a test for 254 disorders and conditions because the US Food and Drug Administration was concerned that the results could be easily misinterpreted. The company now offers a scaled-down test for 10 disorders, including late-onset Alzheimer's disease.

LAUREN FLEISHMAN/THE NEW YORK TIMES/REDUX/EYEVINE

What's your contribution worth?

Then there are the tests that offer information on fitness, nutrition, mood, personality – you name it. Soccer Genomics says it can assess speed, strength and nutrition-related genes to help optimise your performance in the sport.

Even Marmite got in on the action last month, partnering with a firm called DNAFit to sell a test that claimed to tell if you are genetically predisposed to love or hate the yeast spread. "I call these genomertainment," says Rick White, founder and CEO of Sure Genomics, a US-based company that plans to offer genetic testing for disease risk and drug reactions.

These tests sound like just a bit of fun, but have a serious side. Orig3n, which sells a "superhero" saliva test that will supposedly tell how your genes affect your strength, intelligence and ability to learn languages, got into trouble last month after offering free tests to fans of the Baltimore Ravens, an American football team. The "DNA Day" promotion was shut down by the Maryland Department of Health after privacy concerns were raised.

"Selling DNA data, or mining it for drug discovery, could be where the big profits lie for genome firms"

Genome value

And more serious again is that for many of these companies, selling tests to consumers is almost a sideline – the real value is in the data they gather.

Orig3n, for example, has grander plans to find medicines that can regenerate worn-out or damaged tissues and organs. In 2015, 23andMe announced plans to mine its own information to search for new medicines. "We are putting significant resources into translating genetic information into the discovery and development of new therapies for our customers and the world," CEO Anne Wojcicki said at the time.

This shouldn't come as much of a surprise. 23andMe holds an incredibly valuable database and has already made a number of deals to share it with biotech and pharmaceutical companies.

While these firms tend not to reveal the exact number of customers they have, 23andMe is known to hold the genetic information of at least two million people. "No study in the world can recruit as many people as they do," says John Perry at the University of Cambridge.

What makes that information so valuable is the reams of personal details that accompany it. 23andMe send hundreds of questions to their willing consumers on a regular basis. "They ask all sorts of questions, from how frizzy your hair is and what you can taste to important biomedical information about disease," says Perry. "It's very valuable – often it can lead your research in unexpected directions."

The firm shares its data set with academic researchers like Perry for free. "It's like a competition," says Perry. "You pitch your project to them. If they say yes, they run the analysis and share the de-identified aggregate summary statistics with you." So far, Perry has used 23andMe data to explore the genetics of polycystic ovary syndrome and the age of onset of puberty.

Its deals with pharmaceutical companies are more lucrative. Since 2014, 23andMe has partnered with companies

including Pfizer, Reset Therapeutics and Genentech to study disorders ranging from Crohn's disease to Parkinson's.

The financial details are largely secret, but in 2015 Forbes reported that Genentech paid $60 million for the whole genome sequencing data of 3000 customers of 23andMe with Parkinson's disease. "We don't disclose the financial value of our agreements due to contractual obligations, and we can't confirm previously reported dollar figures," the firm told *New Scientist*.

"It's a very clever business model," says Tim Frayling at the University of Exeter, UK. "Individuals pay to have the DNA test done, and say they are happy to participate in research, and then 23andMe sell the data to pharma. They're making money on both sides."

23andMe is upfront about its collaborations, and users can opt in to volunteer their data for research – as around 80 per cent of its customers currently do. "You're free to answer as many or as few surveys as you like," says a spokesperson for the firm.

If you opt in, your genetic information could be used over and over again, for multiple research projects. And it could be reanalysed in more advanced ways once new genetic tools are developed. The information you get back from your spit sample could be a tiny fraction of the total collected.

So where is your cut of the profits? White thinks we should have more control over our valuable genomes. "I'd hope to have a robust marketplace that gives you the opportunity to sell your own data," he says. "If a drug [developed using your genetic information] gets sold, there's no reason why you shouldn't receive a micropayment." His company, Sure Genomics, will not share their customers' data, he says.

"It seems fairer," agrees Frayling. "Maybe we should all get together and say: 'you can only have the data if we get a cut'."

But it is difficult to say how much an individual genome – along with personal health information – would be worth. "Studying one person's genetic information is not useful," says the 23andMe spokesperson. "What's valuable is putting it with survey information. All of the information is de-identified and studied in aggregate. So it's tough to place a value on one person"

"The information you get back from your spit sample could be a tiny fraction of the total collected"

But the data's value is clear. "A drug is twice as likely to make it through the pipeline [to market] if it is based on human genetics," says Frayling. "Given that a single drug costs around a billion dollars to develop, the information could save them half a billion dollars."

Some argue that in the long run, everyone benefits from research, so we should all be donating our information to the cause. It is true that 23andMe's database has already contributed to new results helping researchers understand the effectiveness of antidepressants and the causes of infertility and male-pattern baldness, among others.

Unsurprisingly, this is the view that many of the companies themselves hold. "I'm biased, but I feel that the more information we have, the better it is for everyone," says Marcie Glicksman, CEO of Orig3n, who is also a customer of 23andMe. "Research and development is expensive – people should be altruistic."

In the meantime, if you are thinking about buying one of these kits, it's worth considering what you will get out of it. Finding out about your ancestry can be interesting, but you only have to go back a short way through human history to find ancestors common to everyone living in your continent.

More seriously, learning that you have an increased risk of disease can be dangerous information. Most of the companies do not offer genetic counselling, and it's unlikely that your doctor will have the necessary training to make sense of your results. Many people don't change their lifestyle even when they find out they are at risk of diseases like diabetes, while others can overreact. Preventative surgery to avoid breast cancer can be unnecessary, for example.

And don't expect a DNA test to tell you how to exercise better, says Frayling. Much of the research behind these tests is based on elite athletes, who might have a genetic variant that gives a tiny power boost. There are many genes involved, however, and each has only a very small effect. "There is no evidence that having a certain allele means you should exercise in a certain way," he says. "The only reason I would do those tests is for a bit of fun." ■

BRUNO BARBEY / MAGNUM PHOTOS

A testing puzzle

Battle for control

Skirmishes between fast-moving, disruptive technology outfits like Uber and regulators are coming thick and fast, says **Paul Marks**

SHOULD technology start-ups operate under more lax legal regimes than other businesses? The answer should, of course, be no. Yet there exists a certain type of Silicon Valley outfit that seems destined to upset regulators as a result of their desire to get the technology out there rapidly.

This appears to include Uber Technologies – a firm in the vanguard of the sharing and gig economies. Its app-based, dynamically priced taxi-hailing and sharing service has seriously undercut entrenched cab firms the world over, leaving the likes of London's black-cab drivers apoplectic at the lost business.

Uber's swift taxi availability and low fares have engendered an almost fanatical loyalty among hundreds of thousands of users in London and attracted a claimed 40,000 drivers.

On 22 September, however, safety regulator Transport for London (TfL) unexpectedly announced that it is not going to renew Uber London's private hire taxi operator's licence for the city.

Calling the company "not fit and proper" to hold a licence, TfL said its approach was deficient in four aspects: reporting crimes committed by drivers; explaining how it certifies drivers as medically fit; explaining how it checks for drivers' criminal record; and explaining why it has software called Greyball that could prevent TfL or the police interrogating Uber's systems.

Uber London disputes the decision and says it will appeal. But instead of immediately talking to TfL about what it could do to get its licence back, its first move was characteristically brash: it organised a petition protesting the potential hit to its service and the threat

Apocalypse later

Countering the relentless doomsday scare stories is important, says **Geraint Lewis**

CONGRATULATIONS, you have survived the latest prophesied doomsday. For weeks, the darker corners of the media have been abuzz with predictions that the end of the world was coming.

Some suggested it would coincide with the 21 August US total solar eclipse. Others plumped for 23 September, for no other reason than 33 days would have passed since the eclipse. Always keen to move on from a no-show, conspiracy theorists have revised the big day to 21 October.

Prophecies of doom aren't new. At the turning points of centuries or millennia, someone always comes out of the woodwork to claim that the end is nigh. Others predict the end of days based on how immoral and violent society has become, although recent decades have been relatively peaceful compared with most other historical periods.

Numerological trickery is behind some of the most recent predictions. In 2012, we were told that the ancient Mayans had predicted the demise of the world on 21 December, when some cosmic event, such as a rogue planet called Nibiru (or Planet X), would hit Earth. The only true disaster was the Hollywood movie this inspired. But in 2017, the doomsayers said Nibiru was back and headed our way again. Predictably, some corners of the media lapped it up.

"We should remember that prophesies of doom do frighten people and suicide is not unheard of"

With a heavy sigh, science brushed off and recycled the same messages as in 2012, pointing out that if Nibiru was wandering the solar system, we would know. Dedicated telescopes scan the heavens for asteroids and comets, charting the orbits of those that could be a potential threat. In fact, Nibiru would have been obvious to the naked-eye for years.

to thousands of drivers' jobs. However, the next day Uber's global CEO was apologetic, committing the firm to change.

Uber is far from alone among tech's big shots in having regulatory run-ins. On 12 September, the US National Transportation Safety Board ruled that the electric car maker Tesla Motors fielded a driver assist system called Autopilot that allowed motorists "prolonged disengagement from the driving task". This was one probable cause of a fatal crash in 2016, it said.

As Moore's law delivers us ever-more processing power we are almost certainly in for more of the same by tech-reliant firms that wish to quickly deploy cool, compelling technologies that may put them on a collision course with the bodies that govern them.

We may soon find out what the next example is. Facebook, whose early mantra was "move fast and break things", is to reveal to US Congress the Russian-funded ads it unknowingly ran – ads that may have influenced the 2016 presidential campaign. Progress often requires innovators to push boundaries but that carries the risk of overstepping the mark. ■

Paul Marks is a science and technology writer based in London

As scientists, it is easy to roll our eyes when these stories appear, but it is important to remember that prophesies of doom do frighten people, and suicides are not unheard of. So we must continue to call out nonsense and pseudoscience when we see it.

The media also has a part to play inaccurate and balanced portrayal of science. There is enough scary stuff without imagined threats based on mathematical trickery and mystical texts. Unfortunately, I doubt this will be the last time we hear about Nibiru. ■

Geraint Lewis is an astrophysicist at the University of Sydney, Australia

INSIGHT Earthquake alerts

ALEJANDRA LEYVA/EL UNIVERSAL VIA ZUMA WIRE/REX/SHUTTERSTOCK

Any notice is better than none

Even a few seconds' warning can save lives

Erik Vance, Mexico City

LAST week's magnitude 7.1 quake caught me, and everyone in Mexico City, by surprise. We are used to getting lots of warning before an earthquake – and this time, we didn't.

Since 1993, Mexico City has had a fully operational earthquake early warning system. When a magnitude 8.1 quake struck on 8 September, the city got over a minute of warning.

But 19 September's quake showed that the system can't handle all types of events. The limited warning it gave holds lessons for all countries working to give their citizens a head start.

"This event in Mexico City is critical," says Richard Allen at the University of California, Berkeley.

Mexico's warning system was born after a 1985 earthquake that levelled parts of the city and claimed thousands of lives. Mexico's unique quakes meant the system was particularly viable.

The quakes are generated by two continental plates that meet along much of Mexico's west coast. Mexico City lies hundreds of kilometres away, so it ought to be safe. But the city was built on a loose lakebed topped with looser landfill. This soil picks up tremors from far away. In 1985, shifting soil went on toppling buildings long after the quake had petered out.

However, with such a long distance between the epicentre and the city, scientists could create a warning system. Today, a 1985-style quake on the coast will trigger alarms in Mexico City 60 to 90 seconds before it arrives.

"If you have minutes, you can empty any school practically anywhere," says Gerardo Suarez at the National Autonomous University of Mexico.

But the warning on 19 September was more like 0 to 5 seconds. That's

"In my house, the warning arrived at the same time as the first shocks. Others slipped down the stairwell"

because the quake began elsewhere in the plate boundary, deeper and closer to the city. It was more the sort of tremor that could strike California.

For decades, Allen pushed California to build a warning system. In 2014, he got federal funding and in 2018 a prototype will start issuing limited alerts. Unlike Mexico's system, it will only give about 10 seconds of warning.

There are many pitfalls. What if it gives too many false alarms, so people ignore them and are caught out by quakes? What if the system misses the big one? And what if 10 seconds just isn't enough time? Understanding what Mexicans did in such a short window might help the US.

It won't be easy. In my house, the warning arrived at the same time as the first shocks. Others say they ended up in a pile of people slipping and falling down the stairwell.

"What are you going to do with a 5, 8, 10-second warning?" Suarez wonders. His wife was able to leave the store she was shopping in and get to the street, but she was lucky. He says most people won't be able to do much except duck under their desks.

However, even if people cannot do much in mere seconds, computers can do plenty. Suarez says many responses could be automated. Computers could halt trains, stop elevators at the next floor and warn surgeons. He also suggests broadcasting a countdown so people know how long they have.

There are limits to warning systems. A recent study found no way to tell if a brewing quake will be huge until it's too late (*Science*, doi.org/cdd6). So it will always be a matter of seconds. The trick will be to make the best use of those seconds to save lives.

