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# General ignorance?

People are more clued up about science than you might think

EVERY now and again, some newspaper or other runs a story lamenting the pig ignorance of the general public. In the run-up to the 2015 general election in the UK, for example, the *Independent* reported that 59 per cent of people in the country could not name the current prime minister. The *Daily Mirror* later reported a “shock” geography poll that found “ignorant Brits couldn’t find France or the USA on a map”.

The credibility of these surveys has to be questioned – is it really plausible that six out of 10 British people do not know who the PM is? But they chime with a widespread belief that the great unwashed are really, horribly unwashed – obsessed with trivia and celebrities and wilfully ignorant of almost anything that matters. The thinking is that more people can probably name the cast of *Made in Chelsea: Croatia* or the stars of the Croatian football team than know anything about Croatian history or politics.

In recent years this belief in mass ignorance has morphed into something more insidious. People are no longer ill-informed, they are well-misinformation. Echo chambers and lying politicians

have ushered in an age of “alternative facts”. People have been given permission to believe whatever they want, and a cesspit of fake news to float their false beliefs upon. We thus live in a world where the US president can claim that authoritative reports of the death toll from a hurricane were fabricated by his opponents – and get away with it.

Against this background you might expect public knowledge of science to be woeful. When we decided to conduct a survey of attitudes to science, technology,

**“Our survey reveals that the public has a surprising level of knowledge and appreciation of the issues”**

medicine and the environment, we feared finding that to be the case. But the results are a breath of fresh air.

Our 2018 New Scientist Asks The Public survey – carried out with a representative sample of the UK population – reveals a high level of knowledge and appreciation of the debates (see page 6). The four issues that the British public think are most likely to have an impact on our lives are

artificial intelligence, genetic engineering, cancer and climate change. A poll conducted among experts would probably pick at least three of those. On climate change especially, the public are way ahead of their elected representatives, regarding it as both very real and very dangerous.

Another surprise is that people have serious misgivings about the technology that has done much to create the post-truth world. Social media inspires more concern than optimism, with the number one worry being fake news.

Our survey thus suggests that misinformation and its sources are less influential than is widely believed. People are, on the whole, better informed and more discerning than they are given credit for, capable of sorting fact from fiction and sensitive to the credibility of information sources.

It would be an overstatement to say that this survey reveals the post-truth age to be yet more fake news, or that the tide is turning against it. But it is food for thought for those who believe the public can be endlessly duped, and a comfort to people who care about such quaint values as evidence and fact. ■

# Hope for the future

Our exclusive survey reveals just how clued-up the UK public is when it comes to science and tech. **Graham Lawton** explores the results

THE UK public is well-informed and positive about science and technology, but its hopes and fears are largely being ignored by politicians. That is the key finding of an exclusive *New Scientist* survey of public attitudes to science, technology, medicine and the environment.

The 2018 New Scientist Asks the Public survey reveals that the issues uppermost in people's minds are genetic engineering, artificial intelligence, cancer and climate change. They believe these things are "most likely to have an impact on society and human life".

But people are not expecting a sci-fi apocalypse – public opinion is surprisingly upbeat. A majority of respondents expect the benefits of genetic engineering and AI to outweigh the downsides and think cancer can be cured. The poll also reveals broad support for genetically modified foods, with 69 per cent of people in favour of such crops saying they could help feed the world.

Of the top four issues, the only source of pessimism was climate change (see diagram, below). Half of people chose it as the environmental problem with the greatest impact; two-thirds of these say it is a threat to human civilisation and the natural world.

The survey questioned a representative sample of the UK population, not just *New Scientist*

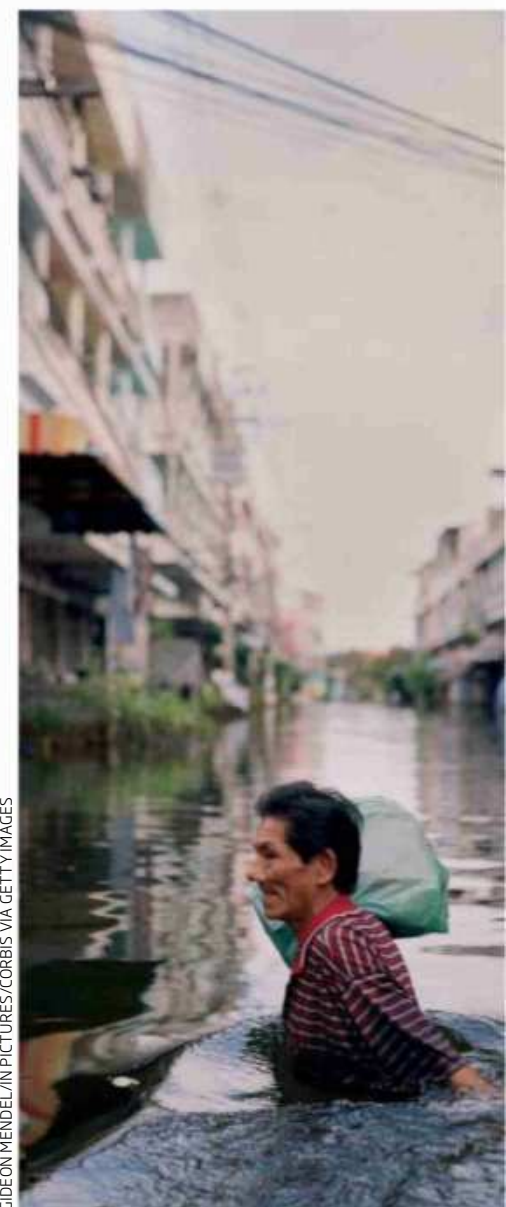
**"The general public's knowledge aligns more to scientific opinion than the mainstream media"**

readers. It shows that the general public's knowledge aligns more closely to scientific opinion than to coverage in mainstream media. AI researchers and genetic engineers repeatedly warn that scare stories about their work in the press are overblown, while cancer researchers are more optimistic than ever about survival rates and cures. It seems scientists' messages are getting through to the public.

"I have found the same myself," says Helen O'Neill, a molecular biologist at University College London (UCL) who is speaking about gene editing at New Scientist Live this week. "People have come up to me after talks saying 'when can we do this?', presuming it is already in the clinic."

On climate change, the public also appears to be in tune with scientific opinion rather than voices in the media. Researchers are deeply worried about whether we can avoid dangerous climate change and fear the consequences for humans and nature.

"It seems that, despite some politicians and climate sceptics denying climate change is real, the UK general public recognise it as a major threat and already know how it should be dealt with – using renewable energy," says geographer Mark Maslin of UCL, who is also speaking at New Scientist Live. "This shows that the public are deeply aware of the issues and do put threats and



GIDEON MENDEL/IN PICTURES/CORBIS VIA GETTY IMAGES

## CAN WE SAVE THE PLANET?

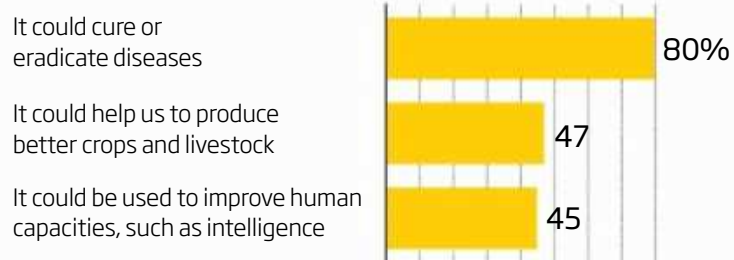
Environmental issues are a source of great pessimism. Close behind climate change as areas of concern are air pollution, plastic waste, extinctions and overpopulation. Only renewable energy is seen as cause for optimism, with just 7 per cent of people rating it as the environmental issue they worry about most.

The public is more divided when it comes to reversing our impact on the planet. Roughly a third of respondents think resurrecting extinct species is a good idea, and about the same number don't like the prospect. They say it could be dangerous and make us less inclined to conserve other endangered species.

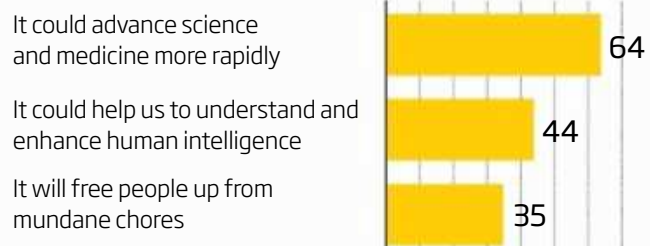
First on the list people would like to be brought back is the western black rhino, followed by dodos and Tasmanian tigers. Forget *Jurassic Park* though – just a third would like to see a return of the dinosaurs.

The 2018 New Scientist Asks the Public survey was carried out by Sapio Research on a representative sample of 2026 UK adults. All interviews were conducted online in August 2018. The answers below reveal people's **hopes** and **concerns** on a range of topics

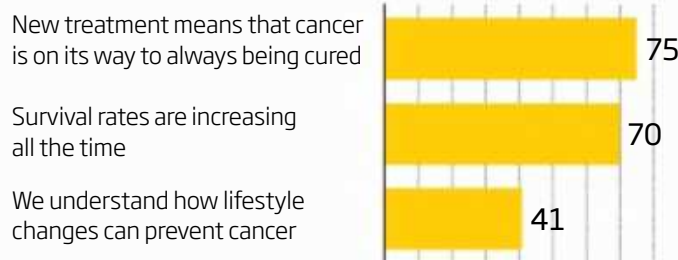
### Genetic engineering



### Artificial intelligence



### Cancer



### Climate change



## HURRAH FOR GENETIC ENGINEERING

One unexpected finding of the survey is that 53 per cent of people support genetic engineering. This was driven mostly by its potential to cure or eradicate disease – seen as a positive by 80 per cent of the people who support the tech. Almost half of them also say they are optimistic about using it to improve human capabilities such as intelligence.

The main reason people worry about genetic engineering is that “it is too dangerous, we don’t know the real consequences”. Designer babies and the

ethics of “playing god” also loom large, along with fears that the technology might only be used to benefit the rich.

GM crops enjoy more support than opposition, with 31 per cent of people saying that this environmental issue is one they worry least about, and only 16 per cent rating it as one of their biggest environmental worries. Popular reasons to support GM crops are that they could help feed the world and save the environment. Opponents are most concerned about possible impacts on health.

solutions together – it is just a shame that the politicians do not see what the public does.”

You might think that politicians would want to follow the views of the public, yet none of these issues are currently high on the political agenda. Climate change especially seems to have slipped political minds, even though the UK is not on target to meet its long-term commitments and has just experienced a long bout of freak weather almost certainly caused by climate change.

## Public optimism

When it comes to AI, the government recently set up an Office for Artificial Intelligence to support this growing industry, but there has been little political debate about the possible impacts on society and human life.

Genetic engineering of humans is similarly low on the agenda despite a recent call from the Nuffield Council on Bioethics for a widespread debate on its implications. The UK will reportedly continue its strict policies on GM crops after leaving the European Union, but there has been little public discussion.

The survey reveals other ways politicians are out of step with public opinion. It found strong support for legalised assisted dying, a complete ban on animal experiments, and compulsory childhood vaccination. Neither of the two main UK political parties advocates any of these policies – perhaps because they are also out of step with mainstream scientific and medical opinion.

Marcus du Sautoy, Professor for the Public Understanding of Science at the University of Oxford, told *New Scientist*: “The most optimistic part of the report is to see how engaged the public is with science. I think it shows an encouraging level of public understanding of science and the issues around it.” ■

Turn over for more survey results

## FEARS THAT TECH WILL TAKE OVER

Our survey reveals a variety of anxieties about current or near-future technology. Social media is seen in a negative light, largely because of fake news, trolls and peer pressure on young people.

Drones also stir up worries, with fears they can be used for surveillance or to deliver drugs and weapons into prisons. Brain implants are seen as highly dangerous, while virtual reality is seen as a positive, but only just. And even though 30 per cent of people say they are positive about artificial intelligence, 24 per cent are concerned about its possible downsides, such as its capacity to put millions out of work or outsmart us and take over the world. Robots inspire similar concerns.



PLAINPICTURE/BLEND IMAGES/JOHN LEE



NAYPONG/GETTY

# A third of UK adults would go to Mars

Clare Wilson

MANY people would consider going on a one-way mission to Mars, according to the 2018 New Scientist Asks the Public survey. But new evidence suggests that the lengthy trip may be bad for the part of your brain involved in forming memories.

The survey (see page 6) found that 50 per cent of men and 30 per cent of women would be happy to go on a return trip to Mars. As for a one-way trip, 40 per cent of men said they would definitely or probably want to go, compared with 20 per cent of women.

This is despite the known physical risks that the six-month journey to Mars would involve. Aside from space-flight accidents, high exposure to radiation from cosmic rays could lead to DNA damage and cancer.

And there may be other unanticipated dangers. A NASA study presented at the recent Federation of European Neuroscience Societies conference in Berlin, Germany, suggests that a two-year mission

with just a handful of crewmates could damage the brain.

The study involved 16 volunteers doing 30-day stints in a simulated Mars base with only three other people for company in their pod. By the end of the study, the participants showed slight

shrinking of a brain area called the hippocampus, made up of sausage-shaped structures that are essential for forming new memories.

The study found that one end of the volunteers' left hippocampus – known as the head end – shrank by about 3 per cent on average.

Team-member Anika Werner of Charité – Berlin University of Medicine suggests this shrinking

**Researchers practise Mars experiments in the Utah desert**



BENJAMIN RA SMUSSEN/GETTY IMAGES REPORTAGE

may have been caused by social isolation and the stress of being watched 24 hours a day. The participants exercised six days a week, so the effect is unlikely to have been caused by inactivity.

What effect it might have on a person's mental abilities is unclear. The hippocampus helps us find our way around, but the navigation skills of the would-be astronauts were unaffected in computer tests during the study.

Hugo Spiers of University College London says the head end of the hippocampus may be less important for navigation and more involved in using memories to guide other kinds of behaviour. However, a longer study by the same team, looking at nine people who spent a winter at an Antarctic base, found hippocampus shrinkage that was linked to worse scores on spatial ability tests.

We don't know how the volunteers' hippocampus shrank. It might have been brain cells dying, a lack of new cells being generated, loss of connections between cells or just a reorganisation of this brain area.

Werner predicts, though, that any astronauts would recover after returning to Earth. "If you have these changes, they are very reversible. The brain is very plastic. But it is something that has to be taken into account." ■

## Only one in five would like to be immortal

WHO wants to live forever?

Only around 1 in 5 people, according to the 2018 New Scientist Asks the Public survey.

In the survey (see page 6), 21 per cent of people said they would be very likely to accept an offer of immortality. A further 30 per cent said they would be somewhat likely to take up such an offer, but around half of people appear to be reconciled to their own demise.

The question posed in the survey was "if you were offered the chance to live forever, how likely are you to take it?". While this is a hypothetical question, some gerontologists believe that radical life extension – if not actual immortality – may be available to people who are alive today.

Even people who are already old may soon benefit from a range of interventions, from drugs to manipulation of their gut microbiota, that can extend their lifespan or at least improve their health in old age, according to a major review published this month in *Nature*.

However, the survey found that more people are worried about radical

life extension than are optimistic about it. The main concerns people have are overpopulation and a "nursing home world" full of geriatrics. Of those who expressed concern about radical life extension, 44 per cent agreed with the statement "I think we should just accept our natural lifespan".

Nonetheless, in a separate question, 58 per cent of people agreed with the statement "longer life expectancies are a good thing".

**"People worry about overpopulation and a 'nursing home world' full of geriatrics"**

The two are not necessarily incompatible. Over the past 200 years, average human life expectancy has doubled in most developed countries due to better diets, public health and education.

These gains are projected to continue, according to Linda Partridge of the Max Planck Institute for Biology of Ageing in Cologne, Germany, lead author of the *Nature* review.

However, "healthspan" – the number of years lived in relatively good health – has not increased as much as lifespan, meaning concerns about radical life extension are probably well-founded.

Graham Lawton ■

## 'Ghost bonds' let hydrogen link to nothing

CHEMISTS have a plan to make ghosts in the lab, by bonding an atom to a patch of empty space.

Normal chemical bonds anchor two atoms together, usually through sharing their electrons. Now, theorists have worked out how to trick a single hydrogen atom into forming a bond with nothing, by luring the atom's lone electron into the same position and state it would be in for a real bond.

Matt Eiles of Purdue University in Indiana and his colleagues are building on work from two years ago that saw the creation of strange, super-sized bonds in other molecules, such as diatomic caesium.

In that case, one caesium atom is in a rare condition called a Rydberg state, which allows its bonding electron to stretch up to a thousand times further than normal from the other caesium atom, essentially forming a very large bond.

Eiles says that by imitating this Rydberg state with a single hydrogen atom, it is possible to make it bond to nothing. The trick involves exposing the hydrogen atom and its electron to a series of delicate magnetic and electric fields (*Physical Review Letters*, doi.org/gd58tv).

"We predict it would live for several hundred microseconds, or even longer in a cold environment," says Eiles. But his team won't be trying to make any ghostly bonds. "As simple theorists, we'll leave this challenge to the experts, the experimentalists."

Some are up for it. "I think it could actually be done," says Johannes Wilhelm Deiglmayr at the Swiss Federal Institute of Technology in Zurich, co-leader of the team that made the unusual caesium molecules. "This would be really fun to see."

If such ghostly bonds are ever created, Eiles says it would be interesting to figure out if they react with other molecules, or alter the rate of chemical reactions.

Andy Coghlan ■



## Artificial genes show life does not need DNA

LIFE need not be based on DNA. So say researchers who have created two new versions of the iconic molecule, which retain its double helix shape but are thinner or chunkier than the original.

"This is changing the rules of the game that every schoolchild learns," says Steven Benner of the Foundation for Applied Molecular Evolution in Florida. It implies that extraterrestrial life might be based on alternative genetic molecules.

DNA carries our genes, which tell our bodies how to grow and are passed from parent to child. The structure of DNA was described in 1953 by James Watson and Francis Crick – with crucial help from Rosalind Franklin.

Watson and Crick realised that DNA is made up of two long chain-like molecules twisted around each other. The two chains are attached via pairs of bases, one base on each chain. There are four types of base, and they only pair up in specific ways: adenine with thymine, and guanine with cytosine. The order of the bases

is what encodes the information in our genes.

Benner and his colleagues made several alternative DNAs in which they swapped out some of the standard bases for various combinations of eight similar molecules. Doing so made some of the resulting DNA-like

**"We currently have no good reason to assume that aliens will have genomes based on DNA"**

molecules physically "skinnier" than standard DNA, while others were "fatter".

Nevertheless, they all performed DNA's crucial function: if two bases paired incorrectly, the misplaced one was swiftly ejected and replaced with the correct one. This is how DNA ensures our genes don't become garbled, and the modified DNA did it just as well. "I was quite surprised," says Benner.

It is not the first time modified DNAs have been found to work as well as the

Life with a twist: genetic code can be made with different molecules

original. Philipp Holliger at the MRC Laboratory of Molecular Biology in Cambridge, UK, has created "XNA", in which the bases remain the same but the chains are altered. Genes can be copied from DNA to XNA and back.

Meanwhile, Floyd Romesberg at the Scripps Research Institute in La Jolla, California, has built DNA with six bases: the originals plus two artificial ones. In 2014, he got all six working in bacteria.

However, the new DNA breaks what was thought to be a cardinal rule, established by Watson and Crick, which these previous modifications obeyed.

In normal DNA, when two bases pair up, one is large and the other small. For example, adenine is large and its partner thymine is small. Even when researchers have created unusually large bases, they have stuck to this rule.

But in the skinny DNA, small pairs with small. Similarly, in the fat DNA, large pairs with large. Both work.

"There's no reason you had to develop a system where you have the pairing of the small with the large bases," says team member Millie Georgiadis of Indiana University in Indianapolis. It seems there are many ways to build a gene (*Journal of the American Chemical Society*, doi.org/ctwh).

"It clearly raises the question of why we ended up with DNA," says Holliger. He suspects it is simply an accident of chemistry: "we are built from what we are built from because that's what was available."

In 2008, researchers made a double helix out of unrelated chemicals – and its bases still paired up. Combined, the findings mean the search for alien life needs to look for more than just DNA. "We currently have no good chemical reason to assume that, if we ever meet aliens, their genomes will be based on DNA," says Holliger. **Michael Marshall** ■

# Moonrakers dug a hole for life theory

Leah Crane

APOLLO astronauts didn't dig deep enough to get a true picture of the moon's history - a finding that may spell trouble for theories about the rise of life on Earth.

When a rock crashes into the moon or a planet, it vaporises parts of the surface and sends up a spray of debris. As bits of melted dust and rock fly through the air, some of them cool into tiny beads called impact glass spherules, which get deposited again. When they are dug up, their composition can reveal when the impact happened.

Researchers analysing these glass beads in samples from NASA's Apollo missions found there were as many from the past 500 million years as from the entire 4 billion years before that - far more of the younger glass spherules than they expected. From this, they concluded that there were far more objects smashing into the moon in the past 500 million years than the rest of its history.

Now, David Minton at Purdue University in Indiana and his colleagues have built the most

detailed computer model ever of how these spherules get made and used it to check this conclusion.

They used it to simulate the distribution of the beads on sites of the kind visited by the Apollo astronauts. When they kept the impact rate at these sites the same for the past 3 billion years, they found that soil samples taken from the top 10 centimetres of these sites would tend to contain more younger beads, while deeper samples would have a more equal number of old and young beads.

That means that the rate of impacts on the moon may not have changed much in the past 3 billion years - it is just that our samples are shallow and that means they are biased towards evidence of more recent impacts (*Geophysical Research Letters*, doi.org/gdqdvpv).

In other words, the Apollo astronauts weren't digging deep enough to get a full picture of the moon's history. "They had this little rake tool, and they would rake up a few centimetres," says Minton. "We'd have to sample a column of a metre or more to see the true impact rate."

The history of impacts on the



Astronauts collected moon samples with a rake during Apollo 17

moon offers clues to meteorite activity that might have affected Earth. That is because impacts on Earth tend to be erased by geological activity, which the moon lacks. "The moon preserves its record far better than the Earth does," says Paul Renne at the Berkeley Geochronology Center in California.

The geological period around 500 million years ago, when it

appeared the moon experienced more impacts, was a particularly important time for life on Earth. There was a dramatic increase in complex life called the Cambrian explosion, and we aren't entirely sure what caused it.

Some researchers think that the apparent increase in meteorite impacts may have somehow stimulated the increase in complex life. But if this supposed increase in impacts turns out to be wrong, we will have to look for other explanations, says Renne. ■

## Sleep training is faster if waking babies soothed

COMFORTING an infant under 3 months of age who wakes at night can help speed the path to a more restful existence. Beyond the 3-month mark, though, interventions by parents may have little impact on a baby's sleeping habits at night.

