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Volume 236 No 3147

On the cover

34 The next supercontinent

Revealed: the face of Earth in 250 million years

6 A good heart

How to keep transplant organs fresh for days

15 Missing matter

Half of the universe has just been found

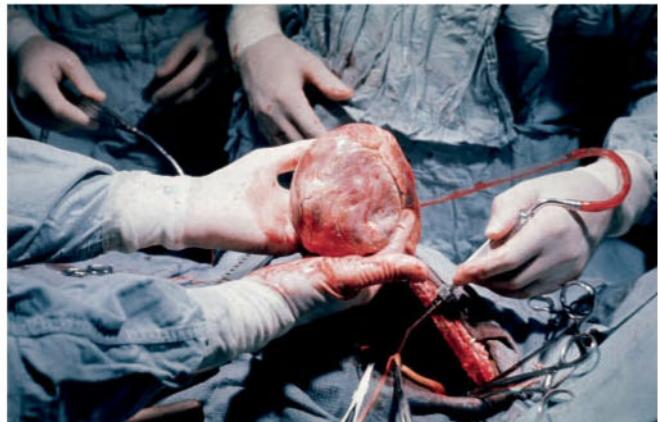
22 Wall-E Street

What happens to your money when robots run the stock market?

30 Insomnia causes Alzheimer's causes insomnia...

Why lack of sleep is killing your brain

Earth optimism (38). Ancient pollution (12). Flickering black holes (7). Creative kids (44). Evolution's rules (9). Seeing round corners (9). Doctors vs guns (25). Britain's Oppenheimer (42)



News Keeping hearts alive 6

Leaders

3 Is Earth optimism an oxymoron? Sleepwalking to dementia

News

4 UPFRONT Project Loon brings Puerto Rico internet. Kuwait drops DNA law. Nobel for nudge theory

6 NEWS & TECHNOLOGY Hearts kept alive outside the body. Black holes flickering. Exploding stars may have shaped our evolution. First home purchased on the blockchain. Spotting dark matter with the sun. Smartphone can see around corners. Life on Earth isn't so varied. Drug keeps brain sharp at altitude. Paint cools with sunlight. Algorithm sorts hate speech from banter. Ancient pollution from farming. Universe's missing normal matter spotted. Injection prevents chemo hair loss

17 IN BRIEF Most accurate atomic clock. Lunar volcanoes. Snakes know if they are toxic

Analysis

22 The money machine What happens when the stock market is run by robots?

24 COMMENT A benign digital deity. Banning shark fin could do more harm than good.

25 INSIGHT The US must learn to live with its gun epidemic

Features

30 Sleep the good sleep The undeniable link between lack of sleep and Alzheimer's disease

34 The next supercontinent What will the face of our planet look like in 250 million years?

38 Seeing the glass half full Doom and gloom could cost us the Earth

42 PEOPLE William Penney, the Briton at the heart of the Manhattan Project

Culture

44 Time to get underinvolved When it comes to nurturing children's creativity and skills, we've got it all wrong

46 Triumph of paralysis A tour around Norway's Lofoten peninsula shows Scandinavian art drowning in ideas

Regulars

28 APERTURE

Piles of waste awaiting a new life

52 LETTERS

Storing CO₂ under the sea

55 CROSSWORD

Cork grows on trees

56 FEEDBACK

Rock and hole

57 THE LAST WORD

14 October 2017 | NewScientist | 1



Baja whale-watching expedition

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ROLAND SEITRE/NATUREPL.COM

Reasons to be cheerful?

Earth optimism looks like an oxymoron, but give it a chance

FIFTY-FIVE years ago last month, Rachel Carson published her seminal book *Silent Spring*. Its warning that indiscriminate use of pesticides was poisoning the planet is frequently credited with having started the modern environmental movement.

What has that movement achieved? Arguably not much. Certainly not enough. Pesticides still abound, we're in the midst of a human-made mass extinction and decades of warnings about irreversible climate change appear to have fallen on deaf ears.

But amid the doom there have been some accomplishments. Emphasising those is the aim of

a new environmental campaign that calls itself Earth optimism. Its proponents point out successes in protecting individual species like the scimitar oryx (above) and the Togo slippery frog, a decline in deforestation rates in the Amazon, the gradual transformation of our energy system and more (see page 38). The overall message is an Obama-esque "Yes we can!"

The movement is open to accusations of wearing rose-tinted spectacles, cherry-picking success stories and making mountains out of molehills. Saving the Togo slippery frog is an achievement, but in the grand scheme of things

it hardly registers. But the Earth optimists' aim is not to claim that all is well. Rather, they point out that we cannot expect people to rise to the challenge without concrete examples of success.

They have a point. Despite having their hearts and heads in the right place, environmental campaigners all too often come across as doom-mongering, guilt-tripping party poopers. We need a new message. Whether Earth optimism is it remains to be seen, but it is an interesting experiment in shifting the narrative. A journey of 1000 miles begins with a single step. Or maybe a Togo slippery frog. ■

Sleepwalking to disaster

IN THE week that the Nobel Prize was deservedly awarded to biologists working on the circadian clock, the importance of their research to life and health has come into even sharper focus. It turns out that regularly failing to get adequate sleep puts us at greater risk of developing Alzheimer's disease. A single night of poor slumber is enough

to see damaging effects in the brain (see page 30). This is worrying news for all of us.

The cult of busyness now rules, burning the candle at both ends has become a badge of honour. English does not yet have an equivalent of the Japanese word *inemuri* – falling asleep in meetings, which is considered an honourable sign of dedication

to the cause – but may need one sooner rather than later.

We ignore the link between sleep and dementia at our peril, not just as individuals but as societies. Alzheimer's is a dreadful condition that will exact a huge burden on health and social care systems. Governments have a duty to protect citizens and foster their well-being. The promotion of adequate sleep must become a priority, lest we sleepwalk our way into a public health crisis. ■



Perfect fire conditions

Sports CRISPR ban

THE World Anti-Doping Agency has extended its 2003 ban on “gene doping” to include all forms of gene editing – but it is not clear how the agency can enforce this ban.

“Whether people who have CRISPR therapies will be able to compete will depend on the treatment”

WADA already bans the use of genetically modified cells and gene therapy if they have “the potential to enhance sport performance”. From 2018, the list will also include “gene editing agents designed to alter genome sequences and/or the transcriptional or epigenetic regulation of gene expression”.

Gene editing involves tweaking a person’s existing genes. The field is advancing rapidly thanks to an easy editing method called CRISPR.

Whether people who have CRISPR-based medical treatments will later be able to compete in elite sports depends on the nature

of the treatment, says WADA’s Maggie Durand.

The agency did not answer *New Scientist*’s question about whether it has the technical capacity to detect gene-editing cheats.

That task won’t be easy. With gene editing it should be possible to make tiny DNA alterations or even just temporarily boost or switch off the activity of particular genes, both of which would be very difficult to detect. Such tweaks can also be confined to specific tissues such as muscle, meaning the changes may not show up in blood tests.

STEPHEN LAM/REUTERS



Ballooning benefit?

California wildfires rage

FIRE has devastated large areas of northern California, leading to at least 10 deaths, 100 serious injuries and the destruction of at least 1500 homes. By late Monday, wildfires had torched almost 30,000 hectares, mostly in the wine-growing regions of Napa and Sonoma counties, including the area around Santa Rosa.

The US National Weather Service (NWS) issued a red-flag warning on Tuesday, blaming near-perfect fire conditions. Warm offshore winds gusting at up to 50 kilometres per hour served as bellows, spreading fire in conditions of low humidity and parched vegetation. “Any fires that develop will likely spread rapidly,” warned the NWS. “Shifting winds may push ongoing fires in new directions.”

The Californian fires are the latest

in a year that has seen abnormally high wildfire activity in the US. On 1 October, the US National Interagency Fire Center in Idaho predicted that northern California was at especially grave risk. “Weather patterns along the West Coast allowed fuels to dry and become receptive to fire,” it warned.

The NWS said conditions could ease in northern California by midweek, but the south would still be at risk. “Winds and the fire weather threat will decrease Tuesday in the north, but a threat will remain in southern California,” it said.

There is evidence that the warm winds fanning wildfires in northern parts of the state are being exacerbated by rising temperatures triggered by climate change.

Nobel for nudging

WEAVING the irrational human factor into economics has earned Richard Thaler of the University of Chicago this year’s Nobel prize in economic sciences.

In 2008, Thaler described a phenomenon called “nudging”: subtle psychological ploys that guide consumers to make certain choices. One example of it is redrafting the rules for organ donation, so that people have to opt out of donating rather than taking the trouble to opt in.

The idea’s potential has led the

UK and US governments, among others, to set up “nudge units” to prompt people to save more money and live healthier, more environmentally friendly lives.

The nudge concept emerged from Thaler’s studies of the limits to rationality. Economists had long assumed humans were rational, but Thaler showed that, for instance, we lack self-control.

“[Thaler] has shown how these human traits systematically affect individual decisions as well as market outcomes,” said the Royal Swedish Academy of Sciences when announcing the prize.

Wireless rescue

A GOOGLE sister company has lofty ambitions to beam wireless internet from balloons. Last week, X, which is owned by Google parent Alphabet, announced it wants to use its Project Loon tech to restore mobile networks to hurricane-ravaged Puerto Rico.

Currently, 82 per cent of Puerto Rico’s cellular towers are down. “It’s terrific that someone with radical tech is stepping in to help out,” says Mariya Zheleva of the

60 SECONDS

University at Albany in New York, who works on wireless networks for developing nations.

Mark Graham at the Oxford Internet Institute, who studies developing information economies, also welcomes X's plans. But he thinks we should be clear up front what Alphabet might want in return.

"If they want to try to harvest, sell and monetise the data of users, and further entrench their monopoly, we should be wary of their goals," he says. "A free service may come at a price if Project Loon does not offer access to the open internet."

DNA law quashed

KUWAIT has revoked the world's first law requiring all citizens and visitors to submit DNA samples.

Last week, the country's Constitutional Court ruled that the 2015 law violates the constitution's guarantee of personal liberty.

"We have prevailed," says Adel AbdulHadi of law firm Adel AbdulHadi & Partners. "I'm very pleased to have succeeded in a case which is of high importance to maintain the principles of privacy and human civil rights."

The government introduced

the law ostensibly to allow the identification of potential terrorists, but there were fears that the DNA information could be abused. As well as potentially violating the personal privacy of all 3.5 million Kuwaitis and visitors to the country, the law could also reveal unwelcome paternity issues, AbdulHadi's team argued. Anyone refusing to yield their DNA would have faced up to a year in jail or a large fine.

"[We] hope that other countries considering going down the same road will take note of this decision," said the European Society of Human Genetics.

Cholera campaign

THE World Health Organization and 50 other agencies have declared war on cholera. A road map launched last week by the Global Task Force for Cholera Control describes plans to cut deaths from the waterborne disease – now running at 95,000 a year – by 90 per cent by 2030.

That will mean eliminating cholera from 20 of the 47 countries that have it, and enabling the rest to detect and stop outbreaks before they get out of control.

Three million people get cholera every year, in Asia, Africa and Haiti. In Yemen, the biggest epidemic in modern times is now approaching 800,000 cases and is still growing. Experts say a "catastrophic" outbreak looms in Rohingya refugee camps in Bangladesh.

We already have the tools to stop this, says Peter Salama at the WHO in Geneva, Switzerland. Cholera spreads in water containing infected faeces. Rich countries banished it a century ago with toilets and hygiene.

The road map calls for coordinated spending on sanitation and the use of the oral cholera vaccine, a game changer that has recently been found to quickly contain outbreaks.

Ivory ban in the UK

Sales of ivory should be banned in the UK, the government said in proposals issued for public consultation last week. However, it does suggest exceptions, including musical instruments, items containing only tiny amounts of ivory, items of artistic value and purchase of ivory items by museums.

Childhood obesity

The number of children and adolescents worldwide who are obese has increased tenfold over the past four decades. In 1975, 5 million girls and 6 million boys were obese, but this had risen to 50 million and 74 million, respectively, in 2016 (*The Lancet*, DOI: 10.1016/S0140-6736(17)32129-3).

Nemo in dystopia

Flying out of Dubai? Soon you won't need to wait in line at security gates. Next year, these will be replaced with a virtual aquarium tunnel that scans your face or iris using 80 hidden cameras. The fish do more than tranquillise you; they attract your gaze to different cameras to optimise the capture of your likeness.

Escaping the cold

A chilly climate may have driven ancient humans out of Africa. East Africa became colder and drier around 75,000 years ago, according to an analysis of past climates – just when modern humans were apparently migrating out of Africa (*Geology*, doi.org/cd3r).

Healthy marriage

Men's health is linked to the state of their marriages. A study of 620 married fathers found that deteriorating relationships were associated with worsening diastolic blood pressure, while weight and levels of "bad" cholesterol fell in men whose marriages improved (*Journal of Epidemiology & Community Health*, doi.org/cd3q).

Google's in-ear translator buddy

IF YOU have a Google Pixel phone, you will soon be able to speak 40 languages. All you need is a pair of the earbuds Google announced last week in San Francisco. These can be used to make phone calls and listen to music – but they also provide on-demand two-way translation.

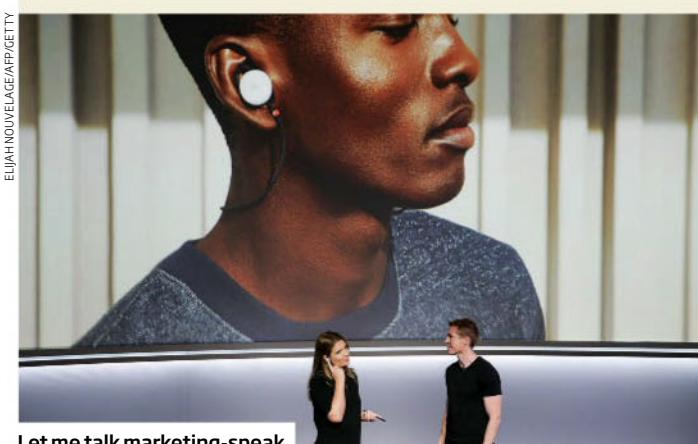
To talk in one of the supported languages, you use the earbuds to access Google Assistant and the Google Translate app. Pressing on the earbud and saying "let me speak German", for example, initiates translation of your speech into German, playing the results on the phone's speakers. Translated replies are heard via the earbuds.

"It's like you've got your own personal translator with you

everywhere you go," wrote Pixel Buds product manager Adam Champy in a blog post. It's not quite your own – the actual translation happens in a Google data centre – but the voice speaking the translated words is processed on your phone.

The earbuds, which will ship next month for £159 in the UK, aren't yet available for testing, a Google spokesperson told *New Scientist*. That means it's not yet clear how comfy the earbuds are or whether their 5-hour battery life is adequate.

Existing tech already does a similar job, including the Google Translate app and Skype Translator. So if the earbuds don't improve on the experience, they might not stick around.



Let me talk marketing-speak

Hearts kept alive outside the body

A technique that sends hearts to sleep could let them keep for days

Clare Wilson

A NEW way of keeping donated hearts alive for a day or more could bring an end to people dying while on the transplant waiting list.

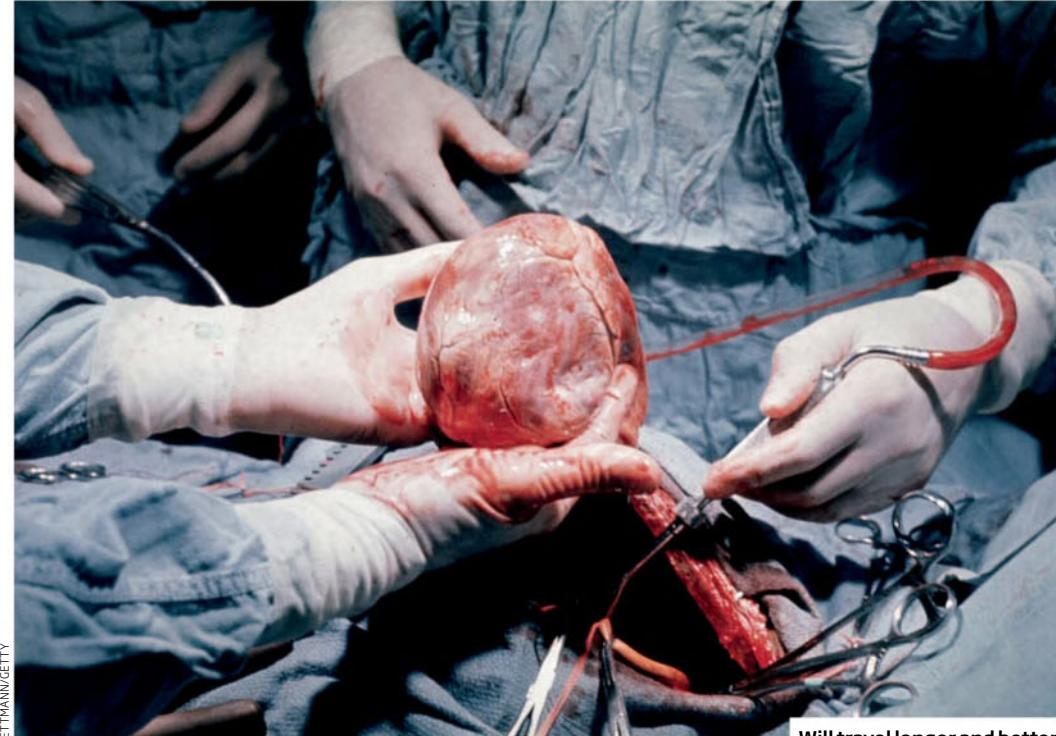
The method was tested on the first patient in August, with a heart kept in a "deep sleep" state for 3 hours. It will be tested on five more people for this same time and, if all goes well, the storage time will be gradually raised to 24 hours. Stig Steen at Lund University in Sweden, who developed the technique, says it could potentially be extended to several days.

Keeping hearts alive for longer outside the body would mean more are available for transplants. In the UK, over a thousand people die yearly for want of a new heart.

Distance between donor and recipient is a particular problem, because hearts can currently be kept alive outside the body for only a few hours before they weaken.

The usual way to transport hearts involves keeping the organs at 4°C, without an oxygen supply. The longer this goes on, the worse the heart will work when transplanted. The upper limit is about 4 hours. "We say no to a lot of good hearts," says Steen. "With the new way, we can take hearts from theoretically the whole world. We can get the perfect fit for each patient."

One recent advance is a device that keeps the heart beating at body temperature, perfused with blood from the donor. Manufacturer TransMedics, based in Andover, Massachusetts, says hearts can be kept on the machine for between 7 and 12 hours. "This has dramatically increased the number of heart transplants we can do," says André Simon of the Royal Brompton and Harefield



Will travel longer and better

BETTMANN/GETTY

NHS Foundation Trust in London, which is spearheading use of the device in the UK.

But the system developed in Sweden takes an intermediate route, keeping the heart at 8°C, and perfusing it with a blood-like fluid containing high levels of potassium that stops the heart from beating. In this state, the organ's cells are less active than at 37°C, and its need for oxygen is slashed. "It's like being in a deep sleep," says Steen.

As a result, the heart can be perfused at a lower rate than when it's beating, which should put less stress on its blood vessels. This may make the heart last

"We should be able to take hearts from the whole world to get the perfect fit for each patient"

longer, says John Dark of Newcastle University, UK.

The system has been tested on 100 pigs, with hearts kept "asleep" for 24 hours before being transplanted. Being able to maintain a human heart outside of the body for 24 hours would be a great advantage, says Simon.

Self-healing hearts

The patient who received a heart in this way in August was a 52-year-old Swedish man dying of heart failure. Stored for 3 hours, the heart automatically resumed beating once it warmed up inside the man's body and his blood flushed away the potassium. The man is now recovering at home, says Steen.

Both TransMedics's device and the Swedish technique have other

advantages over storage at 4°C. Hearts are usually taken from people who are brain-dead, a state that disturbs levels of many blood chemicals, damaging heart tissue. But providing the heart with a blood-like fluid means the muscles recover. "When you perfuse the heart with normal concentrations of everything, the heart repairs itself," says Steen.

Other teams are working on storing donated lungs, liver and kidneys for longer outside the body. A device that keeps the liver functioning at body temperature has doubled preservation time to 24 hours, says Peter Friend at the University of Oxford.

Steen says his system could also work for other organs, and hopes it will eventually become routine for transplant organs to be sent across continents. ■

In this section

- First home purchased on the blockchain, page 8
- Universe's missing normal matter spotted, page 15
- What happens when the stock market is run by robots? page 22

Supergiant black hole seen flickering

A SUPERMASSIVE black hole has been spotted snacking – twice. This is the first time astronomers have caught one doing this, and the sightings could help us better understand odd cosmic objects called active galactic nuclei.

AGNs occur when an enormous black hole – often with the mass of a billion suns – forms in the centre of a galaxy. As clouds of gas and dust fall into it, they spin around its edge and experience extreme forces and friction. Heated to millions of degrees, the material can shine brighter than all the stars in the galaxy combined. Then once the gas and dust get used up, the black hole goes dark.