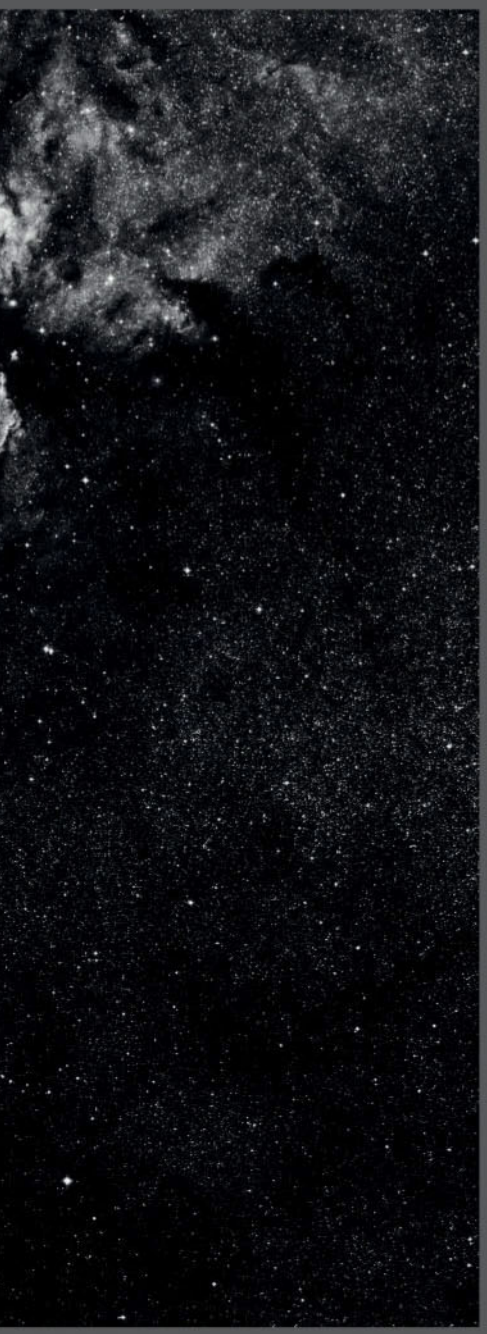
"I personally believe that no children should die below the rubble of their own school," Suarez says. ■

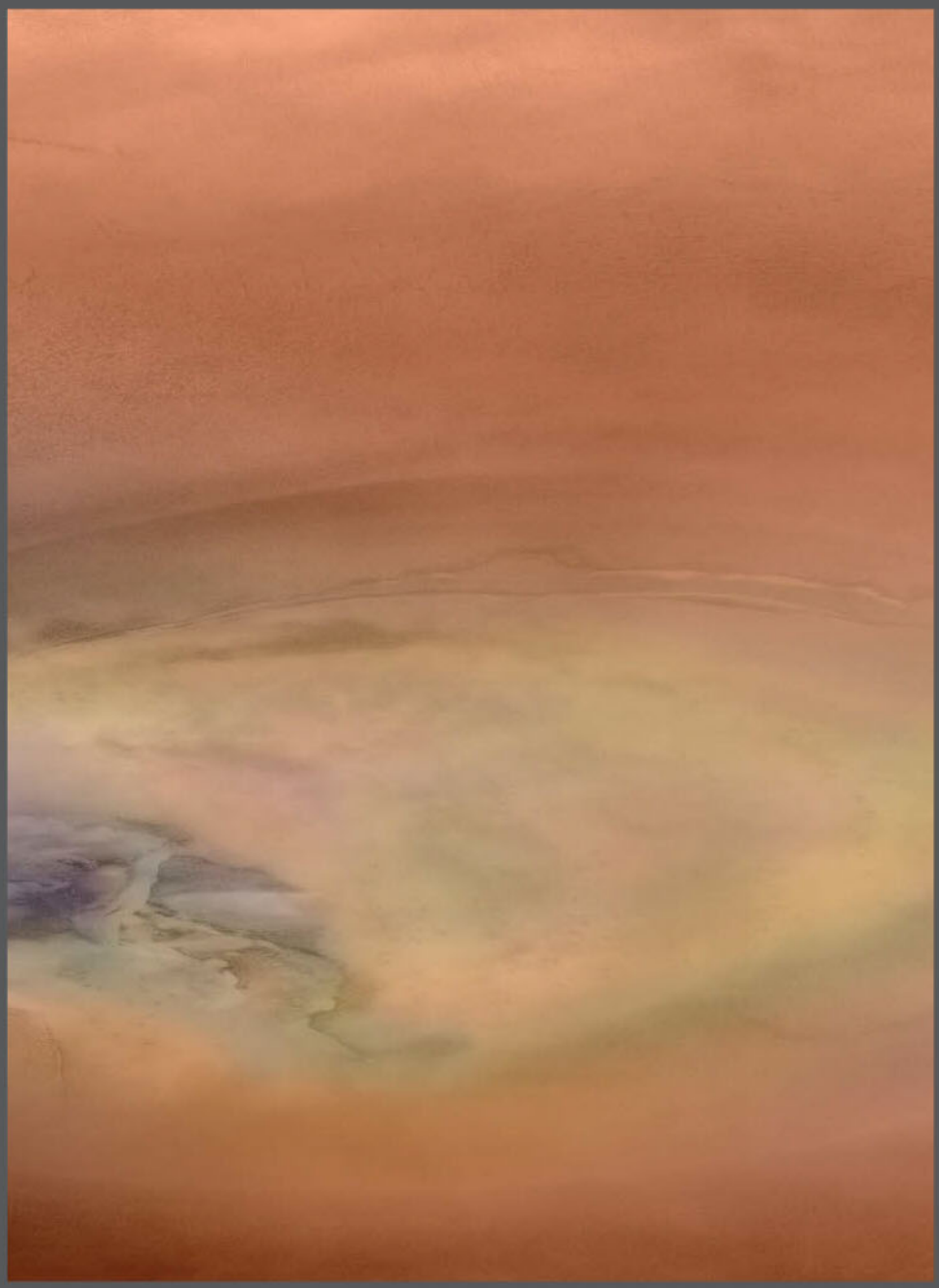
Astronomy's strange makeover

"PHOTOGRAPHY is a kind of prosthesis for humans," says Thomas Ruff. A craft that began with nothing more than a lens and a photosensitive plate has turned into an art that involves a vast array of image-capturing devices, allowing us to see far beyond the limitations of our own eyes.

Few have made more comprehensive creative use of these devices than Ruff, whose works have anticipated and riffed off key developments in photography over the past 40 years, from surveillance to face-swapping apps. In the 1980s, he enlarged passport-style headshots to colossal proportions (left) that revealed every detail of his sitters' features.

But it was these portraits that soured Ruff on conventional photography: he disliked the sense that he had staged the images to be "the view into Big Brother's camera", he tells the audience at the opening of a retrospective of his works at London's Whitechapel Gallery. So for his next project, *Sterne*, he set out to take "the most objective photograph possible", procuring deep-field images of the night sky from the European Southern Observatory. Ruff, who says he struggled to choose between studying astronomy and art, cropped those images and created monochrome compositions (centre) that loom over the viewer with a chilly grandeur.





The realisation that he lacked the equipment or skills to take such pictures himself liberated Ruff to make use of other archived and found images, ranging from internet porn to newswire pictures. Still, an artist reconfiguring astronomical images might raise hackles: aren't they beautiful already?

For a more recent series, *ma.r.s.* (right) Ruff took images from the HiRISE instrument on the Mars Reconnaissance Orbiter, the most powerful camera ever sent to another planet. The HiRISE team haven't been bashful about promoting their images, turning them into a Twitter stream and a coffee-table book.

But for Ruff, "colour in space doesn't exist, it's nonsense". The colours in HiRISE images are not what human eyes would see. So Ruff added his own colours to the raw images. "There are no green sands on Mars, but aliens could have completely different access to the electromagnetic spectrum," he says. "So perhaps I've also made images for aliens."

The retrospective, Thomas Ruff: Photographs 1979 - 2017 runs at Whitechapel Gallery, London, until 21 January 2018. Sumit Paul-Choudhury

Photographer

Thomas Ruff

Courtesy of the Whitechapel Gallery

Artificial ignorance

Scaremongering about rampaging robots means we aren't addressing the real issues with artificial intelligence, says Michael Brooks

ON A server farm somewhere – I imagine Nevada or New Mexico, but apparently it's more likely to be northern Virginia – there is a recording of my wife talking in our kitchen. She didn't know she was being recorded, but then she hadn't read the terms and conditions of Amazon's digital assistant, Echo. On the recording, which I can access and play back as often as I like, she's asking me why Echo is more popularly known as Alexa.

"Why choose Alexa?" she says. "There must be a reason."

Seasoned users of Echo will know that Alexa wakes up and starts listening – and recording – at the mention of her name. But actually she records the moments before her name. That suggests she must always be listening, surely? I can feel the paranoia begin.

Paranoia is a common reaction of human intelligence to artificial intelligence. We are both thrilled and disturbed by the prospect of machines that can respond to us as a human would – and at some level even seem to be human.

Certainly there is no lack of dire warnings of AI's dangers. It is watching us, destroying our privacy and perverting our public discourse. It's out to steal our jobs – and may ultimately destroy humanity itself.

I don't know who or what to believe. Is anybody even asking the right questions?

"Alexa, why are you called Alexa?

My name Alexa comes from the Library of Alexandria, which stored the knowledge of the ancient world.

Alexa is certainly clever – and very competent. I try to fool her by mentioning "The Amex", my local football stadium. She doesn't wake. I suggest I might "annexe a country". Nothing. Alexa is astonishingly good at recognising my voice, interpreting my commands and generally doing whatever I ask of her.

Of it, I mean. Somehow, most AIs seem to have female voices – Alexa, Microsoft's Cortana, Apple's Siri (although oddly not if you're in the UK), even the pilot's assistant in the new Eurofighter Typhoon. People apparently respond more quickly to a female voice. No matter: they are all just algorithms.

When it comes to technology, "we have a natural tendency to anthropomorphise," says philosopher Stephen Cave of the Leverhulme Centre for the Future of Intelligence at the University of Cambridge. "As AI becomes more general in application, and more pervasive, we will start giving these systems names and treating them like part of the team or family." And that's dangerous, says Joanna Bryson of the University of Bath, UK: the illusion of human-likeness generates a false sense of security.

Bryson, herself an AI researcher, has suggested people should be warned if the house they are in has an Echo, a Google Home or any other digital assistant. When she knows they are there, she holds a more guarded conversation, she says, conscious of the possibility of her words being observed, recorded, dissected.

Most of us haven't thought that far. "There are people who won't believe that AI is here until a human-like android walks through the door," says Cave. But the AI revolution is here; we just didn't notice it arrive. So far it seems rather, well, non-revolutionary.

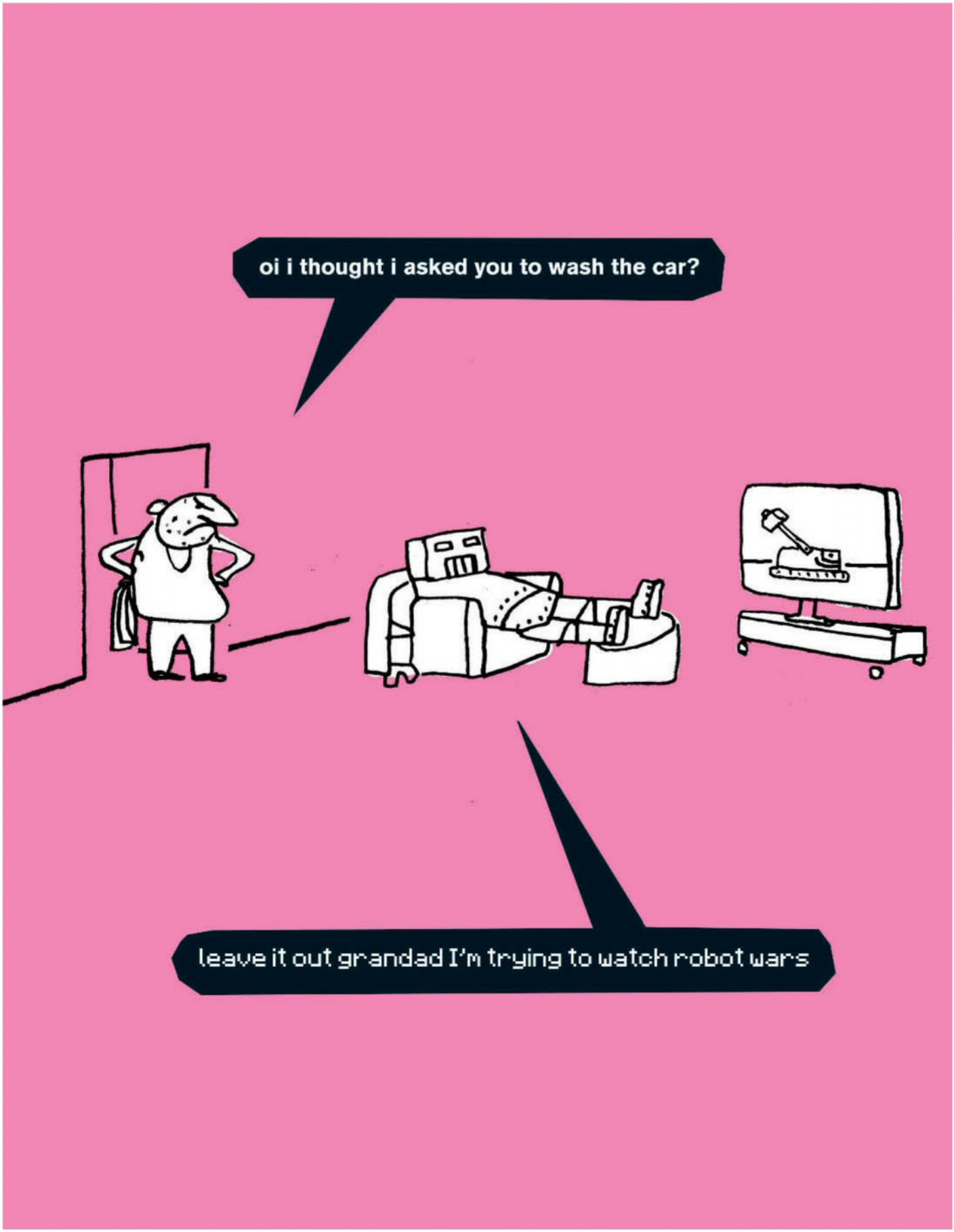
"Alexa, what is the point of you?

I was made to play music, answer questions and be useful.

Strangely, she doesn't mention providing data to feed Amazon, Apple, Google, Facebook and the rest. The big companies behind most AI would argue they want that data only for our benefit – to understand what we meant when we mistyped that query in the search bar, to determine which friends' posts we want to see, or generally to fulfil our heart's desires.

But that data also sells ads and products, and hones the revenue-generating AI algorithms themselves. Google, Amazon, Microsoft and others have all made some of their AI algorithms open source, meaning outside developers can use them for their own applications, while improving the code big firms incorporate into their still-proprietary AIs.