It takes time for babies to learn to sleep through the night. To better understand the role of parents in the

process, Sabrina Voltaire at Pennsylvania State University and her colleagues spent nine months following 107 families living in the US who had newborns.

Each family recorded the baby's waking frequency every night for one week before the child was 3 months, 6 months and 9 months old. The researchers also installed cameras in families' bedrooms for one night during the reporting weeks to observe parents' interventions when their babies woke up.

Voltaire found that the babies whose parents responded promptly

to their night wakings before they turned 3 months old experienced a faster decline in their tendency to wake at night. But after the first three months, babies showed a similar pace of sleep development whether or not parents intervened when they woke (*Sleep Medicine*, doi.org/cttk).

The findings contradict the popular "cry it out" approach: letting babies cry until they fall back to sleep.

**"Almost all experts agree that the 'cry it out' approach is inappropriate for very young babies"**

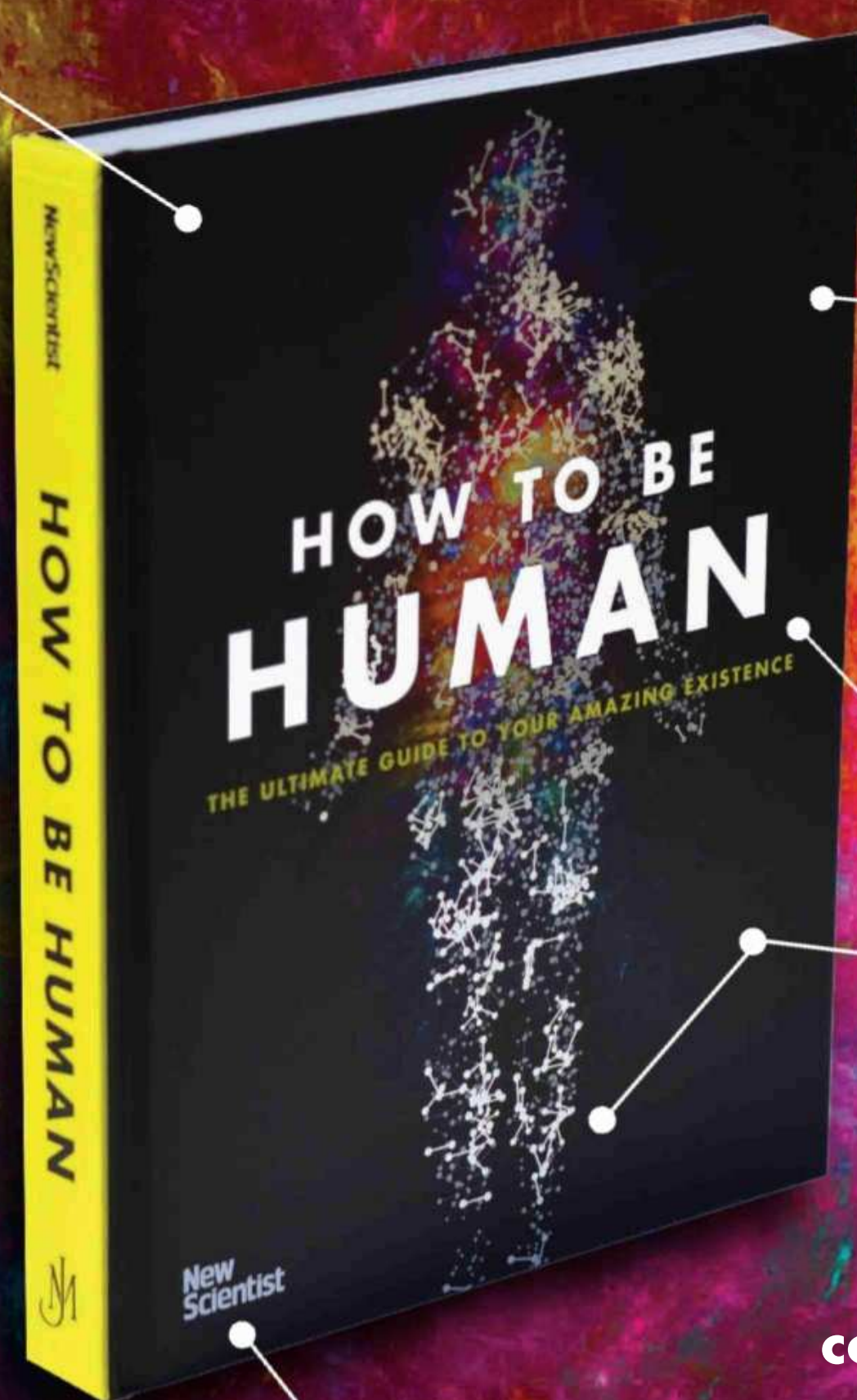
Many parenting books recommend this method because there is an assumption that prompt intervention when a baby cries at night might encourage infants to keep waking up.

"Almost all experts agree that sleep training, including 'cry it out', is typically inappropriate for babies less than 3 months of age," says Jodi Mindell at the Children's Hospital of Philadelphia, Pennsylvania.

"Parents need to be aware of the appropriateness of their responses to their babies by considering a baby's age as well as their developmentally based skills," she says. Yvaine Ye ■

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## Melting Arctic permafrost bleeds acid

SOME patches of Arctic permafrost are leaking acid as they melt. The dribble of acid is destroying rocks and releasing more carbon dioxide into the air – but it isn't clear how much.

Permafrost is soil and sand that normally remains frozen. Climatologists have warned for years that Arctic permafrost is thawing because of climate change. This will transform the landscape, and release carbon that is locked away in the permafrost in the form of CO<sub>2</sub> and methane – adding to the greenhouse effect. Now it seems that some regions of the Arctic might release more CO<sub>2</sub> than expected.

Scott Zolkos at the University of Alberta in Canada and his colleagues studied permafrost in the western Canadian Arctic, which is distinct from that in other areas. "The permafrost is more ice-rich and more sediment-rich," says Zolkos. "So when that permafrost thaws, the material it exposes is different."

The team analysed samples of water from sites upstream and downstream of thawing permafrost patches. The run-off water contained significant amounts of sulphuric acid, which formed when sulphide minerals were exposed by permafrost melt. The sulphuric acid then began reacting with limestone rocks, releasing CO<sub>2</sub> (*Geophysical Research Letters*, doi.org/gd58xx).

This doesn't happen in other regions, says Zolkos, because other permafrost doesn't contain enough sulphide minerals. Instead, carbonic acid forms when CO<sub>2</sub> dissolves in the meltwater. This acid also destroys limestone, but the reaction consumes rather than releases CO<sub>2</sub>.

What will happen next depends on which parts of the Arctic melt first. "If there is carbonate weathering where sulphides are present, that can create CO<sub>2</sub>," says Zolkos. "But if it's carbonate weathering where sulphides are absent, that will likely consume CO<sub>2</sub>." Michael Marshall ■



DIGITAL FIRST MEDIA/THE MERCURY NEWS VIA GETTY IMAGES

## New Apple Watch's potential risks

Clare Wilson

THE latest Apple Watch will give people warnings if their heart rate goes too high or low and let them take a read-out of their heart's electrical activity.

It is being billed as a giant leap in home healthcare – but critics say it will lead to huge numbers of people getting told they have heart problems when they don't.

The Series 4 watch will go on sale in the US later this month costing \$399, Apple announced at the product launch last week, calling the device "an intelligent guardian for your health".

An electrocardiogram (ECG) is usually just available in hospital. Pads put onto your body detect your heart's electrical activity, which is shown as the well-known

spiky lines on a monitor.

Now Apple Watch users will be able to get an ECG at the touch of a button, by putting a finger on the watch's side. After 30 seconds, you get told if the result is normal or suggests a problem. The recording can be shared with a doctor.

Having the function built into the watch will mean many people

**"Many more people will start regularly taking their ECG – and that is where problems may start"**

will start regularly taking their ECG, especially if they worry about their health – and that is where the problems may start, says Venkatesh Murthy at the University of Michigan.

The feature will be useful for

The new Apple Watch is billed as a leap in home healthcare, but is it?

some people who need home monitoring, namely those who have a condition called atrial fibrillation, where the heart beats irregularly. This causes symptoms such as breathlessness, tiredness and chest pain, and puts people at risk of a stroke.

But many people can have an irregular heart rhythm without symptoms. They will be told by their watch to take the ECG result to a doctor. They could then go on medications such as blood thinners, which can trigger bleeding as a side effect. It is unclear whether there is any benefit from treating symptomless atrial fibrillation. Even if doctors advise no treatment, people will be falsely alarmed, says Murthy.

Several trials have investigated whether it is helpful to give ECGs to people without symptoms. The US Preventive Services Task Force has concluded that the evidence fails to show this approach does more good than harm.

*New Scientist* has asked Apple if the company has any specific measures to avoid misdiagnosis, but has yet to receive a response.

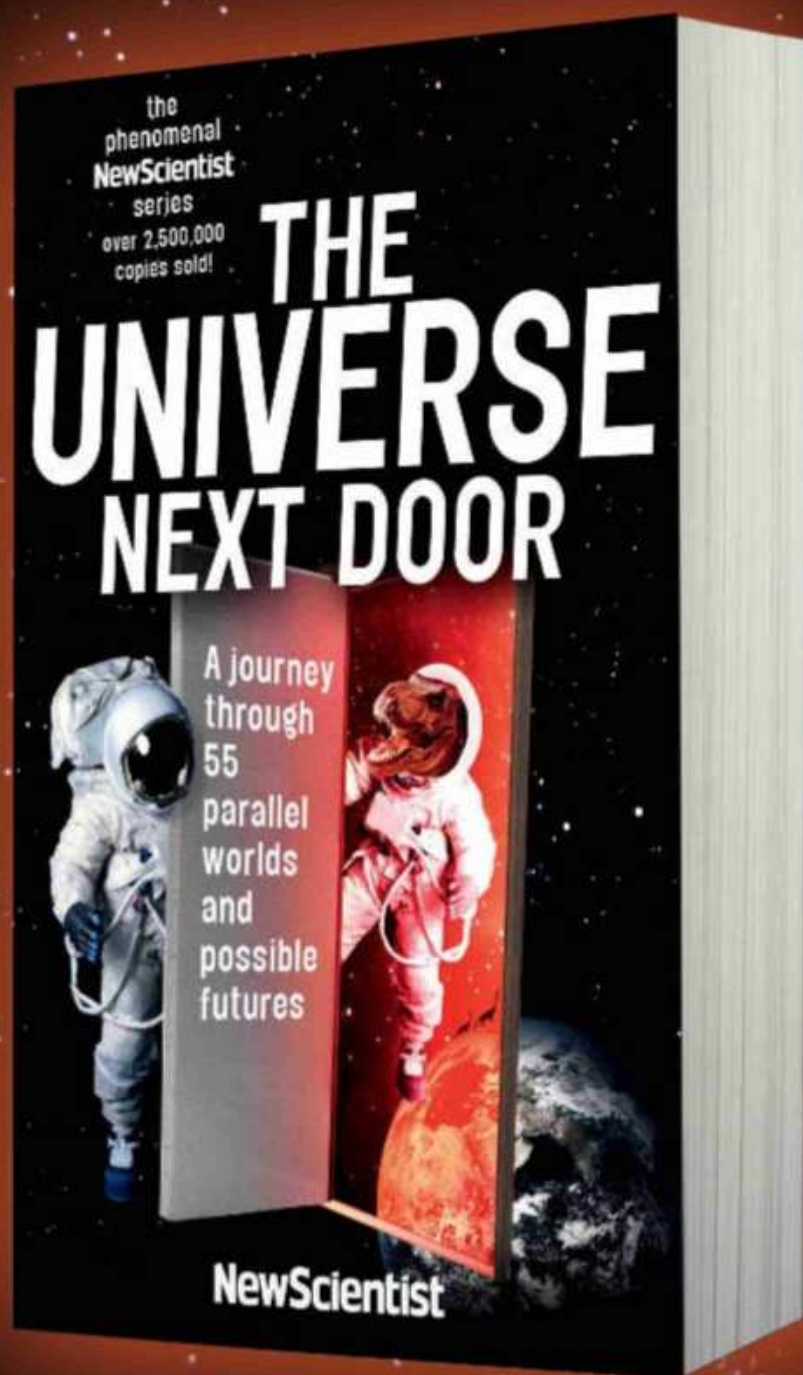
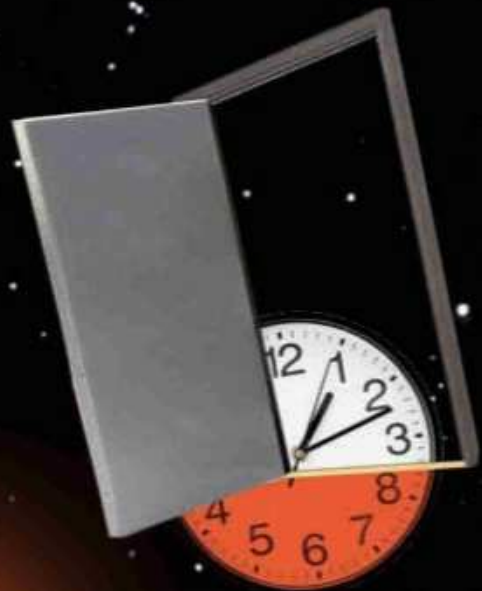
Another function, the intermittent heart rate monitor – which works through sensors built into the back of the watch face – may also have potential for false alarms. For example, people who are very fit could be wrongly sent a notification saying that their heart rate is too low.

"Your heart rate naturally falls when you are relaxed or sleeping. Is that going to set off an alarm? They haven't released the data," says Murthy.

And there is a third new medical feature. This will call emergency services if the wearer is detected to have taken a hard fall and stays immobile for 60 seconds.

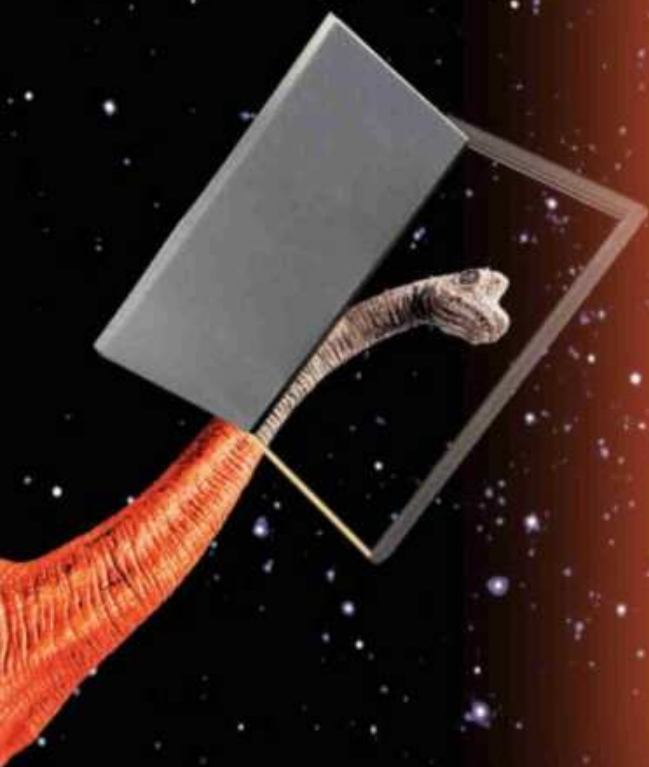
All such functions will no doubt be appreciated by people with health concerns – not to mention the worried well. ■

**WHAT IF TIME STARTED  
FLOWING BACKWARDS?**



**WHAT  
IF THE  
RUSSIANS  
GOT TO  
THE MOON  
FIRST?**

**WHAT IF DINOSAURS  
STILL RULED THE EARTH?**

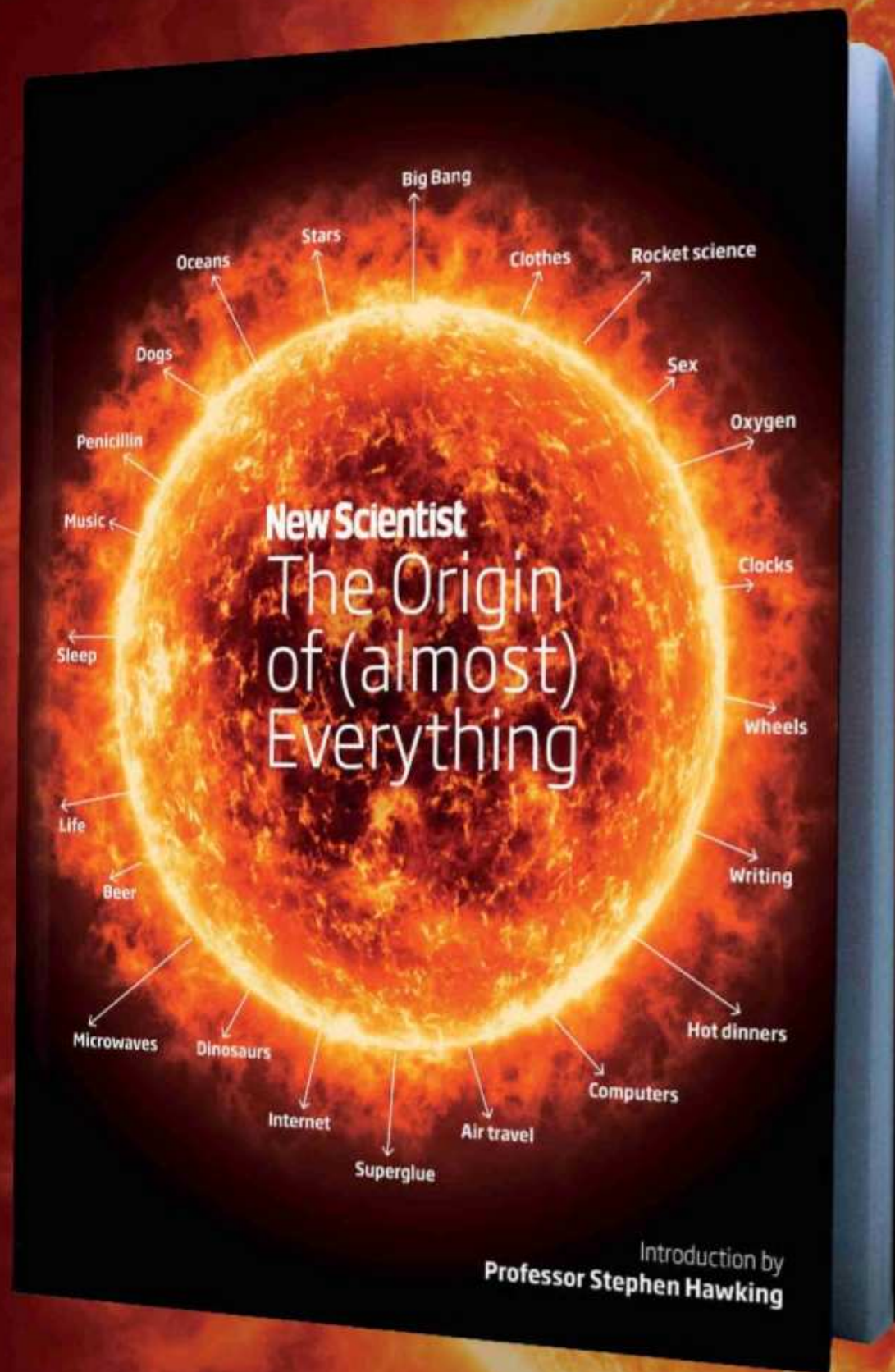


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# Gluten's subtle effect on the mind

Alice Klein

SOME people say they don't feel good after eating gluten – but perhaps that is because of its effects on mental health rather than on the gut.

Gluten is a protein found in foods including wheat and rye that causes the negative reaction in coeliac disease, an autoimmune condition affecting about 1 per cent of us. Another 12 per cent of people say they get bloating, tiredness and other symptoms after they eat gluten-rich foods.

But there is no agreement on whether this “non-coeliac gluten sensitivity” is a real condition, particularly because several studies have shown that people who have it report the same symptoms if they eat an inactive substance they think is gluten.

However, even if gluten doesn't cause gut troubles, it may trigger other symptoms in some people, says Jessica Biesiekierski at La Trobe University in Australia.

Biesiekierski and her colleagues investigated with the help of 14 people with self-reported gluten sensitivity. In one experiment, the participants were asked to

eat a yogurt on separate days two weeks apart. On one of the days, the yogurt contained gluten, on the other day it was gluten-free. The participants didn't know which yogurt was which.

In another experiment, people were given two batches of muffins to eat a few weeks apart. Again, one batch contained gluten and

one didn't, and the volunteers didn't know which was which.

The volunteers reported similar levels of bloating and cramps regardless of whether they ate the gluten-containing or gluten-free foods, reinforcing previous findings that gluten isn't responsible for gut upsets in people without coeliac disease.

That wasn't the only discovery. Participants reported feeling more tired after eating gluten-containing yogurt and reported

**Gluten is found in the flour used to make most breads and cakes**

fewer positive emotions after consuming the gluten-containing muffins than after they ate the gluten-free foods. The effects were small but statistically significant, and may explain why some people say they feel better after going gluten-free, says Biesiekierski, who presented the results at the annual meeting of the Gastroenterological Society of Australia in Brisbane earlier this month.

The findings chime with previous work by Biesiekierski showing that gluten seemed to cause more symptoms of depression than an inactive substance in 22 people with gluten sensitivity. Similarly, a 2015 study led by Antonio Di Sabatino at the University of Pavia in Italy found that gluten caused more symptoms of depression and “brain foginess” than an inactive substance in 59 gluten-sensitive individuals.

Michael Potter at the University of Newcastle in Australia says the evidence is building. “These studies suggest there are definitely people who have reproducible mental health responses to gluten when they undergo blinded challenges.”

Even if gluten can directly affect mental health, it is likely to occur in only a few sensitive people, says Biesiekierski. “We're certainly not saying that everyone will get depression after eating gluten,” she says. ■



MONKEY IMAGES/PLAINPICTURE

# A star spinning so slowly it shouldn't exist

A DISTANT pulsar is taking it slow – so slow that it shouldn't exist. Radio pulsars are rapidly spinning neutron stars that emit a beam of powerful radio waves. But we have just found one rotating so slowly that its beam should have been snuffed out.

Chia Min Tan at the University of Manchester, UK, and his colleagues found this sluggish star using the

Low-Frequency Array (LOFAR), a set of radio telescopes based mostly in the Netherlands ([arxiv.org/abs/1809.00965](https://arxiv.org/abs/1809.00965)).

It takes 23.5 seconds for this pulsar, called PSR J0250+5854, to complete a rotation. That might sound fast, but it is the slowest radio pulsar ever spotted – most others have rotation periods in the single digits.