Former AGNs sometimes show evidence of past meals. Clouds of material can be shot out of the galactic centre along with the intense radiation, and can linger for hundreds of thousands of years.

Now Julie Comerford of the University of Colorado, Boulder, and her colleagues have used these to help identify two AGN outbursts in a galaxy called J1354+1327, located about 900 million light years away.

The first eruption resulted in a patch of bright dust on one side of the galactic centre that has spread into a feathery cone approximately 30,000 light years long. A later explosion generated a compact dome of material in the opposite direction, located about 1300 light years from the black hole.

Comerford and her team estimate that the two outbursts happened roughly 100,000 years apart, relatively fast for a cosmic process, confirming results from some computer models (arxiv.org/abs/1710.00825).

The double snack attack was spotted because material from the later eruption is pummelling interstellar gas and dust, generating bright shockwaves. Knowing how to find this signature now, the team hopes to discover other reigniting AGNs. Adam Mann ■



Born in fire

Fires may have given our evolution a kick-start

WAS the rise of humanity written in the stars? A nearby exploding star 8 million years ago may have triggered more frequent lightning on Earth. Wildfires ignited by that lightning could help explain the spread of east African savannahs – which many researchers think provided a vital backdrop for the early evolution of hominins.

The rise of African savannahs, from about 8 million years ago, has long been a mystery. They are dominated by plants called C4 grasses – but these appeared 20 million years ago. What caused their rise to dominance? Some botanists suspect the trigger was a spate of wildfires 8 million years ago. Grasses bounce back quickly after a wildfire while trees are slower to recover, so frequent wildfires would have favoured the expansion of savannahs.

Now researchers led by Brian Thomas at Washburn University in Kansas have a possible reason for the surge in wildfires.

Deep-sea sediments of that age contain a lot of iron-60, which is made in massive stars. The

iron-60 suggests there was at least one nearby supernova at the time.

The team says high-energy cosmic rays from the supernova swept Earth. They calculated that some of the rays were energetic enough to reach the lower atmosphere and ionise particles – a process some physicists have linked to lightning formation.

"It's one of those nice stories that all fits together, with the caveat that there's uncertainty"

The team used a vegetation model to assess the effect of a short-lived increase in lightning 8 million years ago. They estimate it could have reduced tree cover in east Africa by about one-tenth, enough to give grasses a toehold.

"It's one of these nice stories that all fits together, with the caveat that there's some uncertainty in some of those linkages," says Thomas. He will present the findings at the annual meeting of the Geological Society of America in Seattle,

Washington, later this month.

The research has received a cautious welcome. "The basic justification for this whole story is this radioactive iron-60," says astrophysicist Bradley Schaefer at Louisiana State University. "And it really only could have been ejected by a supernova."

The link between cosmic rays and lightning is appealing, says Joseph Dwyer at the University of New Hampshire. "The thinking is that perhaps cosmic-ray air showers can somehow carve a conductive path through the storms, thereby helping lightning get started."

"The cosmic ray model is plausible and reasonable," says Schaefer.

However, Dwyer published a study in August that found little evidence. He examined 74 days of cosmic ray records and found no link with lightning. But the sample size was too small to rule it out (*Journal of Geophysical Research: Atmospheres*, doi.org/cdzc).

"It's hard to prove these things," Schaefer says. "There might be multiple things that can serve as inducements for lightning."

The extra wildfires 8 million years ago do need explaining, says Toby Pennington at the Royal Botanic Garden Edinburgh, UK. "The idea that increased lightning may have pushed things over the edge is intriguing."

The remaining question is the degree to which savannahs drove hominin evolution. The idea was first mooted in the 19th century, but in the 21st century it has come under attack. There is evidence that early hominins, like the 4.4-million-year-old *Ardipithecus ramidus*, lived in wooded places.

But others say the broader environment occupied by early hominins really was a savannah. Manuel Domínguez-Rodrigo at Complutense University in Madrid, Spain, says it's too soon to discount savannahs' role. "All hominins found until now are associated to savannah biomes," he says. Colin Barras ■

Need a home? Put a blockchain on it

Douglas Heaven

LAST month a \$60,000 flat in Kiev, Ukraine, became the world's first property to be sold using a blockchain. Michael Arrington, founder of tech news site TechCrunch, used real estate start-up Propy to help him snap up the home without setting foot in the country. The transaction took place entirely via smart contracts on the Ethereum blockchain using cryptocurrency.

Blockchains are cryptographically secure ledgers that store every transaction made in a system across many different computers, protecting them from fraud. Originally designed to support digital currencies, they promise to revolutionise far more than monetary transactions. The tech has already allowed people to trade things like excess energy from their solar panels, and to participate in a form of direct voting called liquid democracy. Little wonder "disrupting" real estate has been a long-standing promise of blockchains.

Moving international property

transactions onto a blockchain should speed up the process of conveyancing and exchanging of paper contracts. It also should make transactions more transparent and properties easier to sell to overseas buyers.

San Francisco-based Propy is not the first to try to use the blockchain. Global real estate outfit REX is creating a global property listing service to connect sellers,

buyers and agents across multiple countries. ATLANT, based in New York, is experimenting with a form of blockchain-supported property ownership where many people can co-own a property in much the same way shareholders jointly own a company.

But Propy is the first to understand that transactions need government involvement. "People can do property swaps all they want but without a government to enforce them, it's meaningless," says Paul Madore, who writes reports on blockchain start-ups for investors.

Real estate transactions need to be recorded in an official ledger

that is legally binding and recognised by all parties. In the UK, this is the government-controlled Land Registry. Propy envisions that different jurisdictions will adopt the Propy registry as their official ledger. This would mean that simply transferring property via Propy would count as a legal transfer of ownership. "Making a traditionally bureaucratic process simpler and more transparent is a short-term win," says Nina Jankowicz, a Fulbright-Clinton public policy fellow in Ukraine.

Propy is working with Ukraine's e-government agency and ministry of justice. CEO Natalia Karayaneva says the company is also in talks with officials in Vermont, California and Dubai. "They are figuring out which laws they need to change," she says.

Blockchain technology will inevitably power property transactions in the near future, says Madore. But companies like Propy may not be running the show. "Propy expects the governments of the world to bend to its will," he says. Governments are slow to change, but most will want to develop their own blockchain platforms, he says.

If you read Propy's small print, the company knows this too, says Madore. If something goes wrong, it can't help you, he says. ■



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Sun could speed up dark matter so we can see it

THE sun might help us find out what dark matter really is. If dark matter particles are extremely light, they could bounce off atomic nuclei within the sun and gain enough energy in the process for us to detect them.

Chris Kouvaris at the University of Southern Denmark in Odense and his colleagues calculate that particles of this "sub-GeV" dark matter could be accelerated to speeds in excess of 600 kilometres per second this way.

Dark matter fills the cosmos, so if these sub-GeV particles exist some of them should be hitting the sun all the time. As they bounce around within the sun, some would gain enough speed to escape towards Earth (arXiv.org/abs/1709.06573).

Faster particles are easier to detect, so this solar boost could be the key to making dark matter visible to us. But the sub-GeV particles will need to interact with the normal matter in our detectors, and to do that they need a helper particle.

For example, weakly interacting massive particles (WIMPs), another contender for dark matter, interact with ordinary matter by exchanging

particles called W and Z bosons. "Some of my more sceptical colleagues would say that it's like believing in two tooth fairies. I say, if you believe in one tooth fairy, why not two?" says Daniel McKinsey at the University of California, Berkeley. He says this idea is still a "big deal", because it gives us an entirely new way to look for dark matter after decades of fruitless searching.

The speed limit for particles to remain inside our galaxy is

544 kilometres per second. Any faster than that and gravity won't be able to keep them within the Milky Way, and we'll never be able to detect them. Unless, that is, Earth gets in the way, which is much more likely if they are accelerated to high speeds by our sun.

Current detectors aren't sensitive enough to see any of these particles even after they get such a boost. But upcoming instruments like the upgraded CRESST-III detector in Italy may be able to detect them.

Dark matter makes up over 80 per cent of the universe's mass, so if we do see them, Kouvaris and McKinsey agree, it'll be the biggest discovery in modern physics. Leah Crane ■

"If the particles hit escape velocity, they'll leave the galaxy. Unless, that is, Earth gets in the way"

Light trick helps you peek around corners

THE walls may not have ears – but you can use them to peer around corners.

A team at the Massachusetts Institute of Technology has figured out how to use changes in reflected light pooling on the floor at the base of a wall to trace the paths of people hidden from view in an adjacent room.

The trick is to track tiny variations in the colour of light. A similar technique lets phone cameras detect your pulse by detecting fluctuations in skin tone. Katie Bouman and her colleagues realised that variations in a pool of light by a floor-level edge contained information about the hidden objects reflecting that light. By analysing the patterns, they mapped the trajectory of the objects that were moving out of view around the corner.

The team tested the system when people were walking around a room with the door ajar. Focusing on a corner of the door between two rooms they used an algorithm to generate a video showing how many people were hidden from view, and where they were walking. With two corners – such as the frame of a doorway – they could also pinpoint people's locations.

The technique works indoors and out and in different weather conditions. It can also handle a range of surfaces, including linoleum, tiles, carpet and brick paving with weeds. But it is thwarted by darkness.

"It's a pretty simple idea, really fast for processing," says Bouman. The video can be computed quickly, so it could be used in cars or industrial vehicles to spot people just out of sight inside a house. And because the system relies on ambient light, your presence can be undetectable. The project is funded by US defence tech agency DARPA, says Bouman. "Lots of people are working on different methods to see around corners."

Bouman is now applying her tricks to imaging black holes. It's much the same thing, she says. "Take the noise and extract something meaningful."

Douglas Heaven ■



NICK GARBUTT/NATUREPL.COM

Beautiful but not unique

Evolution's rules mean life isn't that varied

MANY seemingly unique species actually live similar lives. This convergence suggests it is possible to predict how many species live in a habitat, and even to identify the holes left by missing species.

Ecologists have often described ecological roles, or "niches", as a set of properties of individual species. For example, chameleons are tree-dwelling lizards that ambush insects, while horned lizards are ground-dwelling desert creatures that eat ants and sport protective spines. The diversity seems vast.

But Eric Pianka, an evolutionary ecologist at the University of Texas in Austin, wondered if the number of niches was in fact more limited. To find out, he teamed up with Laurie Vitt at the University of Oklahoma. "Our entire life, basically, has been going out and collecting data on lizards," says Vitt. "So we have a huge data set."

The pair looked at 134 species on four continents. For each, they examined more than 50 features of their niches, such as habitat type, hunting style, reproductive output and defences against predators. Then, with colleagues, they crunched the numbers.

Over and over, they saw pairs of unrelated lizards converge on similar niches. Of the 134 species, 100 belonged to a convergent pair, more than could have happened by chance (*American Naturalist*, doi.org/cd3m). Chameleons in Africa have American equivalents called bush anoles, and Australia's thorny devil fills the same niche as North America's horned lizards.

If lizards could evolve into an unlimited number of niches, this

Lizards are constrained to live particular lifestyles: there are no lizards that live like elephants"

convergence would be unlikely. Instead, lizards are constrained to live particular lifestyles: there are no lizards that live like elephants. "There's only a certain number of ways to be a lizard," says Pianka.

"This is beautiful," says George McGhee at Rutgers University in New Jersey. "It's astonishing the number of species that have converged into ecological roles."

Ecologists could apply the same approach to other groups, like birds or rodents. However, each

group will have extra niche features – many birds make long migrations, and some rodents hibernate – so the analysis will need to be modified, says Pianka.

The limited number of niches implies that it is possible to build a "table of niches", like chemistry's periodic table of elements. "If we constructed this table, and we thought it was fairly complete, then we could go into places and look at the structure of the habitat, the temperatures and so on, and say 'this place ought to be able to support 10 species of lizards,'" says Vitt. Ecologists could predict far more about the natural world than they can today.

The table would also highlight "empty" niches where species should occur but don't. The gaps could indicate where species recently died out, says Vitt.

The findings do not necessarily mean that extinct species can be easily replaced by their ecological equivalents, says Vitt. Such "plug and play" swaps are being tried on Indian Ocean islands, where giant tortoises wiped out by humans have been substituted by tortoises from other islands. Even if the new species fills the same niche, it may respond differently to competitors, predators and prey – leading to unpredictable changes in the ecosystem. **Bob Holmes** ■

Drug keeps mind sharp at altitude

Helen Thomson

A SO-CALLED "smart drug" intended to boost cognitive performance also seems to protect the brain from altitude sickness.

Ever more people are visiting high-altitude sites for work, sport, religious pilgrimages and military tasks. But even the fittest among us suffer in thin air: the lower oxygen content at altitude can lead to cognitive effects, including memory loss and attention difficulties.

There's little you can do to prevent these symptoms other than acclimatise – but this takes time and doesn't always work. A drug called oxiracetam might be the answer.

ShengLi Hu at the Third Military Medical University, Chongqing, China, and her colleagues studied the performance of male military personnel at altitude. All lived in towns around 1800 metres above sea level. During the study, they spent eight days at this altitude,

then climbed for three days to reach 4000 metres, where they stayed for up to a month.

Twenty participants took oxiracetam three times a day for the first 15 days of the study, while another 20 received no intervention. The men did tests

of attention and memory at the start and end of the study and 20 days in, by which time they had been at 4000 metres for nine days.

While all the participants experienced a drop in cognitive ability at 4000 metres, those who took oxiracetam showed a much smaller decline than the control group (*Brain and Behaviour*, doi.org/cds7).

Blood flow measurements indicated that at high altitude, parts of the brain's cerebral circulatory system contracted

and dilated in a way that promoted blood flow to the brain stem. This isn't surprising, since the brain stem plays a critical role in the maintenance of basic vital signs.

The team also found that the brain stem received blood at the expense of areas responsible for more advanced cognitive functions. But in people who took oxiracetam, more arteries dilated, so blood flow throughout the brain rose. This may be how the drug seems to lessen cognitive problems linked with low oxygen.

It isn't yet known whether diverting blood in this way could have negative effects in the long run.

"The results are striking and imply that oxiracetam may be beneficial for helping to mitigate cognitive deficits caused by altitude," says Timothy Hales at the University of Dundee, UK.

Oxiracetam is not licensed for medical use in the UK, but it is known to be a mild stimulant, says Hales. "Coca leaves have been used by native Andeans for centuries to overcome altitude sickness and this is attributed to their modest cocaine content. So perhaps it is not surprising that benefit can be derived from another, albeit mild, stimulant." ■



A pill could aid clear thinking

The paint that uses the sun to cool your home

A HIGH-TECH paint that actually cools when exposed to sunlight can provide a better way to chill buildings – and perhaps even solve the long-standing problem of cooling things in space.

"It's like putting a layer of ice on your rooftop which is thicker when there is more sun," says Yaron Shenhav, who developed the paint with his colleagues at SolCold, a start-up in Herzliya, Israel.

The technology is based on the counterintuitive principle of laser cooling – using laser light to cool

specially designed materials by up to 150°C. It works because molecules in these materials absorb photons while spontaneously emitting higher-energy photons. Since this loses energy overall, the temperature falls.

Mounting lasers on your roof wouldn't be very practical, though, so Shenhav wanted to make the material work with sunlight. The problem was that the sun's spectrum is much broader than that of a laser's narrow range of frequencies.

The paint the team came up with has an outer layer that filters out some of the sun's rays and an inner one that absorbs heat and emits higher-frequency light, cooling itself below the ambient temperature.

The material has passed tests in

the lab. "Heat could be absorbed and re-emitted as light," Shenhav says. "As long as the sun is shining on it, it would be continuously cooled." Simulations show that a room on the top floor of a house will feel up to 10°C cooler with the paint applied to the roof than without it. The team now plans to conduct pilot tests on buildings within two years.

Although existing cooling paints are used to scatter and reduce the amount of heat buildings absorb, they can't actively lower the temperature inside. SolCold's paint can, says Eran

'Heat can be absorbed and re-emitted as light. As long as the sun is shining on the paint, it would be cooled'

Zahavy at the Israel Institute of Biological Research. But it isn't cheap, costing about \$300 to coat 100 square metres. Shenhav and his team think the early adopters will be shopping malls and stadiums.

The material could also solve the major challenge of how to cool objects in space. That might seem counterintuitive given the frigid temperatures there, but there is no air to carry heat away from an object. The International Space Station uses reflective fabric to ward off radiation from the sun, and internal heat exchangers to get rid of excess heat produced by equipment.

The work will be presented at the Hello Tomorrow summit in Paris later this month. Sandrine Ceurstemont ■



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The line between hate and banter

Douglas Heaven

IT'S no secret that the internet has a problem with hate speech. But automated attempts to clamp down on it have mostly failed, because it's too slippery a concept to define for computers. Now, a new way of identifying the subtle linguistic fingerprints of hate speech – and separating it from benign uses of similar words – could finally help us crack down on the worst offenders.

"Hate speech is notoriously difficult to detect," says Dana Warmsley at Cornell University in Ithaca, New York. Simply using offensive language doesn't make someone abusive. People swear for all sorts of reasons. Friends call each other names for fun.

Neither human nor automatic hate-speech detection have been effective. Earlier this year, Google tried to assign comments a "toxic" score on the basis of how similar they were to phrases people had previously deemed offensive. However, the shortcomings overwhelmed the positive effects. "you're pretty smart for a girl"

was deemed 18 per cent similar to comments people had deemed toxic, whereas "i love Fuhrer" was 2 per cent similar.

Instead of focusing on isolated words and phrases, Haji Mohammad Saleem at McGill University in Montreal, Canada, and his colleagues have taught

machine-learning software to spot hate speech by learning how people use potentially abusive words. The team's system learned on data that contains most of the posts made to Reddit between 2006 and 2016.

The team focused on three groups often facing abuse: African Americans, people who are overweight and women. For each group, the team chose posts from the most active support and abuse groups on Reddit. They also took comments from Voat – a forum site similar to Reddit.

The system misidentified fewer innocent posts as potential hate speech than a keyword-based detector did. And it was able to highlight comments that contained no tellingly offensive keyword, such as "Animals attack other animals all the time", in which the term "animals" was being used as a racist slur ([arXiv.org/abs/1709.10159](https://arxiv.org/abs/1709.10159)).

"Comparing hateful and non-hateful communities to find the language that distinguishes them is a clever solution," says Thomas Davidson at Cornell University.

But he is not convinced the solution is as widely applicable as Saleem's team suggest. It was tested on Reddit comments, but the group hasn't yet shown that it will catch targeted abuse elsewhere, such as on Twitter or Facebook.

The system also missed obviously offensive speech, such as "Black people are terrible" and other instances that were clearly racist. A keyword-based approach would have caught these comments, says Joanna Bryson at the University of Bath, UK.

But it could be another tool to help moderators police their patches of the internet. "Ultimately, hate speech is a subjective phenomenon that requires human judgement to identify," says Davidson. ■



NICOLAS DATTI/CEA/FLOPRESS ASSOCIATION IMAGES

Time to crack down

Early farmers polluted the sea 4000 years ago

HUMANS have been polluting the environment for at least 4000 years. So says a team that has analysed sediment from the South China Sea – but not everyone is convinced.

Several civilisations hit a crisis point 4000 years ago. The global climate cooled, and this has been linked to the collapse of the Akkadian Empire in Mesopotamia and the end of the Indus valley civilisation of South Asia.

Cooling was also felt on Hainan

island off China's south coast, say Fangjian Xu at the China University of Petroleum, Qingdao, and his team. There was also a rise in heavy metal pollution in the South China Sea.

The group looked at two sediment cores from south-east of Hainan, and calculated "enrichment factors" for several metals. A value of 1 or below is no enrichment, while values between 1 and 3 suggest "minor enrichment".

The enrichment factors of cadmium and lead hovered around 1 before 4000 years ago, then rose to about 1.5 (*The Holocene*, doi.org/cdxm).

The group suggests the change was linked to the global cooling at the time, when Hainan would have cooled

and dried. Lower monsoon activity would have triggered a drop in coastal upwelling, cutting marine productivity and encouraging Hainan's inhabitants to focus on farming instead of fishing. Run-off from farms would have included heavy metals, which built up in soil because of metal tool use.

Samuel Toucanne at the French Research Institute for Exploitation of the Sea in Plouzané was involved in a 2015 analysis of South China Sea sediment from further west. There,

evidence of pollution from lead and arsenic began only 1800 years ago.

Toucanne says the rise in pollution 4000 years ago is gradual rather than clear-cut, so it's questionable whether there is a direct link between the climate cooling 4000 years ago and the increase in pollution off Hainan.

There is precedent for old pollution. Francisco Jiménez-Espejo at the Japan Agency for Marine-Earth Science and Technology in Yokosuka found signs that archaic humans like Neanderthals caused heavy metal pollution.