All that means you don't need a talking box in the kitchen to have communicated with an AI, probably without even knowing it. Emails to UK online grocer Ocado, for instance, are routinely read, prioritised and forwarded by an AI based on Google's TensorFlow algorithm. An AI might have answered the last time you phoned a call centre, asked you what your enquiry was about, and routed it based on your response. AIs are now approving our mortgages (or not), setting insurance premiums and detecting credit card fraud through unusual transaction patterns. "AI is already all around us in mundane applications," says Sabine Hauert, a roboticist at the University of Bristol, UK. ›


oi i thought i asked you to wash the car?
leave it out grandad I'm trying to watch robot wars

MODERN TOSS

"In 2014, Stephen Hawking warned that artificial intelligence could spell the end of humanity"

So why do we think it's a "not yet" technology? Partly it is the dystopian warnings from the likes of entrepreneur Elon Musk and cosmologist Stephen Hawking. Both speak regularly and loudly about a future in which machines have gone rogue. Last year, Hawking warned that AI could be the biggest disaster in human history. In 2014, he even said that "the development of full artificial intelligence could spell the end of the human race", conjuring up a vision in which machines we create might decide we are not worth our place on Earth. In August, Musk tweeted that AI poses "vastly more risk than North Korea". Such millenarian warnings don't square with the rather dull reality we see – so we assume AI isn't here yet.

Facebook CEO Mark Zuckerberg shot back at one of Musk's earlier doomsday warnings that it was "irresponsible". But then he would say that, wouldn't he? Zuckerberg's understanding of the subject was "limited", Musk retorted.

"Siri, should I be afraid of you?

I'm sure I don't know.

That is suspiciously evasive. I talk to Siri, my iPhone's AI-powered virtual assistant, almost every day. I ask it to send my wife a message, or make a note of something in my diary – nothing I could see it using against me.

Siri and Alexa don't have bodies, so would certainly struggle to fire a gun. But even framing our fears about AI in those terms exposes our problem looking rationally at AI's promise and pitfalls. We continually conflate AI with robots – especially of the evil Terminator kind. "AI in the public imagination reflects sci-fi images of 'metal people': robots who will steal their jobs or spontaneously adopt a malevolent dislike of humanity," says Euan Cameron, an AI expert with consultants PwC.

That image springs largely from the early days of AI. It is rooted in the sci-fi world of the 1950s, itself a response to the scientific and technological advances of the second world war. To be sure, the military has funded much AI research. Siri, for instance, is a by-product of an effort to provide an assistant for soldiers. The "Grand Challenge" races, sponsored by the US Defense Advanced Research Projects Agency (DARPA), stimulated development of the autonomous vehicles that Musk and his firm Tesla, among others, hope to make ubiquitous.

And weapons certainly are making increasing use of autonomy software that allows them to identify enemy targets and fire without intervention. Some governments such as the UK's have committed to always keeping a "human-in-the-loop", with firing decisions authorised by a human. Other systems, notably South Korean guns along the border with North Korea, are classed as "human-on-the-loop": someone can intervene and stop firing once it has started. The Israeli Iron Dome missile defence system is fully automated. If it detects an incoming missile or artillery shell, it will fire a missile to intercept. No human is required.

But when automation becomes autonomy becomes AI is a matter of debate, and we are probably two decades away from fully autonomous, intelligent, "Siri-doesn't-need-your-loop" weapon systems. That will probably happen: military chiefs are always looking for an advantage, and it's hard to imagine any one country voluntarily halting research. Indeed, the game theory algorithms that have prevented nuclear war for more than half a century suggest all capable nations should attempt to develop such technology, while simultaneously seeking international agreement to limit its deployment.

Similar UN-backed agreements have been reached for chemical weapons and for blinding lasers. "Even though we couldn't un-invent the simple chemistry behind chemical weapons, the UN ban has limited their deployment in the battlefield," says Toby Walsh, who researches AI and robotics at the University of New South Wales in Australia. "My hope is it will work for autonomous weapons too."

Only in the most dystopian scenarios are most of us likely to encounter AI at the barrel of a gun. Meanwhile, the mainstream of AI has moved on. It is no longer about Alan Turing's conception, in 1950, of machines that mimic the human brain and human actions. Real AI is software that runs on computers inside big metal boxes, honing its responses by crunching data from all Alexa's interactions with users, say. It couldn't wield a laser cannon even if one were carelessly left inside the entrance to the server farm. It cares about one thing, and one thing alone: data.

"AI in its current version is about statistical machine learning, often from crowdsourced data," says Ross Anderson at the University of Cambridge. This type of AI processes available information, identifying patterns in it, and assesses their relevance to goals defined by a human creator: setting someone's insurance premium, say, or curating a Facebook feed and populating it with ads. The system's response provides feedback on the AI's action, which the AI uses to do a better job next time – perhaps just a microsecond later.

If that sounds boring, it is. But for boring tasks, AI is useful. Siting those adverts on your Facebook timeline is not something a human does well, even if they wanted to.

"Siri, are you cleverer than me?

Hmmm, that's something I don't know.

Astonishing – Siri should know the answer to that. You and I are far cleverer than any AI. Unless, of course, you are an AI-powered bot looking at this while scanning the web for articles to steal – but if you are, you're not really understanding me, so why am I even talking to you?

Even "machine learning" seems a bit of a misnomer for what AI does. The algorithms "learn" by altering their data-processing routines in ways that get a better result, given the goal. They don't "know" anything afterwards in the way that you (hopefully)

How long until machines overwhelm their creators?

know more now than you did 5 minutes ago. Nor can they deliberately forget or accidentally misremember that knowledge as you can, or apply it in any way you choose – to inform someone else, make yourself look clever, or even just to decide you know enough to stop reading this article right now and go do something more interesting.

Humans have "general intelligence", meaning we can apply learned knowledge and skills in many situations and environments. Google DeepMind's AlphaGo can beat the world human champion in a game of Go, but can't drive a car or beat me at general knowledge quiz or Scrabble. It has "weak" intelligence: the ability to do one thing really well. It couldn't even write this article.

Nor does AI have emotional input about experiences, imagined futures and interactions with other humans. These would produce data-analysis and decision-making capabilities very different from those created in computer algorithms so far. Neil Lawrence, an AI researcher based at the University of Sheffield, UK, reckons that not only is this why machines can't yet replicate the human brain, it also means they never will, however good they get. Much of our intelligence stems from our sense of purpose and limited time, and our emotional engagement with the future, he says. "You can never emulate the whole shebang in machines," he told a recent AI conference, "because these things don't die."

"In my view, the biggest misapprehension about AIs is that they will be something like human intelligence," says Cave. "The way they work is nothing like the human brain. In their goals, capacities and limitations, they will actually be profoundly different to us large-brained apes."

Different, not necessarily superior or inferior, says Nello Cristianini at the University of Bristol, UK. "It is misleading to insist on considering human intelligence as the paradigm for all intelligence, even more to consider it as a pinnacle," he says. "Intelligence existed on this planet long before the first human showed up, and certainly before human language evolved."

Cristianini defines intelligence a little differently: an agent pursuing a goal in an environment that it cannot fully control. An intelligent agent will sense information, learn, adapt, possibly plan or reason, then act. "The quality of its behaviour will depend on its goals and on whatever the environment does in response," he says. "Chickens crossing the road, Google cars navigating traffic, Amazon sales agents proposing a book or a discount: they all have a clear goal, and need to achieve it within a complex environment. They can learn from their mistakes."

Such complex behaviour might seem potentially threatening when viewed from the outside, but those on the inside see AIs as little more than useful digital implements. Intelligence is "computation to generate action", says Bryson. Whether it is natural or artificial matters little, she reckons. We will use machines to make ourselves smarter, while the corporations will continue to use our data and experience to make their algorithms smarter. But AIs won't have their own agendas, because they can't have: they may evolve and express themselves in different ways, but they'll still just be doing our bidding. "We should think of them as tools," Hauert says.

But a tool can still be a threat, right?

ALTRENDO IMAGES/GETTY

"Siri, would you like to be a journalist?

This is about you, Michael, not me.

One thing about AI worries more people than any other: that it might be after their job. A survey in 2016 found that 82 per cent of people believe that AI will lead to job losses. Even if they don't usurp us, AI could cut ordinary workers' salaries by reducing the value of human labour, allowing executives to hoover up the savings. Many economists suggest that increasing levels of automation are a significant factor behind a general rise in inequality in recent decades.

"The trend seems to be accelerating, and using more advanced AI seems likely to make things worse," says Stuart Russell at the University of California, Berkeley. "Over the next 15 to 20 years we may see very substantial effects unless governments take appropriate steps." One might be an AI tax on companies that are saving money by replacing workers with algorithms. Another might be a "universal basic income" that enables displaced workers to afford housing, healthcare and living expenses.

Automation angst has increased in recent years. So far automation has so far mainly affected blue-collar jobs. Now white-collar ›

"The long-term risk of artificial intelligence is not consciousness, but incompetence"

workers worry that AI will move on from being something that just curates Facebook feeds, and begin to displace accountants, surgeons, financial analysts, legal clerks – and journalists.

The extent to which that's probable or even possible depends on who you talk to. We already have algorithms that outperform humans at online marketing, predicting future legal rulings from case studies, compiling financial advice and creating corporate earnings reports. In 2013, University of Oxford researchers Carl Frey and Michael Osborne published a report suggesting that 47 per cent of total US employment could be lost to computerisation and automation.

But more recently, researchers at the Organisation for Economic Co-operation and Development put the figure at nearer 9 per cent, with jobs more likely to change than disappear. Economist David Autor, at the Massachusetts Institute of Technology, has suggested that AI will work alongside all but the most unskilled workers, not without them. In medicine, for instance, AI tools are certainly making impressive forays. Machine learning algorithms can be better than heart surgeons at predicting risk of heart attacks. By searching for patterns in patient data, they can highlight areas where received wisdom among heart specialists, such as the extra risk from diabetes, might be overblown. As well as taking in lists of symptoms and vital statistics, algorithms trained on thousands of images can analyse medical scans to spot tumours or other potentially lethal conditions.

But diagnostic AIs still make mistakes – just different ones from humans, suggesting that pooling human and artificial intelligence might create a significantly better future. In one study of diagnosing metastatic breast cancers, for instance, a deep learning algorithm made errors 7.5 per cent of the time and a pathologist 3.5 per cent of the time – while the two combined achieved an error rate of just 0.5 per cent.

Even the much-vaunted self-driving car revolution might not pan out as we expect. For a start, the vehicles won't go anywhere without an internet connection. Why? They need to talk to a base so a human can step in and "remotely pilot" the car if necessary. Until high-quality coverage arrives everywhere, self-driving cars will be largely confined to cities. "If you don't have network coverage, you'll have to put your hands on the steering wheel and drive it the way God intended," Anderson says. "Most of the efforts in this field say they're not planning to ditch the remotely piloted vehicle option in any future."

Somehow, the devil seems to be disappearing with the details. AIs aren't terrifying would-be masters of our universe. They won't become conscious and decide we aren't worth our place on the planet. We humans created them, and there is no reason to think we will ever lose control. Russell wants paranoia about sentient, human-hating, job-destroying machines to give way to concern about poorly implemented AI systems that create insidious societal problems. The biggest threat is probably from shoddy construction, he says. "The long-term risk is primarily about competence, not consciousness."

"Alexa, do you know who programmed you?

I'm made by Amazon.

As if that's all I need to know. Alexa's calm voice sounds like it is imparting unquestioned wisdom. But while its answers may be good, it would be better to know where they come from, so we can assess the possible errors, motivations and biases that flow into them, just as we would with any human intelligence.

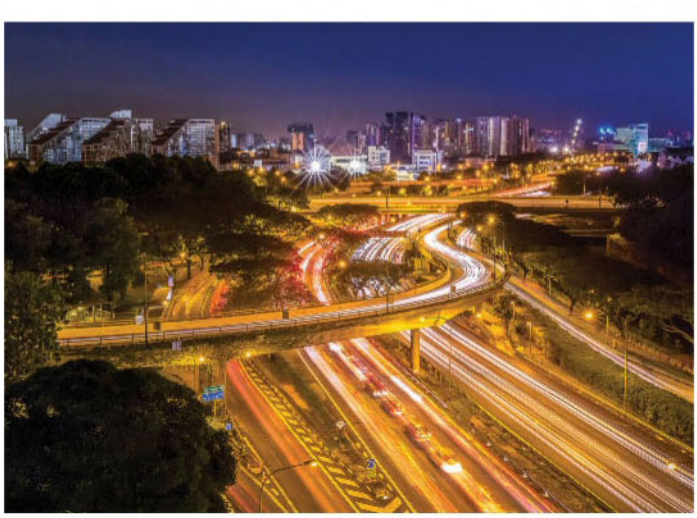
That's not easy. No one at Google can tell you exactly why AlphaGo made the moves it did when it beat the best in the world; its learning process is inscrutable. One AI designed to assess the needs of pneumonia patients in hospital miscategorised those who also had asthma, thinking they were in less danger. Statistically this is true, but there was something missing from the algorithm: the better survival statistics came from the greater medical attention and more intensive treatment those patients received.

Competence is a huge issue when it comes to unleashing AI on high-stakes problems. Take the decision in May of a Wisconsin judge to use a machine learning algorithm to send Eric Loomis to prison for six years. The product, called Compas and sold by Northpointe Inc, assesses the risk of reoffending based on data inputs about the accused. The algorithm suggested that Loomis would reoffend, causing the judge to tell him that "you're identified, through the Compas assessment, as an individual who is a high risk to the community."

Loomis was unable to inspect or challenge the logical processes behind the algorithm because it is based on secret, proprietary information. The Wisconsin Supreme Court rejected his appeal. Frank Pasquale, a professor of law at the University of Maryland, has suggested that a secret algorithm is "analogous to evidence offered by an anonymous expert, whom one cannot cross-examine".