As we have now seen a slow pulsar, that probably means there are many more out there, says Tan, but they are difficult to find. “The radio that comes from a pulsar is sort of like a lighthouse; you can only see the

signal if the radio beam points towards you,” says Tan. “For a longer period pulsar, we expect the beam to be much narrower compared with a faster pulsar, so we expect these to be harder to detect.”

The way pulsars create radio waves is thought to depend on charged particles being accelerated by the neutron star's spinning magnetic field, but this one seems to spin too slowly.

**“This pulsar takes 23.5 seconds to complete a rotation. That might sound pretty swift, but it isn't”**

Alice Harding at NASA's Goddard Space Flight Center in Maryland says this may point to the magnetic field being unusually complicated. “You definitely would not be able to create this pulsar without some significant additional distortion of the magnetic field,” she says.

This pulsar may help us figure out exactly how others like it generate their beams, and why they might stop, says Jim Cordes at Cornell University in New York. “We'd need a few hundred of them, but this may be the harbinger of that population of very slow-moving objects.” Leah Crane ■



JASON LANGLEY/ROBERT HARDING

# Vast parts of Earth should be left wild

Michael Le Page

TO AVOID mass extinctions of plants and animals, governments should protect a third of the oceans and land by 2030 and half by 2050, with a focus on areas of high biodiversity. So say leading biologists in an editorial in the journal *Science*.

This isn't just about saving biodiverse areas, says Jonathan Baillie of the National Geographic Society, one of the authors. It is also about saving ourselves by protecting wider natural systems, or ecosystems, and their benefits to us, known as ecosystem services. "We are learning that the large areas that remain are important for providing services for all life. The forests, for example, are critical for absorbing and storing carbon," says Baillie.

At present, just 3.6 per cent of the planet's oceans and 14.7 per cent of land is protected by law. At the 2010 Nagoya Conference of the Convention on Biological Diversity, governments agreed to protect 10 per cent of the oceans

and 17 per cent of land by 2020.

But this isn't nearly enough, says Baillie. In the editorial, he and his coauthor, Ya-Ping Zhang of the Chinese Academy of Sciences, want governments to set much bigger targets at the next major conference on biodiversity in 2020 (*Science*, doi.org/cttj).

"We have to drastically increase our ambition if we want to avoid an extinction crisis and if we want to maintain the ecosystem services that we currently benefit

**"We have to drastically increase our ambition if we want to avoid an extinction crisis"**

from," says Baillie. "The trends are in a positive direction, it's just we have to move much faster."

It is hard to work out how much space is needed to preserve biodiversity and ecosystem benefits, the pair say, because there is so much we don't know about life on Earth – like how many species there are. However, most estimates suggest between

Forests are havens for wildlife and crucial carbon stores

25 and 75 per cent of high-biodiversity regions or major ecosystems must be protected. And we should err on the side of caution when setting targets.

"There is no doubt we need far more land and sea secured for conserving and retaining nature," says James Watson at the University of Queensland in Australia. "Targets like 50 per cent are in the right ball park when it comes to the minimal amount of area needed to conserve biodiversity."

But Watson and others stress that which areas get protected is even more important than the overall percentage. "The key thing is to protect the right areas," says Jose Montoya of the Station for Theoretical and Experimental Ecology in Moulis, France. "If we merely protect a proportion of the territory, governments will likely protect what's easy, and that's usually areas of low biodiversity and ecosystem service provision."

What's more, a third of the 3.6 per cent of land that is already meant to be protected is actually being exploited, Watson's team reported last month. So merely declaring areas to be protected isn't enough. ■

## Whose line of code is it anyway?

ARTIFICIAL intelligence has joined a group of actors improvising in a live stage performance, providing a novel twist on the Turing test – used to assess machine intelligence.

AI has written scripts, poetry and jokes before, but Kory Mathewson at the University of Alberta, Canada, and Piotr Mirowski, a computer scientist and drama school graduate, have gone a step further and used a robot in comedy theatre.

They based their work on *The Actor's Nightmare*, a play featuring improvised performance where actors are forced to make incongruous lines fit believably into a constantly evolving scene. One actor might be reading *War and Peace* while a second has to ask for a divorce. "*War and Peace* and an acrimonious divorce don't really make sense together," says Mirowski, and this is where the potential for comedy lies.

In Mirowski and Mathewson's version, *Improbatics*, three actors appear on stage – as a "human with free will", a "puppet" and a "cyborg". Only the first can devise their own lines; the puppet gets fed from a human off-stage, and the cyborg gets lines generated by an AI called A.L.Ex.

The Turing test, devised by computer pioneer Alan Turing, requires a machine to convince an interrogator it is human. At the end of *Improbatics* the audience had to guess who was playing each role (arxiv.org/abs/1809.01807).

AI still has some work to do. The audience always guessed the identity of the AI-controlled improviser, but in two out of six shows some thought there was a second AI performer.

For the cast, dealing with the lines from the AI was tricky. "It was like performing with a very new improviser with strange impulses," reported one actor. "Nervous and unpredictable", remarked another. Mirowski describes the cyborg actor as being "the most adversarial stage partner possible". Frank Swain ■

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## Paradise may have been found 10,000 years ago

HUMANS sailed to Madagascar more than 10,000 years ago – 6000 years earlier than we thought – according to new work.

The question of when humans settled the island off Africa's east coast has been puzzling us for years because there is so little to go on. Previous findings of tools and animal bones suggested that humans were present by 4000 years ago, although the evidence is disputed.

James Hansford at the Zoological Society of London and his colleagues have now found signs of an earlier human presence. On 10,000-year-old bones of extinct

elephant birds – once the world's largest bird – the researchers identified cut marks left by human butchers.

The bones were found nearly a decade ago near the Christmas river in southern Madagascar. Carbon dating indicated that they were more than 10,000 years old.

Although no tools or other human-made products were found at the site, Hansford and his colleagues have now realised that the bones have scratch marks that look like impacts from stone blades. They compared them with previously identified tool marks on animal bones and modern butchery marks, and concluded they were made by humans (*Science Advances*, doi.org/ctsf).

Madagascar was once a paradise for elephant birds, giant lemurs and dwarf hippos, but all three have gone extinct in the past 1000 years as human settlements have spread.

## Winged bot probes mysteries of fly flight

A ROBOT with insect-like wings can dodge a swatting hand with the agility of the fruit fly that inspired it. While it is 55 times bigger than an actual fruit fly, DelFly is helping us understand some of these avoidance tactics.

Of particular interest is a move called a banked turn, in which flies tilt their bodies to perform a sharp change in direction. This requires sophisticated sensory

and motor controls that aren't fully understood. What has puzzled researchers is that the flies continue to drift sideways after this manoeuvre, which was thought to be undesirable to the flies as they seem to lose control over their trajectory.

To examine this, Matej Karásek at Delft University of Technology in the Netherlands and his colleagues programmed DelFly

to use similar wing movements and body rotation patterns as fruit flies to perform a banked turn. Initially DelFly drifted sideways too. However, the team was able to remove this drift by adjusting the orientation of DelFly's head to align with its body right after a turn.

Surprisingly, this tweak didn't improve DelFly's turning speed or agility, suggesting that drifting isn't really a downside for flies (*Science*, doi.org/cts6).

## Basking sharks leap like great whites

LANGUID basking sharks that eat tiny zooplankton jump out of the water, or breach – a behaviour more normally seen in smaller great white sharks to capture seals. Now we know more about how they do it despite their size.

Jonathan Houghton at Queen's University Belfast and his colleagues monitored breaching basking sharks. They estimate the sharks reach 18 kilometres per hour to breach, the same as great whites. This means an 8-metre-long basking shark would use 45 to 51 kilocalories to breach, more than a great white. But because basking sharks are almost twice as big as great whites, the energy used per kilogram of body weight is similar (*Biology Letters*, doi.org/ctrj).

The analysis may reveal more details about how basking sharks breach, but why they do it is still unknown. "It's a mystery," says David Sims at the Marine Biology Association in Plymouth, UK.

## Close a wound - no stitches required

WOUNDS are usually fixed with stitches and staples that damage surrounding tissue. This could be avoided with a new bandage that seals wounds without stitches.

Kaushal Rege at Arizona State University and his colleagues made the bandage by combining silk and gold nanorods in a thin material. When a laser is shone on the bandage, the gold converts the light into heat. This leads to structural changes in the silk and the collagen of the tissue it is applied to, causing them to intertwine and bond together.

The team found that incisions in pig intestines closed with the bandage withstood higher fluid pressure than those closed with stitches (*Advanced Functional Materials*, doi.org/cts7).

## Turn a drop into a bubble with sound

BURST a soap bubble and it splits into droplets. Now we can do the reverse, turning a droplet into a bubble using only a blast of sound.

People have already managed to suspend small particles in the air with ultrasound waves, which have frequencies beyond those the human ear can detect.

Duyang Zang at Northwestern Polytechnical University in China and his colleagues have now discovered that by controlling the sound pressure - the force the sound wave exerts - they can create a bubble from a levitating droplet.

The team placed a droplet of soap solution in an acoustic levitator. They increased the sound pressure on the droplet by gradually turning up the volume of the device, which allowed them to flatten it into a film and then curve it into a bowl that filled with air.

Once the bowl reached a certain volume, the air molecules trapped inside began to resonate with the sound waves and vibrate violently. This increased the pressure on the bowl-like structure, inflating it and eventually creating a bubble.

The work is more than just a new way to blow bubbles, says Zang. The technique could be used to create ultralight materials or tiny capsules to carry medicine (*Nature Communications*, [doi.org/gd57s8](https://doi.org/gd57s8)).



## Mice may be harmed by chemicals that replaced BPA in plastic

PLASTIC bottles are often sold as “BPA-free”, meaning they don’t contain bisphenol A, a chemical used in plastic production that disrupts reproduction in mice. Now it seems the chemicals that replaced it may harm mice too.

As with BPA, this could spark fears that they might leach out of food or drink packaging and affect people, but there is no evidence yet to support such worries.

Patricia Hunt of Washington State University in Pullman discovered problems with BPA’s replacements 20 years after she

helped draw attention to BPA.

As with her earlier findings, she noticed that mice in cages made of certain plastics began to show reproductive problems, such as abnormal eggs and low sperm counts. She found cage surfaces to which mice were exposed were contaminated, this time with the BPA substitute bisphenol S.

Hunt and her colleagues then exposed female mouse fetuses to tiny amounts of a range of BPA replacements while their eggs were developing. She also exposed male mice to the chemicals just

after birth, when they start to develop sperm.

Compared with control groups, exposed mice later had chromosomal abnormalities in cells destined to become sperm or eggs, suggesting they will produce less sperm or a greater number of abnormal eggs (*Current Biology*, [doi.org/ctsr](https://doi.org/ctsr)).

Oliver Jones at RMIT University in Australia says it is too soon to worry about the findings. His reasons include the fact that chemicals that affect mice don’t always do the same to us.

## Supplement stems damage to joints

AN ANTIOXIDANT supplement has shown promise in helping mice with osteoarthritis, the most common joint disorder.

The only existing treatments for people with osteoarthritis are painkillers and drugs that reduce inflammation, but nothing halts or reverses the condition.

To look for alternatives, Rik Lories at the Catholic University of Leuven (KUL) in Belgium and his colleagues screened gene activity in cartilage samples from people and mice with osteoarthritis. They found depleted levels of a protein called ANP32A, which drives production of an enzyme that counters oxidative stress. When the researchers bred mice unable to make ANP32A, the animals developed osteoarthritis.

The team turned to N-acetyl cysteine (NAC), a supplement that neutralises oxidative stress. When mice with osteoarthritis were given NAC, it cut joint damage to the level seen in healthy mice (*Science Translational Medicine*, [doi.org/ctsm](https://doi.org/ctsm)).

Lories says that, in people with osteoarthritis, insufficient NAC may reach cartilage to heal damage. His team plans to focus instead on ways to boost ANP32A.



## Plastic hits young turtles hardest

YOUNG turtles off Australia’s Queensland coast are more at risk of swallowing plastic than their elders.

Autopsies on 246 sea turtles that washed up dead on beaches across Queensland showed that 58 had each ingested between one and 329 fragments of plastic. The rest died of other causes, such as boat collisions. Of the plastic fatalities, four were adults or near adults, 41 were juveniles and 13 were very young “post-hatchlings”.

One explanation is that young turtles swim nearer the surface, where plastic floats, and drift with

plastic-rich currents. “It may be that they are less selective than adults and encounter higher concentrations of debris,” says Britta Denise Hardesty of the Australian federal agency CSIRO, who led the survey.

The team calculated how the risk of death rose as plastic in the gut increased, based on animal size and age. For young turtles about 45 centimetres long, swallowing 17 fragments raised the risk by 50 per cent. Swallowing one fragment carried a 22 per cent risk. Plastic can kill by blocking or perforating the gut (*Scientific Reports*, [doi.org/ctsb](https://doi.org/ctsb)).

# Towards a low carbon future

The world needs more energy but delivered with fewer carbon emissions. Embracing that dual challenge is the way BP thinks about every aspect of its business, says **Kathrina Mannion**

“The world is facing a huge challenge,” says Kathrina Mannion. The global population is rising and expected to reach 9 billion by 2040. The standard of living is rising for many people, who want access to transport, to nutritious and plentiful food supplies, to development and so on. To achieve all this, they need energy.

“But how are we collectively going to meet this massive demand while also reducing emissions?” she asks. The issue is that greenhouse gases are emitted through use of fossil fuels in activities such as transport, power, heating and agriculture. But these gases play a role in global warming.

Mannion’s question may sound unusual given that she works for BP, one of the world’s biggest oil and gas companies. But that’s the point. BP believes it has a key role to play. And Mannion is heading a unit inside the company that is helping drive action across the business.

“No one company or sector alone can deliver a low carbon future. Everyone, from consumers to corporations to governments, needs to take responsibility. At BP we’re asking what we can do to help to play a role in addressing this challenge,” she says. “As part of that we launched the Advancing Low Carbon programme,” for which she is the programme director.

Earlier this year, BP announced a number of new low carbon targets. “We’re trying to reduce emissions in our own operations, to improve our products to help our customers reduce their emissions, and also to create new low carbon businesses. The Advancing Low Carbon programme is looking to encourage more action in all of these areas,” says Mannion, who has a degree in ecology.

For example, BP is one of the top wind energy producers in the US, generating 2259 MW of renewable power. That’s enough to power every home in Philadelphia.

But it’s not just renewable energy sources she is focusing on. “We know that the world

will be using fuels and lubricants for many decades to come. So we are looking at ways to make those the most efficient or low carbon fuels and lubricants we can,” she says.

One example is Biojet, a lower carbon jet fuel made partly from recycled cooking oil that BP sells in Sweden and Norway. This reduces greenhouse gas emissions by more than 60 per cent compared to standard jet fuel.

This low carbon thinking can be seen in BP’s lubrication business too. Its Castrol business has developed an innovative new way to change and recycle used engine oil, set to hit the market after 2020 (see “All Change,” opposite) and a range of carbon neutral lubricants.

Applying this kind of innovative thinking to its shipping fleet means that BP tankers operate more energy efficiently too.

BP has also invested in external companies that have potential to reduce carbon emissions. A good example is Solidia Technologies, which has developed a form of cement that captures and stores carbon dioxide as it dries.

The ability to quantify the impact of these efforts is a crucial part of the Advancing Low Carbon programme. Mannion is adamant that these figures must be supported by evidence and clear and provable data. So the figures and the approach are all checked by independent observer Deloitte to ensure that it is thorough. “We’ve brought in an external partner who looks at these activities to check our figures and make sure they are robust and verifiable,” she says.

The Advancing Low Carbon programme is beginning to change BP from the inside by energising low carbon thinking. “We need to think right across the company how we can encourage and drive low carbon action,” says Mannion. “To deliver significantly lower emissions, every kind of energy needs to be cleaner and better.” ■

**More at:** [newscientist.com/BP](http://newscientist.com/BP)

**Kathrina Mannion,**  
**BP’s Advancing Low**  
**Carbon programme**  
**director**

**Right: Biojet is**  
**a lower carbon**  
**aviation fuel**

**Below: BP is one**  
**of the top wind**  
**energy producers**  
**in the US**

**“BP is**  
**focusing**  
**on carbon**  
**emissions**  
**in every**  
**aspect of its**  
**business”**





## All change

Nexcel is a reusable and easily replaceable cell, like a cartridge, that contains all the oil for an engine along with the oil filter. It's being developed to be engineered into cars of the future. So an oil change will be as simple as lifting out the cell and replacing it with another, which takes about 90 seconds.

Because the used oil is contained, all of it can be recycled. That has significant benefits. The world produces about 6 billion litres of used engine oil every year but only about a quarter is recycled. In fact, about 2 billion litres is not recovered by licensed waste companies and so ends up in local waste streams, where it can be hugely damaging.

Nexcel will allow engine oil to be efficiently recycled and reused. It also does away with the need for oil to be stored and sold in single use plastic containers.

The system can also improve engine efficiency. One factor that determines this is the temperature of the engine oil. The oil becomes less viscous, reducing friction within the engine, as it heats up. That's one reason why hot engines are more efficient. In contrast, an engine running on cold oil uses up more fuel and is therefore more wasteful.

When a conventional engine starts from cold, it has to heat all the oil in the sump – usually around 5 litres. "That's a large volume of oil to be heated before you reach the optimum temperature," says Rachel Fort, a chemist who is a senior formulation technologist at Nexcel.

But the Nexcel system feeds oil into the engine in small, precisely controlled amounts that quickly heat up. So the engine can operate more efficiently from the start.

In-house testing indicates that this, along with other lubricant technologies enabled by Nexcel, could translate to a reduction in carbon dioxide emissions of 2 grams for every kilometre driven. "That may not sound like much, but every gram is important," says Fort. "Over the lifetime of a vehicle, that equates to about a third of the vehicle mass."



Above centre:  
Rachel Fort, Nexcel

Above: The Aston  
Martin Vulcan uses  
the Nexcel system

# The white stuff

Milks made from peas, nuts and more are taking supermarket shelves by storm. **Chelsea Whyte** explores which you should be drinking

MOVE over cows, there's a new milk in town. There are many, actually. The old alternatives – soy, rice and coconut milk – are now joined on grocery shelves by alt-milks made from almonds, cashews, macadamia nuts, oats, peas, flax, hemp – the list goes on and on. You can even buy milk made from potatoes or bananas.

Since 2012, non-dairy milk sales in the US have risen 61 per cent, according to market research by Mintel. There is a similar trend in the UK, with plant-milk sales up a third since 2015. More than half of that is almond milk, with soy and coconut milks making up another quarter of the market.

As you might expect for the latest food trend, these milks are mostly bought by millennials, or adults younger than 35. Manufacturers appeal to that generation's values by positioning the products as a healthy alternative, both for the body and the planet. But is that really true?

Nutritionally, it depends on which milk replacement you consider. In general, they are made by grinding up plants and soaking them in water, then adding emulsifiers and stabilisers to thicken the liquid and keep it from separating, but they have a lot of variety (see “What’s in a name?”, above right).

In terms of protein, soy milk is quite like cow's milk, and it contains similar omega-3 fatty acids that are important for heart health. Almond and cashew milks have less than half the calories found in cow's milk, but are lower in protein. Coconut and hemp milk have a rich texture owing to their high fat content and they also include a small



amount of dietary fibre not found in cow's milk. Oat and rice milks are higher in carbohydrates than both cow's milk and other plant-based alternatives.

Milks made from legumes, such as peas, soya beans and peanuts, also offer amino acids not found in cereal crops. Each type of alternative milk has its nutritional benefits and limitations. Any one

**“Milk alternatives are only healthy if combined with a rounded diet, though the same is true of dairy milk”**

of them can be considered healthy only when combined with a rounded diet, though the same can be said for dairy milk.

“Almost all of these products are fortified,” says P.K. Newby, a nutrition and sustainability scientist at Harvard University. Many non-dairy milks have vitamin D, vitamin B12 and calcium added to make them more similar to cow's milk.

Few of them have added iodine, though, which helps make thyroid hormones that regulate our metabolism. A 2017 study of iodine

**Sales of alternative milks are rapidly growing in the UK and US**

levels in seven types of plant-based milks available in the UK found average iodine concentrations of just 1.7 per cent that seen in cow's milk. The authors found that only three of 47 alt-milks on the market were fortified with iodine, and the concentration in those was just a bit over half that seen in cow's milk.

Still, Newby says people who use milk in their coffee or just for cereal could easily switch to

a non-dairy alternative without much dietary impact (see “Where to start with alt-milk”, below).

“It’s not like most people are drinking this for the nutrients, as such,” she says. “They tend to meet their nutrient needs with other foods.”

## Glass half-full

There are some alt-milks it makes little sense to produce in bulk. Rice milk is an option for those with dairy, nut, gluten and soy allergies, but it has far less protein than cow’s milk and often has significant amounts of sweeteners added to improve the flavour.

It is also one of the most environmentally costly alt-milks to produce. When rice paddies are flooded to stimulate plant growth, submerged biomass decomposes without oxygen, producing the potent greenhouse gas methane.

“Rice has a much greater carbon footprint than other cereals,” says Elin Röö, who studies the environmental impacts of food production at the Swedish University of Agricultural Sciences. “It’s very low in nutrition. I don’t see why you should use it.”

Of course, cows are notoriously bad for the environment as well. The carbon footprint of producing cow’s milk varies from place to place, but in Western countries, it is typically around twice as big as that of making plant-based alternatives, says Röö.

A 2010 report by the Food and Agriculture Organization of the United Nations found that the production, packaging and transportation of cow’s milk emits 4 per cent of all human-caused greenhouse gas emissions.

In fact, lactating cattle are the main source of greenhouse gases among all livestock and poultry. These emissions include methane that builds up in a cow’s digestive tract and is then burped out or emitted from its manure. Carbon dioxide and nitrous oxide are also released from any land cleared for

feed crops. Fertilisers used to grow feed further add to the greenhouse gas emissions.

“You need to produce a lot of feed for the animals,” says Röö. “Most of the energy in that feed is lost in the process of feeding animals, so in general, all the resource use is much bigger for animal products than for plant-based milks.”

Land management plays a role in the environmental impact of every kind of milk. Some cattle graze on grassland, which stores more carbon than land that has crops turned over each year. But a 2017 study by the Food Climate Research Network at the University of Oxford found that the carbon sequestered in the soil would only offset up to 11 per cent of the animals’ emissions.

Carbon isn’t the only environmental concern to consider. Nuts are notorious water sinks, with some requiring nearly as much water to produce as cow’s milk. “We made a calculation that came to a water footprint of 917 litres per litre of almond milk, the same order of magnitude as cow milk, 1000 litres per litre,” says Arjen Hoekstra at the University of Twente in the Netherlands.

He also found that producing 1 litre of soy milk requires

## WHERE TO START WITH ALT-MILK

Each non-dairy milk option has its pros and cons. Decide what is most important to you - nutrition, sustainability, allergies - and then get tasting. Here are a few brief reviews of some of the most popular alt-milks.