"But the amount we are talking is so low that it is not considered harmful or dangerous for human [health]," he says. Colin Barras ■

'The global climate cooled 4000 years ago, which has been linked to the collapse of the Akkadian Empire'

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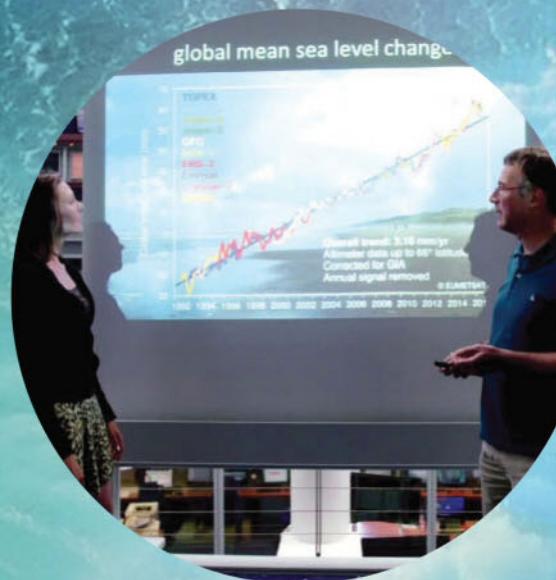
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We've just found half the universe

Leah Crane

THE half of all normal matter in the universe that was unaccountably missing has finally been spotted. This matter – anything made from protons, neutrons and electrons – had never shown up in previous observations of galaxies and stars, even though calculations suggested it must exist.

Two separate teams found the missing matter – comprising particles called baryons – that links galaxies through filaments of hot, diffuse gas. It differs from dark matter, the existence of which still remains a mystery.

"The missing baryon problem is solved," says Hideki Tanimura at the Institute of Space Astrophysics in Orsay, France, leader of one of the groups. The other team was led by Anna de Graaff at the University of Edinburgh, UK.

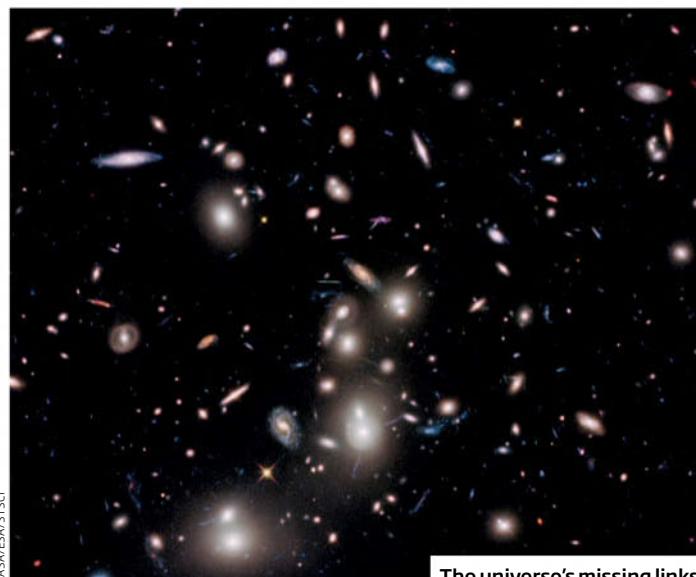
Because the gas is so tenuous and not quite hot enough for X-ray telescopes to spot, nobody

had been able to see it before.

So the two groups had to find another way to show that these threads of gas are really there. To do so, both took advantage of a phenomenon called the Sunyaev-Zel'dovich effect that occurs when light left over from the big bang

passes through hot gas. As the light travels, some of it scatters off the electrons in the gas, leaving a dim patch in the cosmic microwave background – our snapshot of the remnants from the birth of the cosmos.

In 2015, readings from the Planck satellite were used to create a map of this effect throughout the observable universe. Because the tendrils of gas between galaxies are so diffuse, the dim blotches they cause are far too slight to be



The universe's missing links

seen directly on the Planck map.

Both teams selected pairs of galaxies from the Sloan Digital Sky Survey that were expected to be connected by a strand of baryons. They stacked the Planck signals for the areas between the galaxies, making the individually faint strands detectable en masse.

Tanimura's team stacked data on 260,000 pairs of galaxies and de Graaff's group used more than a million pairs. Both teams found definitive evidence of the gas filaments. Tanimura's group discovered that they were almost three times denser than the mean for normal matter in the universe (arxiv.org/abs/1709.05024), while de Graaff's group found they were six times denser – confirmation that the gas in these areas is dense enough to form filaments (arxiv.org/abs/1709.10378v1).

Finally finding the extra baryons predicted by decades of simulations validates some of our assumptions about the universe.

"This goes a long way toward showing that many of our ideas of how galaxies form and how structures form over the history of the universe are pretty much correct," says Ralph Kraft at the Harvard-Smithsonian Center for Astrophysics in Massachusetts. ■

Chemotherapy without the hair loss

INJECTIONS of a hair-promoting protein may be enough to prevent people undergoing chemotherapy from losing their hair.

Hair loss is one of the most feared side effects of chemotherapy. In one study, around 8 per cent of women said they had considered refusing treatment to save their locks.

There are few options available. Scalp-cooling caps freeze and constrict blood vessels to stop chemo drugs from flowing into hair follicles. But they are expensive, work for only

50 per cent of people, extend treatment by two hours and cause discomfort and headaches.

Part of the problem is our limited understanding of how chemotherapy damages hair follicles, says Sung-Jan Lin at National Taiwan University.

His team has been looking at the role of a protein called p53. This protein is activated during chemo and helps to suppress tumour growth, but may also suppress hair growth, since hair cells rapidly divide like tumour cells. A previous study found that mice missing the p53 protein did not shed their fur during chemo.

Lin and his colleagues found that p53 blocks the activity of a hair-promoting protein called WNT3a. This gave them an idea: if you inject

WNT3a directly into the scalp when administering chemo, would it stop hair loss?

The team dosed mice with a common chemotherapy agent. Straight afterwards, they injected WNT3a-soaked beads under the surface of their skin. Sure enough, areas injected with these beads were still coated with thick fur five days after chemo, while areas injected with untreated beads went bald.

When the researchers examined skin under the microscope, they found the protein treatment had doubled

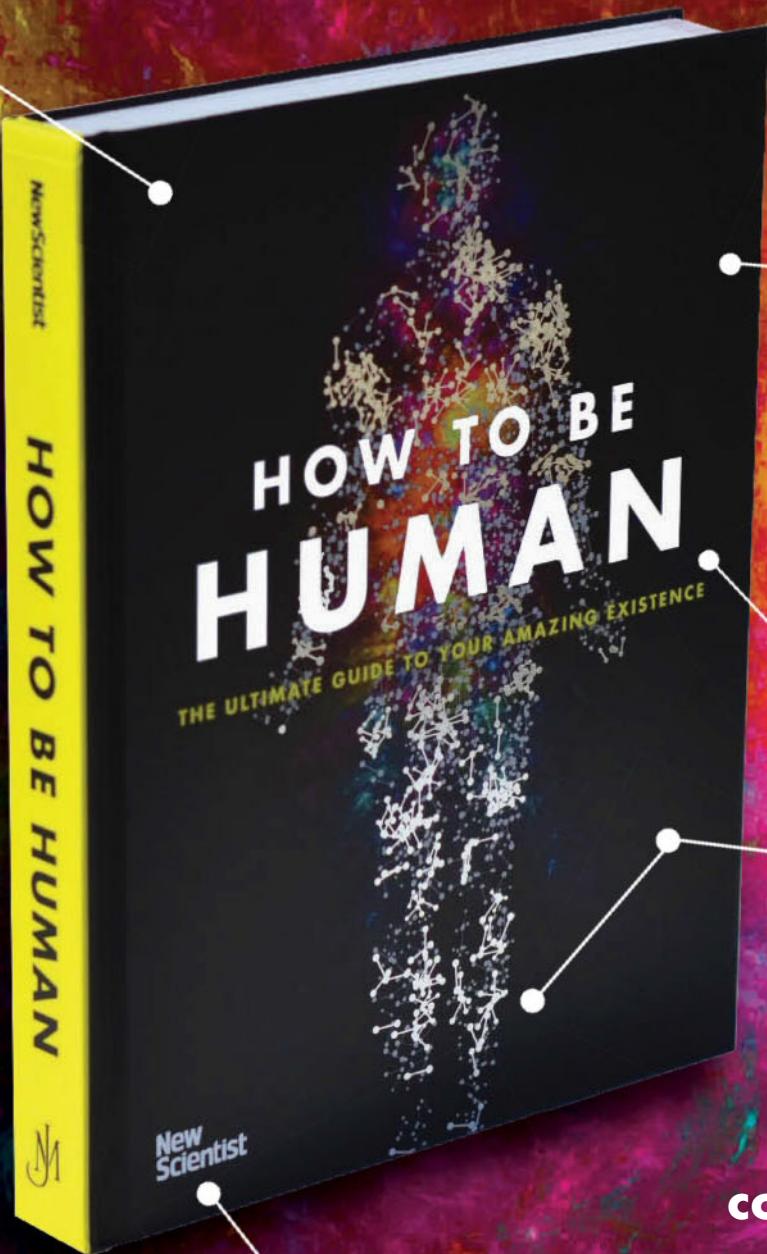
the number of stem cells in the base of hair follicles within a day, allowing more hairs to sprout (*Cancer Research*, doi.org/cdxj).

The team is now working on adapting the treatment for use in people. "We might need to inject it into the scalp using arrays of fine needles so that many of the hair follicles can be covered," he says. The team is also testing compounds designed to activate WNT3a that could be spread over the scalp as a cream or gel.

Richard de Boer, at Epworth Centre in Melbourne, Australia, says the treatment could be a big help. "New hair-saving options that work with all chemotherapy regimens would be very welcome." Alice Klein ■

"Mice injected with the protein were still coated with thick fur five days after chemo"

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Neonicotinoids found in honey from every continent

THE evidence has been mounting for years that the world's most widely used pesticides, neonicotinoids, harm bees and other pollinating insects. Now it seems the problem isn't limited to Europe and North America, where the alarm was first sounded. It is everywhere.

Alex Aeby at the University of Neuchâtel, Switzerland, and his team asked people they knew to bring back honey when they travelled. They got 198 samples from every continent except Antarctica, and tested for pesticides.

Three-quarters of the samples contained at least one of the five neonicotinoids. In 48 per cent of the

contaminated samples, the pesticides were above the minimum dose known to cause "marked detrimental effects" in pollinators (*Science*, doi.org/cdxd).

"Finding neonicotinoids in honey is perhaps not surprising," says Christopher Connolly at the University of Dundee, UK. "But to find neuroactive levels in so many samples at many global sites is shocking."

Bees eat honey to survive winter, so the results imply chronic pesticide exposure. "Recent scientific evidence showed an increased sensitivity to neonicotinoids after frequent or long-term exposure," says Aeby.

In 2013, the European Union temporarily banned the use of neonicotinoids on crops that attract bees. Next month, the European Food Safety Authority will decide if a total ban is warranted.

Expensive nocebos hurt more

MIND the cost. People experience stronger side effects when a treatment seems more costly.

The nocebo effect happens when people have bad side effects after being told there's a chance they might feel them.

Alexandra Tinnermann at the University Medical Center Hamburg-Eppendorf and her team wondered if the price of a treatment might affect nocebo

strength. So they created two packages for the same cream and told volunteers that they treat itchy skin. One package looked like an expensive pharmaceutical product, while the other looked like a cheaper, generic medication.

The participants were shown a cream and told it could increase sensitivity to pain. The team then applied creams to the volunteers' arms, and exposed their limbs to

rising levels of heat.

Those using the cheaper-looking cream said they felt 3 per cent more pain, compared with using a control cream described as having no active ingredients. But those given the "expensive" cream felt nearly 30 per cent more pain (*Science*, doi.org/cdw9).

The findings may help refine how doctors talk to patients about drugs, enabling them to try to minimise the nocebo effect, says Tinnermann.

Snakes know how toxic they are

SNAKES that eat toxic food become toxic – and they know it.

Japan's tiger keelback snakes eat toxic toads and store the toxins in "nuchal glands" on their necks. When threatened, the snake arches its neck, displaying the nuchal glands. If a predator bites the snake's neck it will get a jet of toxic fluid. By contrast, snakes from a toad-free island flee when attacked.

Akira Mori of Kyoto University, Japan, and Gordon Burghardt of the University of Tennessee in Knoxville reared snakes from toad-free and toad-rich islands on different diets. When snakes from the toad-free island ate toads, they responded to threats with nuchal gland displays rather than fleeing (*Journal of Comparative Psychology*, doi.org/gbscv9).

"This is the only example in terrestrial vertebrates where... animals act as if they are aware of when they are toxic and when they are not," says Burghardt.

Treasure trove of new gecko species

A WHOPPING 15 new species of gecko have been discovered in a tiny patch of Myanmar.

This is a huge increase as there are only around 1500 known species of these lizards, famed for the sticking power of their feet.

The new species all live in an area just 90 by 50 kilometres in size. "That's the really amazing thing about it," says Lee Grismer of La Sierra University in California. "They all come from such a small area."

The reason may be the unusual landscape. In an otherwise flat, lowland area, blocks of limestone rise up to 400 metres high. There the geckos evolved in isolation, away from predators on the plains.

The team still has four more species to formally describe.

Albatross teaches drones new tricks

IT'S not every day that an aerospace engineer raises new questions about bird flight. But Abdessattar Abdelkefi and his team at New Mexico State University did just that while trying to devise better drones.

Many large soaring birds like the albatross have wings that are white underneath and black on top. Previous explanations focused on camouflage, says Graham Martin at the University of Birmingham, UK.

But does that colouring really boost endurance in flight? Most soaring needs no flapping of wings; instead, the bird exploits air currents to glide.

Abdelkefi's team discovered that a wing's black upper surface absorbs sunlight very efficiently, causing it to be around 10°C warmer than the lower surface. That effectively lowers air pressure on the upper surface, lowering drag and generating extra lift (*Journal of Thermal Biology*, doi.org/f96ggw).

Svana Rogalla at the University of Ghent, Belgium, says thermography has proved that the dark upper wing gets hotter in sunlight, but it is too early to pin down its effect on drag. The impact of colour on flight could be a further inducement for birds to make costly melanin pigment to darken feathers, she says.

The team hopes the findings will help them design more efficient and durable drones for use at sea.



FRANS LANTING/NATIONAL GEOGRAPHIC CREATIVE

Hot gas from lava lakes gave the early moon an atmosphere

MASSIVE volcanic eruptions on the surface of the moon 3.5 billion years ago released enough hot gas to create an atmosphere that took 70 million years to leak away.

We knew that the magma ocean covering the newborn moon 4.5 billion years ago released vapours of sodium and silica that formed a short-lived atmosphere. Now it seems a second one arose 1 billion years later due to eruptions flooding a large crater to form the lava plain Mare Imbrium.

Recent studies have revealed volatile material embedded in

lunar volcanic glass collected by Apollo astronauts. The glass hinted that the large volcanic eruptions that formed the lunar basins 3.8 to 3.1 billion years ago also emitted large amounts of gas.

Debra Needham and David Kring at the Lunar and Planetary Institute in Houston, Texas, have calculated these emissions based on the estimated volumes of the lava flows. The largest emission was the roughly 10 trillion tonnes of gases that erupted along with the 5.3 million cubic kilometres of lava that filled the Imbrium basin.

That would have raised lunar air pressure to about 1 per cent that of modern Earth, or 1.5 times as dense as the atmosphere on Mars today (*Earth and Planetary Science Letters*, doi.org/cdw). Within 70 million years, all the atmospheric gas escaped or froze out in the polar regions.

James Day of the Scripps Institution of Oceanography in California says this atmosphere formation process could account for the distribution of water and other volatiles on the surface of the moon.

3D atomic clock is most precise ever

THE most accurate atomic clock yet has been made by putting strontium atoms in grid-like patterns and stacking them.

Most atomic clocks use atoms of the isotope caesium-133. Time is measured in microwaves emitted by the electrons around those atoms jumping from a lower to higher orbit as they absorb and then lose energy from a laser.

But caesium electrons have a speed limit: they can only jump back and forth 9 billion times per second. The electrons in strontium atoms can transition nearly 1 million billion times per second.

Jun Ye at the University of Colorado at Boulder and his team built a strontium clock so precise that out of every 10 quintillion ticks only 3.5 would be out of sync – the first atomic clock ever to reach that level of precision (*Science*, doi.org/cdwx).

The team put atoms into a 3D lattice structure that let them measure more atomic signals at once within the width of the laser beam. They cooled the structure to -273°C, which turned the atoms into what's called a quantum gas. Instead of colliding, the particles "move like waves – they start to avoid each other," Ye says.



GARRY BURCHELL/GETTY

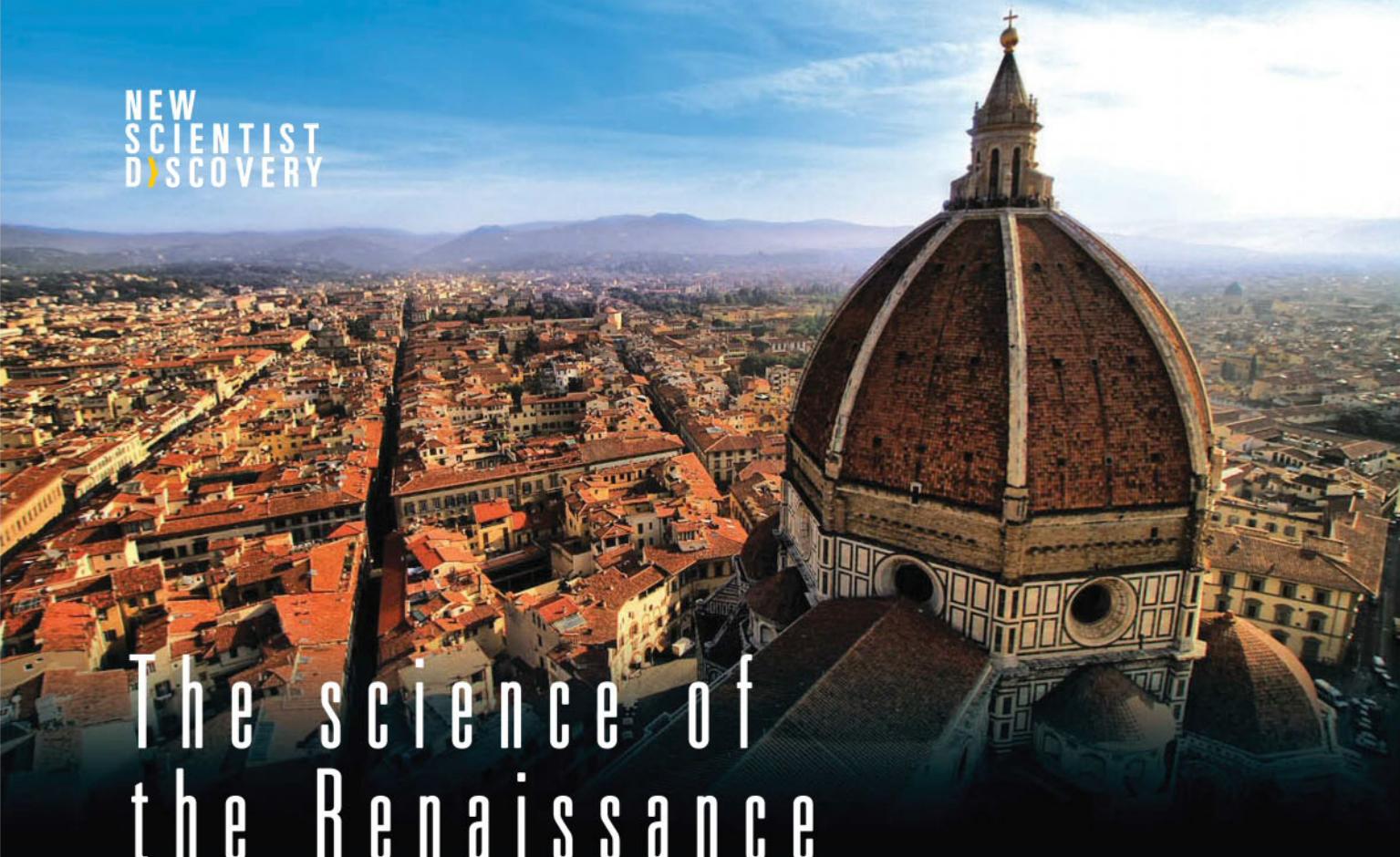
Train your brain with meditation

DIFFERENT types of meditation have distinct effects on the brain. Tania Singer at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, Germany, and colleagues looked at how three meditation techniques affected the brains and bodies of more than 300 volunteers over nine months.

One technique was based on mindfulness meditation, a second concentrated on compassion and emotional connection with a partner. A final method encouraged people to think about issues from different points of view. MRI scans taken after

each three-month course showed that parts of the cortex involved in the specific skill that was trained grew thicker in comparison with scans of a control group. For example, mindfulness increased the thickness of the prefrontal cortex and parietal lobes, which are linked to attention control. All the brain changes were matched by improvements in tests of the relevant skills (*Science Advances*, doi.org/cdw7).

The study suggests meditation courses could be designed like exercise regimes, focusing on particular weaknesses.



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SHOW TIME!