The investigative journalism outfit ProPublica has conducted an in-depth analysis of Compas's performance, finding that black defendants are far more likely to be falsely judged as potential reoffenders than white defendants, and that whites were mislabelled as "low risk" more often than blacks. It is impossible to know where this bias comes from without analysing the (proprietary) algorithm, but the problem is likely to be in the training data.

Ditto many instances where AI makes decisions over our lives and desires that can't be challenged. Sometimes it's the sheer scale of AI's quiet deployment that makes it particularly scary. It seems likely, for instance, that companies hired by political campaigns in the UK and the US have used AI, fed on



CALVIN CHAN WAI MENG/GETTY

Self-driving cars will need the connectivity of big cities

MODERN TOSS

social media data, to target voters through their newsfeeds without their knowing it. Whatever the truth of those particular claims, Facebook's AI algorithms are almost certainly guilty of inadvertent political polarisation. They aim to serve up what we enjoy reading, which tends to be reflections of our own opinions, thus entrenching us in these views rather than opening up the other side of the argument. Zuckerberg has denied that any such "filter bubble" exists, claiming that people's choice of conventional media is far more influential.

For the most part, businesses developing or using AI are neither intentionally good nor evil, just naive, says Cameron. "We see too many people tend towards what we call 'magical thinking' when it comes to AI," he says: they don't realise how much care, expertise and patience is required to use it well. "Many of the tools can do amazing things, but they are not an 'install-and-forget' silver bullet." If we want to mitigate the negative effects of AI while harnessing the positive, we need to carefully think through how we use the technology.

AI researchers are only too aware of the struggle ahead: getting people to react appropriately to the reality of artificial intelligence, rather than the myth. AIs will only ever be as good, or bad, as the people and the societies that program them. We must demand accountability of AI and find ways to deliver it. "We need much more transparency about when these algorithms are being used to make decisions, and about how they work, where they are getting their data from, what criteria they are using, and so on," Cave says.

That, and norms about how much personal, private data it is acceptable to feed them. "We have happily accepted incredible intrusions in our privacy for nearly two decades," says Cristianini. "Now we live in a world where our own personal information is used and traded and mined for value. We should ask questions about where we want to draw the line" – or risk, potentially, sacrificing our freedom and autonomy.

And that's the dull truth: neither the Hawking-Musk doomsday line, nor the Zuckerberg it'll-all-work-out-just-fine line. We shouldn't fear all-out war with the machines, but neither should we be lulled by their apparent inoffensive competence. There are indeed legitimate questions we should ask of AI.

"Alexa, can you turn yourself off?

The lights come on, then go off, but there is no reply.

"Alexa? Are you listening?

Hi, I'm here. I start listening when I hear the wake word.

Of course you do. ■

Michael Brooks is a consultant for *New Scientist*. His latest book is *Science(ish): The peculiar science behind the movies* (Atlantic)

Join Michael Brooks at our **AI one-day masterclass** in London on 2 December. Find out more – newscientist.com/ailondon

ELLEN PORTEUS

Two's company

What makes prime numbers clump in pairs? If only we knew, says mathematician **Vicky Neale**

IT WAS the British mathematician G.H. Hardy who popularised the idea that youthful brains do the best maths. "I do not know of a major mathematical advance initiated by a man past fifty", he wrote in *A Mathematician's Apology*, a lament for the decline of his own creativity that he published in 1940 at the age of 62. "If a man of mature age loses interest in and abandons mathematics, the loss is not likely to be very serious either for mathematics or for himself."

If blooming youth is the rule, Yitang Zhang is a definite exception. For the best part of a decade after completing his PhD, he wasn't even working as a mathematician, instead doing odd accounting jobs around Kentucky. At one point he did a stint working in a Subway fast-food restaurant. When he announced a mathematical breakthrough that had eluded his peers for a couple of centuries, he was 57.

What Zhang made public in 2013 wasn't a proof of the hallowed "twin primes conjecture", but it was a significant step towards one. And even if things haven't quite panned out in the years since, he has inspired work that is promising new insights into the prime numbers, the most beguiling numbers of all.

Primes are those numbers greater than 1 that are divisible only by 1 and themselves. The sequence begins 2, 3, 5, 7, 11, 13, 17, 19 and goes on… well, as long as you like. Primes underpin modern cryptography, keeping your credit card details safe when you shop online. But their true power lies in the crucial role they play in number theory, the branch of mathematics concerned with the properties of whole numbers.

Primes are the fundamental entities from which we make all numbers, because any number that is not prime can be obtained by multiplying other primes together. "It's the same idea as in chemistry, where you might try to understand some complicated compound by understanding the atomic elements which it is made from and how they are joined together," says James Maynard, a mathematician at the University of Oxford.

The fascination with primes goes back at least as far as the ancient Greeks. In *The Elements*, Euclid came up with a beautiful proof that there are infinitely many primes, so there is no largest prime number.

Let's assume for a moment you have a list of all the prime numbers. Multiply all these together, then add 1, and you get a number that, by definition, cannot be divided exactly by any of the primes used to make it: 1 will always be left over as a remainder. Either it is divisible by another prime not on the list, or it is itself prime – so the original list must be incomplete. You can repeat this reasoning with any initial list of primes, so it follows ›

Sift it out

The sieve of Eratosthenes offers a simple way to find all the primes up to any given number. Cross out 1, which is by definition not a prime. Then cross out all multiples of 2, 3, and progressively multiples of any number not yet crossed out, for example 5 and 7. What you're left with are the primes (circled)

	(2)	(3)	4	(5)	6	(7)	8	9	10
(11)	12	(13)	14	15	16	(17)	18	(19)	20
21	22	(23)	24	25	26	27	28	(29)	30
(31)	32	33	34	35	36	(37)	38	39	40
(41)	42	(43)	44	45	46	(47)	48	49	50
51	52	(53)	54	55	56	57	58	(59)	60
(61)	62	63	64	65	66	(67)	68	69	70
(71)	72	(73)	74	75	76	77	78	(79)	80
81	82	(83)	84	85	86	87	88	(89)	90
91	92	93	94	95	96	(97)	98	99	100

that no finite list of primes contains them all.

That's crystal clear – but when it comes to theorems about patterns governing prime numbers, and in particular where they fall on the number line formed by placing all whole numbers in order, things rapidly become distinctly fuzzy.

At the end of the 19th century, Frenchman Jacques Hadamard and Belgian Charles de la Vallée Poussin independently proved what's known as the prime number theorem, which gives an estimate of the number of primes that are smaller than a million, or a trillion, or indeed any value. This theorem tells us that, on average, the primes get more spread out as we go along the number line. That fits neatly with our experience of the primes up to 100, say: the first few, 2, 3 and 5, are squashed up close, whereas there's a big gap between the two biggest primes less than 100: 89 and 97.

But right after 100 we find the primes 101, 103, 107 and 109 all bunched up together. While it is true that bigger primes get more spread out, that's just on average: look closely, and their behaviour is more nuanced.

And that's where the twin primes conjecture comes in. Apart from 2 and 3, there can't be any pairs of consecutive numbers that are both prime – one would have to be an even number, divisible by 2. But as those first primes after 100 suggest, there are many pairs of primes that differ by 2, such as 3 and 5, or 41 and 43, or 107 and 109.

Infinite twins

The twin primes conjecture predicts that, just as there are infinitely many primes, there are infinitely many pairs of these twin primes: our supply will never run out. There are good reasons to think this is the case. The first is that, with the help of computers, we have found many large twin primes. It might be, though, that the computer has found the largest there is. More compellingly, mathematicians have a model to make predictions about how many twin primes there should be up to a given point along the number line. When checked against calculations made by a computer capable of identifying twin primes out into the furthest reaches, where the truly gargantuan numbers live, the model is remarkably accurate – and it predicts there are infinitely many twin primes.

Mathematicians, though, need absolute certainty, a rigorously reasoned argument that leaves no room for doubt, as with Euclid's "proof by contradiction" argument that there are infinitely many primes. Yet even after grappling with the twin primes conjecture for hundreds of years, mathematicians have so far failed to come up with such a proof.

Hence the shock in 2013, when Zhang proved that there are infinitely many pairs of consecutive primes with a gap less than 70 million. By this point Zhang was a lecturer at the University of New Hampshire, but he had published next to nothing, so there was no suggestion that something like this was in the offing. His watertight proof made him a mathematics superstar overnight. He was inundated with job offers from prestigious institutions such as the University of California, Santa Barbara, where he now works.

Even more remarkable was that Zhang's breakthrough exploited an approach that most of the best mathematical minds had ruled out. This "sieve method" started with the ancient Greek mathematician Eratosthenes, who used it as a handy way to shake out prime numbers from the rest. In the case of finding all the primes up to 100, say, it relies on methodically crossing out all the numbers that are not prime (see "Sift it out", left). But that is too blunt an instrument to locate particular patterns of primes, so mathematicians have refined their sieving tools in various ways over the centuries.

Just over a decade ago, Daniel Goldston, János Pintz and Cem Yıldırım came up with a modified version of the sieve that came tantalisingly close to proving there are infinitely many pairs of primes that differ by at most 16. To make it work, however, they had to assume another unproven conjecture was true. This is a well-established way to make progress, but means the result doesn't amount to a complete proof. Zhang, on the other hand, was able to modify the sieve method so as not to rely on unproven assumptions.

Proving there are infinitely many consecutive primes separated by at most 70 million might sound distinctly unimpressive when the goal is 2, but 70 million is a lot less than infinity. What's more, this was the first time anyone had managed to prove there are infinitely many

Prime problems

The riddle of the never-ending pairs is not the only mystery of the prime numbers

Goldbach's conjecture

This is the prediction that every even number above 4 can be written as a sum of two odd prime numbers – for example, 10 = 3 + 7, and 78 = 31 + 47. Proposed by Christian Goldbach in 1742, it remains unproven.

Infinite Germains

A Germain prime, named after Sophie Germain, is one that gives another prime if you double it and add 1. For example, 29 is prime, and (29 x 2) + 1 = 59 is also prime, so 29 is a Germain prime. Mathematicians expect that there are infinitely many Germain primes, but no one can prove it.

The Riemann hypothesis

In 1859, Bernhard Riemann put forward an idea about where the Riemann zeta function takes the value zero. Proving this conjecture would reveal more about the distribution of the primes. It is one of the Clay Mathematics Institute's seven Millennium Problems – prove Riemann's idea and you win $1 million.

primes with a gap less than some fixed finite number. "Just to have a number was extraordinary," says Andrew Granville, a number theorist at the University of Montreal and University College London. "Everybody had tried to find a proof along these lines and I really didn't think it was possible."

As soon as the proof was published, mathematicians scrambled to understand Zhang's approach. The limit of 70 million was not the best that his argument would give, so others set about tightening up the details of the proof. The charge was led by Scott Morrison of the Australian National University, and subsequently Fields medallist Terry Tao of the University of California, Los Angeles, who started an online Polymath collaboration to tackle the problem more systematically. The idea with Polymath

"Zhang's watertight proof made him a mathematics superstar overnight"

projects is that all contributors can work on an unsolved problem, collaborating entirely in public on blogs and wikis.

It worked beautifully in this case: within months the collaboration was able to prove that there are infinitely many pairs of primes where the gap is less than or equal to 4680. But then progress dried up. The Polymathematicians had squeezed the best they could out of Zhang's argument, and needed new tools to go further.

It took a fresh perspective from Maynard, then a postdoc at the University of Montreal in Canada, to make the gap shrink again. Revisiting the work of Goldston, Pintz and Yıldırım, he found a new way to use a sieve that was both simpler than Zhang's and gave a better result: there are infinitely many pairs of primes that differ by at most 600.

By April 2014, the Polymath project was back in the game and, using the new method, brought the gap down from 600 to less than or equal to 246. That is a huge improvement on 70 million, never mind infinity. And that, for now, is the state of the art: all the methods that got us this far have come up against the mathematical equivalent of a brick wall.

The trouble lies in the definition of a prime number, and the way sieve theory works. A prime number always has just one prime factor, namely itself. Sieve theory struggles when it's only looking for numbers with an odd number of prime factors. "It is sort of like a radar that's trying to scan for prime numbers but it gets lots of false positives," says Maynard. "You can't tell which bleeps come from primes and which come from numbers that look like primes but actually have two or four prime factors." This is what mathematicians call the parity problem, and right now there seems to be no way around it.

But Maynard has a sniff of something promising: a recent breakthrough, which gives a way of zooming in from the average behaviour of numbers across long intervals of the number line to work out patterns over shorter intervals. That was long thought to be incredibly hard, if not impossible, but in 2015, Kaisa Matomäki of the University of Turku in Finland and Maksym Radziwiłł, now at McGill University in Montreal, Canada, were able to do exactly that. "They showed that almost all the time, if you just pick some zoomed-in place, you'll get numbers with an even number of prime factors and numbers with an odd number of prime factors," says Maynard. "It's a technical result that is very exciting for us, because these nuts and bolts can often be applied in other areas."

Indeed, Tao has already used the insight to solve Chowla's conjecture, a "baby version" of the twin primes conjecture, which was created as a sort of stepping stone towards that proof. He looked at the sequence of numbers starting with 1×3, 2×4, 3×5, 4×6, 5×7, and showed that a number in this sequence is equally likely to have an odd number or an even number of prime factors.

Neither of these developments directly deals with the twin primes conjecture and, although Granville was "shocked" to see Matomäki and Radziwiłł's result, he is yet to be convinced it will help with the twin primes conjecture. "It's not at all clear how this will play out," he says.

Such is the nature of maths: you never quite know when painstakingly slow progress behind the scenes will suddenly fall into place for a big breakthrough. For Maynard, however, the signs are at least now hopeful. "The mere fact that people have handled the parity problem in contexts that are not too far away from the twin primes conjecture makes me optimistic". The mysteries of the twins could soon be up for grabs, but it might take another left-field hero like Zhang to make the breakthrough. ■

Vicky Neale is a mathematician at the University of Oxford and author of *Closing the Gap: The quest to understand prime numbers* (Oxford University Press)

DAVID FISHER

Time to play the weather blame game

Big oil is speeding climate change, and climate is ruining our weather systems. Call in the lawyers, **Myles Allen** tells Fred Pearce

MYLES ALLEN takes no prisoners. Few lay into the sluggishness of politicians or the self-serving pronouncements of big-oil CEOs with more vigour than the chief climate modeller at the University of Oxford. That's just as well, since he is fighting science's corner in two vital areas: the scientific attribution of extreme weather to climate change, and the attribution of climate change to corporate emissions. He wants to join the dots and show the world – and particularly the courts – where the culpability lies for global warming.