**Soy:** It is the closest in nutritional value to cow’s milk and the flavour is mild but distinct.

**Rice:** For those with allergies to nuts, soy, dairy and gluten, rice milk is the way to go. It is a bit thin on flavour and texture.

**Banana:** Another allergy-free option, with a bit more substance than rice milk, but it can be difficult to find.

**Almond (or other nuts):** The flavour

## WHAT’S IN A NAME?

Until recently, manufacturers have labelled pretty much any opaque whitish liquid made from plants as “milk”, but there is pushback.

France has now banned plant-based milks from being marketed using dairy-related words. Jean-Baptiste Moreau, a cattle farmer and member of parliament who suggested the ban, has said the aim is to “combat false claims”.

In the US, dairy farmers are gearing up for their own fight in this arena.

297 litres of water. That includes water that ends up in the milk itself, water that evaporates during production and water polluted by those processes. It also accounts for the water used to make the sugars and starches that flavour and stabilise the milk.

In a 2010 report, the UNESCO Institute for Water Education assessed the water footprint of global food crops. It found that of the plants used for alt-milks, water usage was highest for nuts, flax and soy, and lowest for coconut, oats, rice and hemp.

“You also have to take into account the water scarcity situation in a region,” says Röö. There are places where you need to irrigate to produce any crops, so they will have higher water

One aim of the DAIRY PRIDE Act - which stands for Defending Against Imitations and Replacements of Yogurt, Milk, and Cheese to Promote Regular Intake of Dairy Everyday - is to enforce regulation against “misbranded milk alternatives”.

Scott Gottlieb, head of the US Food and Drug Administration, has indicated that the agency may soon enforce a standard that defines milk as coming from the “milking of one or more healthy cows”.

usage. And there are places like Sweden, she says, that rely more on rain stored in the soil - but that also adds to a water footprint.

On the whole, it is clear that alt-milks are friendlier to the environment than traditional dairy, but their growing popularity may cause problems.

## “Alt-milks are better for the environment than dairy, but their growing appeal may cause problems”

As more people jump on the bandwagon, manufacturers are starting to compete to introduce new flavours and new types of plant-based milks. Röö warns that this trend may cause unintended environmental harm.

If demand for coconut milk skyrockets, for example, it will become more profitable to grow coconut trees, which could lead to deforestation as farms expand. To avoid that, it is best to have several non-dairy options to choose from. So maybe the proliferation of alt-milks is a saving grace.

All that said, sometimes the impacts on the food system may not be worth the end product, says Röö, as with rice milk. Or take banana milk, which involves blending bananas, usually adding some sugar and spice for flavour, and straining the mixture. Then it must be packaged, stored and transported. “Is it worth it? Or is it best to just eat the banana?” asks Röö. ■

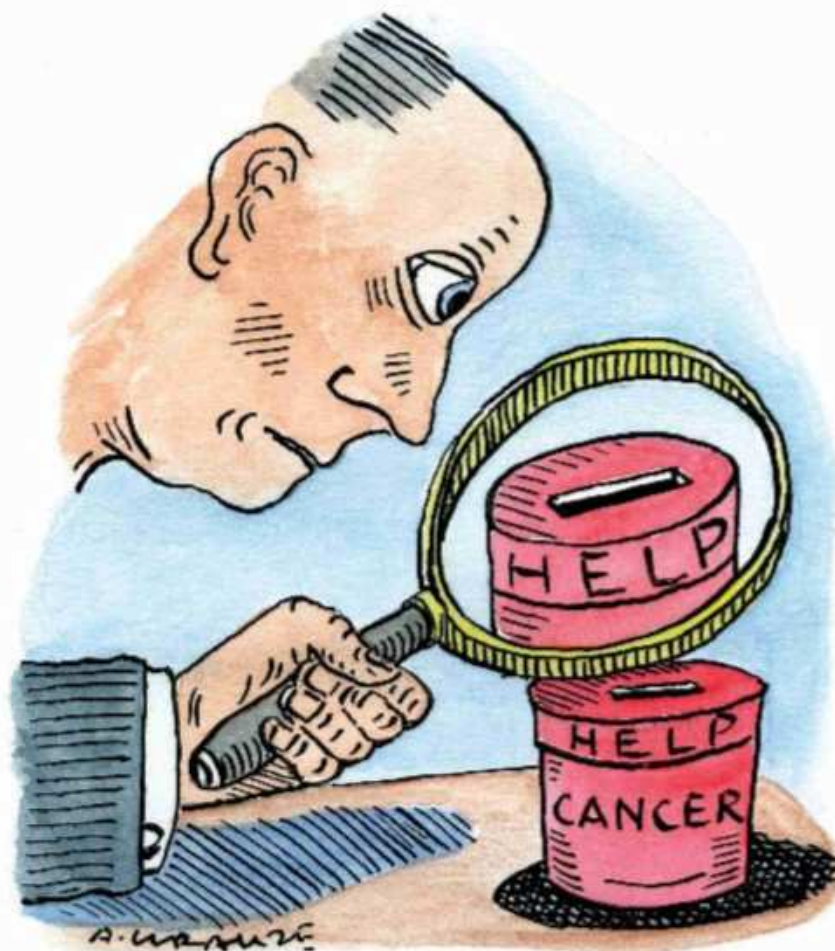
# Good intent, bad science

Blinkered coverage of crowdfunded cancer treatments is fuelling unproven and potentially harmful therapies, says **Michael Marshall**

CROWDFUNDING campaigns to help people with cancer pay for ineffective alternative treatments are becoming more common. They often come with six-figure targets to meet the cost of controversial therapies. Headlines are almost guaranteed.

*The BMJ* reports concerns over this, based on information I gathered working for the charity Good Thinking. By sifting fundraising sites like JustGiving and GoFundMe, I identified appeals from people in the UK who sought money for unproven or disproven treatments, finding 400 in the past three years. Those have raised £7 million, the bulk destined for clinics abroad.

Although the treatments, such as extreme diets and alkaline therapy, aren't backed by scientific evidence, people who are desperate and vulnerable are often tempted by remarkable



testimonials. For those who see such stories in the media, and who care about following good scientific evidence, the natural reaction is to try to protect people from possible physical, emotional and financial harm.

Questioning these appeals isn't easy. People with cancer often view these therapies as beacons of hope, and their supporters don't want to consider that their efforts to help may cause harm.

Instead, journalists must review the role they play in promoting and proliferating the appeals. Their influence is potent. As I sifted through appeals and the heartbreaking stories of desperately ill people, I was alarmed by just how many cited success stories they had read in newspapers as their reason for trusting questionable treatments.

Most concerning of all were the frequent cases where someone

## Hands off evolution

It is an outrage that Turkey is ditching Darwin from biology textbooks, says **Rachael Jolley**

AS TURKISH children returned to school, they will have faced significant changes to biology lessons that risk limiting their understanding of the world. In Hungary, academic freedoms are also under attack.

Both changes are down to the rise of authoritarian politics and they put science education and

research independence in danger. In Turkey, information about natural selection and Darwin's theory of evolution is being removed from school biology texts for 15-year-olds.

Announced last year, the changes are taking effect now. They follow criticism of the teaching of evolution by Turkish

preachers led by controversial Islamic creationist Adnan Oktar.

Pressure to change the curriculum seems to have ramped up after a failed coup in 2016. According to figures from the Ministry of National Education, religious schools have also increased tenfold in Turkey in the past 10 years. Many children have no other option but to attend one.

Amid all this upheaval, last week Turkish daily newspaper

**"Information about natural selection and the theory of evolution is being removed from school texts"**

*Cumhuriyet* lamented "the end of secular education" in the country.

Meanwhile in Hungary, the government of prime minister Viktor Orbán is putting pressure on the independence of scientific research and attempting to censor teaching. Members of the Hungarian Academy of Sciences are seeing a gradual restriction of their independence as the government sets up parallel institutions and cuts funding.

The academy, founded in 1825, is due to see about half its budget of 25 billion forints (\$90 million) taken away in 2019. The government is also aiming to shape its decision-making board.

had died – sometimes just months after glowing coverage of their treatment. While the uplifting story of a community helping fund someone’s “cure” is attractive, the subsequent reality when that hope proves fruitless seems far less newsworthy.

This leaves the public with a skewed view of the efficacy of such treatments, and serves as an advertising tool for clinics which, under UK law, wouldn’t be able to directly promote their therapies.

If journalists wish to avoid promoting ineffective treatments, they would do well to view such stories not just as human-interest ones, but as science and health stories. This means examining the evidence behind treatments, seeking expert opinion on their efficacy, and choosing not to run stories that fail such scrutiny.

I’m certain no journalist would want their work to be used as a recruitment tool for therapists whose treatments offer nothing but heartbreak and false hope, yet until reports of miraculous cancer cures in questionable clinics are approached with an appropriate level of scepticism, I fear such places will continue to flourish. ■

Michael Marshall is project director at Good Thinking, a charity dedicated to challenging pseudoscience

These changes are directly related to a leadership that doesn’t like critics or an independent media. It is typical of the censorship that invariably occurs as countries move away from democratic values and slip towards intolerance. Their governments take aim at those who inform the public – typically academics, journalists and activists – and try to silence them. Worldwide attention is needed. ■

Rachael Jolley is editor of the quarterly global magazine *Index on Censorship*. She will introduce a debate on science censorship on 2 October at the Royal Institution in London

## ANALYSIS Low-carb diets



MINT IMAGES LIMITED/ALAMY STOCK PHOTO

# Can cutting carbs help reverse diabetes?

Clare Wilson

UK POLITICIAN Tom Watson left a lot of people scratching their heads last week when he revealed he has lost 45 kilograms and “reversed” his type 2 diabetes on a low-carb diet. Although it was coupled with an exercise regime, this is not supposed to be a healthy way to eat. What’s going on?

Watson’s achievement cuts to the heart of the biggest controversy in nutrition science today. Mainstream medicine says diets should be low in fat and high in starchy carbohydrates such as bread, potatoes and pasta.

People should especially shun saturated fat, from red meat and dairy, because this is said to raise cholesterol and so the risk of heart disease. This is the advice from the UK National Health Service and in most Western countries.

According to this orthodoxy, weight depends on the balance between calories in and calories out. If you want to lose weight, you have no option but to double down on avoiding fat because it has more than twice the calories per gram as the other two main food groups, carbs and protein.

If people have a low-fat and low-calorie diet they do lose weight – and if they had type 2 diabetes to start with, their blood sugar levels may well return to normal. But medicine’s dirty secret is that this is not the only way.

Watson’s alternative approach is not a new one: it has been in and out of fashion, known variously as the Banting, Atkins or keto diet. It involves minimising all carbs, whether sugar or starch – including wholegrain sources

**“Mainstream medicine says diets should be low in fat and high in starchy carbs such as bread and pasta”**

like brown rice. Instead, people fill up on protein and fat-rich foods like meat, fish, cream and butter.

Even fruits are shunned because of their sugar, although vegetables help to bulk out meals. This is why supermarket shelves these days proffer carb substitutes like cauliflower rice and courgette spaghetti. One bonus is that people don’t need to calorie count.

It really shouldn’t work, and yet it does. Randomised trials show that it is

**Fat-rich foods like meat can form part of a low-carbohydrate diet**

at least as good as low-fat diets at helping people lose weight – in fact some trials suggest it is better. All that saturated fat doesn’t even raise people’s cholesterol.

The explanation is unclear. Some advocates say it is because the body no longer needs to make as much insulin, the hormone the body uses to cope with an influx of sugar. Certainly the low-carb approach is popular among people with type 2 diabetes – a disease of high blood sugar.

Another theory is that low-carbing forces your body to get calories by burning fat instead of sugar, which affects your metabolism.

Sceptics say low-carbing only works because the monotony makes people eat fewer calories overall, even though they aren’t counting them. But when people go short of calories they generally get hungry, and one thing low-carbers like to shout about is that they aren’t hungry.

For now, the explanation for the success of low-carb dieting is unclear. But it certainly seems time for mainstream medicine to acknowledge that there is more than one way to lose weight. Watson has said he will set up an expert panel to look into ways to respond to the UK’s burgeoning diabetes epidemic. If so, there could be interesting times ahead for nutrition science. ■





## Storm damage

**EXTREME** storms have caused destruction and taken lives across the globe this week, with Hurricane Florence forcing millions to evacuate in the US, and Typhoon Mangkhut wreaking havoc in the Philippines and southern China.

Florence brought torrential rain to the south-eastern coastline of the US, forcing this resident of Marion, South Carolina, to wade through high floodwaters (bottom right). In New Bern, North Carolina, two residents can just be seen paddling in a canoe through a flooded street (centre, top). Winds unleashed by Florence ripped the steeple clean off the Elah Baptist Church in Leland, North Carolina, on 15 September (top right).

On the same day on the other side of the world, Typhoon Mangkhut began tearing through the Philippines. Marines can be seen here repairing their makeshift barracks in Cagayan, towards the northernmost tip of the country (bottom, far left). Guangdong province in southern China was also hit over the weekend - the pedestrians shown here are struggling against the wind and rain in the city of Shenzhen (top left). In Hong Kong, the windows were blown out from One Harbourfront, a major commercial building (centre bottom).

As *New Scientist* went to press, Florence had caused 31 fatalities and it is thought that about 100 people have died as a result of Mangkhut.

Florence has now been downgraded to a tropical depression, but the US National Hurricane Center forecast at least two further days of excessive rainfall this week in parts of southern New York state and New England, and there are fears this could cause flash flooding. Mangkhut is continuing across southern China, but weakening. Andy Coghlan

## Photographs

Clockwise from top left: Xinhua/REX/Shutterstock; Jim Lo Scalzo/EPA-EFE/REX/Shutterstock; Mark Wilson/Getty Images; Gerald Herbert/AP/REX/Shutterstock; Anthony Wallace/AFP/Getty Images; George Calvelo/NurPhoto via Getty Images

SINCE ITS ORIGIN IN THE BIG BANG 13.8 BILLION YEARS AGO, THE COSMOS HAS UNFURLED A STORY OF MAJESTY AND WONDER. THERE'S MUCH WE THINK WE GRASP, BUT SO MUCH MORE THAT LEAVES US IN THE DARK. OVER THE FOLLOWING NINE PAGES, WE EXPLORE THE GREATEST ENIGMAS – THROUGH THE PLANETS, STARS, GALAXIES AND OTHER STRANGE FEATURES THAT EMBODY THEM

# THE MYSTERY OF THE UNIVERSE IN 10 OBJECTS

## OBJECT

# 1 COSMIC MICROWAVE BACKGROUND

### WHAT IS IT?

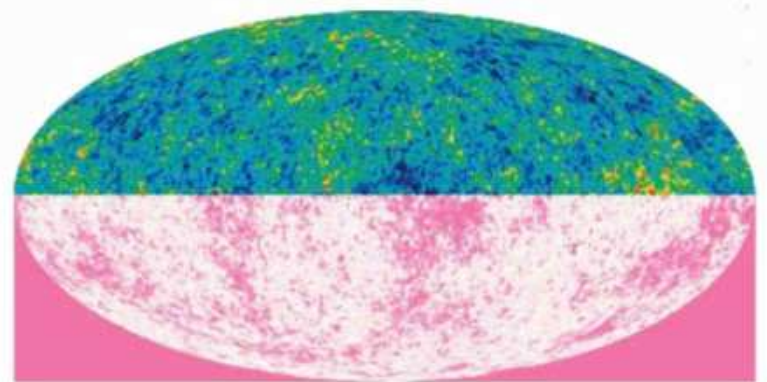
Afterglow of the big bang

### WHERE IS IT?

Everywhere

## MYSTERY

### HOW DID IT ALL BEGIN?



**W**HEN the curtain came up on the universe, the lights stayed down for a moment. For about the first 380,000 years, a mere instant on the cosmic stage, charged particles buffeted light around the early universe as if in an opaque fog, and not a glimmer escaped. Then things cooled enough for atoms to form, scattering ceased – and light was liberated.

Remarkably, we can still see that light. We know from observations of galactic motions that space has been expanding since the cosmic beginning, and that this light has expanded and cooled with it. Now it suffuses all of space, a bath of low-frequency microwaves with a temperature of 2.7 kelvin.

Since its discovery in 1964, we have made incredibly precise maps of this cosmic microwave background all across the sky. The best, the Planck satellite's four-year scan completed in 2014, caused some head-scratching. The big bang afterglow seemed to cast doubt on whether the bang was so big at all.

The problem has to do with inflation, a theory devised by cosmologist Alan Guth and others in the 1980s to explain why stuff in the universe seems so uniformly distributed in all directions. In a plain-vanilla big bang, quantum fluctuations should have produced differences in the density of matter that grew as the universe expanded. Guth explained cosmic sameness by proposing the existence of an “inflaton” field that filled space-time at the big bang, forcing it apart at faster than light speed. This would mean everything we see originated from a tiny, uniform region of original space.

Inflation quickly became gospel. But the more energy the inflaton field had, the more space-time would ➤

LEFT: MATTHEW CUSTAR TOP: NASA/WMAP SCIENCE TEAM

## 2

OBJECT

## THE LORIMER BURST



## WHAT IS IT?

A fleeting, intense radio signal



## WHERE IS IT?

Origin somewhere outside our galaxy

## MYSTERY

## WHAT CAME BEFORE THE BIG BANG?

have been shaken by tiny gravitational waves at the beginning of time. And yet we see no traces of gravitational wave effects in the Planck map.

It is not impossible to square this with inflation, but it is difficult, says Anna Ijjas, a cosmologist at Columbia University in New York. “What we learned from the Planck is that the simplest models are out,” she says.

That leaves inflationary theory out of sorts. “We can try to fix it, or we can find something better,” says Ijjas. The Planck map is prodding her and others, including one of inflation’s key architects, Paul Steinhardt at Princeton University, towards a different view of the start. It wasn’t a bang, they say, but a bounce.

Models describing “cyclic” universes that expand, contract and then expand again have been around for a while, and recently other circumstantial evidence has built up in support of them (see “The Lorimer burst”, right). Their attraction is that although they squeeze the universe down very small, it would never have been at the tiny sizes where the most poorly understood quantum effects come into play. The uniformity arises naturally from the squeeze.

The right answer is still anyone’s guess, but Ijjas says she expects to be able to make predictions based on bouncing models within a couple of years, and compare them with observations of the cosmic microwave background. The start of the cosmos may have been dark, but we may soon see it in a new light. **Joshua Howgego**

“EVIDENCE IS BUILDING UP TO SUPPORT THE IDEA THAT THE BIG BANG MIGHT NOT HAVE BEEN THE BEGINNING”

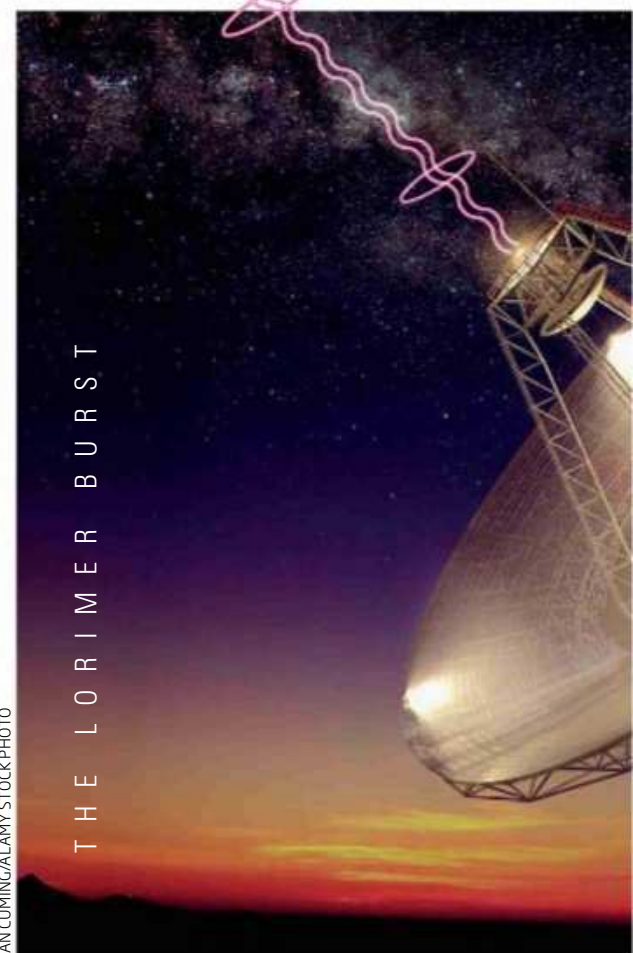
IT WAS gone almost as soon as it came, so it is hardly surprising that we didn’t even notice it. Only in 2007, six years after the event, did Duncan Lorimer at West Virginia University and his student David Narkevic spot it. They were scouring archived data from the Parkes radio telescope in New South Wales, Australia, when they noticed a burst of radio waves of almost unimaginable ferocity. Lasting less than 5 milliseconds, it hit Earth on 24 July 2001, releasing roughly as much energy as the sun spits out over five days.

Since then, we have picked up over 30 more such fast radio bursts (FRBs) – and there is precisely zero consensus on what generates them. Suggestions range from colliding neutron stars to alien spacecraft. The explanation that sits most neatly in the sweet spot between jaw-dropping and not entirely implausible, however, is one that credits bouncing black holes as the bursts’ source. As if that weren’t enough to swallow, that could also mean the cosmos did not begin in a big bang.

At the heart of this radical idea lie singularities, phenomena that arise out of Einstein’s general relativity. This theory explains how gravity arises through the warping of space-time, and thus how the entire universe evolves.

Singularities occur where Einstein’s equations cease to make any sense, because mass is so concentrated that space-time becomes infinitely warped – places like the interiors of black holes. By general consensus, what we need to wipe out these annoying singularities is a quantum theory of gravity, in which space-time is not a smooth and infinitely malleable fabric, but instead comes in discrete chunks.

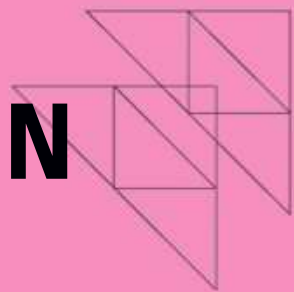
In 2014, Carlo Rovelli at the University of Aix-Marseille in France and Francesca Vidotto, now at the University of the



IAN CUMING/ALAMY STOCK PHOTO

Basque Country in Spain, realised that there is a limit to how much these chunks can be warped and compressed. When a black hole reaches a certain density, gravity would be overcome by outward pressure from space-time itself. The result is a quantum bounce, an explosion that transforms the black hole into a “white hole” that spews out everything its predecessor consumed. Within the framework of one particular quantum gravity theory, loop quantum gravity, Rovelli, Vidotto and Aurélien Barrau at the University of Grenoble-Alpes, France, showed that the bouncing of primordial black holes – gravitational mini-monsters thought to have formed in the aftermath of the big bang – could produce high-frequency radio signals in the same ballpark as FRBs.