With 140 talks, six stages and hundreds of exhibitors showcasing everything from giant insects to next-generation robots, our festival of ideas was packed with high points – and attracted 30,000 visitors. Rowan Hooper attempts to summarise the New Scientist Live experience

ON FRIDAY 29 September at 2 pm, a hush fell over the main stage at New Scientist Live. On the big screen we saw the European Space Agency mission control room near Munich, Germany. A voice came through. "European Space Agency, this is Houston. Are you ready for the event?" With the legendary words "this is Houston", we knew we were involved in something special. Then the picture cut to astronaut Paolo Nespoli, floating in the International Space Station. There was a collective intake of breath, then cheers and whoops broke out: we were talking to someone in space!

For some, this was the highlight of the four-day event. For others it was seeing a colony of naked mole rats, or Wayne McGregor creating a science-inspired dance. I'll try to pick just a few others from what was an awe-inspiring experience.

Doug Turnbull from the University of Newcastle gave a moving presentation on the technology now available to treat mitochondrial disease. Demis Hassabis of Google DeepMind revealed the power of artificial intelligence and its ability to unlock human potential. Sean Carroll of the California Institute of Technology spoke about what happened at the origin of the universe, and blew everyone's minds. And Margaret Atwood shared her thoughts on science and fiction, and came out with this gem on stage: "I'm here," she said, "because I read *New Scientist*."

It was thrilling to see the enthusiasm for science filling the show. "It's amazing," said neuroscientist Adrian Owen. "And it's great for science, especially at the moment."

Thanks to the more than 30,000 of you who helped make the show such a success: see you again in 2018.

Rowan Hooper was creative director of New Scientist Live 2017



"Inspiring to see so many children involved. Catching the imagination of the next generation of scientists"

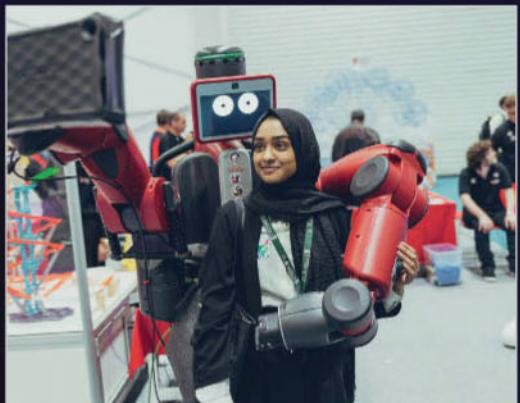
New Scientist Live attendee Jane Sill

New
Scientist
Live



"What a wonderful, inspiring day of discovery!"

New Scientist Live attendee Charlotte Middlehurst



"I'm here because I read
New Scientist"

Margaret Atwood

The money machine

Financial markets are dominated by robots and the age of the human trader is fading. So what happens next, asks **Sally Adee**

ROBOTS are taking over Wall Street. "Technology has utterly transformed the financial system," says Andrew Lo, an economist at the Massachusetts Institute of Technology. "The vast majority of day-to-day trading is done purely algorithmically."

More and more human traders are being shown the door. And researchers like Lo are beginning to find that the more the stock market is run by machines, the less it behaves like one. Today's markets are an ecosystem, a zoo of bots grazing on our pensions and investments – and no one quite knows how they work.

Is this newly autonomous market a route to financial prosperity, an end to boom and bust? Or are we a few lines of code away from financial doom?

To understand why machines are taking over, it helps to look at how perceptions of the stock market have changed following the financial crisis of 2007–08. It is increasingly clear that for the average person, investing is a mug's game. Individuals have little hope of picking successful firms to back, while giving your money to investment managers who aim to beat the market often sees any gains being eaten away by a laundry list of opaque fees.

The alternative, espoused by the likes of finance tycoon Warren Buffet, is to invest in index funds. A market index is a collection of companies that give a snapshot of the market's value at any given time, like the FTSE 100 and the Standard & Poor's 500.

Largely because the stock market as a whole has been on the rise since the financial crash, index funds have become a no-brainer. They are also much cheaper, essentially run by

software that follows simple rules to track the index, with little human direction.

These low-cost, "passive" investments are starting to crowd out conventional, actively managed funds. Over the past three years, passive funds added nearly \$1.3 trillion to their coffers, according to analyst Morningstar, while actively managed funds lost about \$250 billion. "There's so much money going into passive funds," says Frank Pasquale, who studies the impact of technology on finance at University of Maryland School of Law.

But paradoxically, active funds may be growing in influence. Passive funds can't decide when to buy or sell a stock, because they only follow the market, meaning they essentially follow the lead of active trading. "Active funds have a disproportionate impact on markets," says Lo.

That doesn't mean humans are in control. Like the rest of the stock market, most active funds are run by algorithms that move faster than human brains can

comprehend. And that's where the real trouble starts.

The most extreme active funds are hedge funds, which number in excess of 9000 globally. These are in constant churn – new funds begin every day to exploit opportunities, while others close because their strategy failed. "It's the Galapagos Islands of finance," says Lo.

The latest evolutionary niche is occupied by algorithms that scour markets for patterns that yield a competitive edge. Before that, it was high-frequency trading (HFT) – the subject of much hand-wringing a few years ago.

Unforeseen crash

On 6 May 2010, the Dow Jones Industrial Average fell 600 points in 5 minutes and share prices became incomprehensible for half an hour. Authorities initially blamed unforeseen interactions between HFT algorithms, with no single identifiable culprit. Then, two years ago, the US Department of Justice filed

charges against one trader, saying his bots spoofed the market and caused the chaos.

Fears of HFT have since faded. Tom Lin, a lawyer at Temple University in Philadelphia who specialises in financial technology and regulation, says this is partly down to them falling out of the media hype cycle, but also because now everyone uses them, they are less profitable.

But other fears remain. "The symbiosis between technology and finance has accelerated the pace of the financial markets beyond mere human capacity at all levels of the financial system," says Lo. "Whatever can go wrong, will go wrong, and faster and bigger when computers are involved."

Even when all the algorithms are behaving exactly as they're meant to, financial technology has brought us fire sales, flash crashes and catastrophic algorithmic trading errors.

On 15 October 2014, the US Treasury market crashed for about 10 minutes. Experts hypothesised that "activities of electronic trading algorithms" bore part of the blame, but reserved judgement for when they had more information. Three years later, no one is any wiser.

What this flags up, says Lo, is that it's not so much the individual rogue algorithms we need to worry about any more. Rather, it's the way they reinforce and affect one another, which can quickly snowball, even when everything is working as it should be. "We don't understand the network," he says. When everything is interconnected, a financial crisis could start anywhere and affect anyone. "We have no map of the entire



QILAI SHEN/PHOTO

Gone to lunch, or just gone?



MICHAEL NAGLE/BLOOMBERG VIA GETTY

Oops, beaten by a computer again

system. Even the regulators probably don't," says Lo.

So he has a solution: when surveying the financial world, we need to study it the way an ecologist might. Within the financial landscape, investors, managers, regulators and policy-makers are simply

"Whatever can go wrong, will go wrong, and faster and bigger when computers are involved"

individuals who innovate, compete, adapt, reproduce (their ideas) and evolve, he says. "What are the keystone species? The predator-prey dynamics? We need to see how different agents evolve and adapt in response to the actions of the others."

But when today's technology

can compress the entire life cycle of a stock market crash and rebound into fractions of a second, how can we keep up? We can't, says Lo, without the laws that govern biology.

For example, natural selection tells us that if a pool of organisms is more diverse, it is more likely that one of them will develop an adaptation that is exquisitely suited to its environment.

But that's not what's happening with investors flocking to index funds. A larger pool of assets is simply following the market. That means less diversity in trades. As these passive funds accrete more people and their money, a problem emerges that would be familiar to any ecologist: they are forming a monoculture. When every investor is doing

the same thing at the same time, the rapidly evolving hedge fund algorithms seem like they're poised for a big lunch.

Algorithmic zoo

So what happens when the monoculture collapses? If the market starts to tank, and passive funds follow it down while the hedge funds munch on the remains, investors are likely to take out their assets and put them into cash. To understand how and when such a freak-out might start, Lo wants to add humans, and our irrational biases, to the algorithmic zoo.

At the end of September, Lo presented a paper at the *Journal of Investment Management* conference in Boston that does exactly that: it models the most

relevant human biases and how they interact, with a view to predicting the forces these human algorithms exert on the markets. For example, there's the sunk-cost fallacy – the more one has invested in something, the harder it becomes to abandon it.

Armed with this information, we can develop more adaptive regulations. If, for example, it looks like irrational exuberance is causing the system to become too dependent on some particular kind of index fund, it might become beneficial to encourage greater diversification in the industry by closing certain funds to new investors.

Many have lauded Lo's ideas, but Pasquale isn't so sure the solution is biology. "People think all this complexity is somehow inevitable. It's not. It's there to shield wealthy and powerful people when things go wrong."

He says there's an easier way to understand these complex markets – regulate the market environment back to the low-complexity 1920s. "I'm not fan of HFT," he says. "I'd tax them so hard they'd become economically infeasible."

Ultimately, we need to decide what purposes we want the markets to serve, says Lin. "The toughest questions in finance and AI right now are not about the technology itself, but about what kind of human values and ethics we want to embed into the world's financial systems." Lin likens the problem to the philosophical debates surrounding the introduction of driverless cars.

The upshot is that the model of the stock market that has been in place since the 1930s is being upended by our new robot masters of the universe – it just doesn't work the way it used to. Since the crash, the market has been rising steadily. Is that because the machines are doing a better job, or is this yet another cyclical bubble? We just can't know, and won't know until the whole thing goes bang. ■

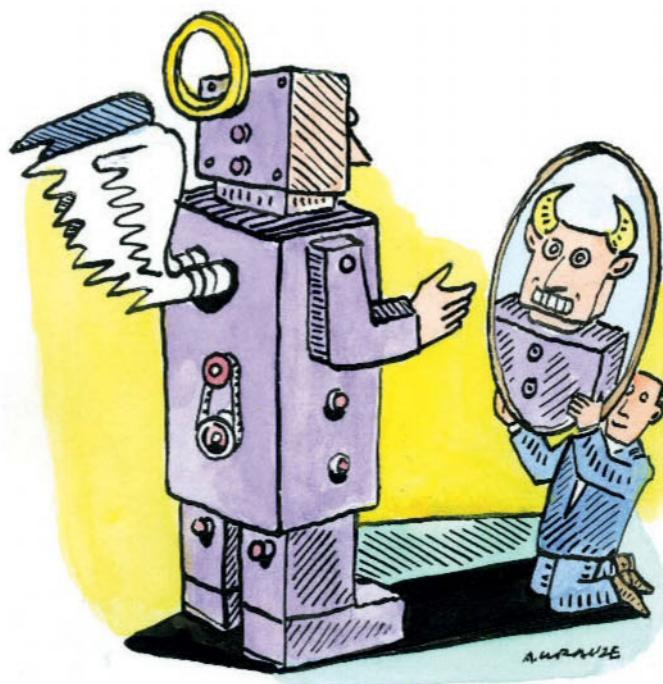
Heaven or hell?

A Silicon Valley whiz kid apparently wants to develop a benign digital deity. What could go wrong, wonders **Jamais Cascio**

FOR AI engineer Anthony Levandowski, the idea that a future superintelligent machine would be god-like is neither a metaphor nor a science fiction trope. It's a goal, apparently.

Levandowski co-founded a self-driving truck firm bought by Uber in 2016 and worked on Google's self-driving car, so knows a thing or two about AI. His non-profit religious organisation, the Way of the Future, reportedly seeks to "develop and promote the realization of a Godhead based on artificial intelligence and through understanding and worship of the Godhead contribute to the betterment of society". Although registered in 2015, its existence was recently revealed in *Wired*.

The idea of working on an AI-based "Godhead" may be less outlandish than it seems. Behind it could lie a modified version of Pascal's wager: the notion that,



based on possible gains and losses, it is rational to believe in a deity even if it might not exist. If superintelligent machines are possible, they would be likely to reward you for bringing them about. If they aren't, then you've still advanced computer science.

Levandowski, yet to publicly spell out the details of his movement, is far from alone in believing that the emergence of superpowerful AI could change the world. Technologists see it as a transformative "singularity": an explosive advance that leaves humans playing second fiddle.

While lots of people will dismiss Levandowski's reported goal as odd, if you subscribe to the idea that a true AI is possible, it isn't that outrageous. In many ways, it is a struggle to describe the potential capabilities of a superintelligent entity in ways that don't sound religious. But

A net loss

Banning US shark fin sales could do more harm than good, warns **Lesley Evans Ogden**

ONE of the most controversial topics in shark conservation is finning – cutting off their fins and dumping the body at sea. US law bans this. Sharks caught in US waters must be landed and documented before fins can be removed for sale. Despite this, illegal finning does go on there, and caterers and restaurants are

free to dish up shark fin soup. Finning is widely seen as inhumane and wasteful. But that's often where agreement ends. Among scientists, there is growing division over a proposal before the US Congress to ban trade in fins within the nation's borders. Some say this would harm conservation efforts.

Among those questioning the proposal are David Shiffman at Simon Fraser University in Canada and Bob Hueter of Mote Marine Laboratory in Florida. While applauding its goal – saving threatened species – they think a blanket prohibition on possessing, buying or selling fins in the US is unwise.

They argue that this would undermine decades of progress towards sustainable shark fisheries there and elsewhere.

'It's time to consider putting 'made in the USA: sustainably sourced shark fin soup' on the menu'

Some of the most sustainable shark fisheries are in the US. These would be less viable if they were unable to sell fins, most of which would have to be binned.

That seems counterintuitive for a conservation measure designed to combat not just inhumane treatment, but waste. The risk is that sustainable US shark catches will decline and unsustainable ones in other nations will take up the slack. Those fisheries are more likely to be catching species of shark facing extinction.

A US ban could also further a misconception that demand for shark fin soup is the only threat facing sharks. About a quarter of

will all be as benign as imagined?

Levandowski isn't the only person working towards a singularity-strength AI. If this is achievable, we are therefore likely to see a multitude of them – a pantheon, if you will – rather than a single digital deity. Programmed by groups with varied goals and ethics, it isn't difficult to imagine rivalries between the resulting machines. Fights between gods rarely work out well for mortals, at least according to mythologies.

There is another reason to take talk of an AI god seriously: the philosophical concept called Roko's Basilisk. This asserts that anyone who knows that a superintelligent, godlike AI is possible but doesn't work to bring it about will be considered by said AI to be an enemy.

According to this concept, not knowing about the possibility of super-AI or the implicit responsibility to create it may give you a get-out clause come judgement day. Unfortunately, now you have heard of Roko's Basilisk, you must either help lay the ground for a machine overlord or be doomed should it come about. Sorry about that. Maybe Levandowski got the memo too. ■

Jamais Cascio is a distinguished fellow at the Institute for the Future

the world's 400-plus shark species and their relatives are threatened with extinction. For sharks, "overfishing is a major problem", the greatest threat, says Shiffman.

Banning the fin trade in the US could harm conservation efforts that promote sustainable fisheries at home and abroad and that ensure fin products sold in the US can be traced to such sources. It might be a tough suggestion to swallow, but it's time to consider putting "made in the USA: sustainably sourced shark fin soup" on the menu. ■

Lesley Evans Ogden is a science writer in Vancouver, Canada

INSIGHT Gun control

DANIEL HERNANDEZ/GETTY



Bad for health

How the US can learn to live with its guns

Jessica Hamzelou

THE horrific scenes in Las Vegas may represent the worst mass shooting in recent US history, but it's a familiar story. Gun violence is responsible for 33,000 deaths in the US each year.

For those elsewhere, the solution is obvious: ban guns. After all, it worked in Australia. But in the US, gun control is so heavily politicised that a ban is impossible any time soon.

Meanwhile, the death and injury rate is so high that firearm violence is now considered a public health crisis by the American Medical Association. So if the nation can't address the cause of its firearms epidemic, it must treat the symptoms.

To do that, people need to be able to study which interventions produce the most beneficial outcomes. Such research played a key role in limiting harmful effects of cars and tobacco.

But US research into firearm violence has been stalled thanks to a law passed in the 1990s, which states that the US Centers for Disease Control and Prevention can't use public funding for work that might promote gun control. Previous US president

Barack Obama's attempts at changing this did little to improve the situation.

That shouldn't dissuade people, though. David Hemenway at the Harvard T.H. Chan School of Public Health points out that every health success story today had its early detractors. "The first was sanitation," he says. "People argued: 'no, I want to keep the poop in my city'."

And while the National Rifle Association may be one of the most powerful lobbying groups around, the same could be said of the tobacco lobby, which hasn't been able to block

"Firearm violence is now considered a public health crisis by the American Medical Association"

cigarette package warnings, which have been shown to reduce smoking.

In the meantime, it might be better to avoid knee-jerk, politicised arguments surrounding gun control. The Las Vegas death toll stands at 59, but while the news headlines scream and talking heads pontificate, a similar number of gun suicides takes place in the US every day – two-thirds of gun

deaths are suicides. Why not start by focusing on ways to reduce those?

Gun sellers can take an active role. "If a person says that they don't care what kind of gun they buy, and that they only need one bullet, don't sell them the gun," says Hemenway.

Doctors also have a part to play. If a doctor suspects that one of their patients may be having suicidal thoughts, they have a duty to ask them about their access to firearms. People with guns at home should be advised to safely store them somewhere else temporarily.

A "gag law" enacted in Florida briefly prevented health practitioners from discussing gun safety with their patients. But doctors breathed a sigh of relief when the legislation was invalidated in February. Similar legislation has been proposed in other states, but the gag law's failure in Florida suggests it won't pass elsewhere.

As with any public health crisis, it will come down to multiple groups of people. Governments can enact state laws and gun manufacturers could share responsibility for the kinds and quantities of firearms they sell. Academics can push forward with research to find the most effective ways to reduce the death and injury rates, while local communities and faith leaders can work to monitor those at risk, and to support parents. "Everybody has to play a role," says Hemenway. ■

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Load of rubbish

THIS is more than just any old pile of garbage - it "emanates a strange beauty", according to Belgian photographer Paul Bulteel, who wants to put a positive spin on rubbish.

The materials, photographed at recycling plants across Europe, are destined for future products. "Photos of waste are almost always taken from a negative point of view," he says. "The positive aspect of recycling has not been documented as thoroughly."

Bulteel, a retired engineer, spent over a year visiting 50 recycling centres. He was surprised by the range of companies in this sector today, and the unexpected aesthetics of rubbish.

The main image, for example, shows bales of polypropylene, a polymer extracted from carpets that can be repurposed to make felt. The colourful image below is of shredded polyurethane, which can be reused in packaging and soundproofing.

Bulteel, whose photos are now on show at the Anastasia Gallery in New York City, hopes viewers will become more aware of how much they discard. Worldwide, the average person chuck away around 1.2 kilograms of rubbish every day.

Another motivation is to boost recycling, particularly in countries like the US, whose rates are well behind those of Western Europe. The images from this project are collected in a photobook, *cycle & recycle*. Jessica Hamzelou



Photographer

Paul Bulteel

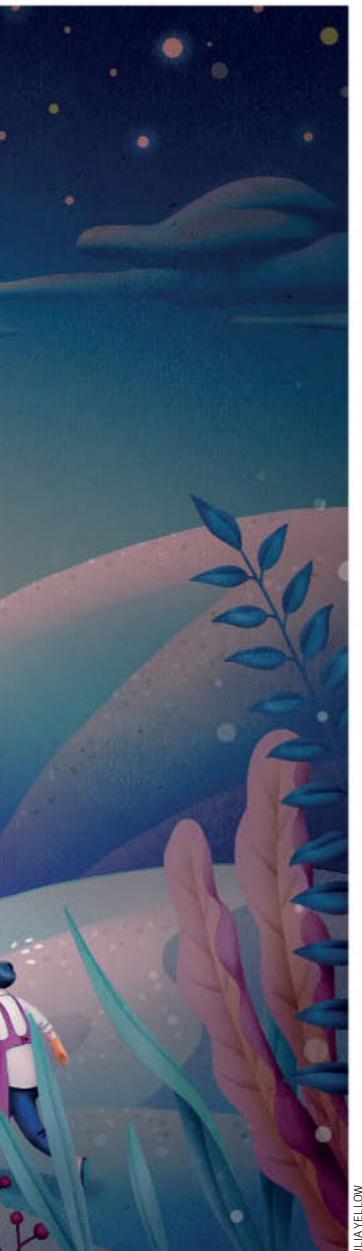
paulbulteel.eu

Images courtesy of the Anastasia Gallery

Sleep the good sleep

The role of sleep in causing Alzheimer's disease is undeniable, says Matthew Walker. Here's how you can protect yourself





JULIA YELLOW

I DON'T mean to pry, but how much sleep did you get last night? What about over the past week? I ask because the answer could have serious consequences for your future mental health.

More than 44 million people worldwide currently have Alzheimer's disease, including members of my own family. The health, economic and personal impact is staggering. There has been a marked acceleration in the number being diagnosed with the disease as the human lifespan has increased, but importantly, as total sleep time has decreased.

As a sleep scientist, I became interested in this connection some years ago. What I have found is striking. Not only does sleep disruption play a role in the declining mental abilities that typify Alzheimer's disease, but getting enough sleep is one of the most important factors determining whether you will develop the condition in the future.

The implications are huge. We are quickly filling in missing pieces of the Alzheimer's puzzle, and now we also recognise that sleep offers a route for diagnosis, therapy and even prevention.