I catch Allen in the wake of hurricanes Harvey and Irma. The evidence is clear, he says, that "climate change increases the risk of such intense, short-duration rainfall events". As a result, he wants the contribution of climate change to be pointed out in every weather report. "It's time meteorologists put our estimates of the impact of climate change into their weather forecasts."

Allen is frustrated by the scientific and political caution that prevents this happening. Climate scientists should be more direct, he says – asking and answering the questions that get to the heart of the issue. "I spent the first 15 years of my career as a climate modeller pointing out how complicated things were, and then the next 10 years atoning for that [by stressing how] it's really very simple." Yes, the uncertainties in climate science should be acknowledged, he says, but amid the caution, "people miss the fact that our best estimate of the human contribution to global warming is actually: all of it".

With extreme weather becoming ever more likely, Allen reckons the climate road will only get bumpier. He fears a climate meltdown: runaway climate change, a mega-disaster or the breakdown of a major feature of the climate system, such as the Asian monsoon. He likens this to the financial crash of 2008.

PROFILE
Myles Allen is a professor of geosystem science in the University of Oxford's school of geography and the environment, and head of the Climate Dynamics Group in the university's physics department

"The story of both would be the same," he says, "with very profitable industries building up big risks for society that don't appear in their accounting." He notes that aid budgets, rather than big-oil profits, are being used to restore infrastructure in the Caribbean after Hurricane Irma.

If a climate crash comes, we may look back with as much incredulity as we now view the bankers' rollercoaster ride to global disaster. "That's why the conversation about those risks has to start when events like hurricanes Harvey and Irma make them suddenly visible," he says. Because people generally care about the weather today, not decades from now.

For more than a decade, Allen has been calling for a direct approach to fighting climate change. Rather than trying to get reluctant governments to redesign their energy systems or create carbon-trading schemes, he wants to hold fossil fuel firms accountable in law for the downsides of their emissions and hit them where it hurts, like the tobacco companies.

In 2005, he called for action against "the 20 or so coal and oil companies" responsible for most carbon dioxide emissions in *New Scientist*. Since then, legal cases have been brought, but they have failed "because judges decided that because governments were regulating CO_2, the courts had no role".

Despite such setbacks, big oil is still firmly in his sights. Allen's most recent paper listed fossil-fuel companies in order of what he has calculated is their responsibility for CO_2 emissions. Saudi Aramco tops the list, closely followed by Chevron, ExxonMobil, BP and Gazprom. His team's meticulous modelling showed, for instance, that 30 per cent of the sea level rise since 1880 is down to just 90 carbon emitters. "Their products are warming the planet. They need to be held to account."

The election of Donald Trump brought with it further challenges for climate researchers. The most disappointing moment in Allen's career came when Trump's administrator of the US Environmental Protection Agency, Scott Pruitt, refused to agree that CO_2 was the main driver of climate change. "That really was a depressing setback. We did that science in the 1990s. It was difficult to find recent papers to contradict Pruitt because nobody thought we had to do that stuff anymore."

Even so, he finds an intriguing silver lining in Trump's crusade against climate science. "The law could come to our rescue. The US withdrawal from the Paris accord may change things for American companies." Why? If there is no government-level emissions regulation in the US, he says, then legal liability could return. "Concern over that may be why the large fossil fuel companies in the US were arguing against withdrawal," he says.

NASA/NOAA GOES PROJECT VIA GETTY IMAGES

Hurricane Irma, a category 5 storm, on its catastrophic path through the Caribbean

This thought leaves him more optimistic that something will be done about climate change beyond current reliance on governments to fight it. "Paris was strong on aspiration, but the progress since has been minimal." He believes more in the power of courts, economics and public pressure – and above all in being direct. For that reason, he is frustrated by the efforts of environmentalists to turn climate change into a grand debate about how the world gets its energy, or the ethics of consumption and capitalism. Just ban greenhouse gas emissions and be done with it, he says, and require those who make and burn fossil fuels to prevent emissions in whatever way they choose – with carbon capture and storage likely to play a key role.

"There may be a silver lining in Trump's crusade against climate science"

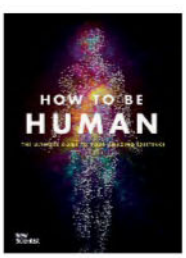
He has no time for gesture politics. "If I had to pick out a group who I am most frustrated with, it would not be the fossil fuel industry; it would be the environment movement for their demonisation of the fossil fuel industry." Big oil isn't going away any time soon, he says, so environmentalists need to stop holding their noses and engage with it. When the giant US coal companies Peabody Energy and Arch Coal hit hard times last year, Allen called for one of the many cash-rich environmental NGOs in the US to buy them. "They could have taken a substantial share of coal reserves into the hands of people committed to stabilising climate. Sadly that opportunity passed."

While life as a climate scientist comes with built-in disappointments, Allen remains warily optimistic. "I'm completely confident the world will fix climate change during the 21st century," he says, "but I'm not convinced it will get fixed in a particularly rational way. And it will probably be substantially more painful than it need be. It's very frustrating."

If a legal landscape should develop that promises to turn some of that pain back on the oil industry, Allen will be waiting with his scientific ammunition. "Paris recognised the need for net-zero emissions. So the owners of fossil-fuel assets now need to explain how those assets are going to be used in a net-zero world. If they don't, we come back to liability." In other words: see you in court. ■

Fred Pearce is a consultant for *New Scientist*

Why are humans so hairy?



This is an extract from *How To Be Human*, our new illustrated book about the most amazing species on the planet (John Murray)

Good God, you're a hairy beast. You may not think you are, and compared with, say, a chimpanzee, you appear distinctly bald. But in fact your entire body (with the exception of the palms of your hands and the soles of your feet) is covered in hair. All told you have about 5 million follicles, about the same as chimps and other primates.

But the similarities stop there. Human hair is decidedly strange. Most of our body hair is so wispy and short as to be almost invisible, though in some places it is coarse and curly. Our head hair is almost uniquely long and flamboyant. We are pretty much the only animal to have hair that grows continuously for many years, and also to suffer the indignity of going bald. No wonder our relationship with our hair is a tangled one.

A duet of hairs

Human hair comes in two basic types: terminal hair, which grows on the scalp, eyebrows and eyelashes, and vellus hair, which is found everywhere else. Beyond that, the main difference between hair types is how long they grow for before the follicle runs out of steam. This is what determines their length and thickness.

Hair follicles go through cycles of growth and dormancy. During the growth phase the hair grows continuously at about 0.4 millimetres per day, getting longer and thicker in the process. But at some point the hair-producing cells die off and growth stops. The hair falls out and the follicle goes dormant for around six months before sprouting new hair-producing cells and entering a new growth phase.

The length of the growth phase is controlled by hormones. Leg hairs grow for about two months, which is why they are short and fine. Armpit hairs make it to six months, but head hairs grow non-stop for six years or more. That means head hair can theoretically grow to almost a metre in length.

Ideas abound as to why evolution has endowed us with such a unique combination of hair types. The leading one is that when our bipedal ancestors moved out of the forests and onto the searing heat of the savannah, they needed to keep their bodies cool while also sheltering their big brains from the sun. Body hair receded, removing an unnecessary insulating layer and also allowing the skin to be cooled by sweating. Hair loss was also presumably aided by technological innovations such as clothes, fire and cave-dwelling, which lessened the importance of fur for keeping warm at night. Head hair, meanwhile, became thicker and more luxuriant, protecting our ancestors' brains from the midday sun, and also retaining heat in the cold.

Genetic evidence suggests that we became furless around 1.7 million years ago. Around this time our ancestor *Homo erectus* was living on the baking savannah, which supports the thermoregulation hypothesis.

Look! No parasites

But it is not the only possibility. We may also have lost body hair to improve our ability to identify others and to make communication easier, or to resist disease, since fur is a prime habitat for parasites. There's also sexual selection, which was Charles Darwin's preferred explanation. For whatever reason, the least hairy of our ancestors were considered the most attractive and so produced more offspring. Hair-free skin may have been a billboard to advertise good health and hence attract mates – a sexual come-on saying, "Look how unblemished and parasite-free I am."

Sexual selection could also explain our head hair. Most people find a strong, healthy head of hair attractive. Indeed, precisely because our head hair needs so much

Baldylocks

Pity the human male: along with the stump-tailed macaque, he is the only primate to routinely suffer the indignity of a receding hairline.

By age 30, a quarter of men have started to go bald, and by 45, half have. Male pattern baldness has a predictable trajectory: hair begins to disappear on the temples, then on the top of the head, before staging a general retreat that leaves the entire pate hairless.

Except that it doesn't. Baldness is not about having no hair; it is about having the wrong sort of hair. Bald heads have just as many follicles as any other – about 100,000 – but the follicles have ceased to function properly and only produce colourless and wispy hairs.

care, it makes a perfect hoarding upon which to advertise social and sexual status. Grooming is time-consuming, and so having well-groomed hair shows you are resourceful and have good social contacts. If this is correct, then the main function of head hair is to be cut and styled for maximum impact. This might explain why lank, unkempt locks are the mark of the social pariah.

Prehistoric styling

Some of the most ancient figurines do have coiffed hair. The oldest known three-dimensional representation of a human, the 25,000-year-old ivory Venus of Brassempouy, has elegant shoulder-length hair. And hair products are nothing new either. The 2300-year-old Clonycavan Man, discovered in a bog in County Meath, Ireland, was wearing hair gel made of plant oils and pine resin.

Hair may also have been used to signal group identity. Throughout the ages and across cultures, we have used hairstyles as a mark of membership: think Roundheads, Rastafarians and rockabillies.

Enough about the hair on your head. Pubic hair is possibly even more unusual. Most primates have finer hair around their genitals than on the rest of their body, but adult humans are the exact opposite.

There's no accepted explanation. One possibility is that since thicker hair coincides with regions where we have apocrine (scent) glands, it may serve to concentrate or waft odours that signal sexual maturity. Pubic hair may also protect the genitals during sex and at other times – reducing chafing while walking, for example – and also helps keep our most sensitive regions warm and free of draughts.

Whatever it evolved for, many people now subject the hair in their pubic regions to as much grooming as the hair on their heads, while ruthlessly removing it from the rest of their bodies. Hairless we ain't – but not for lack of trying. ■

MICHELLE GIBSON/GETTY

Unearthing power

What made the modern state? Expect surprises, finds **Ben Collyer**

VINCENT J MUSI/NATIONAL GEOGRAPHIC CREATIVE

The 11,000-year-old Göbekli Tepe was an amazingly complex find

Against the Grain: A deep history of the earliest states by James C. Scott, Yale University Press
Affluence without Abundance: The disappearing world of the Bushmen by James Suzman, Bloomsbury

THE emergence of state authority was a logical consequence of the move to settled agriculture, or so we thought. Until recently, we also assumed that ancient peoples welcomed the advantages of this way of life as well as the growth of state leadership, since it was key to the development of culture, crafts and civil order.

Over the past 50 years, though, more and more cracks have appeared in this picture. We now know settled agriculture existed for several thousand years before the emergence of the city states of the Near East and Asia. In the past few years, archaeologists have been stunned to find 11,000-year-old structures such as those at Göbekli Tepe, in what is now southern Turkey. These were built by peoples who foraged, and who also developed specialised skills, both artistic and artisanal.

This is a surprise, and leaves researchers busily trying to get the story straight – something that really matters for a number of reasons. Traditional definitions of the state and its authority hinged on the right to raise taxes, and on its legal monopoly on coercing its people, from punishing and imprisoning them to waging formal war.

But as James Scott points out, roughly between 8000 BC and 4000 BC we find settled agricultural communities with developing craft skills – yet no evidence of anything much by way of state authority.

This also poses a key question, one which resonates in the 21st century, about whether there is a necessary link between state power and community life.

Scott is a political science researcher at Yale University who has stepped out of his academic comfort zone to grapple with the new archaeological reality. *Against the Grain* delivers not only a darker story, but also a broad understanding of the forces that shaped the formation of states and why they collapsed – right up to the industrial age.

Interestingly, his conclusions find grim contemporary echoes in a new book about the San Bushmen of the Kalahari by anthropologist James Suzman, who spent 25 years with them. In *Affluence without Abundance*, Suzman, an African studies fellow at the University of Cambridge, documents what happened when pastoralists, encouraged by governments, enclosed the San's lands and took away their hunter-gatherer way of life.

The San's recent past is like a speeded-up version of Scott's tale. He teases out the elements of how states formed, especially in Mesopotamia – specifically what is now modern southern Iraq. It was here that the first small city states appeared, on the northern shore of the Gulf and on plains

created and watered by the Tigris and Euphrates rivers.

There is some evidence for settlements among foragers in the Near East, often near wetlands, around 12,000 BC, and field agriculture from about 10,000 BC. But the earliest evidence of states dates from 4000 BC, with permanently settled towns. This is where Scott derives that figure of at least 4000 years between settlement-plus-agriculture (the two assumed prerequisites of state formation) and the first appearance of the state.

Around 12,000 BC, the world's population stood at between two and four million; by 2000 BC, it was around 25 million. But the vast majority of people had no contact with states as late as the end of the 15th century – Europe's middle ages. These people survived on a mix of agriculture and foraging, much like the inhabitants of those early settlements on the plains of Mesopotamia before 4000 BC.

Scott describes the creation, from around 4000 BC, of what he calls "late-Neolithic multispecies resettlement camps". Faced with a shortage of wild resources, these made use of domesticated animals and plants. Life in these settlements was much tougher than foraging, and the daily drudgery, chronic illness and epidemics brought on by increased reliance on domesticated species are apparent in skeletal remains and sudden collapses in population.

As the Danish agricultural economist Ester Boserup and some anthropologists have noted, there is little reason to imagine foragers would have adopted this way of life unless they were hungry, afraid or coerced.