# 3 OBJECT SUPERNOVA SN 2017CBV



## WHAT IS IT?

Stellar explosion

## WHERE IS IT?

Galaxy NGC 5643, 55 million light years away

## MYSTERY

### HOW WILL IT ALL END?

**H**ALFWAY across the universe, a star lies dead. You write it off as routine, the sort of thing that happens a million times in this crummy neighbourhood. Only slowly do you realise how this case could shake cosmology to its core.

Something like this unfolded in March 2017 when, on a routine patrol of the night sky, David Sand at the University of Arizona came across something new. At first glance, it was just another type Ia supernova, the fiery end of an over-bloated white dwarf star.

White dwarfs pack the sun's mass into just the volume of Earth. They often come in pairs, with one star feeding off the other, sucking material from it. Eat too much, and this vampire star can exceed the critical density at which carbon atoms in its core fuse into heavier elements. "It's basically a runaway thermonuclear bomb," says Mark Sullivan at the University of Southampton, UK. Within seconds, the star becomes billions of tonnes of radioactive shrapnel. As this decays over weeks and months, it gives off heat and radiation visible halfway across the universe.

Extensive observations of SN 2017cbv, however, suggested that the exploding star's mysterious companion was not another white dwarf, but a larger star. This matters because we assumed type Ia supernovae all had the same trigger, and therefore a uniform brightness, meaning how they look to us depends only on their distance.

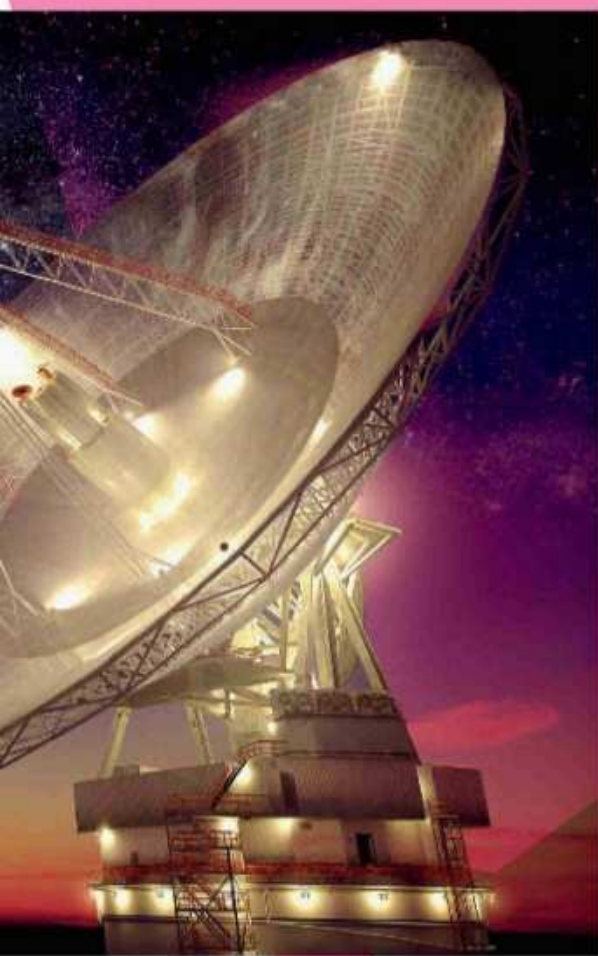
That assumption lay behind one of the most perplexing recent results in cosmology: the discovery in 1998 of a bunch of far-off type Ia supernovae that were consistently dimmer than expected. The conclusion was that these were further away than we had thought, pulled away from us by a shadowy force that is causing the universe to expand at an ever-increasing rate.

No one knows what the "dark energy" responsible might be. "I hate to use the word antigravity, but it's a good way of thinking about it," says Sullivan. Dark energy's pull determines the universe's size, its longevity, and even the manner of its eventual demise. If it were to grow sufficiently strong, it could eventually overcome the gravitational attraction holding matter together, resulting in a "big rip" that would spell the end for anything interesting in the universe. A universe without enough dark energy to keep it stretched apart, meanwhile, could collapse back in on itself in a "big crunch".

Anomalous supernovae such as SN 2017cbv have caused raised eyebrows. "There are a lot of things about type Ia supernovae that are still mysterious," says Peter Garnavich at the University of Notre Dame in Indiana - for example, that they have at least two possible triggers. "If you got those mixed up, you could be misled," says Sullivan.

Could that, in turn, mean we have been led down a dark alley with dark energy? Perhaps. "If there are two populations, and they're mixed, we can get a systematic error," says Garnavich. "There's a chance that we're not understanding the physics well enough."

Others are less concerned, saying the dominant uncertainty is not in our theoretical understanding of the explosions, but in our inability to measure them accurately enough. The best way to clear up the case would be to witness more stellar deaths as they happen, rather than a few days later, as is generally the case. "It would be fantastic if we found a smoking gun," says Sullivan. That would blow things wide open. Gilead Amit



It's not possible to confirm the existence of a white hole based on a single burst. But if their idea is right, the researchers have identified a pattern that should emerge given enough FRB sightings.

And here's the thing, says Barrau: the big bang is a singularity, too. What's more, "the structure of the singularity inside black holes is not very different from the one at the big bang. If black holes do bounce, it is highly probable that the universe did too." Rather than emerging from nothing, perhaps the cosmos we know formed when a previous one contracted until it could shrink no more, and then... BOING! The lesson of fast radio bursts could be that the beginning was anything but the beginning. **Daniel Cossins**



NASA/CXC/U. TEXAS

S N 2 0 1 7 C B V

## OBJECT

# THE BOSS GREAT WALL

### WHAT IS IT?

Galaxy supercluster

### WHERE IS IT?

On average, 6.8 billion light years away

## MYSTERY

### ARE WE IN A SPECIAL PLACE?

**O**UR entire cosmology is built on the idea of our own unremarkableness: that we're nothing special and neither is Earth.

The idea dates back to the Renaissance, and Copernicus's discovery that Earth revolves around the sun. Suddenly we were no longer at the centre of Creation.

It has since become clear that Earth is just another planet orbiting just another star in a galaxy like many others, and Copernicus's discovery has morphed into the Copernican principle: that, on average, nowhere in the universe is particularly special. Everything looks the same, and there are no remarkable places. The assumption is absolutely baked into our current models of the universe, built on Einstein's general theory of relativity.

Central to the Copernican principle is the idea of scale. Imagine the universe as a crowd of people. Up close you can see individual quirks. Zoom out enough, though, and all you see is a uniform lump of person.

So while on smaller scales the universe is very distinctive, made up of individual solar systems, galaxies and clusters of galaxies, at some scale, generally taken to be about a billion light years, those differences disappear. Averaged out, the web of stuff that makes up the universe looks homogeneous.

Various challenges to this idea have emerged recently. Perhaps the biggest is the BOSS Great Wall, discovered in 2016. Named after the Baryon Oscillation Spectroscopic Survey that discovered it, the "wall" is really a huge filament of nearly a thousand galaxies, strung out over a billion light years.

The Virgo supercluster, a dense patch of galaxies including our Milky Way, seems to be part of something much bigger, too. "We are living in the outskirts of a large supercluster named Laniakea," says András Kovács at the Institute for High Energy Physics in Barcelona, Spain. Demarcated in 2014, it is 500 million light years across. That same year, we also discovered a vast empty patch known as a super-void right by us,

stretching 2 billion light years across.

All in all, we might be occupying a rather unusual spot in the universe, between a large supercluster on one side and a super-void on the other. "Such a scenario might be a rare configuration in the cosmic web," says Kovács.

That need not spell the end for the Copernican principle, says Brent Tully of the Institute for Astronomy in Hawaii: perhaps our odd positioning just makes it harder for us to see a universe that is homogeneous overall. Tully is working to stretch our maps further out into the universe, doubling the distance over which homogeneity is measured.

But at some point we reach a limit. "If inhomogeneous patches are larger than this scale then that would challenge our current standard paradigm," he says. If we identify anything much bigger than the BOSS Great Wall, the disturbance to the fabric of space-time caused by its huge mass could even change our calculations of how fast the universe is expanding, and hence its current age. At the moment, two competing measurements of the universe's expansion rate don't agree. Extra lumpiness could be the key to solving that – and unlocking the door to more specialness. **Colin Stuart**

# 5

## OBJECT

# THE TARANTULA NEBULA

### WHAT IS IT?

Star-forming cloud

### WHERE IS IT?

Large Magellanic Cloud, 163,000 light years away

## MYSTERY

### WHAT MAKES MONSTER STARS?

**T**HE first signs a storm was brewing came in 2010. That was when a team of astronomers found four gargantuan stars in the Tarantula

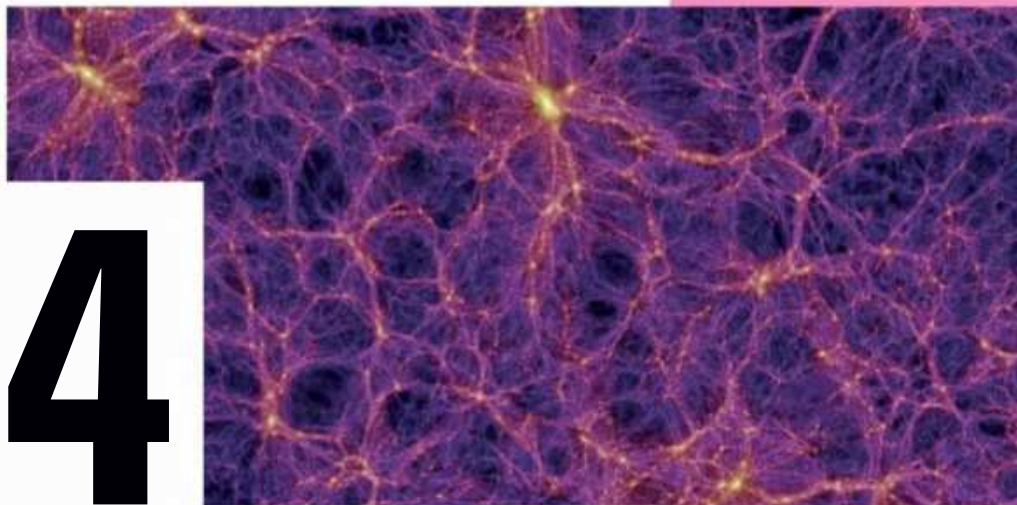
nebula, a star-forming area in our neighbouring galaxy, the Large Magellanic Cloud. The largest tipped the scales at 265 times the mass of the sun. "We were absolutely surprised by the discovery," says team member Fabian Schneider at the University of Oxford. It has potential consequences for everything from black hole abundance to the likelihood of alien life.

Traditional stellar theory suggests that stars above 150 solar masses shouldn't exist. Their light, in trying to escape, would exert so much pressure that "the star's surface layers would be peeled off and ripped apart", says Schneider.

But the monster stars were not one-offs. This year, Schneider and his colleagues found a whole host of overweight stars in the nebula. Stars of up to 200 solar masses seem to be commonplace, with some even larger.

A local quirk? A statistical fluke? Probably not, if a result from the other end of the cosmos stands up. A team using the ALMA radio telescope array in Chile recently found a way of weighing stars in galaxies so far away that we see them as they were in the universe's infancy. By analysing the light the

THE BOSS GREAT WALL



# 4

VOLKER SPRINGEL - MAX PLANCK INSTITUTE FOR ASTROPHYSICS

## 6

# “THE UNIVERSE IS A BATTLEGROUND BETWEEN TWO FACTIONS OF COSMOLOGISTS”

stars emit, the researchers can determine the ratio of different chemical isotopes the stars must contain, giving them a handle on their masses. It seems there are theory-smashing stars in these galaxies as well.

If so, the consequences are far-reaching. A few hundred million years after the big bang, the universe had cooled to a cold, unexciting soup of hydrogen atoms, floating around in Stygian darkness. At some point, the first stars formed, lifting the cosmos out of its dark ages. Astronomers who recently caught the signal of this event were stumped because it was much stronger than they were expecting - something that might be explained if these first stars were supersized, too.

More massive stars also means more supernova explosions at the end of stellar lives. “We’re talking about 70 per cent more,” says Schneider. Again, we may have evidence for that. Supernova SN 2007bi, which exploded over a billion light years away, seems to have erupted from a star of more than 200 solar masses. When such supernova remnants collapse back in on themselves, they might also create up to four times as many black holes as we thought, increasing the chance of spotting black hole mergers using gravitational wave detectors.

Most importantly, perhaps, having more supernovae could roughly double the quantity of heavy elements produced when massive stars die. This is how elements such as oxygen, carbon and iron get spewed out into the universe, creating a richer supply of ingredients important for life. All very hot - but as for how these massive stars come to exist, well, we still have no clue. Colin Stuart

## OBJECT

# GALAXY NGC 1052-DF2

## WHAT IS IT?

Ultra-diffuse galaxy

## WHERE IS IT?

Around 60 million light years away in the constellation Cetus

## MYSTERY

# DOES DARK MATTER REALLY EXIST?

**F**OR two factions of cosmologists, the universe is a battleground. They are bogged down in a squabble over what stops galaxies flying apart.

The conflict has been brewing since the 1970s, when measurements of rotating galaxies showed that they were consistently spinning too fast to retain the matter they contain. In most galaxies, 10 to 100 times more matter is needed to hold them together than we can detect.

By far the bigger faction thinks the discrepancy is down to the influence of a mysterious gravitating “dark matter” that we have yet to observe directly. But a rebellious minority believes that dark matter is an illusion, and that galaxies maintain their shapes because of a new facet of gravity we have yet to properly understand.

The ultra-diffuse galaxy NGC 1052-DF2, discovered earlier this year, seemed to be a game changer: it needs no invisible matter to keep it spinning at the measured rate. But perversely, this object with apparently no dark

NGC 1052 - DF2

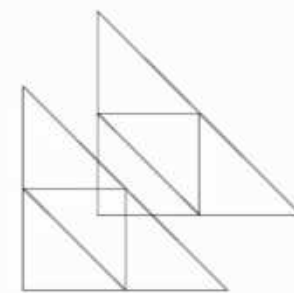
NASA/CXO/FABIAN ET AL.; RADIO: GENDRON-MARSOLAIS ET AL.; NRAO/AUI/NSF OPTICAL: NASA, SDS

matter “could be evidence for the existence of dark matter”, says the galaxy’s co-discoverer Pieter van Dokkum at Yale University. That’s because it is quite possible to imagine that a single galaxy could somehow be stripped of dark matter, but much less easy to imagine one galaxy where modified gravity doesn’t apply. “At face value, this is a huge problem for alternative gravity theories,” says van Dokkum.

Not so fast, says Andrew Pontzen at University College London: the result “is very far from clear cut”. Van Dokkum’s team could not directly measure the speed of stars within NGC 1052-DF2, so instead identified 10 of its star clusters and used their rotation speed instead. That may not be a representative sample, says Pontzen. “You can get very misleading answers just by the luck of the draw.”

And modified-gravity adherents soon got their riposte in. Stacy McGaugh of Case Western Reserve University in Ohio and his colleagues showed that the original analysis failed to consider that NGC 1052-DF2 is embedded in the gravitational field of a larger elliptical galaxy. Take that and other uncertainties into account, and the measurements are consistent with something being up with gravity. “If I were to play a spin game, I’d describe this object as a great success of modified gravity,” says McGaugh.

Later this year, van Dokkum will be using the Keck 10-metre telescope on Hawaii to try to measure the rotation of this wispy misfit from the combined mass of its stars, as well as find other faint galaxies with similar behaviour that might break modified gravity once and for all. “The hunt is now on,” he says. “If we could rule out this whole class of theories, that would be a major advance.” **Stuart Clark**



20 per cent of Jupiter’s mass. Combine that figure with its size, and the average density of the planet is little more than that of polystyrene packaging.

We now have a growing roster of these puffy planets: just this year we found WASP-127b, which has very similar vital statistics to KELT-11b. The problem is that they fly in the face of everything we thought we knew about planet formation, based on our solar system. “We don’t really understand how they get so inflated,” says Joshua Pepper of Lehigh University in Pennsylvania, who led the KELT-11b team.

Our solar system makes sense to us. There are the small rocky planets including Earth close in, and gas giants such as Jupiter further out. When the planets were forming, the heat near the sun chased off most gas, but greater quantities of volatile substances condensed in the cooler, outlying regions, providing bigger solid cores around which vast balls of gas accumulated. However, the puffballs and various other oddballs we have found show this is far from always the case.

The only lead we have to go on is that the oddities are always very close in to their star. “It certainly seems to be related to the level of radiation they are getting,” says Don Pollaco at the University of Warwick, UK, who helped discover WASP-127b. But calculations show that is still not enough to account for their inflation.

Hot Jupiters and puffy planets are all thought to form further out and migrate inwards. All planets are hot early on, as the clumping together of the debris that forms them releases gravitational and kinetic energy. If they migrate before they can cool off, perhaps the environment by the star is so toasty that they can never shed excess heat. Or perhaps the planets get reinflated, possibly by particle winds or magnetic fields from the stars.

No one truly knows. “When you think about it, it is incredible,” says Pollaco. “Something is working incredibly efficiently to inflate those planets.”

The more planetary oddities we see, the more we must confront a wider question: are they the rule, and our solar system the exception? Again, the jury is out. “We don’t know if our solar system configuration is common or rare,” says Pepper. “We just simply haven’t been able to probe enough systems in enough different ways to know that.” **Stuart Clark**

## 7 OBJECT PLANET KELT-11B

### — WHAT IS IT?

“Hot Jupiter” exoplanet

### — WHERE IS IT?

The Kelt-11 star system, 320 light years away

### MYSTERY

## IS OUR SOLAR SYSTEM NORMAL?

ON THE face of it, it’s a biggie: fully 1.4 times the diameter of Jupiter, the largest planet in our solar system. But it is nothing unusual in itself. Discovered in 2016, KELT-11b at first seemed to be just one of many large “hot Jupiters” orbiting close to their star, causing a large drop in light whenever they cross its face.

But when astronomers calculated KELT-11b’s mass, they found it was a minnow, with just

# 8 OBJECT SAGITTARIUS A\*

- **WHAT IS IT?**  
Supermassive black hole
- **WHERE IS IT?**  
Centre of the Milky Way, 25,640 light years away

## MYSTERY

## HOW ARE SUPERMASSIVE BLACK HOLES MADE?

**I**F YOU can get a good view of the Scorpius constellation, look for its tail. Follow its curve into the dark sky nearby and you will find yourself looking right at it: the centre of the Milky Way. There resides the sinkhole of our galaxy, a supermassive black hole known as Sagittarius A\*. Staggeringly extreme, it weighs in at 4 million solar masses and yet stretches just 44 million kilometres across. All that matter is squeezed into a space about the size of Mercury's orbit around the sun.

Bamboozling though black holes are, we think they are a natural consequence of how matter makes a galaxy. It condenses to form stars, and some of those eventually become so big that they collapse under their own gravity to form a stellar-mass black hole.

Such an object can become supermassive over time. Its immense gravity slurps up dust, gas and light from its surrounding galaxy into a disc around itself, eventually pulling this material over its "event horizon", never to be seen again. The more a black hole eats, the more massive it gets and the stronger its pull becomes. The biggest can capture a tenth of the mass of the sun into their discs each year.

But calculations suggest there is a hard limit to black-hole voracity. "The disc radiates and it can push the matter away, and that will shut off accretion," says Scott Kenyon at the Harvard-Smithsonian Center for Astrophysics in Massachusetts.

In reality, however, black holes seem to regularly flout that rule. Sagittarius A\* is a

baby compared with the heftiest black hole yet found. This freak, which is 3.5 billion light years away at the heart of a quasar called OJ 287, has the mass of a billion suns. To get that big, it would have to have eaten about nine sun-sized stars every year for 10 billion years. Even more confounding is the earliest known supermassive black hole, which had grown to 800 million times the sun's mass when the universe was just 700 million years old.

Perhaps these truly gargantuan monsters form when everyday supermassive black holes merge, giving them a kick-start - although the violence of that process seems equally likely to scatter any nearby material that would help them keep growing, says Kenyon. Or they could be devouring incredibly massive stars.

Or perhaps we have got things precisely the wrong way round: galaxies didn't give birth to all supermassive black holes, but black holes may have come first, says Avi Loeb, also at Harvard. "It all depends on how you define a galaxy," he says.

If the early universe contained precursor galaxies that were just clouds of warm gas, these might directly collapse into a black hole if they got dense enough, says Loeb. "You can imagine some black holes being made shortly after the big bang and being around for a while, attracting matter and then making a galaxy," he says. That would give them time to Hoover up stars to grow into the supermassive creatures we see today.

Chelsea Whyte

# 9 OBJECT EARTH

- **WHAT IS IT?**  
Largely silicate world orbiting G-type star
- **WHERE IS IT?**  
Down there

## MYSTERY

## IS THERE LIFE OUT THERE?

**O**N THE night of 8 December 1990, a spaceship buzzed by 960 kilometres above Earth. As it skimmed past, it scanned the surface for light, heat and radio waves, looking for signs of life.

This was no close alien encounter. The ship, Galileo, was one of our own, en route to Jupiter. But one of NASA's mission scientists, Carl Sagan, had the idea of using a slingshot past Earth for a dry run of life-detection technology. Sure enough, Galileo detected abundant water, oxygen, methane and a pigment that soaked up red light. Taken together, these observations were "strongly suggestive" that Earth was teeming with life.

## WATER, WATER!

It remains the only such place we know of. Yet given the number of planets in our own galaxy, let alone the whole universe, it seems staggeringly unlikely to be the only place. To scratch this itch, we need to find life elsewhere. The default assumption is that it will resemble Earth life. That means it will need liquid water.

Within our solar system, the prime candidates are Mars, which almost certainly had a surface ocean in the past and may retain remnants of it underground, and some icy moons of Saturn and Jupiter, especially Enceladus and Europa. "Even though they have an icy surface, they have an ocean of liquid water beneath," says Zita Martins, an astrobiologist at the University of Lisbon in Portugal. "They also have minerals that could be used to build organic molecules and a source of energy, so they are a perfect target." Outside the solar system, the prime targets are medium-sized rocky planets orbiting sun-like stars, or possibly in the liquid-water-friendly "habitable zone" around dimmer red dwarfs.