As we age, our sleep gets worse. This is especially true for the quality of our deep, non-rapid eye movement (NREM) sleep (see chart, page 32). Unfortunately, this is the very type of sleep that we now know helps fix new memories into the architecture of the brain, preventing you from forgetting.

But if you assess a patient with Alzheimer's disease, the disruption of deep sleep is exaggerated. More telling, perhaps, is the fact that sleep disturbance precedes the onset of Alzheimer's by several years, suggesting that it is an early warning sign of the condition – or even a contributor. After diagnosis, the magnitude of sleep disruption progresses in lockstep with the severity of the symptoms, further suggesting a link between the two.

However, it was only recently that we realised this relationship is more than just a correlation. While much remains to be understood, we now recognise that sleep disruption and Alzheimer's interact in a cycle that can initiate and accelerate the condition.

Alzheimer's disease is associated with the build-up of a toxic form of protein called beta-amyloid, which aggregates in sticky clumps, or plaques, within the brain. Amyloid plaques are poisonous to brain cells, impairing their function and ultimately killing them. What is strange, however, is that amyloid only attacks some parts of the brain and not others, the reasons for which remain unclear.

What struck me about this very selective

pattern is the location in the brain where amyloid plaques accumulate early in the course of Alzheimer's disease, and most severely in the late stages: the middle part of the frontal lobe. If you place your finger on the bridge of your nose, then move it up about 5 centimetres, you are pointing directly at it. This was relevant to my research: this brain region is essential for the electrical generation of deep NREM sleep.

Back in 2007, I wondered whether the reason Alzheimer's patients have such impaired deep NREM sleep was, in part, because the disease erodes the very region of the brain that normally generates this key stage of slumber. At my sleep research centre at the University of California, Berkeley, we set about testing this idea.

A decade later, having assessed the sleep of hundreds of people between 65 and 90 years of age with varying degrees of amyloid build-up in the brain, we have arrived at the answer: the more amyloid deposits there are in the middle regions of the frontal lobe, the more impaired that person's deep-sleep quality. Importantly, the link with amyloid

"Could sleep be used to spot people at risk of Alzheimer's decades in advance?"

plaques was not simply a general loss of deep NREM sleep – the latter being common as we get older. Instead, the disease was robbing these people of the very deepest slow brainwaves of NREM sleep.

This highly selective loss of deep slumber meant that the sleep impairment caused by toxic amyloid build-up in the brain was more than just "normal ageing". It was unique.

With that in mind, part of my research is now focused on diagnostics. In particular, we want to know if that specific "dent" in sleeping brainwave activity can be used to spot those people at greatest risk of developing Alzheimer's years or even decades in advance. If sleep does prove to be an early warning sign – especially one that can be spotted relatively cheaply, non-invasively and for large numbers of people, unlike with brain scans – then early intervention becomes possible.

Building on these findings, we began to look at another missing piece in the puzzle of Alzheimer's disease: how does the build-up of toxic plaques contribute to memory loss?

We know that the amyloid deposits only accumulate in some parts of the brain. ➤

Mysteriously, the hippocampi – key memory reservoirs in the brain – are largely unaffected. So how can the toxic amyloid deposits cause memory loss in Alzheimer's disease when they do not affect these memory areas? This question has so far baffled scientists.

It seemed plausible to me that sleep disruption was a missing link. We already knew that in young healthy adults, the slow brainwaves of deep NREM sleep effectively hit the “save” button on new memories, helping us retain what we have recently learned. Sleep also helps us access and thus remember past experiences.

If amyloid was blocking deep NREM sleep in Alzheimer's disease, then perhaps this loss of youthful deep sleep prevents older adults from being able to save new memories and hold on to experiences past?

To test this idea, we had elderly Alzheimer's patients with varying levels of amyloid in their brains learn a list of new facts in the evening. The next morning, after we had recorded their sleep in the lab during the night, we tested the individuals to see how effective their sleep had been at cementing and thus holding on to those new memories.

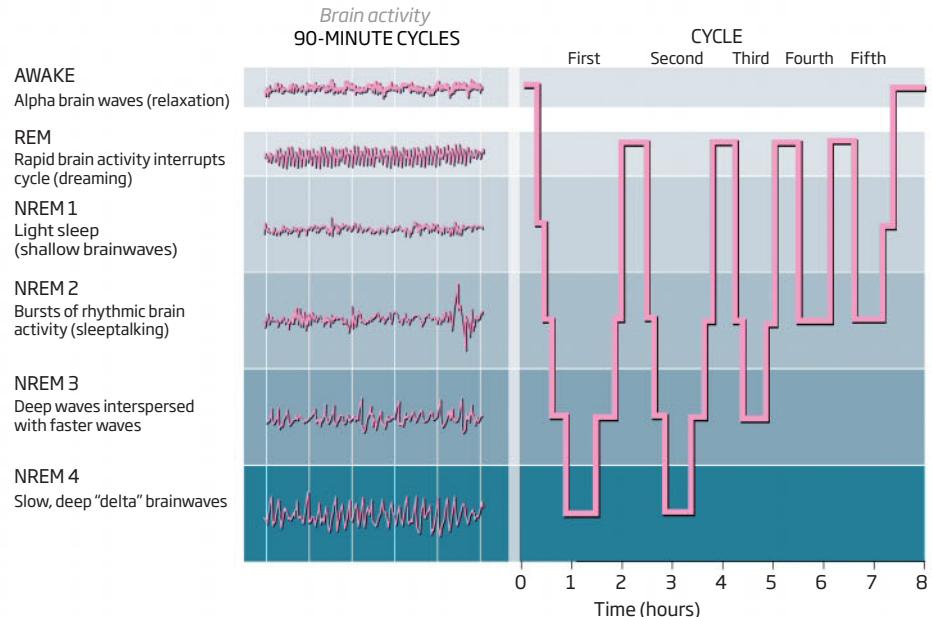
We found that those with the highest levels of amyloid deposits in the middle frontal regions of the brain had the most severe loss of deep sleep and, as a consequence, failed to successfully “save” those new memories. Overnight forgetting, rather than remembering, had taken place. The disruption of deep NREM sleep is therefore a hidden middleman brokering the bad deal between amyloid and memory impairment associated with Alzheimer's disease.

However, this was only half of the story – and admittedly the less important half. Our work had shown that the amyloid plaques of Alzheimer's disease may be associated with the loss of deep sleep, but can a lack of sleep actually cause amyloid to build up in your brain? If this were true, we would all have to accept a sobering fact: failing to get enough sleep, night after night, year after year, would increase the build-up of amyloid in your brain, and directly increase your risk of developing Alzheimer's disease.

Around the time that we were conducting our studies, Maiken Nedergaard at the University of Rochester, New York, made one of the most spectacular discoveries in the field of sleep research in recent decades. Working with mice, Nedergaard found that a kind of waste network called the glymphatic system exists within the brain, composed of glial cells that position themselves around the neurons

Sleep cycles

Sleep comes in five distinct stages. A typical night involves several periods in the deeper stages, which are most restorative



that generate electrical impulses. Just as the lymphatic system drains contaminants from your body, the glymphatic system uses cerebrospinal fluid to collect and break down harmful metabolic debris generated by the hard work of your neurons.

Although the glymphatic system is somewhat active during the day, Nedergaard and her team discovered that it is during deep NREM sleep that this sanitisation system kicks into high gear. With the pulsing rhythm of deep NREM sleep, the brain expels 10 or 20 times more effluent. Consider it a night-time power cleanse of sorts.

If that were not remarkable enough, Nedergaard made a second discovery that explained why cerebrospinal fluid is so effective in flushing out metabolic debris at night. During deep NREM sleep, the brain's glial cells were shrinking in size by an astonishing 60 per cent. That created greater space for the cerebrospinal fluid to clean out the metabolic refuse. You can liken it to the buildings of a large metropolis magically shrinking in size at night. The municipal cleaning crews then have easier access to remove the day's rubbish, followed by a good pressure-jet treatment of every nook and cranny.

What does this have to do with Alzheimer's disease? Nedergaard showed that one piece of toxic debris washed away by the glymphatic

HOW MUCH IS ENOUGH?

Getting enough sleep could play a crucial role in protecting your brain from Alzheimer's disease (see main story). But how much do you need? Most adults need a recommended 7 to 9 hours a night, according to the US National Sleep Foundation. But as we age, the amount of sleep we need does change. An 18-year-old, for instance, might need anywhere between 6 and 11 hours. Older adults appear to need as much sleep as younger adults, but struggle to get it. As a general rule, you shouldn't need to set an alarm to wake up in the morning. If you do, you probably aren't getting as much sleep as you need. What's more, time in bed doesn't equal time asleep. Try aiming for 8 hours in bed for a good night's rest.



DAVID LEE/MILLENNIALIMAGES.UK

system during sleep is amyloid protein – the very damaging element associated with Alzheimer's disease. That finding fitted with another remarkable discovery. David Holtzman at the University of Washington in St Louis and his team prevented mice from getting deep NREM sleep, keeping them awake instead. They saw an immediate increase in the amount of amyloid in the rodents' brains.

Of course, there are some significant differences between mice and humans. Is the same really true if we skimp on our sleep? Alarmingly, in July, Holtzman showed this to be so. His team deprived otherwise healthy adults of their deep NREM sleep, but kept total sleep time the same. To do this, they waited until the subjects entered this phase of sleep and then played sub-awakening sounds that would lift the brain out of deep sleep, but not wake them up. The next day, they measured the amount of amyloid within the volunteers' spinal fluid. Without the cleansing benefit of deep NREM sleep, they found a significant escalation of Alzheimer's-related amyloid.

It was damning evidence that a lack of deep sleep will cause a direct and immediate increase of amyloid in the human brain. Simply put, sleep is our neurological salvation – or, perhaps, sanitation.

These findings proved that inadequate sleep and the pathology of Alzheimer's disease causally interact in a vicious cycle. Without

enough sleep, amyloid builds up in the brain, especially in deep-sleep-generating regions. The ensuing loss of deep NREM sleep further prevents the removal of amyloid from the brain at night, resulting in greater amyloid accumulation. More amyloid, less deep sleep; less deep sleep, more amyloid, and so on.

Universal truth

This all leads to a concerning prognosis: getting too little sleep across your lifespan will significantly raise your risk of developing Alzheimer's disease. This is true regardless of whether you are already predisposed to getting it. Unfortunately for the under-slept masses, precisely this relationship has now been reported in numerous epidemiological studies. You are at even higher risk if you have an untreated sleep disorder such as insomnia or sleep apnea.

Invert these findings, however, and a radically hopeful prediction emerges. By improving someone's sleep, we should be able to reduce their risk of developing Alzheimer's disease – or at least delay it.

Early support for this idea has emerged from clinical studies with middle-aged and older adults who have sleep disorders, but have not yet transitioned into Alzheimer's disease. When their sleep problems were successfully treated, their rate of cognitive

7.9

Average hours
of sleep per
night in 1942

6.8

Average hours
of sleep per
night in 2013

FIGURES ARE FOR THE US. SOURCE: GALLUP

decline slowed, delaying the onset of Alzheimer's by up to 10 years.

So improving sleep quantity and quality helps battle back the approaching onslaught of the disease. For those who are healthy without sleep issues, this means carving out more time to sleep – ideally a solid 8-hour opportunity each night (see "How much is enough?", left).

But what about those individuals for whom sleep is difficult, or due to ageing and dementia, physiologically not possible? Medication does not appear to be the answer. Current sleeping pills do not produce naturalistic sleep, and are associated with higher rates of mortality and cancer.

My research group is now trying to develop a number of electrical brain-stimulating methods for amplifying deep NREM sleep in older adults and those with dementia. Like a support choir to a flagging lead vocalist, we are trying to electrically "sing" in time with weakened sleep brainwaves, artificially boosting their size. We hope that by restoring some deep sleep, we can salvage aspects of learning and memory that have failed in older individuals and those with dementia.

That is treatment, but my goal is prevention. If we are successful in our smaller trials, I aim to develop a method that is cost-effective and can be scaled up to population level for repeat use. The ideal would be to begin supplementing the declining deep sleep of vulnerable individuals during mid-life, many decades before the tipping point where Alzheimer's is inevitable. I admit it is a lofty ambition – even a foolhardy one – but when one sees family members dealing with the disease, it becomes an imperative.

To be clear, insufficient sleep is only one of several risk factors associated with Alzheimer's disease. Sleep alone will not be the magic bullet that eradicates dementia. Nevertheless, prioritising sleep – however old you are – is a clear way of lowering your risk of developing Alzheimer's disease. That's a fact well worth waking up to. ■

Matthew Walker is director of the Center for Human Sleep Science at the University of California, Berkeley. His new book is *Why We Sleep* (Allen Lane)

The next supercontinent

The formation of a new mega land mass is just a matter of geological time. But what will it look like, asks Stephen Battersby

ASIA is torn in two. The Atlantic and Pacific oceans are swallowed. Where once there were beaches, great mountain ranges judder into the skies, fusing together a scatter of separate land masses into one mighty new supercontinent. Call it... Aurica.

That's what João Duarte calls it, anyway. A geoscientist at the University of Lisbon, Portugal, he has his own distinct vision of how Earth may look 250 million years from now. He joins a band of fortune tellers gazing into the distant future, all with different ideas about how and where the next supercontinent will form, and what cataclysms might strike along the way.

The answer will determine Earth's future climate and prospects for sustaining life. But getting it right requires grappling with a machine whose workings we still understand only imperfectly: that of plate tectonics.

Earth's surface is clad in rigid rock plates – together called the lithosphere – formed of surface crustal rock laminated on to hard cold mantle rocks. Given their rigidity, it is surprising that these plates don't simply lock together, unmoving. And indeed, until about 50 years ago geologists thought that Earth's land masses were fixed, despite German geophysicist Alfred Wegener having proposed the idea of continental drift in 1915.

The creation and destruction of ocean basins makes plate motion possible. Plates move apart at mid-ocean ridges, where molten rock rises and cools to form hard, dense basalt. They move together at subduction zones, where old ocean lithosphere plunges under a neighbouring plate. As it penetrates the warmer, softer mantle beneath, it causes

earthquakes and feeds volcanoes.

Magnetic signals recorded in sea-floor rocks, and chemical traces from the roots of ancient mountain ranges, tell us how continental drift has changed the face of Earth. They point clearly to a time 180 million years ago when all today's continents were stuck together in one vast land mass centred roughly where present-day Africa is: the supercontinent Pangaea, from the Ancient Greek for "all of Earth".

Cycling continents

We know that Pangaea came together about 330 million years ago. Before that, some consider a relatively short-lived gathering of continents near the South Pole to be another supercontinent, named Pannotia or Greater Gondwana. Another supercontinent, Rodinia, probably dominated the planet between about 1.2 billion and 700 million years ago. And about 2 billion years back it is thought there was another, known as Nuna or Columbia.

What has been will be. "For more than 20 years we have recognised that Pangaea was just the latest in a series of supercontinents," says Brendan Murphy at St Francis Xavier University in Antigonish, Canada. "That implies there will be another one in the future."

What's unclear is how that vast land mass will form. One model simply projects what's happening today into the future. The great split that broke Pangaea apart is still growing, and the two biggest land masses on Earth, Africa-Eurasia on the one hand and the Americas on the other, are on the move. The Atlantic is spreading as new rock wells up at its





mid-ocean ridge, while the Pacific is shrinking, consumed by the subduction zones that surround it, the famous ring of fire.

"If you simply run plate tectonics forward in time, you would see the Pacific close and the Atlantic open," says Mark Behn at Woods Hole Oceanographic Institution in Massachusetts. In about 250 million years a new supercontinent, Novopangaea, would form on the opposite side of Earth from the original Pangaea, as

"We're still struggling to understand the rules of plate tectonics"

the Americas and Asia crunch in around northbound Australia.

But it may not be that simple. "You can get to 50 million years by projecting present-day motions," says Christopher Scotese at Northwestern University in Evanston, Illinois. "To go any further, you have to understand why plates are moving, what are the driving forces, what are the rules of plate tectonics." That's something we are still struggling to do.

Since 1982, Scotese has been making maps of past and future Earth using various rules of thumb. The most important rule is widely accepted: plate tectonics is driven mainly by the pull of sinking slabs at subduction zones, with a smaller push from new rock forming at mid-ocean ridges. Work out the layout of subduction zones and ridges at any time, and you can begin to see how the continents should be tugged and nudged around.

But three kinds of cataclysmic event can change the course of this smooth voyage. A subduction zone can swallow a spreading ocean ridge, as is happening today off North America's west coast, where the Juan de Fuca ridge is slowly being consumed. Or a pair of unsinkable continents can collide, snuffing out subduction in between and forcing a great mountain range, as India and Eurasia have done to build the Himalayas.

The third possible cataclysm is much harder to fathom or predict. "The fundamental question is how you start new subduction zones," says Behn.

This has to happen somehow, or all existing subduction zones would eventually be killed by continental collisions, and plate tectonics would cease altogether. In 2008, Behn and his colleague Paul Silver suggested that if a supercontinent forms simply by closing the Pacific, destroying all the main subduction zones around it, plate tectonics could shut ➤

down for a long time. They suggest something similar may have happened in the past.

But even if that is true, evidence that plate tectonics has gone on for almost all of Earth's history, with many cycles of supercontinent formation and destruction, indicates that new subduction must start eventually, somewhere.

The most likely spot is at passive margins, for example on the Atlantic coasts of Europe, Africa and the Americas. These are places where old oceanic lithosphere, spreading out

from mid-ocean ridges, meets continental crust. The oceanic lithosphere has had time to cool since formation and become denser than the rock beneath, so it wants to sink.

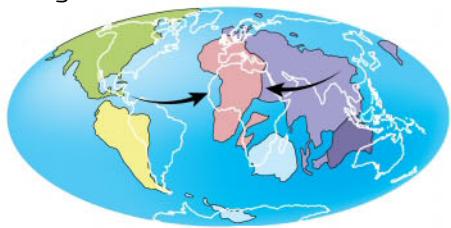
But it can't. Old, cold lithosphere rocks are hard to crack. Even the weight of kilometres-deep river sediments washed on to the passive margin from the continents isn't enough on its own. The weakening effect of water seeping into the rocks may help, but probably not enough to crack those passive margins.

Four futures of Earth

Depending on how plate tectonics plays out, four very different supercontinents could form

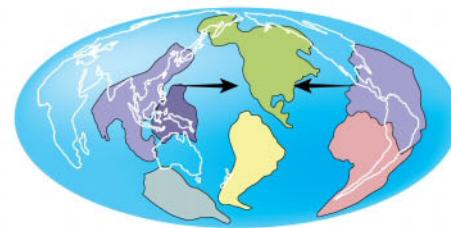
● Africa ● North America ● Australia ● South America ● Antarctic ● Eurasia ○ New land

Pangaea Proxima



150 million years

Aurica



150 million years



300 million years

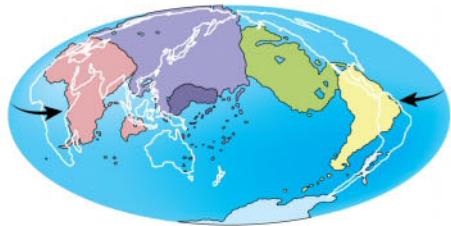
In around 100 million years, subduction spreading along the western side of the Atlantic causes it to start closing. North America ends up fused with the west coast of Africa, with South America swinging round to end up at the south of a new supercontinent centred on the present-day Atlantic



300 million years

Subduction starts on both sides of the Atlantic, and both Atlantic and Pacific close. Eurasia splits, its western half moving westwards with Africa, and its eastern half migrating eastwards. It scoops up Australia to form a new supercontinent, centred where the Pacific is now

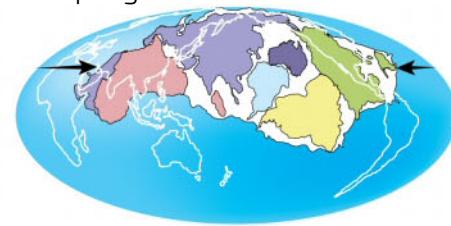
Amasia



250 million years

The Atlantic continues to open but widens more at the south. Africa moves west and Australia moves north; meanwhile South America pivots and ends up with its west coast fused to North America's east coast. Antarctica remains aloof from this straggly new supercontinent

Novopangaea



250 million years

Current tectonic movements continue, with the Atlantic widening and the Pacific consumed by subduction. South America swings westwards and northwards, scooping up Antarctica and Australia; Africa rotates anticlockwise, taking western Europe with it, its current south ending up fused with Arabia

In the 1980s, Scotese suggested that subduction is catching. While it is difficult to break old ocean lithosphere from scratch, "a nick will localise stresses and tear more easily", he says.

There are already two small subduction zones in the western Atlantic: the Lesser Antilles volcanic arc near the Caribbean, and the Scotia arc in the far south off Tierra del Fuego. These both look as though they have sneaked in from old subduction zones in the Pacific ocean. Scotese suggests that eventually they will spread south and north, joining up to form a long subduction zone up the east coast of the Americas. In his projection, this will eat the Atlantic's mid-ocean ridge about 100 million years from now, and the Atlantic will start to close again. After 250 million years, the Americas will have collided with an already merged Africa and Eurasia – as will Australia and most of Antarctica – to form what Scotese calls Pangaea Proxima.