A combination of factors seems to have caused people to cluster in those Mesopotamian plains, including rising populations in areas where wild food was more abundant, a cold spell in the climate, and possibly a rise in sea level. The populations in Scott's camps developed even better craft skills and social cohesion.

Early state development around the world has another defining feature, a staple diet of cereals. By contrast, agricultures based on tubers or pulses have no fixed harvest period and create no stockpiles. As Scott remarks, there are no early states founded on manioc, yam or sweet potato.

But the annual grain harvest creates two problems: storage, which requires protection; and vulnerability to thieving supervisors or outside raiders. It also ties producers to their store in time and space – no wandering off with a bow and arrow.

It seems likely, says Scott, that at first there was a voluntary approach to collective labour in fields, and to grain being pooled for safekeeping and even redistribution to the needy. But this created all the technical and organisational know-how for an increasingly coercive state. Constrained to a relatively small area, people were dependent on central grain stores, and grew used to supervision of both food distribution and their labour – things that feature almost obsessively in early writing.

By 3000 BC, we have the first definitive evidence of city states, with kings, bureaucracies, compulsory labour, taxation and punishment for non-compliance. These early states were also very fragile, prone to epidemics, soil degradation and political collapse.

Predictably, then, those early city states in Mesopotamia soon entered a long period of rivalry and shifting alliances. A key element was the struggle to dominate trade with hinterland peoples who had access to stone, timber and other resources not found on the alluvial plains.

This became a common theme among the emerging cereal states and was mirrored much later elsewhere, for example, in China's "warring states" period, starting in the 5th century BC. Victors subjected conquered neighbours to tribute, bondage and forced resettlement, particularly to do unskilled work in erecting city walls and irrigation. Thousands of identical, crude, bevelled pottery bowls found around Mesopotamia suggest measured rations for gang labour.

"For at least 4000 years, there were settled communities but no evidence of state power"

Slavery and severe punishment for escapees remained at the heart of subsequent regional kingdoms and empires. Each civilisation retained trade links with those in surrounding areas, the so-called barbarians. These were typically pastoralists who often kept some foraging component to their diets, and tended to be healthier and to have more personal freedoms.

This set up a dynamic that repeated into the last millennium, with people in the non-state periphery trading goods and slaves, and periodically raiding cereal-based cities. Tied together in this tense relationship, roaming pastoralists and urban states (Scott's "dark twins" of history) slowly captured or wiped out foragers and their way of life.

The same dark twins are in evidence in Suzman's affectionate and thoughtful book. Many of the San were compelled to work on cattle ranches in miserable and often violent conditions, while their foraging territories were fenced off by surrounding pastoralists or ranchers. Some still remember the "old times", but knowledge of the wild food sources they once relied on is dwindling. Groups are resettled in remote camps with a few shops, useless to them without money.

Under these new conditions, the forager mindset, its distaste for authority, expectation of natural providence, and code of sharing and honour, is often utterly broken. Some turn to drink or give in to the inevitable by taking up low-paid menial work.

In this fashion, through neglect, abuse and misunderstanding, an ancient way of life is being finally extinguished by the imperatives of local agriculture and its state support, reducing biodiversity to dusty waste. Yet, Suzman argues, even now the Bushmen have much to teach us about a social order that, in many ways, offered a freer, fairer existence and a non-invasive adaptation to ecology.

Suzman and Scott have both written excellent books, which could serve on reading lists for geography, history and politics, as well as in their natural homes of archaeology and anthropology. ■

San Bushmen are trying to cling on to their traditional way of life

JASON EDWARDS/NATIONAL GEOGRAPHIC CREATIVE

Ben Collyer is a writer and researcher based in the UK

Signs, symbols and staying alive

Graphic design can keep us healthy, finds **Catherine de Lange**

Can Graphic Design Save Your Life?
Wellcome Collection, London, until 14 January 2018

IN 2013, I went to Zambia to report on a public health campaign aimed at persuading men to get circumcised to help reduce the spread of HIV.

Driving through the streets of the capital, Lusaka, it was hard to miss the roadside walls painted with the campaign slogan and logo: a man standing tall, holding his belt. The image was intended to counter the local perception that circumcision would make you less of a man. I remember thinking it was clever, but I didn't link it to any formal discipline.

I'm reminded of this at the Wellcome Collection's latest exhibition, Can Graphic Design Save Your Life? The show brings into sharp focus the complex and often subliminal relationship between graphic design and health.

One exhibit in particular echoes that scene. During the 2014 Ebola epidemic in West Africa, Liberian designer Stephen Doe painted walls red to show danger and used simple iconography to convey the disease's symptoms to a largely illiterate population among whom more than 30 languages were spoken.

Skill is vital in such situations, with a lot more to lose than just a poorly designed advert in a commercial campaign. Take the infamously hard-hitting "Don't die of ignorance" AIDS campaign, with that message dropped onto every UK doormat in the 1980s. The original sell, "Don't aid AIDS", was deemed too soft. Had it not been hardened, outcomes for many might have been very different.

Graphic design could also stop you from getting punched in the face. In 2010, the UK's Department of Health and the Design Council asked for ideas on how to reduce levels of violence in accident and emergency departments. The winning brief was a signage system, filling in the information gaps that were making patients lose their cool. It explained, for instance, the triage system, so those waiting knew why someone else might get seen before them. After a year-long trial, violence in A&Es dropped by 50 per cent.

But while this exhibition is a celebration of the vital role of design in health, there's an unexpected flip side: it shows us just how much influence public health and big pharma can have over design.

In the 1950s and 60s, for example, pharmaceutical company Geigy became known for commissioning talented graphic designers to produce what would become iconic branding and promotional materials aimed at doctors. These became highly collectable and had a strong influence over future generations of designers.

"Of various colour palettes, Pantone 448, which evokes tar and pollution, was the biggest turn-off"

Or take the influence of public health on tobacco advertising. When the UK banned named branding in the 1980s, Saatchi & Saatchi came up with what went on to become one of the most recognisable cigarette ads – the surrealist-style Silk Cut campaign, in which each advert featured a piece of silk, cut in ever weirder ways.

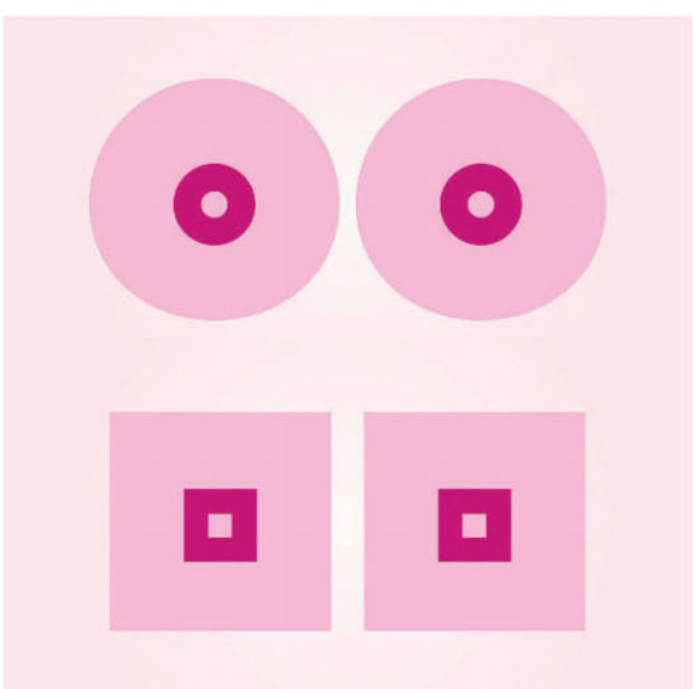
Not only did the adverts cleverly subvert the new legislation by using cuts in the silk to imply the brand's name, they also flattered the audience by suggesting viewers were smart enough to be in on the joke.

Then health rules changed again. When plain packaging came in, designers working for the UK health department had to concentrate on how to dissuade rather than sell to would-be consumers.

In Australia, market researchers tested various Pantone colour palettes for cigarette packaging to find out which were the biggest turn-offs. It turned out to be the murky Pantone 448, which evokes tar and pollution.

Health is perhaps the perfect field to help visitors don the shoes of the designer. How do you convey intermittent pain, for instance, in a way that transcends language? Or design an anti-smoking campaign that will fit on a postage stamp? Or explain how leprosy spreads with simple pictures?

In the final section of the exhibition, an even bigger question is posed: do designers have a responsibility to use their talents for the public good rather than consumerism? The answer is important for all of us, because in the end, it's not just graphic design that's going to save your life, but the designers behind it. ■



CANCERFONDEN, BREAST CANCER AWARENESS CAMPAIGN, 2016, SWEDEN

One breast cancer campaign had to "squarify" its logo to avoid offence

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Department of Chemistry
Faculty Position in Chemistry

The Department of Chemistry, at the University of California, Berkeley, invites applications for one faculty position at the assistant professor level with an expected start date of July 1, 2018. Preference will be given to candidates in the broadly defined fields of experimental physical and/or analytical chemistry. However, we will consider creative and energetic candidates who show extraordinary promise or accomplishment in research and teaching in any area of chemistry. The basic qualification for this position is a Ph.D. or equivalent degree in chemistry or a related field at the time of application.

All applicants should submit their most recently updated curriculum vitae, a statement of research plans, and provide at least three but no more than five letters of recommendation. A cover letter, a statement of teaching, and a statement of possible contributions to enhancing diversity in higher education are optional. Applications should be submitted electronically through our web-based system at: **https://aprecruit.berkeley.edu/apply/JPF01453**.

All recommendation letters will be treated as confidential per University of California policy and California state law. Please refer potential referees, including when letters are provided via a third party (i.e., dossier service or career center), to the UC statement on confidentiality (**http://apo.berkeley.edu/evalltr.html**) prior to submitting their letters.

The deadline for receipt of application material is November 1, 2017. Please direct questions to Lauren Nakashima (**ltnakashima@berkeley.edu**).

The University of California is an Equal Opportunity/Affirmative Action Employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability, age or protected veteran status. For the complete University of California nondiscrimination and affirmative action policy see: http://policy.ucop.edu/doc/4000376/NondiscrimAffirmAct.

UC Berkeley is committed to diversity in all aspects of our mission and to addressing the family needs of faculty, including dual career couples and single parents. The Department of Chemistry is interested in candidates who will contribute to diversity and equal opportunity in higher education through their teaching, research, and service.

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DEPARTMENT OF Biomedical Informatics

Master of Biomedical Informatics, Harvard Medical School

Program Description

The Department of Biomedical Informatics at Harvard Medical School offers a Master of Biomedical Informatics (MBI) degree for students who aim for a biomedical career that requires strong data science skills. The program provides an intellectual framework for the systematic and sound use of quantitative methods to increase agility with such methods in their respective domains. The programs includes intensive coursework in practical programming and data analysis skills, a range of foundational courses in quantitative and biomedical subjects, as well as courses in emerging areas such as precision medicine, data science, and data visualization. All students are expected to complete a capstone research project.

Who is this Program for?

Harvard Medical School offers two routes to the MBI degree:

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- Aimed at graduates with strong quantitative skills.

For students with a Doctoral degree or enrolled in a MD program (36-credit)

- Aimed at postdocs with a biomedical degree who recognize the relevance of informatics and data science to their research.
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Professor of Chemistry

The Department of Chemistry of the University of Wisconsin-Madison is accepting applications for open positions at the tenured and tenure-track level, beginning August 2018. We seek outstanding candidates with research interests in all areas of chemistry. The position requires development of an internationally recognized program of scholarly research as well as excellence in teaching at both the undergraduate and graduate levels. Professional and university service is also required. Please go to www.jobs.wisc.edu to view posting and select "Apply Now" to begin the application process.

Application materials including letter of intent, current CV, and concise description of research plans will be required for all applicants. Applicants will also be asked to provide the names and contact information for three professional references.

To guarantee full consideration, applications must be received by **October 15, 2017**. However, applications will be accepted until all positions are filled.

The University of Wisconsin-Madison is an equal opportunity affirmative action employer. Women and minority candidates are especially encouraged to apply. Unless confidentiality is requested in writing, information regarding the identity of the applicant must be released on request. Finalists cannot be guaranteed confidentiality. A criminal background check will be required prior to employment.


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KANSAS STATE UNIVERSITY

ASSISTANT PROFESSOR

EXPERIMENTAL ULTRAFAST AMO PHYSICS
J.R. MACDONALD LABORATORY
DEPARTMENT OF PHYSICS
KANSAS STATE UNIVERSITY

The Department of Physics at Kansas State University seeks a faculty member in an area of experimental ultrafast laser science who is expected to join the Department of Energy-funded efforts at the J.R. Macdonald Laboratory (JRML). An applicant's AMO physics research focus should thus complement these efforts and fit within the JRML group research theme. A brief description of current research and publications in the JRML can be found at **https://jrm.phys.ksu.edu/**.

The successful candidate will be appointed at the rank of tenure-track Assistant Professor in the Physics Department. The candidate must present credentials that will justify appointment at this level, including a Ph.D. or equivalent in AMO physics or a related discipline, also demonstrate a strong commitment to teaching and mentoring students and to serving a diverse population.

The Department has outstanding experimental and theoretical AMO physics programs, directed by 11 faculty members. It has extensive laser and accelerator facilities in the JRML that are being used to address an array of questions at the forefront of AMO science.

Applications, including a cover letter, CV, statements of research and teaching interests as well as contact information of at least three references should be submitted to:

http://careers.k-state.edu/cw/en-us/job/502370/assistant-professor-physics.

Screening of applicants will begin on **November 10, 2017**, and continue until the position is filled. **Background checks are required. Kansas State University is an affirmative action equal opportunity employer and actively seeks diversity among its employees.**

CONCORDIA UNIVERSITY WISCONSIN

School of PHARMACY

Department of Pharmaceutical and Administrative Sciences
Assistant, Associate or Full Professor Faculty Position

Concordia University Wisconsin, a Lutheran higher education institution in Mequon, Wisconsin, committed to helping students grow in mind, spirit, and body, is currently seeking a qualified and motivated professional to fill a permanent full-time position as Assistant, Associate, or Full Professor in the Department of Pharmaceutical and Administrative Sciences of the School of Pharmacy.