But is this Earth-centrism blinding us to other possibilities? "What is relevant for life to emerge and persist is mostly unknown," says astronomer Amaury Triaud at the University of Birmingham, UK. "We only know that our conditions are propitious, which tells us what is sufficient, but not

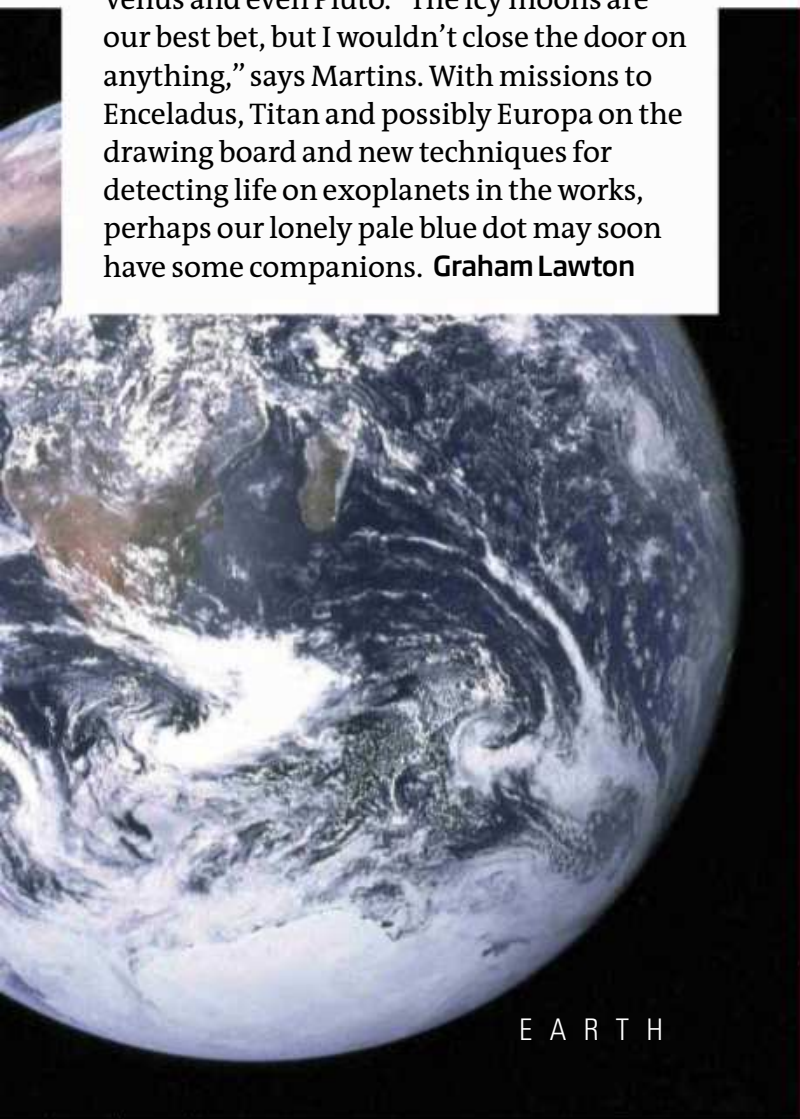


NASA/CXC/COLUMBIA UNIV./C. HAILEY ET AL.

what is necessary for life to start and thrive.”

Triaud says the search should be extended to other types of exoplanet: those orbiting brown dwarfs, white dwarfs and red giants; circumbinary planets orbiting two stars at once; planets with no atmosphere; and even exomoons orbiting gas giants. These may seem unlikely crucibles for life, but that is the point. “Most people think that getting a yes/no answer to whether there is life out there is sufficient,” says Triaud. “I want to find out how frequently and under which conditions life emerges and persists.”

Our own solar system offers similarly left-field targets. Titan, another of Saturn’s moons, makes up for a lack of liquid water with lakes of hydrocarbons that may be home to life based on different chemistry. Even further-fetched possibilities include the clouds of Venus and even Pluto. “The icy moons are our best bet, but I wouldn’t close the door on anything,” says Martins. With missions to Enceladus, Titan and possibly Europa on the drawing board and new techniques for detecting life on exoplanets in the works, perhaps our lonely pale blue dot may soon have some companions. **Graham Lawton**



“EMBARRASSINGLY,  
OUR THEORIES  
SUGGEST NOTHING  
SHOULD EXIST”

# 10 OBJECT THE UNIVERSE

## — WHAT IS IT?

Everything

## — WHERE IS IT?

Everywhere

### MYSTERY

## WHY DOES ANYTHING EXIST AT ALL?

**T**HERE is plenty to recommend the standard model, our best description of particles and their interactions. But it has the odd awkward lapse. “It is a somewhat embarrassing fact that it fails to explain our existence,” says Werner Rodejohann at the Max Planck Institute for Nuclear Physics in Germany.

Actually, it’s worse than that: the standard model positively insists we don’t exist. It says that in the big bang, matter and antimatter should have been created in equal measure. These two famously don’t get along, annihilating one another in a flash of light whenever they come within touching distance. They should have snuffed each other out in a hot orgy of mutual destruction during the first second of the universe’s existence, leaving a cosmos filled with nothing but light. “It would look very different, not least because planets and stars and life could not evolve in such an environment,” says Tara Shears at the University of Liverpool, UK.

And yet here we are. Somehow, matter won.

One possibility is that the antimatter is just hiding: some of it, somehow, escaped the death match, taking refuge in little safe spots that eventually became distant regions as the cosmos cooled and expanded. In that case, there should be stars and galaxies made exclusively of antimatter. But we are yet to spot any hint that they exist.

So for now, we have to think something must have tipped the balance in the early universe. We know that there are subtle differences in the outcomes of interactions involving certain matter and antimatter particles. This so-called CP violation is where Shears and her colleagues are seeking an answer. But so far, any differences we have found are roughly a billion times too small to explain the cosmic imbalance.

### SHAPE-SHIFTERS

Some researchers hope to find the answers among neutrinos. What little we know of these elusive, shape-shifting particles that come in three flavours – electron, muon and tau – is already gesturing towards new physics, says Rodejohann. We have hints of significant CP violation in measurements of how often they and their antimatter counterparts switch between flavours while travelling through our planet. We also know they have tiny masses, which goes against the standard model prediction that they should be massless.

The least implausible way to explain this is to invoke the existence of a heavier cousin called the sterile neutrino. In a mathematical trick called the “seesaw mechanism”, these heftier relatives would weigh down one end of the seesaw, lifting the lighter ones to ensure they have a small mass.

The catch is that for this trick to work, neutrinos must be their own antiparticle. If so, then the asymmetry seen today might be explained by these heavy neutrinos having decayed to lighter particles in the maelstrom of the early universe, with more of them choosing to become matter than antimatter.

It could take a decade to firm up hints that neutrinos violate CP and can be their own antiparticles. Even then, we would need to track down their heavy cousins. “But the neutrino story is appealing because the same guys that suppress neutrino mass also explain why matter dominates,” says Rodejohann. “It happens naturally, and it kills two birds with one stone.” **Daniel Cossins** ■

THE UNIVERSE

# PATCHWORK PREDATOR

It had the jaws of a crocodile, claws of a bear and feet of a bird. But what was *Spinosaurus* really like? Colin Barras investigates

**H**AVE you heard the one about the blind men and the elephant? One man feels its tail and thinks the animal is like a sturdy rope. Another touches its tusk and says, no, an elephant is like a spear, and so on. The moral of this ancient parable is that we shouldn't assume too much from personal experience. But there is a more literal message that no scientist should ignore: unfamiliar animals with strange features are hard to understand if you can't see the living, breathing beast.

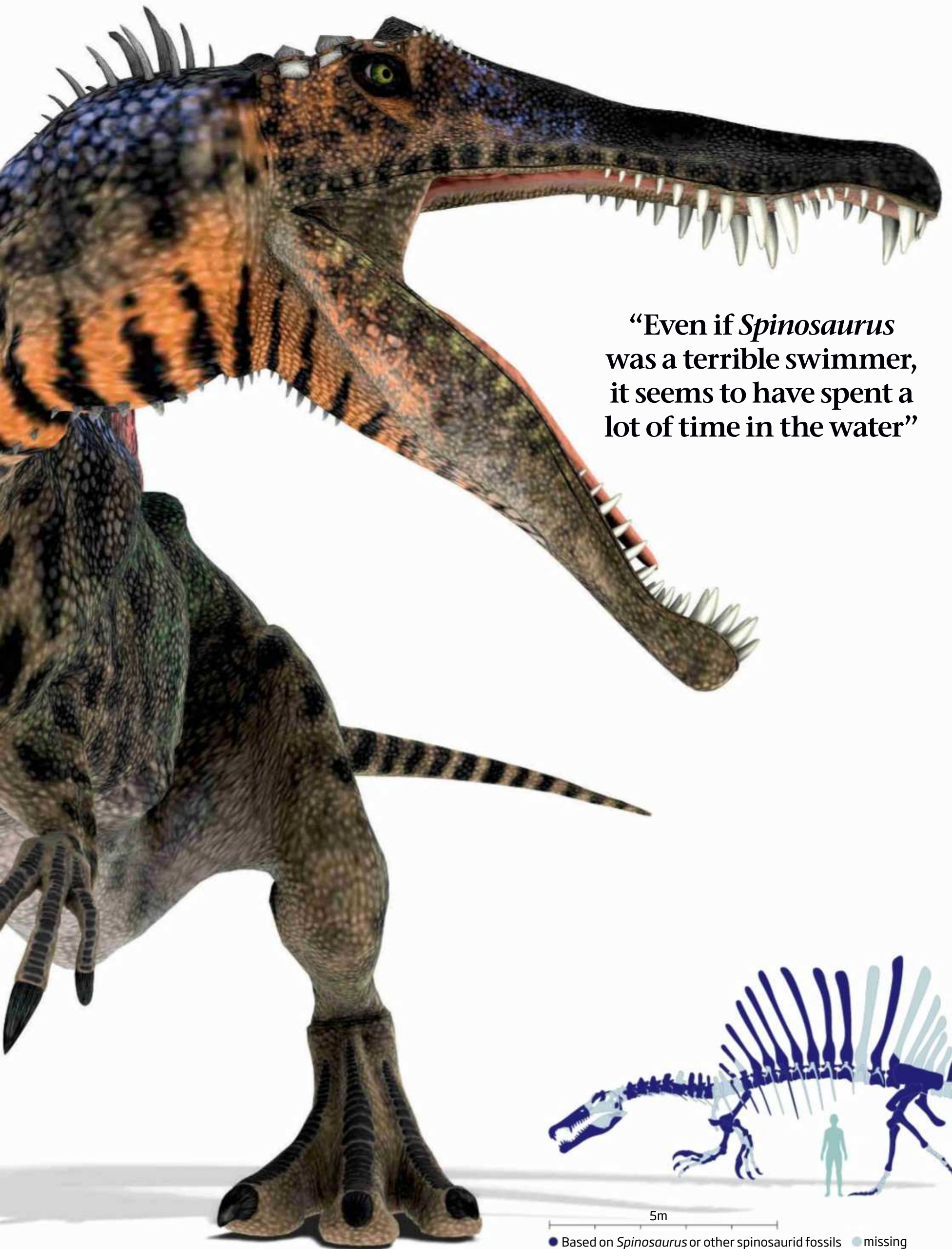
Over the past few years, palaeontologists have been working on their own version of the parable, with one of the most fearsome animals ever at the heart of it. Look at the jaws of *Spinosaurus* and you might conclude it was like a crocodile. Examine its gigantic claws and it is like a bear. Its broad, flat toe bones are like those of a wading bird. What could the life of a creature with such apparently conflicting features have been like?

"It's almost like working on an extraterrestrial," says Nizar Ibrahim at the Carnegie Museum of Natural History in Pittsburgh, Pennsylvania, who is excavating the bones of one of the most complete specimens we have found. Making sense of this fantastic beast would pay dividends, because *Spinosaurus* might explain one of the biggest mysteries of dinosaur evolution.

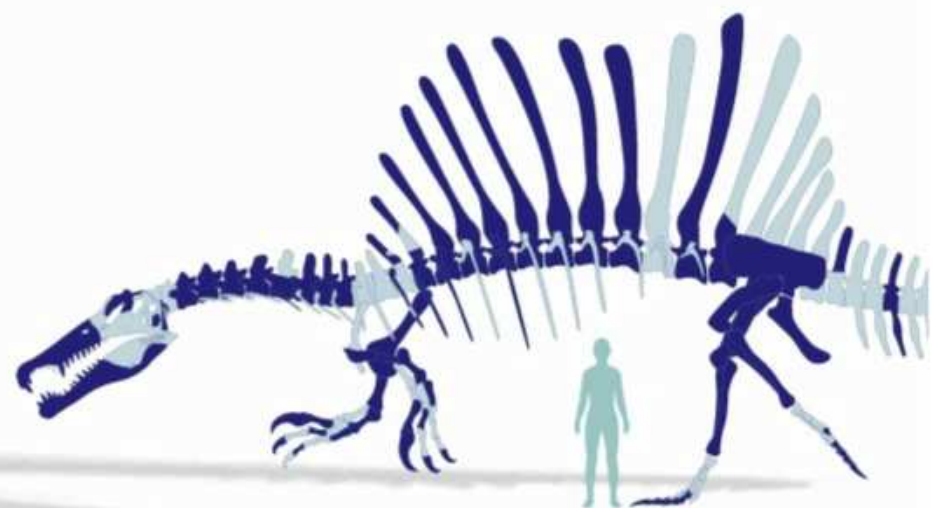
Everyone agrees that *Spinosaurus* was a giant. We don't have a complete skeleton, but estimates suggest it was about 15 metres long, making it the largest carnivorous dinosaur yet found (see diagram, page 38).

It belonged to a dinosaur family called the spinosaurids that appeared roughly ➤





“Even if *Spinosaurus* was a terrible swimmer, it seems to have spent a lot of time in the water”



5m  
● Based on *Spinosaurus* or other spinosaurid fossils ● missing

150 million years ago. These animals had crocodile-like jaws and teeth, but lacked the sail that *Spinosaurus* itself had. And like many crocodiles, they probably ate fish. A spinosaurid fossil discovered 35 years ago in the UK even had partially digested scales in the space where its stomach had been. Fish was on the menu for many of the creatures that shared the world with dinosaurs, including the reptilian ichthyosaurs and plesiosaurs that patrolled the seas. But spinosaurids are the only large dinosaurs known to have eaten fish.

Huge jaws are the only tool a crocodile needs to catch prey, but spinosaurids also had formidable claws that were at least 30 centimetres long. They have been compared to the huge claws grizzly bears use to hook fish out of streams. But last year David Hone at Queen Mary University of London and Thomas Holtz at the University of Maryland pointed out that the animals couldn't see their claws, which makes them an unlikely precision hunting tool. Maybe the claws were actually used to dig up burrowing prey, says Hone. No one knows.

*Spinosaurus* arrived into this dinosaur family about 100 million years ago. The most complete skeleton of the animal was discovered in Morocco in 2008 by local fossil hunters who sold their find to rich collectors. It ended up at the Milan Natural History Museum in Italy.

Ibrahim realised how important the specimen was and tracked down the site where it had been unearthed. He and others, including Paul Sereno at the University of Chicago, are still searching it. "We've not actually excavated all the bones of the skeleton yet," says Ibrahim. "Our ideas about *Spinosaurus* are changing right now as we add new bones."

A description of the specimen published in 2014 caused a stir by suggesting *Spinosaurus* was weird, even for a spinosaurid. Ibrahim

## A JUMBLE OF PARTS

*Spinosaurus* had a set of bizarre features that could almost have belonged to different animals

### JAWS OF A CROCODILE

They were just right for eating fish. That in itself was odd because no other large dinosaur did so

### CLAWS LIKE A BEAR

The animal had fearsome claws. But it couldn't see them, making them an unlikely hunting tool

### DENSE LEG BONES

These are the sort of legs that look designed to help an animal move around more easily in water

### FEET LIKE A SHOREBIRD

The feet seem designed not for swimming or running, but straddling mud

### TROUBLESOME SAIL

If *Spinosaurus* did spend lots of time in water, its sail would have made it liable to capsize

and Sereno's team reported that the animal's torso was long, its hips were weak, and its hind legs were short. What is more, it had feet like a modern web-footed shorebird, with long toe bones that had flat undersides. No other spinosaurid we know of had feet like that.

These aren't the features of a dinosaur that chases down prey on land. Ibrahim and Sereno argued that they indicate an animal in the early stages of an evolutionary transition from land to water. The team points to similar features in the ancient four-legged ancestors of whales, which independently evolved 50 million years ago when they were still living by rivers. Like those early "walking whales", *Spinosaurus* had unusually thick-walled and dense leg bones, a feature believed to reduce buoyancy and allow animals to move around more easily in water.

"The authors make a reasonable case for this animal being aquatic," says Hans Thewissen at Northeast Ohio Medical University, who studies the early evolution of whales.

The study had its critics, however. Ibrahim and Sereno's team also concluded that *Spinosaurus* might have walked on all fours, bearing some of its weight on the knuckles of its forelimbs. But only a handful of living animals knuckle-walk, and several palaeontologists thought it was a premature conclusion, especially given that the Moroccan skeleton was missing its forelimbs. Ibrahim

and Sereno's team had reconstructed them using other spinosaurid fossils.

There is also debate about how comfortable *Spinosaurus* was in water. The most dramatic of the animal's features are 1.7-metre-tall bony spines projecting vertically up from its backbone. They look a lot like the spines inside a bison's fatty hump, and 20 years ago some researchers argued that *Spinosaurus*, too, had a fatty hump. Today the consensus is that the bones supported a sail, probably used for social or sexual display.

Either way, the bony spines put a limit on *Spinosaurus*'s swimming ambitions. "That's a considerable amount of weight when you cover it with even a small amount of flesh," says Sereno. One consequence is that the animal would have been prone to overturning when swimming.

Even if *Spinosaurus* was a terrible swimmer, its dense leg bones and shorebird-like feet suggest it spent a large chunk of its life wading and feeding in shallow water. "That's arguably the most interesting thing about this animal," says Hone. Dinosaurs dominated Earth for 135 million years, but *Spinosaurus* is almost the only one known to have evolved adaptations for aquatic life. That means we have the debate back-to-front: the oddity isn't *Spinosaurus*'s features, but that water-loving dinosaurs were so rare.

A further question is why *Spinosaurus*'s descendants didn't evolve into a fully aquatic dinosaur. "I've often wondered about this," says Sereno.

Recently, he's concocted a hypothesis. Dinosaurs walked with their legs vertically beneath the body. Other animals with that set-up, like horses, must undulate their bodies up and down when they swim to increase propulsive efficiency. Sereno suspects dinosaurs would have had to swim this way too. But dinosaurs' tails were anatomically set up to thrash from side to side. Combining that with a vertically undulating torso makes for a very inefficient swimmer, says Sereno. Worse, *Spinosaurus* couldn't evolve to lose the long tail because it acted as an anchor point for major leg muscles.

It is a speculative idea that Sereno hasn't published yet, and Hone suspects it isn't a complete explanation for the lack of aquatic dinosaurs. Whatever was going on, *Spinosaurus* was evolution's best attempt to turn a dinosaur into a sea monster – but for one reason or other, it was a doomed. ■

Colin Barras is a science writer based in Ann Arbor, Michigan



Why are our intuitive beliefs about economic issues often so misguided, asks psychologist Pascal Boyer

# It's the economy, stupid!

**D**URING the last US presidential election campaign, Donald Trump and Hillary Clinton both promised to “protect” America against foreign imports. In Europe, right-wing populist politicians are gaining ground by claiming they will reduce immigration to create more jobs for local people. Left-wingers, meanwhile, promise to tackle growing wealth inequality by taking from the rich and giving to the poor. All these ideas reflect a shaky grasp of economics. Nevertheless, they are often attractive to voters. That is no accident.

Most of us have little or no education in economics, but that doesn't stop us holding beliefs about all sorts of things from the benefits of international trade, the effects of immigration and the origins of inequality, to the power of big business, the consequences of regulation and whether the state should provide education, transport and healthcare. These “folk-economic” beliefs are often vague, incoherent or just plain wrong. But they are not random – people everywhere seem to have similar intuitions. It is as if the human mind is designed to misunderstand the mass-market economies we have created.

As a psychologist, this intrigues me. In my latest book, *Minds Make Societies*, I argue that folk economics has its roots in human evolution – and has profound consequences for today's world. In modern democracies, political parties differ mostly in terms of their economic policies, meaning that politicians

can capitalise on our mistaken intuitions to gain support. Fortunately, knowing where these beliefs come from, and the forms they take, can help us make more savvy economic and political judgements.

For centuries, economists have bemoaned the economic ignorance of ordinary people. It wasn't until 1996 that the chasm in thinking was revealed when the Survey of Americans and Economists on the Economy became the first to ask both groups the same questions. Although the views of experts varied somewhat – economics is complex and not

**“It's as if the human mind is designed to misunderstand mass-market economies”**

an exact science, after all – they were in stark contrast to those of the public. For example, 50 per cent of economists thought trade agreements had helped to create jobs and just 5 per cent believed they led to job losses, whereas ordinary people took a far more negative view – 17 per cent and 54 per cent, respectively. Likewise, while 69 per cent of the public saw excessive executive pay as a reason the economy wasn't doing better, just 12 per cent of economists did.

Despite these findings, there are surprisingly few systematic studies of folk economics. Economists tend not to be interested in why people's perceptions are so awry. But evidence

from psychology and anthropology does shed some light on the phenomenon. It reveals that people have an intuitive mental template for how exchange, the action that lies at the root of economic activity, should occur. This “exchange psychology” is not simply shaped by self-interest, the media or the political arguments we are exposed to. It is seen in people from early childhood and has been documented in a diverse range of cultures. This suggests that our naive economic beliefs, like many of our social and political preferences, are an outcome of evolution.

In a paper published last year, Michael Bang Petersen of Aarhus University in Denmark and I argued that the human mind evolved to think about economics in specific ways. Our intuitions about production and exchange are adaptations to the particular context in which our species developed. As a result, they are unsuited to the economy of the modern world, which appeared very recently in evolutionary terms.

The key factor is that humans, in contrast to most other animals, evolved to be highly cooperative. Hunting, foraging, community defence and even parenting were done in groups. There was some division of labour, because of individual differences in talent, but not much specialisation. And our ancestors shared resources, especially when it came to goods with highly variable availability, such as game. Trade mostly took place between people who knew each other, or between groups ➤



that shared repeated exchanges. Technology was simple enough that they could track how much effort was involved in making most things. And verbal communication provided rich information on the behaviour of others, which was used to select the most cooperative partners with whom to do business.

The way we think about exchange is the result of millennia living in these conditions. In recent years, numerous experiments using economic games have highlighted these psychological effects. For instance, we have a strong sense of fairness, and intuitively expect and prefer that the proceeds of a joint effort be shared in proportion to each participant's contribution. Indeed, free-riding – reaping the benefits of trade or joint effort without paying a cost or contributing – triggers anger and strong

towards large retailers like Walmart, Carrefour, Tesco and Aldi. Everyone knows they make big profits. However, they also generally sell goods cheaper than their smaller competitors. We can all see that we gain a little – by buying an apple for 40 cents instead of 50 cents, for example – but we cannot detect the aggregate amount of these small savings, the impact on society as a whole. Most people don't realise that this aggregate consumer benefit can be hundreds or thousands of times larger than the profits made by large retailers. Of course, that doesn't necessarily mean we shouldn't tax their profits.