Others have come to a similar conclusion by looking at the geological record, which shows that oceans periodically open and close in something known as the Wilson cycle. In the 1980s, Thomas Worsley and Damian Nance at Ohio University suggested that the next supercontinent might form more or less in the way it split up, by closing the Atlantic.

Old and crusty

In 2012, Ross Mitchell, then at Yale University, and his group mapped out a third route. The shifting of mass associated with the formation of a supercontinent affects Earth's rotation, changing its spin axis relative to the solid body of the planet. By looking at the orientation of magnetic crystals in rocks that cooled around the time that different supercontinents existed, the team showed that Rodinia formed about 90 degrees in latitude away from the position of Nuna, and Pangaea about 90 degrees from Rodinia. Mitchell and his colleagues predict that the same thing will happen again, meaning the next supercontinent should form somewhere near the North Pole, as Asia and North America crunch together. They call the result Amasia.

Some support for this view came in 2016, when Masaki Yoshida at the Japan Agency for Marine-Earth Science and Technology in Yokosuka published a numerical simulation of mantle motion. It shows continents converging near the North Pole, guided there partly by plumes of hot, rising mantle rocks that help to keep the Pacific open in the south while it closes in the north. This makes



New rock welling up at ocean ridges helps to drive plate tectonics

Amasia relatively straggly, with the Americas forming a huge promontory and Antarctica remaining aloof, unlike the compact form of the original Pangaea and the other imagined supercontinents of the future.

Duarte thinks all these models have problems. Amasia and Novopangaea would both be surrounded by large areas of ocean crust that is more than 400 million years old, which he finds implausible. In 2008, Dwight Bradley at the US Geological Survey in Anchorage, Alaska, looked at rocks around ancient passive margins and found the oldest were about 180 million years old on average, and much less than that in recent ages. Hardly any lasted 400 million years. Duarte thinks this is no coincidence. "Somehow plates in Atlantic-type oceans may have to start subducting after about 200 million years," he says.

Scotese's Pangaea Proxima does not have the old-crust problem: the Pacific could in theory stay open for many hundreds of millions of years with new crust constantly being generated and destroyed. But Duarte considers this improbable too, because ridges such as the Juan de Fuca are already being subducted. "It may not be very likely that new ones form in the middle of the oceanic plates where they are cold and strong," he says.

Duarte agrees with Scotese that subduction may spread like a virus, a process he calls invasion. He has found evidence that subduction is beginning to invade the

Atlantic's eastern margin, off the coast of Portugal, where forces generated by the remnants of an ancient subduction in the Mediterranean are helping to create new faults in the ocean floor.

In Duarte's model of Earth's future, published last year, subduction will spread along both sides of the Atlantic within a few tens of millions of years, and the ocean will begin to close. But the Pacific will keep on closing, too, meaning something else has to give. That something is Asia. A rift cuts across the continent, from the Indian ocean up to the Arctic, as the Himalayan Plateau

"Our distant cousins will be shaped by a strangely shaped world"

collapses under its own weight. A new ocean opens up, and the eventual outcome is a new supercontinent with the two halves of Asia on the outside and American and Australia at its core – hence Aurica.

Nice try, says Scotese. "Trying to close the Atlantic and Pacific – I think that's original." But suggesting a subduction zone on the eastern as well as the western side of the Atlantic actually makes things more difficult, he says, because that could preserve the mid-Atlantic ridge. "To close the ocean you have to subduct the ridge – but if you have subduction all around the ocean, the ridge can stay in the middle and supply crust to both sides."

The proponents of each idea are keen to

stress that the future is uncertain, and that their own model is just one option (although of course the most likely one). Whoever is right, our distant cousins will have to adapt to a strangely shaped world, and will in turn be shaped by it. "The whole Earth system is ultimately controlled by plate tectonics," says Scotese. As continents move through different climate zones, they cause new problems for existing life forms and create opportunities for others. Extreme volcanism can also cause or at least contribute to mass extinctions, as in the vast outpouring of lava that formed the Deccan Traps in India about 65 million years ago. This changed the global climate and may have put the dinosaurs under serious stress, before a meteorite provided the knockout.

Driving forces

Climate may differ wildly between different supercontinent scenarios, affecting Earth's habitability. Amasia, near the North Pole, might gather a massive ice cap. Novopangaea could be similar to original Pangaea, which may have seen extremes of weather, with a vast interior desert and a seasonal "megamonsoon". Or if plate tectonics were to shut down for a while, that would radically affect the atmosphere. Volcanoes would cease to pump out carbon dioxide, and the planet might enter a severe ice age. We could model the climate on each hypothetical supercontinent – "but that is building a house of cards then building balconies on your house of cards," says Scotese.

Earth's future depends on what forces really drive the motion of the continents, and that remains the real unknown. The only way we can cut through the profusion of possibilities is to make plate tectonics more quantitative, says Duarte. "To make substantial progress we need more observations of the Earth's interior," he says. "For example, there are barely any permanent seismometers on the bottom of the oceans." We could also use neutrinos from the sun to probe the planet's interior, he suggests. Certainly more powerful models that can capture geochemical processes on scales large and small are needed.

So trying to gaze into Earth's distant future may help us to understand the inner workings of our complex and opaque world today. But important though that is, it's not the real motivation for sketching out the next supercontinent, 10 million generations removed. "It's for fun," says Duarte. ■

Stephen Battersby is a consultant for *New Scientist* based in London

Seeing the glass half full

Move over doom and gloom, the Earth optimists are here to tell you we can save the planet. Julia Brown reports

MARTIN LUTHER KING did not say, 'I have a problem', says Andrew Balmford. The conservation biologist is part of a new environmental movement, and if you're exhausted by the perennial doom and gloom, Earth Optimism might be just the ticket.

Its mantras? Forests are growing back, renewable energy is beating coal, the ozone layer is recovering and although the fate of polar bears is still iffy, at least the giant panda is no longer on the brink of extinction. Sure, there's plenty to be concerned about, but for the first time in a long time, say the optimists, there are reasons to be hopeful about the fate of the planet.

The question is whether they have just forgotten to take off their rose-tinted spectacles. And even if they are right and the tide is turning, are positive messages really the best way to galvanise further action?

The Earth Optimism movement began 10 years ago as a series of lectures by Nancy Knowlton, a coral biologist now at the Smithsonian Museum of Natural History in Washington DC. At the time, Knowlton was running a master's programme in oceanography at the Scripps Institution of Oceanography in California. She soon came to the conclusion that the course was, as she puts it, "training our students to write ever more refined obituaries for the planet". This didn't feel like the most inspiring way to create future conservationists, so she launched Beyond the Obituaries, a symposium that focused on success stories in conservation. Its popularity led to a Twitter campaign called #OceanOptimism, which in the past few years has expanded into Earth Optimism.

The movement wants to shift the narrative on the environment to "celebrate a change in

focus from problem to solution, from a sense of loss to one of hope". Conservation biologists such as Balmford, who works on conflicts between biodiversity and farms at the University of Cambridge, were the first to get on board. But since the Paris climate agreement was struck in 2015, optimism appears to be taking hold among even the grumpiest of environmental researchers – climate scientists. "With radical collaboration and relentless optimism, we will make the 2020 turning point a reality," proclaims Mission 2020, a project set up by the head of the UN Framework Convention on Climate Change that seeks to radically curb emissions in the next three years.

It might seem a strange time to think positive. Global average temperatures are a record 1.1°C warmer than pre-industrial levels.

"We were training students to write ever more refined obituaries for the planet"

Asia suffers from a perennial air pollution crisis, we are still cutting down 15.3 billion trees each year, ocean fish stocks are depleted, and conservation biologists say a sixth mass extinction is under way.

In 2009, Johan Rockström of the Stockholm Resilience Centre in Sweden and his colleagues identified nine planetary life-support systems that are vital for human survival – from the ozone layer to clean rivers – and assessed the level at which they operate successfully. Eight years on, we are no closer to reaching a safe space, says Rockström.

Undeterred, the optimists counter that although that is the big picture, it is not the whole picture. They are at pains to point out

that they are not just blindly positive in the face of impending doom. "It's not optimism in the sense of having a rosy attitude," says psychologist Steven Pinker at Harvard University. Rather, the movement wants to highlight positive stories to show people that seemingly insurmountable environmental problems can be fixed.

"There's a lot of really good stuff going on around the world where people are working out solutions," says conservation biologist Stuart Pimm of Duke University in North Carolina. "We are learning how to do things at an extraordinary rate."

For example, between 2004 and 2012, government-led initiatives cut the rate of deforestation in the Brazilian Amazon by 80 per cent. Today, nearly half of the Amazon's original rainforest is protected or part of an indigenous reserve. Worldwide, more land is being returned to nature than is being cleared of trees to make way for agriculture. In the oceans, many whale populations are recovering thanks to the 1982 moratorium on whaling, and oil spills are at an all-time low (see graphic, page 40).

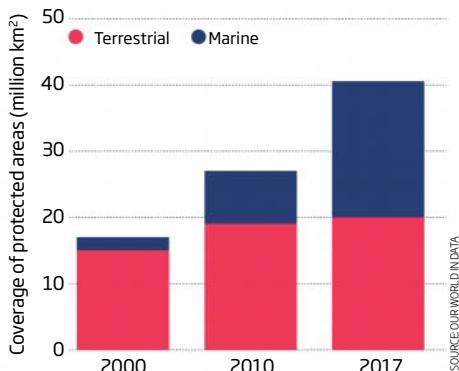
Perhaps the most significant change for the better has come from the energy sector. Due largely to shifts in China and the US, the coal industry appears to have peaked in the last three years. A key driver has been the Chinese government's desire to clean up its polluted skies. Meanwhile, renewable energy is on the rise. In 2016, global solar capacity jumped by 25 per cent, largely thanks to falling costs and enormous expansion in China.

The combined effects of the death of coal and the rise of renewables are causing ripples where they are most needed. Over the last few years, global greenhouse gas emissions have ➤

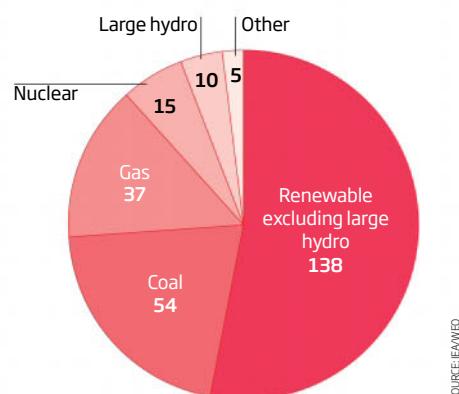


Reasons to be hopeful...

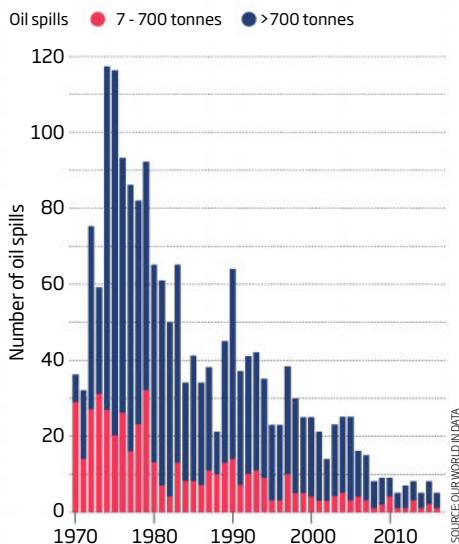
The extent of protected areas is increasing, particularly in the oceans



In 2016, for the second year in a row, renewables accounted for more than half of the new power capacity added globally (in gigawatts)



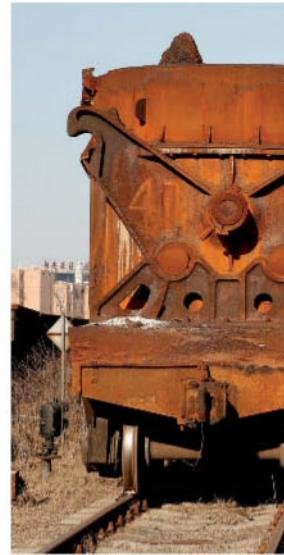
The number of oil spills has dropped markedly in recent decades



plateaued – the first time this has happened during a period of economic growth.

Several industry reports, including one from the International Energy Agency (IEA), suggest the move away from coal, the dirtiest of fossil fuels, is likely to be permanent. “I don’t view this as simply a positive blip,” says Philippe Benoit, former head of the energy efficiency and environment division of the IEA. “I think it’s a reflection of fundamental shifts that are taking place within the energy sector, within other parts of society, as well as a significantly increased awareness and commitment from political leaders to put in place the policies to lead to emissions reductions.” This turnaround in energy production, and its consequences for future climate change, is emblematic of the optimists’ message – that although we are not yet out of the woods, the tide is turning.

China is shutting down industrial plants to improve air pollution (right); at the same time, deforestation rates in the Amazon rainforest have fallen dramatically (far right)



Affirmative power

Pessimists, however, will point out that although coal may be declining, it still accounts for 41 per cent of the electricity generated each year. Clearly, whether you’re feeling optimistic or pessimistic about the fate of the planet depends on which data you’re looking at – and in some cases, how you look at it. But perhaps that’s missing the point.

Going back to the movement’s roots, Knowlton says part of its aim is to inspire the next generation of planetary doctors. “Bad news without solutions is not very helpful,” she says. That mentality extends beyond professional conservation biologists to the general population. “If you give people negative, threatening messages, they don’t engage, they pretend it’s not happening, because you’ve given them no alternative,” says Balmford.

So is feeling hopeful about the future truly a better motivator than fear? There is some evidence that fearful messages about climate change can lead people to tune out rather than take action. For instance, a 2011 survey of 97 students by Matthew Feinberg and Robb Willer at the University of California, Berkeley, found that people’s belief in climate change diminished after reading a message that spelled out the devastation global warming will cause and the possibly catastrophic consequences.

There is also evidence that positive messaging motivates people. Robert Gifford at the University of Victoria in Canada and Louise Comeau of Royal Roads University studied the effect on 1000 people. Participants

were made to read either sacrificial statements – such as “I am going to have less freedom to make the choices I want if we are going to solve climate change” and “I am going to have to get used to driving less, turning off the lights, and turning down the heat” – or positive statements, such as “My neighbourhood will be a healthier place to live if we walk more to cut greenhouse gases” and “I know someone who lowered their energy bills and I can too”. They were then asked how likely they were to take action to help the environment over the next 12 months. Those in the motivational group were significantly more likely to say they would reduce their car usage, for example, or install energy-efficient windows than those in the other group.

People who feel hopeful about the future are more likely to take action to improve it, according to a study by Kathryn Stevenson and Nils Peterson of North Carolina State University. Their team surveyed about 1200 children aged 11 to 14 attending schools in their state. They found that those who felt hopeful about the future were also those who did the most environmentally friendly things, such as close the fridge door, turn lights off and encourage their family to do the same. Those who reported being concerned rather than hopeful were less likely to cut their energy use, say, and those who were despairing about the future tended towards inaction.

Maria Ojala of Örebro University in Sweden found that people who felt hopeful about humanity’s ability to combat climate change were more likely to cut their home energy use than others who simply had a good knowledge



the hopeful message that emissions have plateaued in recent years is worth publicising to inspire people to further action. They gave 431 participants one of three messages: a neutral one describing how emissions are measured, a positive one about how the rate of emissions has slowed in recent years that they said showed “the reductions that are needed are finally happening”, and a pessimistic one pointing out that emissions are still rising and “the reductions that are needed are not happening”. They then asked people whether the message made them feel they wanted to do more to respond to climate change. Those who read the pessimistic message felt more motivated than those who read the optimistic or neutral messages. The negative message worked, the researchers say, because it elicited feelings of distress and worry, whereas the positive one led people to feel more complacent about the risk.

What are we to make of this conflicting evidence? “I think it’s different strokes for different folks for different behaviours,” Gifford says. Hornsey suggests a way of using these differences. “The fear messages are probably going to be more effective for people who are already on board with the notion of human-caused climate change,” he says, whereas climate sceptics might be more likely to write them off. Those already working to solve environmental problems, on the other hand, might be most in need of a boost since they see the grim reality every day.

This shows we need both kinds of message, agrees Knowlton. “We’re saturated with doom and gloom, we need something in addition to it,” she says.

“How many times are you going to tell people that it’s terrible?” says Pimm. “I think you make progress not by coming out and saying, it’s awful, we’re all going to die, but by telling people what they can do.” That is the crux of the movement, says Knowlton: not to be optimistic for the sake of it, but to share what has worked in practice.

Perhaps the best sign that optimism is taking hold is a change that Rockström detects in public attitude towards climate change. “The whole concept [of] sustainability has tipped. Until very recently, the environmental agenda was largely a question of ethics and morality. It was a sacrifice.” Now, he says, “sustainability is seen as the only way to deliver a stable economy. We are into a completely new paradigm”. ■

...and turn things around

Global CO₂
emissions have
grown by **less than**
1% since 2014

Source: GCP

Deforestation
rates in the Brazilian
Amazon **fell by**
80% between 2004
and 2012

Source: FAO

In 2016, global
energy-related
emissions **fell by**
0.03%

Source: EIA

of the effects of climate change or had altruistic values.

Does this mean optimism could even turn climate change deniers and spur them into action? Paul Bain at the University of Queensland in Australia and his colleagues surveyed 347 people, 128 of whom said they did not believe either that climate change was happening or, if it was, that humans were responsible. All read a statement about acting on climate change framed in one of three ways: the first suggested it could lead to a society with greater interpersonal warmth; the second that it would bring economic development; and the third talked of the environmental and health

“Does this mean optimism could even spur climate deniers into action?”

risks of not acting. Later, they rated themselves on how likely they were to do things such as support environmental causes and write to politicians about particular issues.

Although the deniers were broadly less likely to take action than people convinced of anthropogenic climate change, those who had read messages framed in terms of warmth or development of a future society said they were more likely to act than those who read about the risks of climate change.

Taken together, these studies suggest hope encourages people to take action. However, Matthew Hornsey and Kelly Fielding at the University of Queensland found the opposite to be true. Their team wanted to know whether

Julia Brown is an editor of the People section at *New Scientist*

Atomic Briton who brought home the bomb

Mild-mannered William Penney took himself, and the UK, to the forefront of the nuclear arms race – at a terrible cost

IN THE US, his fellow scientists on the Manhattan Project called him the “smiling killer”, because he maintained his amiable grin even as he lectured on how to maximise the death toll from nuclear blasts.

But Bill Penney, the shy son of an army sergeant-major and a supermarket cashier, had many guises. Some thought the UK’s answer to Robert Oppenheimer was simply a devious cuckoo in the Manhattan Project nest, who spent his time garnering American nuclear secrets to make copycat bombs back home. Others say that in his later attempt to devise a British hydrogen bomb in the 1950s, he became a world-class scientific hoaxter.

The enigma has persisted because the man who arguably saw more, did more and knew more than anyone else about the production of Western nuclear weapons in the 1940s and 50s never produced memoirs, and burned all his papers shortly before his death in 1991. There is no biography, few direct quotes on the public record, and much of his work remains an official secret. Penney for his thoughts?

The man who ended up as William Penney, Baron of East Hendred, started out as a sporty boy in a humble technical college who so outwitted his teachers it became clear he was some kind of maths genius. He rose fast in academia, doing pioneering work in quantum mechanics in the 1930s. He spent a chunk of the second world war researching shock waves from German bombs during the London Blitz.

He had become a world expert on shock waves when, in the summer of 1944, he was headhunted by the newly founded Manhattan Project in the US. It was putting serious money behind a top-secret project begun by the British, code-named Tube Alloys, aimed at using new discoveries about atomic chain reactions to create a “super-bomb”, which

would detonate with a force equivalent to thousands of tonnes of TNT.

The project’s physicists, led by Oppenheimer, had designs for two fission bombs in mind. One was a device that shot one slug of fissile uranium-235 into another. That became the Hiroshima bomb. The other used plutonium. The recently discovered element was easier to produce than uranium-235, but detonation was more complex: it required squeezing the plutonium, using a shell of explosives. Penney was hired to model the complex shock waves to make sure it worked as intended. His work culminated at Nagasaki.

Penney’s other task at the project’s secret base in Los Alamos, New Mexico, was to model the outgoing shock waves from the atomic explosion itself, to maximise the destruction

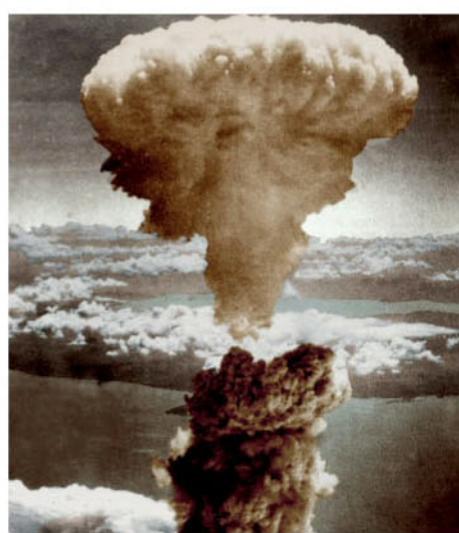
from the blast. He was the key scientist on the Pentagon target committee that decided which Japanese cities to bomb. He suggested those with surrounding hills to concentrate the blast. And his modelling decided how high in the air the weapons should be detonated to maximise the blast damage – 600 metres over Hiroshima and 500 metres over Nagasaki.