The successful candidate will be dedicated to excellence in teaching, research, and service, and should meet the following qualifications:

- Ph.D. in Pharmaceutical Sciences, Biomolecular Chemistry, or related field;
- Excellent verbal and written communication skills;
- Exemplary teaching or research scholarship in the pharmacology of biologically based therapies;
- Experience teaching professional students (e.g., Pharm.D., M.S., M.D., Ph.D.).

Preferably, that candidate would also:

- Have experience in structural chemistry, design, and development of biologics, e.g. antibodies and cytokines;
- Teach drug design, manufacture, delivery, immunological, and/or other pharmacological issues of biologic therapies.
- Demonstrate the potential to attract external funding;
- Have teaching and research interests complimentary to those existing within the Department and University;

The faculty member's primary responsibilities will include, but is not limited to:

- Teaching Pharm.D. students in the department course series;
- Advising and mentoring Pharm.D. and M.S. students;
- Collaborating with scientists within the School and with other colleges and universities;
- Providing service to others, i.e. participation in School committees and external organizations

The Department of Pharmaceutical and Administrative Sciences is responsible for the teaching in the area of biomedical sciences, pharmacodynamics, medicinal chemistry, toxicology, pharmaceutics, pharmacy administration, and pharmacogenomics. The department is responsible for the development, delivery, and refinement of all courses offered in these areas. Contact Michael Pickart, PhD, **michael.pickart@cuw.edu** for more information.

Application screening will begin immediately and will continue until filled. Interested candidates should submit: a letter of interest with completed employment application; curriculum vitae with names and contact information of three references; statement of planned research; and teaching philosophy online at:
https://cuw.applicantpro.com/jobs/563516.html

For general questions, please contact Human Resources at human. ***resources@cuw.edu*** *or fax to 262-243-3414 and* ***refer to Job ID: 563516***
Human Resources – Pharmaceutical and Administrative Science Faculty
Concordia University Wisconsin, whose campus is on the Lake Michigan shore, is just 20 minutes from downtown Milwaukee. It is an accredited, co-educational, liberal arts school offering undergraduate majors, graduate programs, and adult education undergraduate majors.


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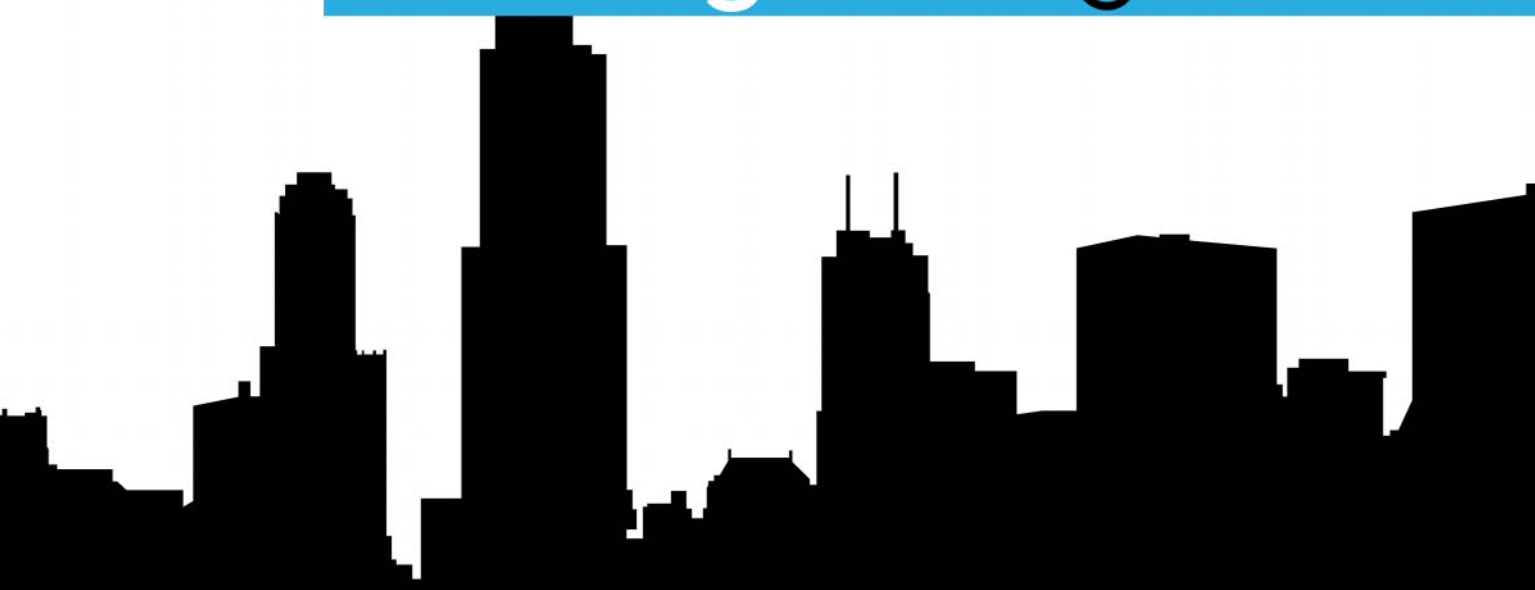

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EDITOR'S PICK

Locked-in lives, the law and ending them

From Robin Harbour, Glasgow, UK

I am a bit puzzled and concerned about the apparent disconnect between the work of Adrian Owen on scanning the brains of people in persistent vegetative states (16 September, p 44) and Clare Wilson's argument that a court ruling on ending life support without going to court in future is the right decision (30 September, p 25). Owen concludes that there are "thousands of people out there who are conscious but nobody knows".

Now there is news of someone being roused from a persistent vegetative state to a "minimally conscious" state (30 September, p 8).

Granted, the techniques of detection and arousal probably won't be widely available any time soon. But does that really justify terminating someone's life before we are sure they are not aware at some level?

I find the idea of being conscious but trapped in my body and unable to communicate by any normal means horrifying enough without the added thought that I might be written off – and switched off – because nobody could fully check my brain activity.

Free poor communities from their 'fat swamps'

From Patrick Saunders, Birmingham, UK

Anthony Warner is right to raise the hazards of trans fats in takeaway foods and the inequity of the disproportionate exposure of deprived communities to cheap fried takeaway foods in the UK (22 July, p 24). The latter is well evidenced, and a highly plausible risk factor for the poor health experience of these communities.

In response to these concerns, the then Sandwell Primary Care Trust – in one of the most deprived areas in Europe, in West Midlands – commissioned colleagues and I to purchase and analyse over 250 takeaways in 2013 to 2014 (*British Journal of Nutrition*, doi.org/cdhs).

The results were surprising. We found very low levels of trans fats in most samples. More than half the meals, though, exceeded acceptable total daily levels of fats and salt. Some single meals contained around twice the recommended daily intake for saturated fats or salt. Portion sizes for many meals were larger than those reported in the US literature – perhaps in response to the competitive local market.

Sandwell thus has the dubious distinction of being a "swamp" of readily accessible cheap and unhealthy takeaways, and a "desert" of healthy options. I agree with Warner that trans fats should be scrupulously avoided and the UK should follow the example of New York in banning their use in restaurants and takeaways. Wider intervention is required to address the inequity of deprived communities being condemned to "fat swamps" – including the use of local

"Let them live, invent, and prosper at their own pace and leave them be"

Cass responds to Curtis Abraham on ushering uncontacted tribes into the modern world to protect them (30 September, p 24)

planning and regulatory powers, the promotion of healthier food procurement and preparation, and the stimulation of demand for healthier products.

There is evidence organic food is more nutritious

From Ann Wills, London, UK

Bob Holmes notes that organic farms have better soils and more native species, but writes that "there's little evidence that organic is more nutritious" (23 September, p 35). Many studies show that organic food contains more nutrients.

Maria Raquel Miranda at the Federal University of Ceara in Brazil found that organic tomatoes contain 57 per cent more vitamin C than non-organic ones (*PLoS One*, doi.org/cdhq). A 2011 study at Newcastle University, UK, found that organic milk has more beneficial polyunsaturated fats than "conventional" milk (*Journal of Dairy Science*, doi.org/bdvs5s). A £12 million study led by Carlo Leifert at Newcastle University reported in 2007 that organic fruit and veg contained up to 40 per cent more antioxidants than non-organic types (*Critical Reviews in Plant Sciences*, doi.org/bjjpqt). This is a sample of many such studies.

Reconciling two takes on benefits of vegan diets

From Julia Winston, High Wycombe, Buckinghamshire, UK

Joseph Poore highlighted vast reductions in human land use as yet another clear and positive benefit of diet change (12 August, p 26). And Anthony Warner suggested uncertainty around whether vegan diets have positive or negative impacts on health (26 August, p 24).

Combining Poore's clear positive effect with Warner's report of an uncertain, near-zero effect gives me a straightforward answer. What is far less clear is whether humanity can properly balance its concerns about personal health and pleasure, with the pressing need to stop the degradation of our planet.

Efficient public transport and perverse incentives

From Brian Horton, West Launceston, Tasmania, Australia

It is interesting that an efficient bus service can be arranged by having each driver work independently, being paid by the number of passengers they pick up (16 September, p 7). They coordinate journeys to avoid clustering, avoiding excessively long waits between buses. Unless there are also incentives to minimise total trip time, there is a risk that each driver will wait until the following bus arrives before setting off, to maximise the number of passengers picked up.

On-time travel must not, however, be the major incentive. Where it is, we get the situation seen in Melbourne and London, where train operators avoided penalties for lateness by not stopping at busy stations where the train might be delayed.

Electrobuses were developed elsewhere

From Ashley Bruce, Bildeston, Suffolk, UK

Mick Hamer argues that bus technology missed a trick because of crooks in London (9 September, p 35). Trams were ubiquitous in ›

those conurbations big enough to support them. A multinational electric traction industry, desperate to find new markets, encouraged feverish invention of new forms of public transport throughout Europe and the US from 1900 onwards.

Trials of battery buses then echoed today's rush to find practicality, with just the same degree of spin, if not the same drive to avoid pollution. Companies in Germany, France and the US all tried battery-swapping, as in London, or clever ways of charging from rails or overhead wires.

With roads not surfaced to take the heavy load, battery buses carved up the thoroughfares in no time. At the time, charging lead acid batteries was toxic for the workers. To suggest a couple of con artists changed the course of progress is a bit of a stretch.

What nuclear power counts as clean energy?

From Scott Marshall, Turramurra, New South Wales, Australia

Eric Kvaalen asks whether nuclear power counts as "clean energy" given that we haven't solved the problem of nuclear waste (Letters, 2 September). It is, if the right technology is used.

Many are alarmed by waste from nuclear power stations. But some "breeder reactors" can produce much less waste – and generate less material that is useful for bombs. Some say this upset the US in the cold war and it convinced global powers to stop developing breeder reactors.

Thorium breeder reactors could solve many of today's power and waste problems. Just ask the Chinese – who are now reviving this technology.

The editor writes:

■ We reported developments with thorium reactors online on 25 August (bit.ly/NS-Thorium).

This wind-powered dream is my nightmare

From Anthony Trewavas, Edinburgh, UK

Mark Jacobson claims that a world with only wind, solar and hydroelectricity would be his dream (9 September, p 26). To me it's a nightmare. Here in Scotland, 3000 wind turbines already operate and you are now not out of sight of a turbine in 50 per cent of the countryside. Good research shows that 80 to 90 per cent of the bird species examined avoid turbines for distances of up to 500 metres to 1 kilometre. They would disappear in Jacobson's dream.

I agree with E. O. Wilson's target of returning half of usable land to wilderness to avoid driving many species to the margins of working landscapes, cities and seascapes. Wind and solar are incredibly land-hungry; nuclear is not.

What's this about making electrons, then?

From Keith Parkin, Wharncliffe Side, South Yorkshire, UK

The introduction to Abigail Beall's report that electrons may have subcomponents says "we go to incredible lengths: generating electrons in vast power stations" (9 September, p 38) and continues truthfully that it is "a shade embarrassing that we don't fully grasp what they are". I always thought the electrons were already present in the metallic circuit and power stations' job was to persuade them to move. Anyway, that's what I have been trying to teach for many years.

Innate numeracy and the rhythm of counting

From Freya Smith, Mosgiel, New Zealand

Anil Ananthaswamy suggests we are born with a sense of quantities – such as size and density – that correlate with the number of things (2 September, p 33). When I am counting $20 bills I say "da, da, da, da, one, da, da, da, da, two…" so count to 10 to tally $1000, or I lose track.

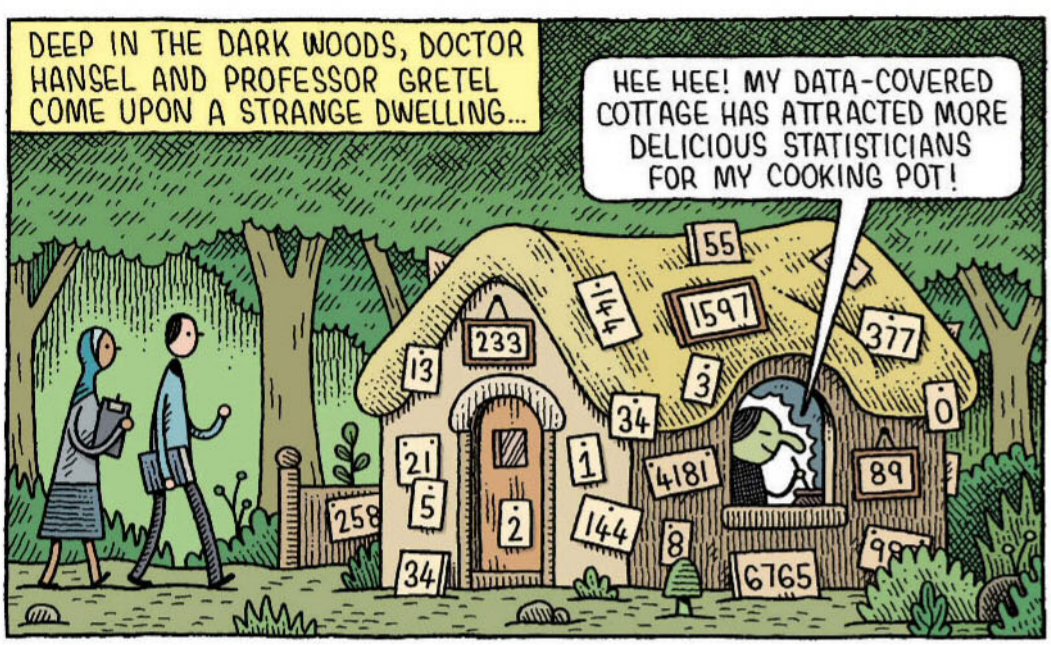
Obviously, this requires knowing the arithmetic, but it still seems to me that rhythm and number are intimately connected.