Similarly, we mistakenly believe that big corporations are all-powerful. Because we intuitively think of exchange as taking place between two individuals, with the stronger, more formidable partner able to dictate terms, we tend to believe that corporate giants like Apple or Samsung "control" the market. We reason that they do not care whether an individual consumer buys their product, so they can fix prices to ensure they make vast profits. What we fail to see is the power of consumers as a whole. No matter how big a company, whether it thrives or dies depends on the aggregate of millions of individuals choosing to buy its products, or not. As a result, many businesses that once appeared to control a market – Nokia, Kodak, Sears and others – are no longer dominant.

This same exchange psychology makes it tempting to believe that government intervention in markets can control prices.

**The benefits to consumers from low prices are often far larger than the profits of big retailers**



MARK WILSON/GETTY IMAGES



Our intuition tells us that regulation will work because it seems to redress the balance of power between the producer and the consumer. But this kind of thinking again misses the bigger picture. A landlord, for example, cannot usually simply dictate prices, because renters generally have a choice of where to rent and thus influence the behaviour of landlords. Price regulations disrupt these incentives, often with perverse effects. Attempts to control food prices, for example, generally result in black markets. Similarly, rent control usually makes housing rarer and unaffordable for newcomers because landlords will almost always demand the highest possible price. In addition, it gives landlords no incentive to maintain housing stock, so renters end up getting poorer value for money.

## Greedy exploiters

Our moral intuitions also shape our folk-economic beliefs. As 18th-century economist Adam Smith pointed out, prudent self-interest motivates people to produce and offer the goods and services we need. Yet, in most cultures, the merchant who buys cheap and sells dear is widely seen as a greedy exploiter. Such moral condemnation stems largely from a lack of information. Modern market transactions tend to be one-offs between partners we know little about. This clashes with our intuitive preference for repeated trade between familiar partners – a form of

## "What we fail to see is the power of consumers as a whole"

aversion. We also prefer to trade with known partners and tend to avoid purely anonymous transactions. Not only that, but we intuitively consider it beneficial to extend small favours to trading partners rather than exploiting their weak positions, because our psychology is built on expectations of long-term interactions.

Evolved dispositions such as these enabled trade to eventually expand from small, local exchanges between known partners, all the way to global commerce networks. At each point in this process, people widened the circle of trade by using the mental tool-kit they already had. For instance, modern global communication enhances our ability to get information about possible partners and select the trustworthy ones. This leads to a paradox. Our evolved exchange psychology made mass-market economies possible while simultaneously making it very difficult for us to understand them.

The scale of modern economies is one major stumbling block. In the small communities of our past, everyone could monitor the effort each participant put in and how much they received in return – who stalked the prey and who killed it, how long people foraged, how much they ate and so on. But that is not the case with complex trade networks and modern technology. What happens in a mass-market economy depends on the actions of thousands or millions of people. As our psychology focuses on individual agents, we fail to see these aggregate effects.

This helps explain our negative attitudes



Protectionist policies intuitively appeal, but tariffs mean the consumer pays in the end

importing from other nations makes your nation poorer. The obvious solution is protectionist policies: impose tariffs on foreign imports if they are cheaper than home products and aim for independence in commodities such as energy and food. But in fact, international trade is not zero-sum – the more of it that happens, the more resources there are for everyone. What economists call “comparative advantage” means that all countries are better off concentrating their efforts on goods they are most efficient at producing, and trading for others.

## Scrounger or just unlucky?

Admittedly, while international trade increases the overall wealth of nations, some individuals may not benefit. Carmakers in the US, for example, might welcome President Trump’s imposition of tariffs on cheaper Chinese vehicles in the hopes that it can save their jobs. But American consumers will pay as car prices increase. It is also worth noting that a lack of independence in certain sectors has not held back some of the world’s richest nations. Singapore has few energy resources, yet is a leading manufacturer, and energy-rich Norway gets by very well importing commodities such as coffee and wine.

Economists may show little interest in folk economics but successful politicians, both left and right, instinctively grasp that they can gain influence by speaking in ways that chime with these intuitions. That’s why some describe the recipients of welfare benefits as lazy scroungers, while others portray them as victims of bad luck. One type of discourse activates our aversion to free-riding, the other our intuitive preference for insurance against uncertainty. Our exchange psychology makes both very plausible, and we respond to whichever echoes the political beliefs we hold.

This means that folk economic intuitions are not just misleading, they are also powerful, because they can be used to justify conflicting conclusions about the world and then direct policies for change. But we are not entirely at the mercy of these evolved ideas. A better understanding of economics will help us see beyond them. So too will the realisation that the human mind is instinctively attracted to certain economic beliefs. Forewarned, we should be less vulnerable to manipulation when politicians try to seduce us with attention-grabbing lines. ■

Pascal Boyer is at Washington University. *Minds Make Societies*, is published by Yale University Press

exchange in which we can better understand their motives and constraints.

Another reflection of the impersonal nature of modern economies is what Paul Rubin from Emory University in Georgia calls “empiophobia” – a fear of markets and suspicion that free competition will have negative social effects. Our mistrust is particularly intense when considering “markets” in sensitive goods, such as organs for transplant or babies for adoption. But it extends much further, to healthcare, housing, education and transport – where we often fear that market processes will lead to inefficiency or tragic inequality.

Sometimes such fears may be justified. Nevertheless, our psychology explains why empiophobia is so common and so easily invoked for political ends. In the past, as cooperators within small communities, it was to everyone’s benefit (and evolutionary advantage) to provide each other with assurance against the vicissitudes of fate. Our ancestors would share food with those unable to acquire their own whether through bad luck or because of illness or old age. By contrast, modern markets seem to exclude such motivations, leaving people fearful that there will be no resources for the weak or the unlucky.

Our instincts around sharing can be seen in popular notions about wealth and poverty, too. Throughout most of human history, resources were shared largely in an egalitarian manner, based on need and a person’s contribution to the joint effort. Crucially, if someone had

more, others had less – it was a classic zero-sum situation. This helps explain both why we tend to see wealth as a pie of fixed size and the appeal of political arguments for taking from the rich to improve the lot of the poor. Yet, in modern economies, wealth is not a fixed resource. The world as a whole is much richer now than it was two centuries, or even 50 years, ago.

A major contributor to increasing global wealth is trade, yet here again zero-sum thinking undermines our understanding. The classic mistake is in believing that

## SEVEN FLAWED IDEAS

Evolution has left us with “folk economics” beliefs that underpin some major misconceptions about mass-market economies, in particular:

- ▶ Wealth is a fixed-size pie – the poor get poorer when the rich get richer
- ▶ Big corporations can impose prices on consumers
- ▶ Importing from other nations makes our own one poorer
- ▶ Prices can be controlled with government regulation
- ▶ Free market competition will have negative social effects
- ▶ It is better to trade with known parties
- ▶ We should be suspicious of the profit motive

# A lunar renaissance

All eyes are on the moon as we near the 50th anniversary of Apollo 11's historic landing. **Simon Ings** rounds up the best ways to celebrate

NEXT July sees the 50th anniversary of the first moon landing, an occasion that is inspiring dramas, documentaries, art shows and festivals.

We need to make the most of it. The most garrulous of the moon's visitors, Buzz Aldrin, is 88. The first man on the moon, Neil Armstrong, died in 2012, while Eugene Cernan, the last man to walk on the moon, died last year. The threads that connect NASA to its lunar heyday are stretching and snapping, one by one.

The culture is changing, too. You only have to say the rocket names out loud. Saturn 5, still the biggest rocket ever used, drips high-octane adventure. Today's launch vehicles – Dream Chaser and the like – sound more like smartphone apps.

*First Man*, in UK cinemas from 12 October, sends us boldly into the past with a biopic of Armstrong. It is directed, unlikely as this sounds, by Damien Chazelle, who wrote the musical *La La Land* and the screenplay for horror flick *10 Cloverfield Lane*.

Ryan Gosling plays Armstrong, and his patented 1000-yard stare serves him well here. Watching Armstrong in interviews – and he gave precious few of them over the years – you had to wonder what it would take for him to express an emotion. Gosling provides inner life by the spade and he does it, true to the man he is playing, almost entirely through intensity and silence. Without this, *First Man* would be the longest 138 minutes in history.

**Foster & Partners's bid for a 3D-printed lunar future**

Actually, the film is a triumph, from its heart-in-mouth sound design, which sets all the hardware rattling and screaming, to Corey Stoll's razor-sharp portrayal of Buzz Aldrin, to a script (by *The West Wing* writer Josh Singer) that gives Armstrong a compelling and entirely credible reason why he would want to keep his moon experiences to himself. Those who

**"Watching Armstrong in interviews you wondered what it would take for him to express an emotion"**

are calling it "unpatriotic" must have seen a different movie – we might not see the actual planting of the US flag on the moon, but it is very prominently there.

Many more on-screen celebrations are planned for the coming months. Todd Douglas Miller's documentary *Apollo 11* is due for release next year, featuring never-before-seen, large-format film footage of the mission.

Sneaking in ahead of the film is Rory Kennedy's new documentary

for the Discovery channel, *Above and Beyond: NASA's journey to tomorrow*. Taking inspiration from her uncle John F. Kennedy's original vision for Apollo, it celebrates NASA's culture of continuity. The agency has always looked back at Earth as avidly as it has stared past it. Your morning weather bulletin is NASA's gift to the world – along with a mature and ever-improving understanding of our changing climate.

Likewise NASA's willingness to work with others. Born out of the cold war, the agency has nevertheless always been open to international collaboration. Armstrong and Aldrin set a Swiss science experiment going on the lunar surface a whole 6.5 minutes before planting their nation's flag in lunar soil, for example.

Artefacts survive to remind us of Apollo's glory days. London's Science Museum houses the command module of Apollo 10, which took part in a dress-rehearsal flight around the moon in May 1969, just two

months before the landing.

Apollo 11's hardware, which sustained Armstrong, Aldrin and command module pilot Michael Collins on their roughly 1.5-million-kilometre journey, is enjoying a modest second odyssey of its own. The Columbia command module forms the centrepiece of Destination Moon: The Apollo 11 mission, an exhibition that has been touring the US since 2017. It lands at Seattle's Museum of Flight in March in time for the anniversary. Its usual home, at the National Air and Space Museum in Washington, is undergoing a major refit ready for its homecoming in 2021.

Apollo's Mission Control Center in Houston, meanwhile, is being restored. By July next year, it will look exactly as it did when Armstrong took that first



UNIVERSAL PICTURES



ESA/FOSTER + PARTNERS



step on 20 July 1969. The flight control consoles are being refurbished, and wallpaper and carpet samples are being compared with recently discovered original samples. Trash cans, book cases, ashtrays and orange polyester seat cushions will all be present.

Elsewhere in the world, there is lots more to see. The Louisiana Museum of Modern Art in Denmark has stolen a march on the competition with *The Moon: From inner worlds to outer space*. Open until 20 January, this is a celebration of the moon as it is seen in paintings, explored in virtual reality, and conjured in fantasy. In the UK there is a little longer to wait: Woolwich in London will be the centre of a major moon festival over the anniversary weekend.

There are also missions to the

moon planned for 2019. Although these uncrewed adventures can't possibly upstage Apollo 11's achievement, they do promise a new era of lunar exploration.

China is gearing up to land two robots: Chang'e 4 is due to launch this December, with the goal of being the first lander on the moon's far side. Chang'e 5, scheduled for 2019, aims to bring about 2 kilograms of lunar regolith back to Earth.

India is planning to send an orbiter, lander and six-wheeled rover to the moon in January 2019. It is all part of India's Chandrayaan-2 mission, which follows up on the successful Chandrayaan-1 lunar orbiter mission of 2008-2009.

There are more modest missions, too. The punchier contestants who entered the never-awarded Lunar X Prize

### Sadly we can't all celebrate the moon landing with Ryan Gosling

are racing to launch their probes. Who will make moonfall first? My money is on Israel's SpaceIL. While everyone else was crashing through the X Prize's deadlines, trying to design wheeled vehicles for their rovers, SpaceIL was racing ahead with a vehicle that bounces about the lunar surface like a steel bunny.

The car manufacturer Audi, meanwhile, hopes Germany's PTScientists, will help land two of its wheeled rovers at the Apollo 17 landing site. Both of these projects need a decent delivery system, so there is a lot riding on SpaceX's Falcon 9 launches from Cape Canaveral next year. SpaceX itself has announced it plans to send a paying customer to the moon, although no date has been given.

Perhaps the most telling anniversary-year project, though, will be the announcement of the results from the European Space Agency's lunar 3D-printing challenge. The moon's next visitors may well have a home designed by Foster & Partners waiting for them, extruded by robots out of sintered regolith.

Alongside planned launches and public celebrations, certain private rites will be performed, too. I am planning to complete Project Arthur's 3D paper model of the iconic Arthur satellite dish in time for the anniversary.

Part of the Goonhilly Earth Satellite Station in Cornwall, Arthur brought the UK into the space age, carrying broadcasts of the moon landing from the US. My paper model is hardly less extraordinary – at least, that is what I am telling myself. It will track the location of the International Space Station using an embedded Raspberry Pi.

Each time the ISS passes overhead, a little red light will blink, reminding me of the night my mother carried me out of my bed and into the living room to see a man step onto the moon. ■

## DON'T MISS

### Read

While Donald Goldsmith reveals the secrets of *Exoplanets: Hidden worlds and the quest for extraterrestrial life* (Harvard University Press), Adam Morton wonders, *Should We Colonize Other Planets?* (Polity).

### Play

The first episode of adventure game *Life is Strange 2* (pictured) is released on 27 September for Microsoft Windows, PlayStation 4 and Xbox One. The character you are protecting behaves with incredible realism, thanks to some clever machine learning.

### Watch

At what point do we stop being human – and does it matter? The play *Future Bodies* explores the future of body enhancement. It's at Manchester's HOME in the UK, from 28 September.

### Visit

Contemporary crystalline art rubs shoulders with pieces from John Ruskin's mineral collection in Liquid Crystal Display, at Sheffield's newly reopened Site Gallery from 29 September.

### Listen

Smuggled eggs, mysterious herbs and bits of bear (don't ask) have all featured recently on ABC Radio National's science-culture podcast *Science Friction*, hosted by Natasha Mitchell.



# The art of video games

London's V&A lifts the hood on game creation – and **Lydia Nicholas** likes what she sees

Videogames: Design/Play/Disrupt at the Victoria and Albert Museum, London, to 24 February 2019

IN A gallery, it is not only the quality of a piece that comes under scrutiny, but also its meaning. Gaming culture's demand to be seen as "real art" sometimes runs alongside a resistance from many fans and creators to being subjected to the kind of analysis that art faces.

Can video games be art? Yes. Obviously yes. Video games are a medium as diverse as films or novels. Some are enormously profitable mainstream hits. Some are familiar rehashings of old tropes. Some are beautiful. Some are violent. Some are nuanced, self-aware, and explore and reflect human experience in ways that surprise and move the player.

This isn't a radical stance and video games are no strangers to prestigious galleries. Several of Porpentine Charity Heartscape's exquisite text-based creations were exhibited in 2017 alongside oil paintings and sculpture in New York at the Whitney Biennial, one of the longest-running exhibitions in the contemporary art world. Somerset House in London has hosted game design festival Now Play This three times in the past four years, always with the support of Arts Council England.

Where Videogames: Design/Play/Disrupt differs is in focusing not on the games themselves, but on the work of creating them. It should delight gamers and developers to see their world celebrated on huge screens. It will also fascinate those unfamiliar with the form and give everyone a chance to play. Bring the friends



ROBIN BAUMGARTEN

and family who still tease you for gaming and see them converted.

The first part deals with the craft of making games. There are pinboards covered in plot points, screens full of programming languages and sections on influences from film and fashion. The developer, whether a giant

**"Bring the friends and family who still tease you for gaming and see them converted"**

studio or an individual author, is brought under the spotlight, and their skill lauded. Some efforts to place the work within hallowed traditions are a little obvious: René Magritte's *Le Blanc Seing* (*The Blank Signature*), featuring a surreal scene of a woman on a horse simultaneously behind and in front of trees, is placed directly below a clip from *Kentucky Route Zero*, which uses the exact same

impossible geometry. This is an homage, or a theft, depending on your mood, but we can all agree such borrowings say little. In contrast, I thoroughly enjoyed the discussion of the extreme difficulty of gothic role-playing game *Bloodborne*: how the challenging, brutal fights were designed to produce cycles of struggle, satisfaction and pride in its players. There is a beauty, unique to gaming, in a perfectly shaped learning curve.

In the show's politics room, titles like "Let's talk about sex" and "Why are videogames so white?" sound glib, but the content itself is forthright and thoughtful. Of course, race, gender, sexuality, class and other social factors affect the creation and experience of video games. Consider how it feels to an Arabic speaker when Arabic text is written backwards in a blockbuster war game, proving

**The Arcade Backpack is designed to infiltrate public spaces**

that no one from conception to marketing to quality assurance thought the language worth checking, even as this player's home country is used again and again as a bloody backdrop for an outsider's heroism.

In the final section, visitors finally get to play. The exhibition's enormous scope is contained in a wonderful selection of tiny creations: a one-dimensional dungeon; a bear on a joyride; the 10-second heartbreak of *Queers in Love at the End of the World*. Even when they force us into difficult choices, even if we fail spectacularly at them, games are revealed for what they are: a medium of delight. ■

Lydia Nicholas is a researcher in ethics and culture at University College London

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6. Selected publications

**Contact Information:**

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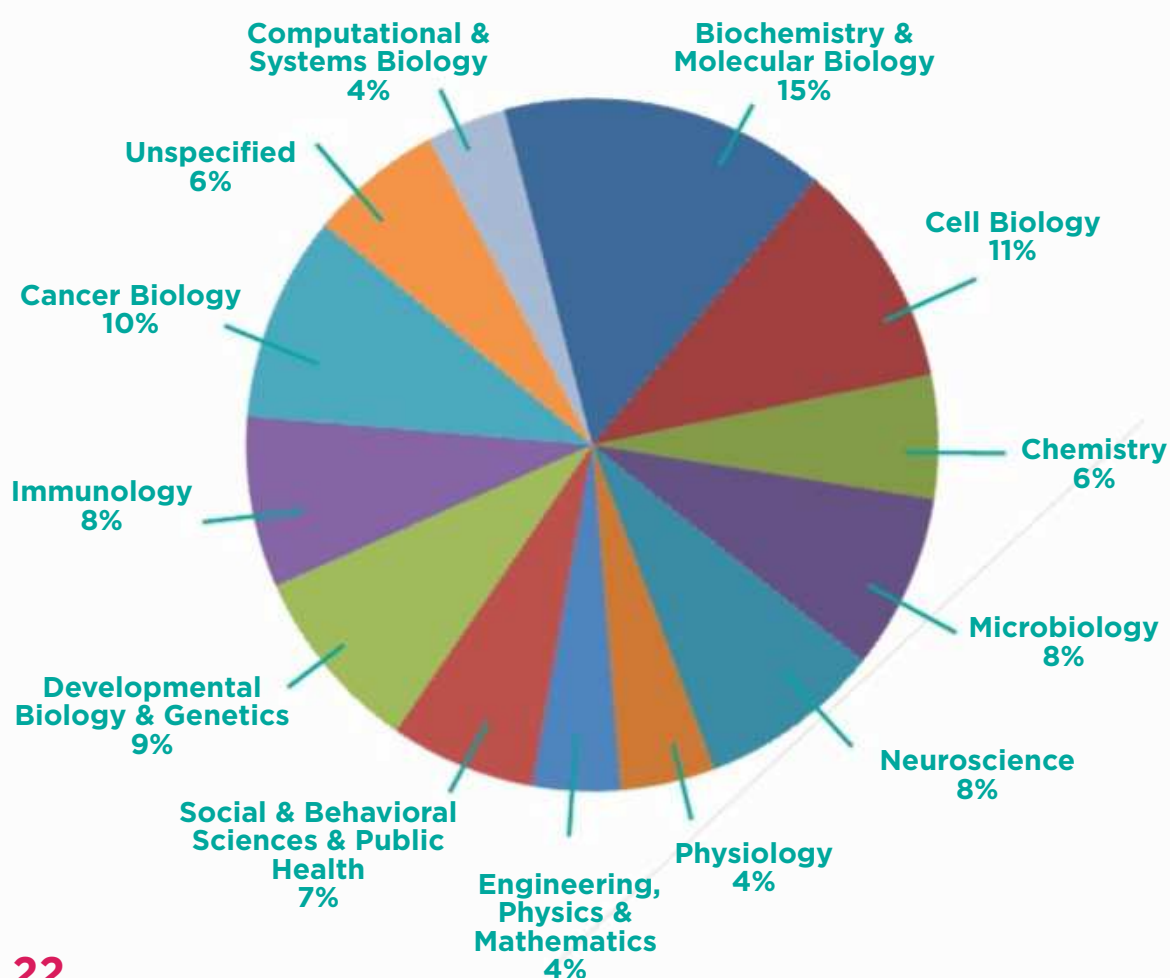
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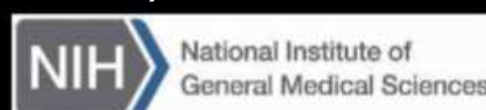
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- 1401652878 **Postdoctoral Opportunity**  
Backman Biophotonics Lab Evanston, Illinois - Northwestern University
- 1401652875 **Research Fellow**  
Boston, Massachusetts (US) - Dana-Farber Cancer Institute
- 1401652850 **Research Fellow**  
Marasco Lab Boston, Massachusetts (US) - Dana-Farber Cancer Institute
- 1401652519 **Postdoctoral Scholar**  
The Pennsylvania State University - Pennsylvania State University
- 1401652518 **Postdoctoral Scholar**  
The Pennsylvania State University - Pennsylvania State University
- 1401651920 **Postdoctoral Associate**  
Durham, North Carolina (US) - Duke Molecular Physiology Institute
- 1401651918 **Postdoctoral Associate Opportunities**  
Durham, North Carolina (US) - Duke Human Vaccine Institute
- 1401651917 **Postdoctoral Associate Opportunity**  
Durham, North Carolina (US) - Duke Human Vaccine Institute
- 1401651708 **NASA Postdoctoral Program** - Application Deadline November 1, 2018  
NASA / Universities Space Research Association
- 1401646847 **NRC Research Associateship Programs** - November 1 Deadline  
Washington D.C. - National Academy of Sciences
- 1401651327 **Fellowships for Postdoctoral Scholars**  
Woods Hole, MA - Woods Hole Oceanographic Institution (WHOI)
- 1401652562 **Three Postdoc Research Positions** - Data Driven Machine Learning Saudi Arabia (SA)  
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## EDITOR'S PICK

## Smoking reduction and a room with a fume



From Miriam Ashwell,  
London, UK

Lara Williams supports the UK ban on e-cigarettes on public transport and in workplaces (1 September, p 22). But how do we know what the health effects of keeping or ending the ban would be?