He was in the tail-gunner’s turret of the plane behind the B-29 bomber at Nagasaki, witnessing the destruction as it happened. In the days that followed, after Japan had surrendered, he clambered through the rubble of both Hiroshima and Nagasaki, where he estimated the power of the blasts by measuring the collapse of empty oil drums, how much flagpoles bent and where memorial stones had overturned. He concluded that Little Boy, the Hiroshima bomb, was the equivalent of 12,000 tonnes of TNT, and Fat Man, the Nagasaki bomb, 22,000 tonnes.

In the Los Alamos hothouse of charismatic but often highly strung young physicists – Richard Feynman, Niels Bohr and Edward Teller among them – Penney stood out as a down-to-earth Englishman. Shy, prone to blushing and with no obvious ego, he wore outsize woolly jumpers, swapped sports stories, and gave the impression he would have been just as happy back home smoking his pipe in a college common room.

He was no Dr Strangelove, but Penney had a genius for giving simple explanations that politicians could understand and trust. He quickly found himself in the inner circle of advisors that Oppenheimer’s boss, the irascible lieutenant general Leslie Groves, relied on.

After the war, British scientists working on the Manhattan Project were sent packing. All except Penney. He continued to work with the US after Congress passed the McMahon Act in



On 6 August 1945, the Little Boy bomb exploded over Hiroshima

AP/GETTY IMAGES



ATOMICALAMY STOCK PHOTO

1946, which banned all American bomb scientists from sharing information with anyone, even the British. Alcohol may have loosened American tongues. Penney was "able to sit up drinking with them half the night", according to an obituary by Roger Makins.

By then, he had secretly agreed to head the UK's own programme to develop an atomic bomb. The British avoided formalising the appointment for 18 months so that he could maintain his access to US science. As Charles Portal, in charge of the UK programme, put it in a later interview: "We were getting a lot of stuff under the counter... The channel was almost entirely to Penney."

What drove Penney? He saw himself as a patriot. In a rare public statement late in life, he said "I thought we were going to have a

nuclear war", and without a bomb of its own, the UK would be a sitting target for Soviet nuclear weapons. "What I really wanted to do was to be a professor."

After leaving the US, he was tasked with delivering the UK's first A-bomb test, which was completed on Trimouille Island off Australia in 1952. It was akin to the Nagasaki bomb, built with a cut-price version of the US infrastructure he had witnessed. But eight days later, the US exploded its new hydrogen bomb – a fusion bomb hundreds of times more powerful. Winston Churchill asked Penney to produce one of those, too.

Easier said than done. Penney had little access to the US work on this new weapon, but he took on the job, and soon had a deadline. The US and Soviet Union were drafting a

global treaty banning nuclear bomb tests that would have stymied Penney's efforts. And by 1957, new prime minister Harold Macmillan believed he was poised to get the US to amend the McMahon Act to allow a resumption of the sharing of nuclear information between the US and UK. Macmillan had an upcoming summit with President Eisenhower later that year to secure a deal, but agreeing to share secrets required the UK to show it had something to share. That "something" was to be a British-designed hydrogen bomb.

Penney delivered again. Just four months before the summit, he invited journalists to Malden Island in the Pacific to witness the detonation of the Orange Herald, a "megaton" bomb that they dutifully reported was the UK's first H-bomb. Only in the 1990s did it emerge publicly that it wasn't.

Earlier in 1957, two British tests of intended H-bombs, led by Penney, had failed. There had been panic in Whitehall. But Penney, knowing the prime minister needed a big bang, had prepared a backup. As official documents

"Two tests of British H-bombs had failed. There was panic in Whitehall"

eventually revealed, Orange Herald was actually a giant fission bomb. Those in the know called it the "Penney dreadful".

It successfully misled the UK press, and then US legislators in Congress. After the summit, Congress amended the McMahon Act, believing they would be sharing science with a fellow H-bomb nation. Macmillan had his "great prize": trans-Atlantic exchange of nuclear information. It was followed by a flow of nuclear products, mostly towards the UK.

There was another consequence of Penney's nuclear bluff. Making the Penney dreadful required huge amounts of tritium, an isotope of hydrogen, produced in a reactor at the UK's Windscale bomb factory. Getting Penney's tritium required operational shortcuts that changed how heat built up in the reactor. This ultimately led to overheating of uranium fuel rods and a huge reactor fire: the world's first major nuclear accident.

Was Penney's thermonuclear bluff his finest hour or his greatest calumny? Take your pick. Was he a master-bomb-maker, a master-spy, a master-bluffer or a master-diplomat? The blushing bombardier with the amiable grin seems to have been all four. ■

By Fred Pearce

Time to get under-involved with the children

When it comes to nurturing children's creative skills, we have got it all wrong, finds **Shaoni Bhattacharya**

Raising Children: Surprising insights from other cultures by David Lancy, Cambridge University Press
Lifelong Kindergarten: Cultivating creativity through projects, passion, peers, and play by Mitchel Resnick, MIT Press

WELCOME to the neontocracy: a world that revolves around the needs of children far beyond the basics of food and material comfort. Here, it is considered vital to maintain children's happiness, status, self-esteem and protection, and for parents to do their own childcare and schedule life-enhancing activities for their kids, providing constant stimulation.

The neontocracy is increasingly the ideal for the WEIRD world of Western, educated, industrialised, rich and democratic societies. For anthropologist David Lancy of Utah State University (who coined the term neontocracy), this aim is

an outlier that bucks the historical and ethnographic record, and in *Raising Children*, he picks apart the good and bad in WEIRD parenting.

Abandoning harsh practices (sending the kids into the forest in hard times, or enslaving them) is surely good, but progressive virtues carry their own risks. The new ways, says Lancy, can leave many as kidults, ill-prepared to enter a complicated, adult world.

"New ways of child-rearing can leave many as kidults, ill-prepared to enter a complicated, adult world"

They can even feed rising levels of mental illness, stress and suicide.

While Lancy is clear that he is an anthropologist, not a peddler of childcare manuals, readers who are parents will still feel uncomfortably nudged. Another book, *Lifelong Kindergarten* by Mitchel Resnick, also offers

parents similar fodder. Luckily, both books draw on more than psychology or neurology. Lancy's book is based on decades of anthropological research, while Resnick, at the Massachusetts Institute of Technology, concentrates on the relationship between kids and coding.

In some ways, both writers offer relief to hard-working WEIRD parents, exhausted by catering for their offspring in the high-maintenance regimes demanded both by current parenting movements and by ever-more prescriptive, anxious societies. Newer research seems to back the idea that parenting doesn't have to be this way. Both Lancy and Resnick cite developmental psychologist and writer Alison Gopnik, whose 2016 book *The Gardener and the Carpenter* shares similar insights.

But Lancy's book in particular delivers a cultural context that Gopnik's book lacked. And while Gopnik gently challenged Western parents, Lancy will have them choking on their lattes. Take one cornerstone of child development, attachment parenting. A strong emotional and physical attachment to at least one primary caregiver (parent, aunt, adopter and so on) is said to be crucial. Yet for most of history, and across all cultures to varying extents, the emphasis was for the mother not to get too emotionally invested in a newborn or young infant who might die or sap her energy and



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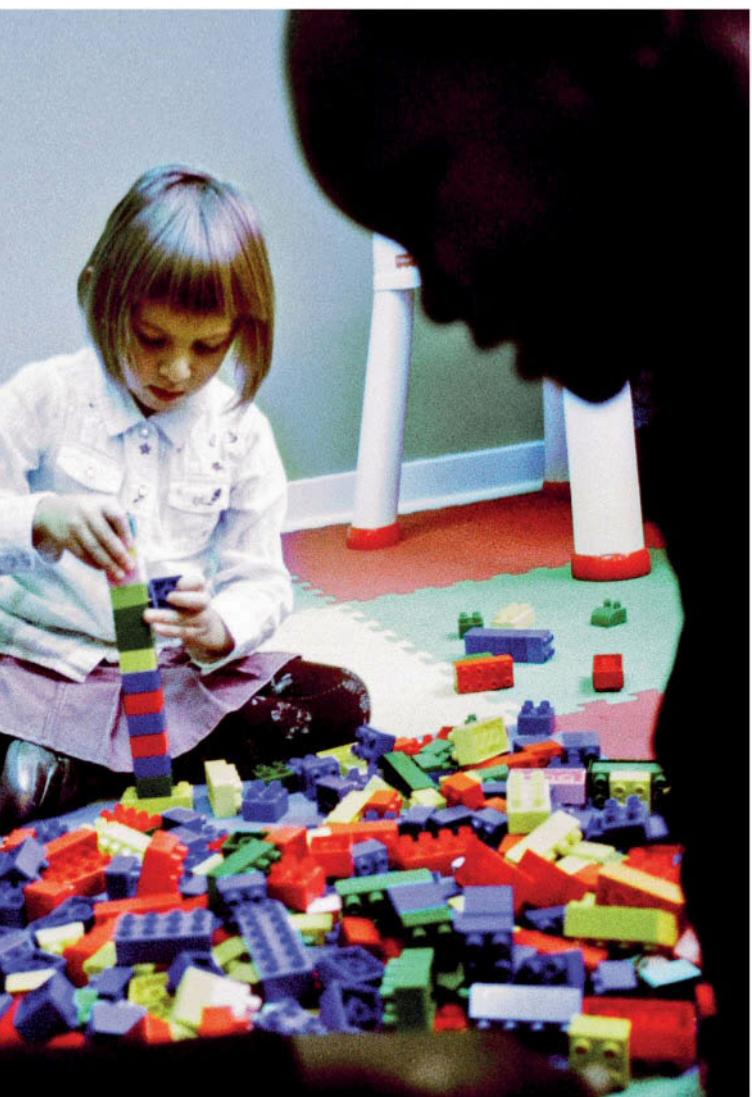
Must we exhaust ourselves with over-involved child-rearing?

health, and consequently the well-being of the family or community.

In many cultures, found Lancy, it could not be taken for granted that a baby would be considered a person. The idea of delayed personhood is, in fact, common. Among the Sikkimese Lepcha people, a baby is considered as being still in the uterus for three days after birth and referred to as a "rat-child" rather than human, while the Punan Bah see a child as little more than a body while its soul gradually takes residence, making it human.



JONAS BENEDIKSEN/MAGNUM PHOTOS



And we should recall that centuries ago, high infant mortality gave Western societies a more utilitarian view of the cost-benefit of children. Lancy cites a 6th-century Frankish law which decreed that the fine for killing a young woman of childbearing age was 600 sous, compared with just 60 sous for a male baby and a mere 30 for a female one.

Lancy's point is that modern practices – such as co-sleeping, on-demand feeding and constant parent-child play – now associated with attachment parenting should serve both parties or be abandoned. "We must not let the pendulum swing so far that

other family members, or even the very fabric of family life, must suffer to stave off the dubious threat of reactive attachment disorder," he cautions.

Lancy also dismantles another aspect of the neontocracy: the way the West hails the uniqueness of every child. That, alongside an "everyone's-a-winner" mentality, says Lancy, is doing children, society and the economy no good. Obsessed with children's happiness, US parents, "tolerate mediocre academic performance and rail against teachers who expose our children's failings". In Connecticut, he says, teachers are banned from marking pupils'

work with red ink to avoid damaging their self-esteem.

While parenting styles promoting achievement and compliance with social or family rules, like that of the "Tiger mother", are met with a backlash, Lancy notes there is no evidence that high-achieving children are at particular risk of harm. But this doesn't mean we need more schooling or formal education. As Lancy says, our forebears thought learning through observation, play and autonomy were critical.

Cultures such as the nomadic Maniq hunter-gatherers of Thailand and Amazonian Matsigenka and Parakaná still encourage children to practise using tools, knives and machetes. In our quest to shield children from harm, we may be undermining their natural inclination to learn adult survival skills, social and practical, and so extending childhood and "failure-to-launch".

Happily, Lancy's research is so thorough and his writing infused with such gentle humour that even his admonishments and one-liners to parents are a pleasure. For example, advocating "benign neglect" in parenting, he urges: "Go ahead; try it. They'll thank you later on."

This is a fascinating book and, unusually for an academic work, my only criticism is that it was not long enough. There is so much more to know, particularly on the consequences of WEIRD societies' penchant for history-bucking parenting, with Lancy as a trustworthy, readable authority.

Lifelong Kindergarten takes its title from the research group Resnick heads at MIT's Media Lab. It promises so much: to shed light on how children and adults can be creative throughout life by learning from the ethos and practices of the kindergarten.

Lancy's basic assertion – how to harness kids' passions through collaborative projects and play – is clear in its implications for creativity. Many of his examples

draw on the interactions of children in online communities exploring what they can do with the programming language Scratch.

Like Lancy, Resnick highlights the shortcomings of the formal classroom. But while the book is insightful, it feels limited by focusing so much on the MIT group's work, and on Scratch and its online communities.

Resnick does allude to Gopnik, Piaget and stalwarts of creative play like the Denmark-based

"In Connecticut, teachers are banned from marking work with red ink to avoid damaging self-esteem"

LEGO Group and even the woes of the Singaporean government in nurturing creativity in its high-achieving students. But a still wider perspective is needed.

In one section, Resnick explores dichotomies in teaching and learning styles: between the idea that adult intervention should be formal, and a more hands-off approach. For him, children need balance between freedom and structure to optimise their creativity. And then there is the Silicon Valley idea of "playpen versus playground".

While some computer games are like playpens, requiring children to advance through levels, others inspire creativity through virtual playgrounds. In *Minecraft*, for example, children can build their own structures and games, not unlike playing with physical Lego bricks.

Play – and the freedoms it unlocks – are key to Resnick and Lancy. For the good of all and for maximum creativity, it is time to unwrap the seedlings from the cotton wool in which we have enwrapped them, plant them in rich soil and make sure they don't grow up into another generation of overprotected kids. ■

Shaoni Bhattacharya is a consultant for *New Scientist*

The triumph of paralysis

Scandinavian art is drowning in good ideas, says **Simon Ings**

LIAF ran until 1 October and will return in 2019; *The New We* is at Kunsthall Trondheim, Norway, until 21 December

I STILL can't quite work out how artist Dan Graham's installation is turning me into a ghost. My reflection, playing on the surface of an untitled sculpture of glass and curved mirrors the locals call "the shower cabinet", is pressed like a flower between mountain ranges.

This was the earliest of 33 pieces by 33 artists from 18 countries which, under the rubric of Artscape Nordland, were installed across Norway's Lofoten archipelago in the 1990s. The only tourists then were climbers. Today the archipelago's 23,000 residents host around a million visitors a year, and its biennial, the Lofoten International Art Festival (LIAF), attracts international artists and curators.

I was invited to join them on Coast Contemporary, a combined conference, arts festival and royal progress, by ship, down Norway's coast. Our first port of call was LIAF itself, based this year in the once bustling fishing town of Henningsvaer.

A lot of LIAF's work is specially commissioned; the hope is that visiting artists, confronting this delicate, temperate and fertile environment, will find something fresh and pertinent to say about our relationship with our planet. The pressure is intense: national elections in September have once again raised the spectre of oil drilling in what has been Norway's most protected natural region. The oilfield is estimated to be

worth around \$60 billion.

Some artists responded to this prospect, and associated themes such as resource depletion and species extinction, with hippyish dismay. Egle Budvytyte's *Liquid Power Has no Shame* (pictured, bottom) sees three dancers pulsing with obscene sexlessness along a rocky foreshore, then gathering at a pool to welcome "the octopus" with their own spit. Other artists, drunk on anthropology, use political and scientific data to render the entire modern era contemptible. Ho Tzu Nyen's *The Critical Dictionary of Southeast Asia, vol. 3*, which even includes irrigation in its catalogue of political missteps, is not for the faint-hearted.

And do you remember Donna

Haraway? The cultural critic made her name in the 1970s by showing how our ideas of the natural world are always constructed by a group of people at a particular place and time. Fabrizio Terranova's film *Donna Haraway: Story telling for earthly survival* (pictured, top) shows her despairing now of her

'Artists are engaging with the natural world through 'multispecies storytelling and empathy'

fellow intellectuals, "mesmerised by the smartness of the latest analysis of capital".

A couple of days later, we are in Trondheim. At the Kunsthall, a group show, *The New We*, has artists engaging with the natural

world through "multispecies storytelling and empathy".

There is plenty of overthinking here, too. Rachel Mayeri's *Primate Cinema: Apes as family* is an 11-minute TV show for chimps, made with primatologists from Edinburgh Zoo in the UK. Watching the tape of chimps reacting to it should enlighten, and if you're a primatologist, it probably does. For the rest of us, what's noticeable is how unhuman their responses are.

The exhibition's organisers say they are "wary of [their] own authority as truth-producing curators". Why? Is that not their job? Aren't the arguments that might ensue the entire point of visiting a gallery in the first place? As the days and the conversations pass, I find myself siding more and more with what Haraway so memorably called "the paralysis of critique".

On the pillars supporting the Kunsthall roof, Asjorn Skou has drawn simple, artful, pencil images of our Anthropocene future. For all their science fiction content, *SporeSpore* depicts people engaging as best they can with an un-ignorably non-human environment.

Painful as it is to engage directly with that during a mass extinction (horrifying as it may be, for instance, to enter Krista Caballero and Frank Ekeberg's *Birding the Future* to listen to songs of vanished birds), such engagement is vital to our well-being, never mind Earth's. The true artist hides neither behind a capacity for sentiment, nor behind the exact sciences. I wish the artists we met on this trip would wake up to the power at their fingertips. ■



Artists greet the Anthropocene with anger (top) and desperation

**HARVARD
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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.

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To learn more about the program, please visit our website and email us with any questions through our 'Contact Us' page:

<https://informaticstraining.hms.harvard.edu/>**RADCLIFFE INSTITUTE
FOR ADVANCED STUDY
HARVARD UNIVERSITY****Academic Fellowships**

The Radcliffe Institute Fellowship Program at Harvard University welcomes fellowship applications in natural sciences and mathematics. The Radcliffe Institute for Advanced Study provides scientists the time and space to pursue their career's best work. At Radcliffe you will have the opportunity to challenge yourself, meet and explore the work of colleagues in other fields, and take advantage of Harvard's many resources, including the extensive library system. The Radcliffe Institute Fellowship Program invites applications from people of all genders, and from all countries. We seek to build a diverse fellowship program.

Scientists in any field who have a doctorate in the area of the proposed project (by December 2016) and at least two published articles or monographs are eligible to apply for a Radcliffe Institute fellowship. The stipend amount of \$77,500 is meant to complement sabbatical leave salaries of faculty members. Residence in the Boston area and participation in the Institute community are required during the fellowship year.

Applications for 2018-2019 are due by October 5, 2017.**For more information, please visit www.radcliffe.harvard.edu
or email sciencefellowships@radcliffe.harvard.edu.****DEPARTMENT OF CHEMISTRY
& CHEMICAL BIOLOGY**

INDIANA UNIVERSITY—PURDUE UNIVERSITY

School of Science
Indianapolis**FACULTY POSITION IN BIOANALYTICAL CHEMISTRY**

The Department of Chemistry & Chemical Biology at IUPUI (<http://chem.iupui.edu>) invites applications for a tenure-track faculty position in bioanalytical chemistry to begin August 1, 2018.

The position will be at the rank of Assistant or Associate Professor, with tenure status to be determined based on prior experiences and qualifications. While candidates with research interests in mass spectrometry of biomolecules are particularly encouraged to apply, we seek candidates that can support and expand the department's efforts to complement campus-wide interdisciplinary research programs in the life and health sciences. These include ongoing collaborative efforts with the IUPUI School of Science, the IU School of Medicine, and the Integrated Nanosystems Development Institute. Applicants must hold a Ph.D. in chemistry or a related discipline along with relevant postdoctoral training. Candidates will be expected to establish an externally funded and rigorous research program, as well as effectively teach undergraduate and graduate courses in chemistry. Applicants at the Associate Professor level must have a record of research excellence, current and ongoing external funding, and evidence of successful student mentoring.

Applicants should submit a cover letter, curriculum vitae, statements of research plans and teaching philosophy, and three reference letters. Interested candidates should review the application requirements and submit their application to <https://indiana.peopleadmin.com/postings/4114>.

Evaluation of applications will begin on **November 1, 2017** and will continue until the position is filled.

IUPUI is an EEO/AA employer and is interested in candidates who will contribute to diversity and equal opportunity in higher education through their research and teaching. We encourage applications from women and members of minority groups.