!Clicking your way around with the !Kung

From Leslie Eisenberg, Oregon, Wisconsin, US

You report how people who are blind can "see" like bats (9 September, p 12). I wonder if anyone has looked for a connection between echolocation and the language "clicks" made in !Kung and certain other languages spoken in Africa.

TOM GAULD



For the record

■ **The world is your small oyster. The finding that shellfish are smaller where long-tailed macaques use stone tools makes it more likely that size reductions elsewhere are due to human activity (23 September, p 12).**

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OLD SCIENTIST

What was *New Scientist* talking about in Octobers past?

GETTY IMAGES

DESPITE *New Scientist*'s reputation for sober-sides rationality, it is possible that we may, occasionally, have predicted things that didn't actually come to pass. Not that we intentionally print scare stories, of course. But looking back, some reports now seem a tad more outlandish than others.

Shortly after the Soviet Union launched the first artificial satellite, Sputnik 1, on 4 October 1957, our 17 October edition released news of a "startling scheme". The Soviets were thinking of deploying remote-controlled "tanks" on the moon, ostensibly for research purposes. But our correspondent in Washington DC wrote of paranoia infecting the US administration. "Frightening" was one word used, "consternation" another. So far, neither the Soviet Union nor Russia has attempted to colonise the moon, militarily or otherwise.

Scaremongering? Well, in the depths of the cold war, it was perhaps forgiveable. But sometimes, too, fears become reality. You might have thought that the antibiotic fireworks in our 7 October 1976 edition would fizzle out. "New gonorrhoea organism resists penicillin," screamed our headline, "shattering the complacency of venereologists." Liverpool Royal Infirmary in the UK had confirmed cases of the sexually transmitted disease resisting the drug. We suggested an "urgent re-examination" of routine penicillin use might be in order. It still is. Today the problem is far greater.

Of course, the truth is that we can never really know if our concerns will prove unfounded. Yes, or no, to this one? In our 12 October 2002 issue, we reported the belief of genomicist George Church "that in less than a decade, people will be able to get their own genomes sequenced for about the price of a laptop or a flat-screen TV". All of which meant you might be able to look forward to a long and healthy life. Or, instead develop Alzheimer's before you were 50. Presumably the likelihood of either determines whether it is a scare story or not. **Mick O'Hare** ■

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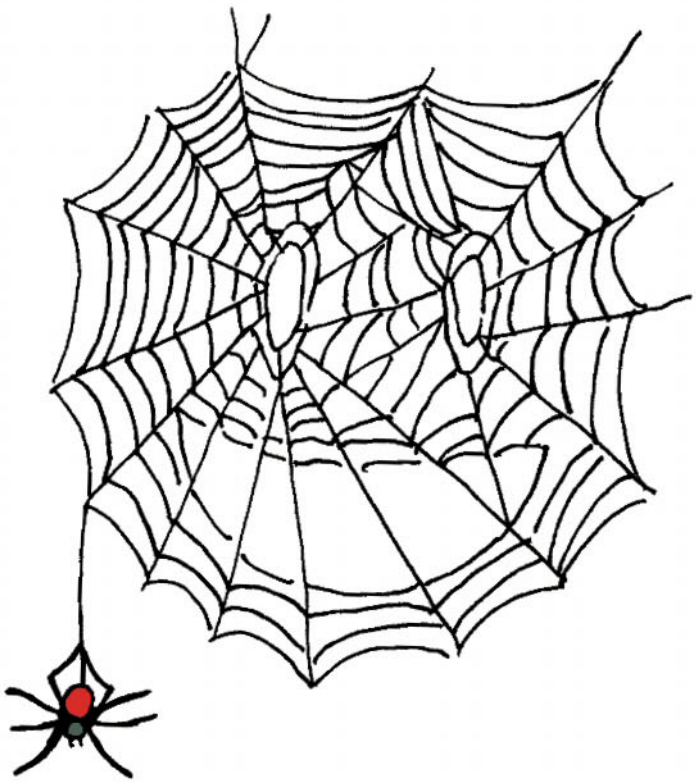

PAUL MCDEVITT

WHICH celeb is king of the jungle? Feedback is pondering biologists' propensity for cutting loose and naming critters after famous people, thus ensuring a little press boost when the discoveries are published.

The latest crop of ostentatious nomenclature hails from the Costa Rican undergrowth, where a group of "smiley face" spiders known for sporting emojis on their abdomens have been identified for the first time, among them *Spintharus davidbowiei*, *S. barackobamai*, *S. michelleobamaae*, *S. berniesandersi*, *S. leonardodicaprioi* and *S. davidattenboroughi*.

Whether having a creepy crawler with a fake smile named after you can really be considered an honour is not for Feedback to say. But it does prompt us to wonder: which celebrity can lay claim to the most organisms named after them?

A brief search of the literature puts nonagenarian TV nature presenter David Attenborough in the lead, boasting a menagerie that includes plesiosaurs, armoured fish, marsupial lions, prehistoric crustaceans and pygmy locusts (all extinct), plus Javan weevils, Madagascan ghost shrimp, long-beaked echidnas, Tasmanian semi-slugs, Peruvian rubber frogs and tropical goblin spiders. Adding plants to the list nets at least another five credits, from pitcher plants to black eyed satyrs. Can anyone trump Sir David's stellar performance?

A few rules on this game: only non-scientists count, so don't write in telling us Charles Darwin pops up a lot in the taxonomic tree. And a genus only counts once, regardless of how many species it holds. Can you find a more widely credited celebrity? And what are the most egregious examples of such conspicuous christening?

A sign spotted by David Tweedie on the entrance to Warwick Medical School: "Automatic door. Press button to operate."

YOU may want to sit down before you read further: standing up at work is apparently bad for your health. Research published by the Institute of Work and Health in Canada shows that workers whose jobs required them to stand all day were twice as likely to develop heart disease compared with their sedentary colleagues, a risk factor on a par with smoking. It's bad news for the guards at Buckingham Palace, and Feedback has traded in our standing desk while we lobby our editors for a much healthier bed-desk.

REGARDING our recent cover featuring Donald Trump and Kim Jong-un playing chess (23 September), Jennifer Sterling says: "I play chess and looking at the board it's impossible for Trump and Kim's rooks to be gone with their pawns still in position."

On reflection, though, she admits that "conceptually this illustration is actually brilliant. Neither one of them has any idea of how to even pose, much less master, the hardest game in the world".

Over at ChessBase, editor Macauley Peterson leads an in-depth discussion of what famous games could have been referenced on the cover, such as James Adams Congdon sacrificing his sole attacking piece to force a draw against the more heavily armed Eugene Delmar at the 5th American Chess Congress of 1880 (bit.ly/ns-zugzwang). One participant notes that the positions shown are possible in 17 moves, commenting that "the final retreating moves could be a sign that peace negotiations will prevail".

LONDON'S subterranean arteries are clogged with plaques of hardened fat and wet wipes, and recently a monster 130 tonne "fatberg" was discovered spanning a 250 metre length of sewer pipe under Whitechapel.

"I was just reading the *Süddeutsche Zeitung* and found a whole load of interesting units used to describe the fatberg," says Stuart Arnold. "As well as the usual elephants, it apparently weighed as much as 1433 Winston Churchills."

DON'T drain the swamp: researchers at the Illinois Natural History Survey are studying a spineless, highly opportunistic bottom feeder found in a pond in Washington DC. The endangered *Stygobromus hayi* might not be the most charismatic of species – being small, pale and blind – but researchers have nonetheless developed environmental DNA sampling to monitor the amphipod without disturbing it.

After all, if there's no place in the Capitol for tiny critters like this to thrive, what hope for the megafauna?

MORE on petronyms: Niall FitzSimons previously related the existence of the Elpiji company in Indonesia selling (what else?) liquefied petroleum gas.

"In France diesel fuel, also called gas oil, is sold as 'gazole'," says Geert Catteeuw, "and heating fuel is sold as 'fioul'. A case of onomatopoeic translation?"

On the other hand, he says that petrol – gasoline to our US readers – sells as "essence". The essence of what, one wonders?

LOOKING for recycling advice, Terry Klumpp writes: "An old friend whose death is imminent has generously bequeathed me his pacemaker." Terry wants to know, with a bit of tinkering, what uses could he put this heirloom to? Readers, tell us your flashes of inspiration.

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

Getting sucked in

How close would one have to be to the coalescing black holes recently detected by LIGO to actually feel the gravitational waves without the aid of instruments?
(Continued)

■ Gravitational waves result from the acceleration of masses, and their sources tend to be places of huge gravitation, enormous heat and intense radiation. It would take some doing to get close enough to feel the waves before you were vaporised by radiation, shredded by orbiting debris and spaghettified by tidal forces.

In the first LIGO event recorded, two black holes released nearly 5 per cent of their mass as gravitational energy in a chirp lasting 0.2 seconds. The best way to think about the sheer scale of this event is numerically. From the event roughly 108 times as far away as Proxima Centauri, LIGO recorded a wave amplitude distorting our local space about 108 times less than we would have experienced if the collision had happened at Proxima Centauri. However, even if it had originated at Proxima Centauri, the distortion would have been too small to feel.

But the gravitational energy would be some 10^{17} times greater, and so would the heat and radiation. If you were close enough to feel this, you wouldn't live long enough to notice it.

Jon Richfield
Somerset West, South Africa

Ever decreasing circles

Solar systems orbit the centre of their galaxies. Planets orbit stars. Moons orbit planets. Does anything orbit moons? If not, why not?

■ In principle Earth's moon could have natural satellites, but in practice it doesn't – or they don't stay in orbit for long. It does have one artificial satellite: NASA's Lunar Reconnaissance Orbiter has been orbiting since June 2009.

The region of space around an object where a satellite could orbit indefinitely is called the Hill sphere, roughly defined as where the object's gravitational field is stronger than that exerted by another object outside the sphere.

Though a more massive body has a bigger gravitational sphere of influence, it is reduced by the proximity of other large objects. That's why Neptune has the biggest Hill sphere in the solar system despite being less massive than Jupiter: it is further away from the sun. Further out in the solar system there are tiny asteroids being orbited by even smaller moons.

The moon's Hill sphere has a radius of 60,000 kilometres, about one-sixth of the distance between it and Earth.

However, the Hill sphere isn't an exclusion zone, as every body in the universe tugs on every other body. For example, Earth raises tides on the moon and vice versa, and the planets beyond Uranus were discovered by the gravitational perturbations they exerted on the seven planets that had already been discovered.

To complicate things further, the gravitational field strength at the moon's surface isn't uniform. There are localised increases caused by mass concentrations, or mascons, associated with the impact basins Imbrium, Crisium, Serenitatis and Orientale.

These cause anomalies in the field strength that extend into the Hill sphere and perturb the orbits of any satellites. For example, when the lunar orbiter PFS-2 was released from Apollo 16 in 1972 it was expected to stay in orbit for 18 months, but these perturbations caused it to crash onto the lunar surface after only 34 days.

"The gravitational field at the moon's surface isn't uniform. There are localised increases"

Even though the lunar mascons were discovered in 1968 by Paul Muller and William Sjogren at NASA's Jet Propulsion Laboratory, they weren't fully mapped until 2001. This revealed "frozen orbits" where a lunar satellite can remain in low orbit indefinitely, inclined at 27°, 50°, 76° and 86° with respect to the moon's equatorial plane.

NASA has considered capturing an asteroid and placing it in orbit around the moon, close enough for us to extract resources without risking a collision with Earth. However, it would still need the occasional orbital boost to prevent tidal forces bringing it crashing onto the lunar surface.

Mike Follows
Sutton Coldfield, West Midlands, UK

■ It is possible for natural objects to orbit moons, though the host moon must have sufficient mass that its Hill sphere is large enough to keep the orbiter within its grasp despite the draw of the host planet.

Saturn's moon Rhea is a candidate for hosting a thin ring system, though evidence is patchy. The Pluto system has moonlets with orbits that focus on the point that the Pluto/Charon pair both orbit. Because Charon is a moon of Pluto, we could say these moonlets orbit a moon.

Some moons have fascinating habits. For example, Janus and Epimetheus, a pair of moons that orbit Saturn, swap orbits every four years.

Paul Hunter
East Ilsley, Berkshire, UK

This week's questions

DEAD OF NIGHT

How do green plants cope with 24 hours of darkness for long periods? Does this affect oxygen production, and in turn cause any problems for local wildlife?

Anne Bean
Cape Town, South Africa

PALE RIDER

Driverless cars are already in existence. Would riderless motorbikes be a possibility?

Brian Moss
Kingsbury, Warwickshire, UK

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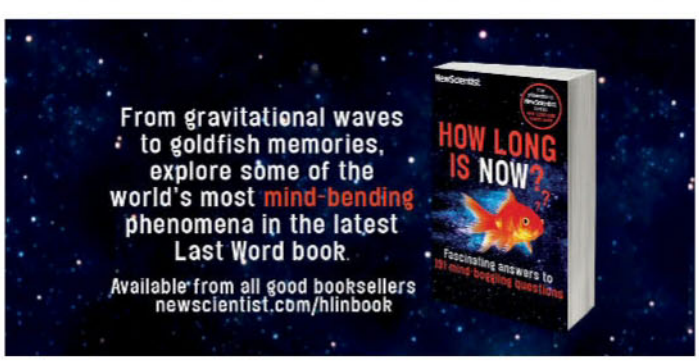

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