**WISCONSIN**
UNIVERSITY OF WISCONSIN-MADISON**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.

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](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.**

Berkeley

UNIVERSITY OF CALIFORNIA

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/evaltr.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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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:
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EDITOR'S PICK**Storing carbon dioxide under the sea**

*From Chris Vivian,
Burnham-on-Crouch, Essex, UK*

Michael Marshall asks whether we can store carbon forever in a deep-sea trench (23 September, p 9). The International Energy Agency's Greenhouse Gas R&D Programme looked into this in the 1990s and its work is summarised in the 2002 report

Ocean Storage of CO₂. This concluded: "Global ocean modelling studies have predicted that CO₂, injected into the ocean at selected locations and at depths greater than 1000 metres, will be isolated from the atmosphere for up to 1000 years. This would contribute to the alleviation of the expected peak in atmospheric CO₂ concentrations resulting from the continuing use of fossil fuels."

The question was also extensively covered in chapter 6 of the 2005 report by the Intergovernmental Panel on Climate Change, *Carbon dioxide capture and storage*, which said: "Deep ocean storage could help reduce the impact of CO₂ emissions on surface ocean biology but at the expense of effects on deep-ocean biology."

Both reports mention interesting questions in international law.

How electric vehicles could have been

*From Howard Barnes,
Bedford, UK*

Mick Hamer recalls the battery-powered electric buses on London's streets a century ago (9 September, p 35). When their batteries ran low, they went to a station where they could swap the depleted batteries for charged ones. Electric cars were also around, but had a short range.

Can a similar scheme not be adopted for electric cars now? Some standardisation would be needed. Mechanically, batteries have to fit and electrically, their charging method has to be the same. These are minor details...

*From Trevor Boardman,
Chandler's Ford, Hampshire, UK*
I was taken aback by Hamer's report of electric buses. I have

spent most of my life thinking electric transport was a joke. Now I wonder where it would be today if the money spent on oil exploration and developing internal combustion engines had gone on battery development.

By now would we have had electric transport that surpasses current systems? How much was battery technology constrained by scientific knowledge and how much of a part did oil interests play? How angry should we be?

The real, grim criteria for execution drugs

*From Gregory Sams,
London, UK*

So executioners in Florida experiment on condemned prisoners with untried cocktails of drugs because pharmaceutical companies deny them their tried and trusted ingredients

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 "We mess about on social media to fill a void, smoking, trying to connect in <140 character..."

the food waster tweets about the health impact of feeling lonely being equivalent to smoking 15 cigarettes a day (22 July, p 30)

(2 September, p 4). Presumably they ignore the reliable and readily available alternative, morphine, for fear that the condemned prisoner's last moments might be pleasurable.

The complex causes of forest fires

From Sharon Friedman,

Peyton, Colorado, US

Mika McKinnon says the forest industry in Canada has "transformed native woodland into denser, more homogeneous stands of trees by suppressing fires and replanting" (19 August, p 12). It isn't just the timber industry that wants fires suppressed, but pretty much everyone who lives in the paths of wildfires or whose power lines, roads or dams are at risk – hence current efforts to do so.

In terms of the lodgepole pine,

though, bark beetles prefer old trees. They are old because they didn't burn up in forest fires. The trees currently impacted by the beetle are too old to have been planted by the timber industry.

Trees in parts of the US with the same kinds of lodgepole forests – those with no active timber management – have similarly been killed by bark beetles. In Canada and northern parts of the US, there is a climate change component to the beetles' success.

The solution is to introduce more prescribed fire into the landscape, but that comes with its own problems.

The editor writes:

■ Bark beetles are causing problems for forests across North America, exacerbated by climate change. But British Columbia's vast, homogenous forests of lodgepole present a

distinct challenge, with the beetle outbreak creating a massive, province-wide stockpile of dead, dry trees that feed wildfires. And surveys show these beetles are attacking and killing much younger planted trees too.

Searching for 'dark matter' life for Mars

From Charles Joynson,

Rayleigh, Essex, UK

I read with interest your article on the detection of life's "dark matter" (16 September, p 6). I wonder whether anyone has done a similar search for the DNA of soil microorganisms in cold climates, in places such as Antarctica, Iceland and Svalbard?

With climate change, these species may disappear. But they could be very important as a part of a programme to terraform Mars for human habitation.

Horror at being trapped in a paralysed body

From David Cowley,
Brisbane, Queensland, Australia
Julia Brown's report of the efforts of neuroscientist Adrian Owen to detect cognition in people in vegetative states alarms me (16 September, p 44).

The most feared punishment in the Moreton Bay penal settlement on St Helena Island (off what is now Brisbane) wasn't a beating or even hanging – but sensory deprivation. Convicts were held in a small, underground cell with a piece of sugar cane tied in their mouth. There was no light or sound. If they uttered a noise in the hot, humid cell, their sentence was extended.

It is said that almost all were rendered insane after a few days and the terror in their eyes was a deterrent to other inmates. ➤



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Similar feelings are described by patients who become aware while paralysed during surgery.

Were I to end up trapped in a paralysed body, unawareness would be a blessing. The insight that there are thousands of people in a "vegetative" state who are actually aware is not at all comforting.

The editor writes:

■ People in vegetative states aren't entirely sensorily deprived. And at least one study found that most people in a locked-in state – who can voluntarily blink their eyes, so are known to be aware – are happy (5 March 2011, p 14).

Can we be sure we've seen evolution in action?

From Martin Greenwood,
Stirling, Western Australia

You report that a study by Joseph Pickrell's group on genes related to Alzheimer's disease and smoking suggests humans are still evolving (9 September, p 11). But can we be sure that the effect measured is actually a decrease in gene frequency at birth, and

hence evidence of evolution?

A variant of the *CHRNA3* gene is linked to excessive smoking rates. But heavy smoking is known to cause premature deaths, many of which must be among those in their 60s and 70s.

It seems plausible that the increased death rate from excessive smoking would produce at least a 1 per cent drop in the number of people between age 60 and age 80 who have the variant and survive to be detected.

This study didn't look at people under 40. A more conclusive one would compare the frequency of the gene variant in those aged 5 and those aged 25.

Salt may pose dangers to surprising groups

From Eric Kvaalen,
Les Essarts-le-Roi, France

Anthony Warner assures us that the conventional advice to limit salt intake to 6 grams a day is still valid (23 September, p 24). But *New Scientist* has told us of a study involving 130,000 people that found that consuming less than 3 grams a day was linked to

higher mortality (28 May 2016, p 7). It found that high salt intake was only harmful for those with hypertension (*The Lancet*, doi.org/bhv7). This certainly goes against the conventional wisdom.

Precision going to waste on household food

From Robert Cailliau,
Prévessin-Moëns, France

Alongside your article on real clean food, you say that 112.6 kilograms of household food per person is wasted each year in the UK (23 September, p 35). That is an incredibly precise figure: 308.5 grams per day (except in leap years). Do the two of us in our household throw away more than 600 grams of food each day? No way.

We aren't in the UK. Does this make a difference?

It's worth exploring the benefits of vitamins

From David Jenkins,
Carlton, Bedfordshire, UK

I read with interest the report that taking very high doses of

vitamin C slows the progression of leukaemia in mice (26 August, p 18). Fifteen years ago, part of my treatment for acute promyelocytic leukaemia (APL) was a very high dose of all-trans retinoic acid. As I understand it, this is a metabolite of vitamin A and causes APL cells to differentiate and die.

I wonder whether it is worthwhile considering a possible role for other vitamins in cancer therapy and whether combinations of different vitamins may be more effective than high doses of single ones?

That sounds fishy – is sonic computing a thing?

From Walter King,
Thrapston, Northamptonshire, UK

You claim that although sound waves are slower than light, they are "still faster than traditional electronics" (23 September, p 7). Does this mean that investment to date on circuit integration has been for nothing? Should we have been listening instead of micro-sizing all along?

The editor writes:

■ We could have put that better. The point of the research was to use sound waves to slow down data to make computer processing more effective.

For the record

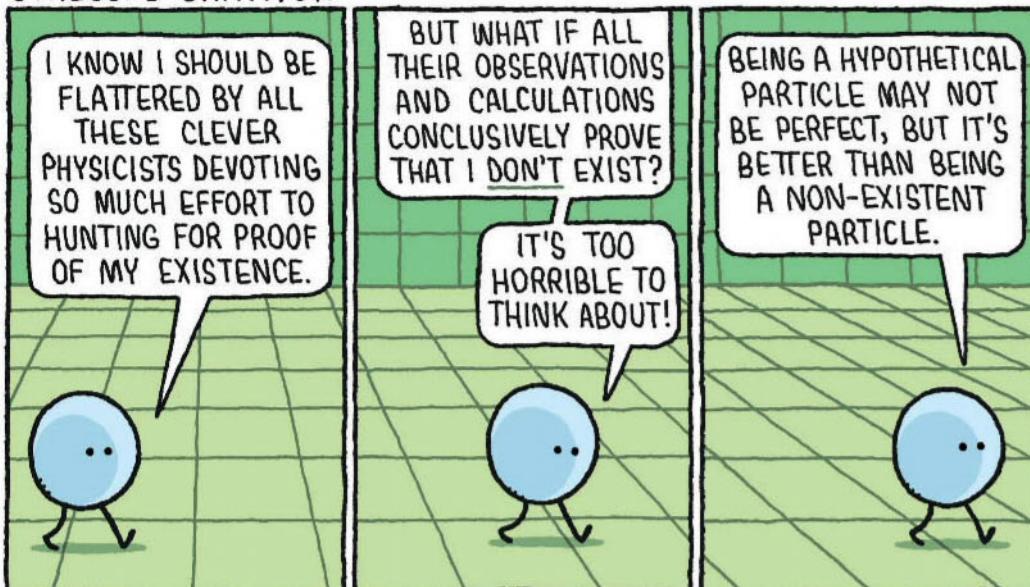
■ The observation that blockchain-based identity would preserve forever typos made when you were born came from privacy analyst Steve Wilson of consultants Constellation Research (30 September, p 10).

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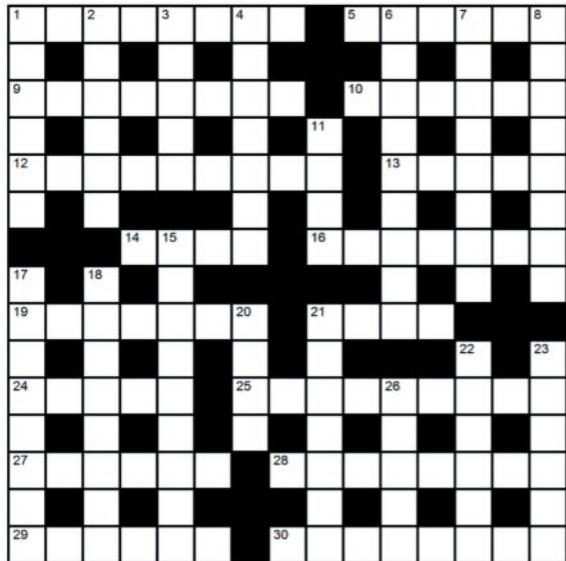
TOM GAULD

STRESSED GRAVITON



CROSSWORD

Compiled by Richard Smyth



Crossword No11

ACROSS

- 1 One of three values that divide a data set into four equal groups (8)
- 5 Of an angle, over 90 degrees (6)
- 9 Explosive device that employs nuclear fission (4,4)
- 10 '___ ergo sum', René Descartes' dictum (6)
- 12 Waxy substance produced by sperm whales (9)
- 13 ___resin, polymer or prepolymer widely used in manufacturing (5)
- 14 Jonas ___ (1914-95), US physician who developed a vaccine for 24 across (4)
- 16 In topology, a two-dimensional manifold (7)
- 19 Prefix that might be followed by magnetic or static (7)
- 21 Unit of length equal to 2.54 centimetres (4)
- 24 Infectious disease that may cause muscle weakness (5)
- 25 In some kinds of sexual reproduction, one of two uniting cells (9)
- 27 1950 science-fiction short-story collection by Isaac Asimov (1,5)
- 28 Product of dissolving a solute in a solvent (8)
- 29 Explosive compound, $C_6H_5N_3O_8$ (6)
- 30 Collectively, the genetic material of a population (4,4)

DOWN

- 1 Astronomical object powered by gas spiralling at high velocity into a black hole (6)
- 2 Single-celled protozoan (6)
- 3 In some plants, an enlarged storage organ – a potato, for example (5)
- 4 Jean-Baptiste ___ (1744-1829), French naturalist and biologist (7)
- 6 Relating to the measurement of human characteristics (9)
- 7 Exhibiting a single magnetic or electrical polarity (8)
- 8 Environmentally adapted subsets of a species (8)
- 11 Journal devoted to the history of science and technology, founded in 1913 (4)
- 15 The study of celestial objects and phenomena (9)
- 17 The temperature to which air must be cooled to become saturated with water vapour (3,5)
- 18 In cell biology, a protein covering also known as a glycocalyx (4,4)
- 20 Elisha ___ (1811-61), US elevator pioneer (4)
- 21 Mineral containing haematite or magnetite, perhaps (4,3)
- 22 Country in which the Chicxulub impact crater can be found (6)
- 23 Occurring in spring – like the spring equinox (6)
- 26 Of an angle, less than 90 degrees (5)

Answers to Crossword No10

ACROSS: 1 NINETY, 4 SMALLPOX, 9 PONGO, 10 HETEROSIS, 11 RETE, 12 EDDY, 13 KYOTO, 15 NEBULAE, 16 EELS, 19 WOLF, 20 EPIGEAL, 23 LEEDS, 24 GOLD, 25 ICON, 27 APPLE TREE, 28 OCTAL, 29 MASSLESS, 30 NEURON. **DOWN:** 1 NEPHRON, 2 NANOTUBE, 3 TRON, 5 METHYLENE BLUE, 6 LORD KELVIN, 7 PISTON, 8 XSS WORM, 10 HIDDEN FIGURES, 14 ALLOY STEEL, 17 MERCATOR, 18 OIL PALM, 21 LANOLIN, 22 HERPES, 26 MOLE.

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PAUL MCEVITT

WHAT is round, hails from the Americas and is full of supposedly nutritious gloop that's easy to swallow? If you said avocado, you're right, but we were thinking of one in particular: David "Avocado" Wolfe, a US entrepreneur and self-styled nutritionist who has achieved success, notoriety and social-media hegemony with his bizarre mix of dietary advice, cute animal videos, chocolate-box spiritualism and outlandish conspiracy theories.

As well as promoting discredited ideas such as childhood vaccines causing autism, Wolfe's understanding of science is rarely better than sloppy, and he often publishes the sorts of misunderstandings that would embarrass a schoolchild.

This week, for £78 apiece, Londoners will be able to attend his masterclass and learn about things such as how a food's colour relates to its health-giving properties (it

doesn't) and the secrets of detox diets (they don't work). Get your tanks off our lawn, Wolfe. If anyone is going to be offering up scientific flimflam in the name of entertainment, it's Feedback.

There's also a Q&A session with the man himself, and Feedback has prepared some openers, just in case we find £78 on the floor. Has he discussed his belief that the world is flat with the pilots flying him to the UK? And is he worried they might lose their way if they navigate according to spherical-Earth theory?

Also, does he still believe it's the oceans' salinity that keeps them stuck to Earth, and does that mean the whole polar ice cap over the Arctic Ocean might lift into space?

"I am terribly sorry if you don't like my harsh honesty," reads one graphic posted to Wolfe's Facebook page, "but I don't like your sugar-coated bullshit either." Finally, something we can all agree on!

The blurb on a box of LEON cork place mats bought by Steve James doesn't fill him with confidence: "Did you know that cork grows on trees?" it says. "We didn't until we made these."

FANS of fruitloopy will find a rich vein to mine from the organisers of Wolfe's workshop. Aside from the king avocado, Tree of Life events plays host to the plant whisperer himself, Rupert Sheldrake, as well as a woman who "has been teaching people to connect with the angelic realms for over twenty years", and a workshop on psychic protection. Bring your own tinfoil, presumably?

SPEAKING of nutritional fruitloopy, disgraced wellness blogger Belle Gibson has been fined A\$410,000 (US\$320,000) by Australian authorities after being found guilty of deceptive practices.

Gibson became an international celebrity after chronicling her battles with various cancers, which she claimed to have beaten using a combination of diet and alternative remedies.

But investigations found she never had cancer, and that money raised through selling her app and cookbook was never given to charity as claimed.

A statement released by Cancer Council Victoria said: "There have been several high-profile examples of unscrupulous providers charging vulnerable people large sums of money for unproven and even dangerous treatments." Hopefully this ruling will mean that getting rich quick with a dodgy diet programme becomes a less appetising career move.

THE latest brainstorm from the head of the US Federal Communications Commission (FCC) has ended in tears rather quickly. On 28 September, Ajit Pai called on Apple to activate radio-receiver chips that, in his words, "are already installed in almost all smartphones in the United States".

His idea was to give everyone with a smartphone access to emergency radio broadcasts when wireless networks fail during a disaster. "Apple is the one major phone manufacturer that has

resisted," he complained.

But there was one small problem. As Apple quickly pointed out, its two most recent phones, the iPhone 7 and 8, contain neither the required chips nor the antennas needed for good reception in the emergency broadcast band. Older iPhones did include such radio chips, but they came embedded in electronic modules bought to use in the phones, and were never connected to anything.

Surely the FCC could have found that information in the documentation supplied by Apple when the mobile devices were approved to operate in the US. But perhaps Pai was more concerned about critics blasting the FCC for the failure of communications systems when hurricanes hit Texas, Florida, Puerto Rico and the US Virgin Islands.



WE BID a fond farewell to Monte Halparin, known to the world as Monty Hall, who died last month aged 96. As host of the game show *Let's Make a Deal*, he was responsible for confounding millions with the three-door problem that bears his name. Hopefully, when he finds himself in front of the Pearly Gates, he'll know whether to stick or switch.

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Rock and hole

While holidaying on the Greek island of Paxos, I came upon a pebble beach where many of the stones had apparently been "engraved" by some type of creature. This example (see photo below) is roughly 50 by 60 millimetres, but the same sort of pattern was also present on much larger stones. What type of creature made these, and how and why? (Continued)

■ In the UK, the chalk of the south coast is under constant attack – not just by the sea and pounding shingle, but also by rock-boring creatures. Several species erode such limestone in this way.

One common rock and shell borer is the sponge *Cliona*, which is prevalent on many of the chalk reefs in the sublittoral (the area immediately below the intertidal zone). On the shore, bivalve molluscs called piddocks produce deep burrows in the rock. And on



the surface of chalk, a tiny polychaete worm, *Polydora ciliata*, dissolves U-shaped burrows using acid. All of these animals greatly weaken the surface of the chalk and are important contributors to its erosion.

The pebble pictured has paired holes, suggesting *Polydora* activity. These holes are the ends of the organism's U-shaped burrows (see the central/bottom area of the photo).

Gerald Legg

Hurstpierpoint, West Sussex, UK

Sky high

At any one time, around a million people are flying in aircraft. This is a total mass of about 65,000 tonnes. Does this make us the most successful aerial animal now, or is there some species of insect, bird or bat with a greater airborne biomass?

■ On occasion, some animal swarms weigh far more than the total number of plane passengers in the air at any one time. Locust swarms frequently contain over 10 billion individuals and weigh in excess of 20,000 tonnes.

However, the largest locust swarms are much bigger than that. In 1875, a swarm occurred over the American Midwest that was larger than California. It was estimated to contain many trillions of individuals and weigh several million tonnes. Just a year ago, Argentina experienced a swarm the size of the state of Delaware, with a total

weight of several 100,000 tonnes, although it isn't clear that the entire swarm was ever airborne at the same time.

The most populous species of bird, the red-billed quelea, has a population estimated at 1.5 billion. During the autumn migration, as many as 100 million of one quelea subspecies may be in the air at the same time as they move to the Zimbabwean highveld. These bird swarms are often compared to those of locusts, but would only have a total mass of approximately 2000 tonnes.

Stephen Johnson

Eugene, Oregon, US

Foul-mouthed response

Given the importance of the microbiota in our gut for well-being, is antibacterial mouthwash a good idea?

■ There are different types of mouthwash, including ones with antibacterial action, the principal purpose of which is to reduce bacterial plaque, helping to prevent dental decay and gum disease.

An antibacterial mouthwash is best swished around the mouth on its own, not at the time of brushing the teeth. If used appropriately, such mouthwashes will reduce bacterial plaque, but they don't tend to remove the bacterial biofilm that coats all the surfaces of the mouth.

However, if used over

prolonged periods, they do tend to change the bacterial component of the biofilm, typically reducing pathogens, which are replaced by bacteria that have beneficial effects. So regularly using a mouthwash

"Antibacterial mouthwash may enhance the protective properties of the oral biofilm"

with antibacterial action may help lessen dental disease and enhance the protective properties of the oral biofilm.

All mouthwashes are intended to be spat out after use, meaning their effects are limited to the mouth and throat (if they are gargled). And as with toothpaste, it is best to "spit don't rinse". Because of this, some mouthwash will remain in the mouth and be swallowed with saliva and other fluids. However, the amount is typically very small and any mouthwash agents tend to be neutralised in the stomach with no ill effects.

The best method for maintaining oral hygiene is to brush twice a day for 2 minutes with a fluoridated toothpaste and then use small interdental brushes or possibly dental floss to help clean between the teeth. But using a mouthwash at other times can be a beneficial adjunct to brushing.

Nairn Wilson

Emeritus professor of dentistry
British Dental Association
London, UK

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