I would like to propose a clinical trial

to test the effect of passive vaping. It will not seek informed consent and it won't even tell people they are taking part in a trial.

It will not bother with a control group and it won't record exposure levels. Indeed it won't be applying measured doses, just random amounts at random times and places. It won't bother measuring lung function, blood or urine levels, inflammatory markers, or collect any data at all. Would you grant ethical approval?

I didn't think so. If politicians and policy-makers want to support the switch to safer nicotine habits, then hospitals and businesses could have vaping rooms. That would encourage smoking reduction but not force the unaddicted to participate in the office, on the bus or when fighting through the toxic fog at building entrances.

## How green can nuclear power really be?

From Mike Follows, Sutton Coldfield, West Midlands, UK  
Chris Baraniuk reports on nuclear power innovations such as floating reactors and shortening the half-life of nuclear waste (1 September, p 32). Perhaps tackling the energy crisis needs something more ambitious.

Just after the second world war, liquid fluoride thorium reactors (LFTRs) and other molten salt reactors were developed as an alternative to those based on the uranium-plutonium cycle. Sadly, the prototypes were mothballed before they could deliver on their promise.

Meltdown of these reactors would be impossible. What little waste they produced would have a much shorter half-life than that generated by existing reactors

and, unlike conventional nuclear power, their fuel cycle could not be weaponised. True, there are practical problems to overcome. But a concerted effort to develop LFTRs could avert the impending energy crisis without threatening the environment – and might reduce international conflict too.

From Larry Stoter,  
The Narth, Monmouth, UK  
You say that about 1 gram of carbon dioxide is emitted as a result of mining the uranium to generate 1 kilowatt-hour of energy in a nuclear power station. What about emissions during its construction, including making the concrete and steel, and from the large number of vehicle movements? I would expect another peak in CO<sub>2</sub> emissions during the decommissioning phase. The really useful figure to know would be annualised CO<sub>2</sub>

## Concerned about the future?

## Wildlife filmmaker Richard Brock says:

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As part of the BBC's prestigious Natural History Unit, Richard has witnessed the changing threats to the natural world first hand. His credits include work on the landmark series *Life on Earth* and *The Living Planet* alongside David Attenborough.

*Richard Brock*

wildlife  
**W&L**  
winners and losers  
how to turn losers into winners

twitter.com/Winners\_Losers\_  
facebook.com/winnerslosersfilms



## "Oh please... I'm tired and depressed even without gluten"

Colin (@diabloamp47) has nothing to fear from news that eating gluten could make you tired and depressed (22 September, p 15)

emissions, from ground-breaking to final decommissioning, of each of the various options for electricity production.

*The editor writes:*

■ Estimates vary: one study suggests total emissions of 3.5 to 12 grams of CO<sub>2</sub> per kWh for nuclear, wind and solar power alike (*Nature Energy*, doi.org/gcqbxxv).

## The long history of work on sterile salmon

*From Tillmann Benfey, Fredericton, New Brunswick, Canada*

As someone who has conducted and published research into farmed salmon for more than 30 years, I take exception to the statement that it has just now been confirmed that triploid Atlantic salmon are effectively sterile (18 August, p 7). This brushes aside decades of research

and dozens of publications in peer-reviewed journals by groups in Canada, the UK, Norway, Ireland and Australia on triploid Atlantic salmon. I reviewed this work in 2015 in *Reviews in Aquaculture* (doi.org/f84pm4).

There is a long history of triploid salmon being used in aquaculture in Australia specifically because they are known to be sterile.

## Stupidity hasn't worked in the past, so why now?

*From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK*  
Chris Baraniuk asks whether stupidity could save us from an AI apocalypse (1 September, p 13). Stupidity has not saved us from an environmental apocalypse – and most likely will not do so. Why should AI be any different? Even if we date environmental

awareness only back to Rachel Carson's 1962 book *Silent Spring* – and so ignore the writers, including Karl Marx and William Morris, who earlier raised warning flags – then for the past half century we have ploughed on to global disaster in the face of massive, mounting piles of evidence that the path we have chosen is the wrong one.

Perhaps we would be better off handing global political decisions to some sort of United Nations Artificial Intelligence and commit ourselves to obeying its decisions, whatever and however uncomfortable they may be.

## Further alternative air conditioning technology

*From Peter Horan, Highton, Victoria, Australia*  
Michael Le Page reports that air conditioning could warm Paris

by an extra 2°C and that it is expensive to install and run (4 August, p 18). Do not overlook absorption and adsorption cooling systems. In these, energy is required only to circulate the fluid being cooled through the evaporator. Such systems can be driven by solar hot water or other heat sources. Perhaps they will not suit some situations, but using energy from the sun directly avoids the need to use energy stored in coal, oil or gas.

## Data protection rules could be backfiring

*From Chris Lewis-Cooper, Usk, Monmouthshire, UK*  
You observed that our inboxes were full of pleading emails because of the European Union's new data rules (26 May, p 22). Now, every website asks for our consent to set cookies and so on. ➤



"This book really nails the paradoxical nature of genius, written by a genius on the scientific study of genius!"

—Scott Barry Kaufman, Author of *Wired to Create and Ungifted*

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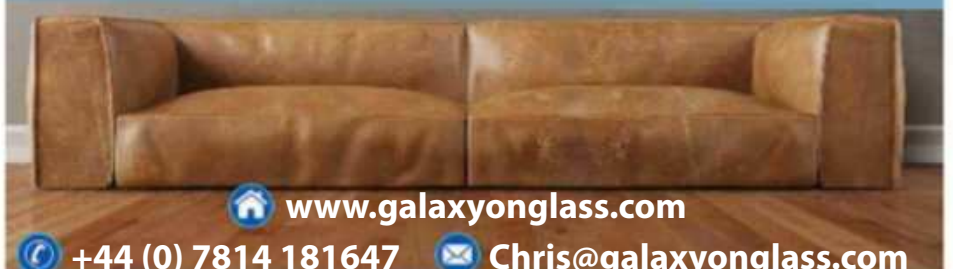
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Has anyone estimated how many hundreds of millions of extra mouse clicks have been caused by the General Data Protection Regulation? And is there a danger that requiring everyone to click through endless distracting GDPR agreements could condition people to automatically consent to more sinister things, without thinking?

### Consciousness pure and simple - perhaps?

From Ed Subitzky,  
New York, US

I much enjoy the ongoing discussion of consciousness in your pages (for example, Letters, 21 July). It seems to me that one cannot just be conscious: you have to be conscious of something, whether it is the scent of a rose, the internal feeling of being happy or sad, or the words you are reading now.

Consciousness, whatever it is, must have content in order to exist. Substituting the phrase "consciousness" with the phrase "consciousness of" makes the entire issue seem more tractable.

### Where cash comes from and keeping track of it

From Gabriel Carlyle, St Leonards-on-Sea, East Sussex, UK

Joshua Howgego writes that the money in commercial bank accounts, which makes up roughly 97 per cent of the money used in the economy, is either created by interest on loans made by that institution, or by you when you make a deposit (25 August, p 36). Perhaps surprisingly, this is wrong.

As the Bank of England itself explained in a 2014 article, "Money creation in the modern economy", in its *Quarterly Bulletin*: "Rather than banks receiving deposits when households save and then lending them out, bank lending [itself] creates deposits."

The article notes that this is why "some economists have referred to bank deposits as 'fountain pen money', created at the stroke of bankers' pens when they approve loans". The consequences are profound. Some economists have argued that, as a result, there should never be a shortage of money for society's most

important needs, provided the system is regulated correctly.

Our own dysfunctional system, long dominated by the interests of finance capital, is a very different matter.

From Daelyn Nicholls, Finley, New South Wales, Australia  
Howgego discusses the risks of a cashless society. Another very significant aspect is a possible discriminatory effect. There seems to be a convenient assumption by both governments and commercial players that everyone is capable of using electronic devices and can understand what assets they have in remote ledgers.

This ignores ageing, intellectual or physical disabilities or simply living in certain places. I have a tiny dyslexic issue that predisposes me to transposing digits and makes online banking a dreadful anxiety inducer.

If anything is likely to reduce a person's ability and confidence to live independently, it would be having to rely on a carer to assist with, let alone manage, their financial affairs.

### The positive side of negative colleagues

From Neil Doherty, Wilthorpe, South Yorkshire, UK  
You report that people paired with mean, negative robots performed a task faster and better than those working alongside kind, positive ones (25 August, p 16). There is at least one other interpretation. I used to get tasks done more efficiently when around negative colleagues because I would be in their presence for less time, have to listen to their negativity for less time and could sooner interact with someone more positive.

### The size of this glacier really is astounding

From Hillary J. Shaw, Newport, Shropshire, UK  
John Sherlock doubts the capacity of the Totten glacier in Antarctica to raise sea levels by more than 3 metres and you respond that its catchment area is more than 500,000 square kilometres (Letters, 1 September). But the world's oceans cover 350 million square kilometres. I calculate that unless the average thickness of this glacier is over 2.5 kilometres and all of it is above sea level, the figures don't stack up.

The editor writes:

■ The ice in East Antarctica really is that thick, and it is almost all sitting on rock.

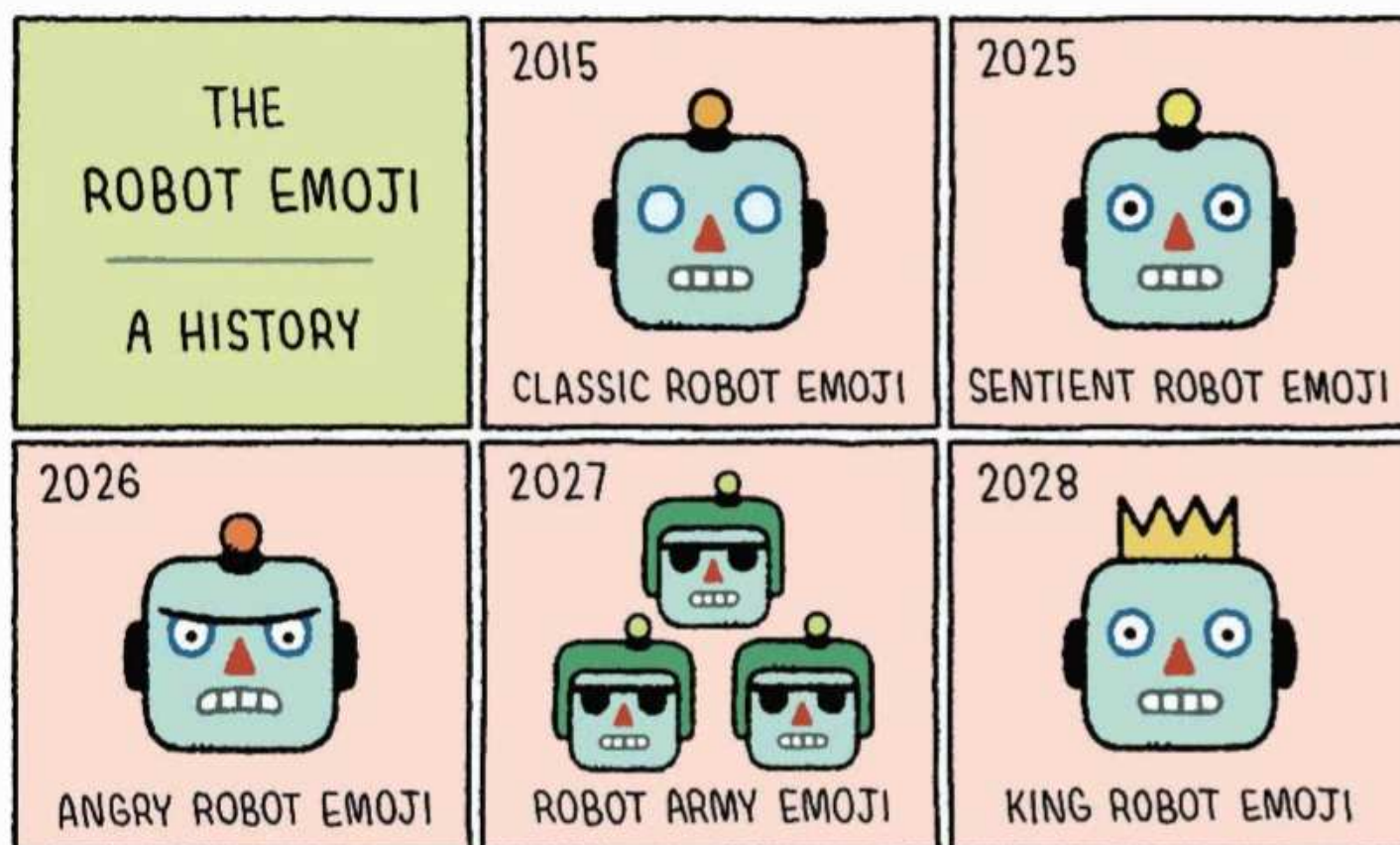
### For the record

■ Land of the rolling wheel, still: Japan's bullet trains do not levitate (Feedback, 8 September).

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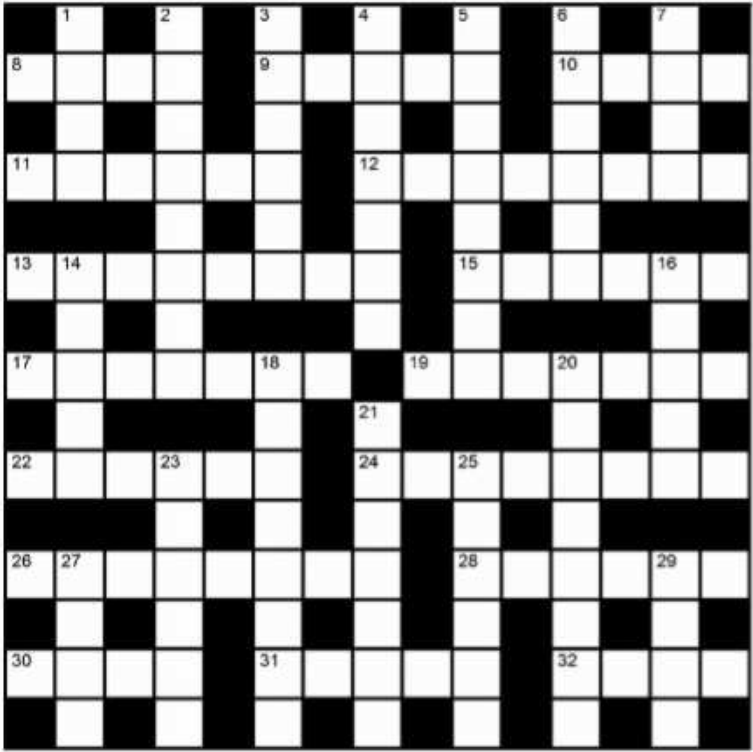
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TOM GAULD



# CROSSWORD

Compiled by Richard Smyth



## Crossword No23

- ACROSS**
- 8 NASA research satellite launched in 2004 (4)  
9 Enzyme that catalyses the joining of molecules by a double bond (5)  
10  $H_2SO_4$ ,  $HNO_3$  or  $C_6H_8O_7$ , for example (4)  
11 Subspecies of zebra, extinct since 1883 (6)  
12 In medicine, relating to arterial pressure during contraction of the left ventricle of the heart (8)  
13 The UK's first road-legal, solar-powered car (8)  
15 Thomas Hunt \_\_\_\_ (1866-1945), biologist known for his experiments with fruit flies (6)  
17 To enlarge the appearance of something (7)  
19 Muscle of the upper arm (7)  
22 Plastic explosive developed in Czechoslovakia in the 1960s (6)  
24 Theoretical substance composed of randomly moving particles (5,3)  
26 Meme complex (8)  
28 Glacial period (3,3)  
30 In measurement, standard quantity or magnitude (4)  
31 Electronic visual medium (5)  
32 Ninth letter of the Greek alphabet (4)
- DOWN**
- 1 Hikaru \_\_\_\_, character in *Star Trek* (4)  
2 Nerve-cell cluster (8)  
3  $NH_3$ ,  $Ca(OH)_2$  or  $NaOH$ , for example (6)  
4 Road safety device invented by Percy Shaw (4,3)  
5 \_\_\_\_ process, technique for the mass production of steel (8)  
6 Steam-like substance (6)  
7 Informative, collaborative, user-modified website (4)  
14 Visible part of an exothermic reaction (5)  
16 First letter of the Greek alphabet (5)  
18 Wildflower of the genus *Digitalis* (8)  
20 Telephone identification service (6,2)  
21 Sulphur \_\_\_\_,  $SO_2$  (7)  
23 In maths, the smallest primitive abundant number (6)  
25 Thomas \_\_\_\_ (1847-1931), "The Wizard of Menlo Park" (6)  
27 Active volcano on Sicily (4)  
29 Logic \_\_\_\_, device in electronics, typically AND, OR or NOT (4)

### Answers to Crossword No22

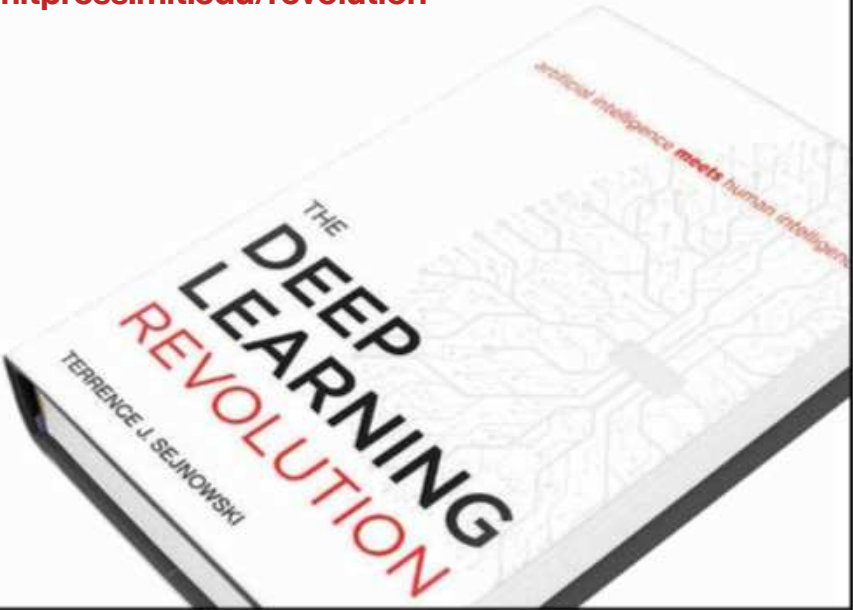
**ACROSS:** 8 ZERO, 9 AKIRA, 10 CERN, 11 RESNIK, 12 ZOO QUEST, 13 RESISTOR, 15 SISKIN, 17 PANGAEA, 19 F NUMBER, 22 ALIENS, 24 CHORDATA, 26 RETROFIT, 28 ROCKET, 30 CHIP, 31 ROTOR, 32 NEON. **DOWN:** 1 GENE, 2 BOUNCING, 3 GASKET, 4 GIZZARD, 5 JACOBSON, 6 SCRUBS, 7 IRIS, 14 EMAIL, 16 INERT, 18 ENSIFORM, 20 MEDICINE, 21 ACETATE, 23 EUROPA, 25 ORRERY, 27 ECHO, 29 ENOL.

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HIGHWAY officials in Germany, who pride themselves on being open-minded and supporting all citizens, have really outdone themselves. Their latest idea is to hire “elf commissioners” to improve safety on a notorious stretch of road. The A2 autobahn outside Hannover sees five accidents a day, on average, something concerned citizen Melanie Rüter suggested was the result of trolls and elves disturbed by traffic noise.

The *Hannoversche Allgemeine* newspaper reports that Rüter and “animal communicator” Marion Lindhof accompanied an official from the highway authority for a routine check of perimeter fences. They noted “very sad energies” emanating from several points of the motorway – drivers will know the feeling.

Rüter asked the elves to look kindly on travellers, while Lindhof apologised to local boars. They then declared that the psychic wounds had been “energetically sealed”.

Rüter says her methods will prove

effective, and is calling for the government to establish an official elf commissioner, someone whose job it is to be away with the fairies in a professional capacity. German news site *The Local* notes that soon after the blessing, a nearby collision between two lorries left one driver with life-threatening injuries.

RARELY a week goes by when Feedback isn’t confronted by the discovery of new, increasingly exotic, forms of water. Previously we have noted the existence of sacred geometry water, radio-wave infused water, “sexy water”, iceberg water, alkaline water and even raw water, for those who feel other waters don’t provide them with enough dysentery.

This time we must thank muscle-bound actor and former New Kid on the Block Mark Wahlberg. When reports of his awe-inspiring workout schedule made the news (“2:30am – wake up”) there he was promoting

superwater AQUAhydrate.

The beverage is purified of any trace minerals, minerals are then added back and the drink is subjected to “a rigorous ionization process that changes the DNA of the water increasing the pH to a 9+ level... for a 2-year shelf life”.

The capacity of water to absorb such esoteric processes seems to be matched only by its ability to turn them into money. That’s what we call a liquid asset!

THE world’s first champagne for astronauts has been launched by French winery Mumm. The Grand Cordon Stellar project addresses a gap in the market: low Earth orbit will soon feature lots of wealthy space tourists, but few bars. To celebrate, Mumm chartered a parabolic flight so that journalists and Usain Bolt could sample the zero-g fizz (Feedback’s invitation was presumably lost in the post). But without the pull of gravity, wine cannot be poured from a bottle, and carbonated drinks effervesce into foam. Mumm crafted a bottle that allows space sommeliers to squirt globules of alcoholic foam into the air, which thirsty travellers can catch with glass scoops. Marvellous!

Mumm may have to wait some time to see a return on their investment. Despite the hype, space tour companies have yet to get off the ground. At least the champagne served to the first group of high fliers will be well aged.

GLOWING stones have been discovered on the Michigan shores of Lake Superior – but fear not, they are totally safe. Local rock collector Erik Rintamaki made the surprise discovery after buying a UV light for a night-time beach-combing trip. To his surprise, he found a previously unrecorded deposit of fluorescent sodalite.

Exciting news for residents of Michigan’s Upper Peninsula (UP), affectionately known as Yoopers. Once geologists had confirmed Rintamaki’s discovery, they also accepted his suggested name for the mineral: Yooperlite.

SOME of Russia’s aquatic life may be feeling green around the gills, after two lakes near the city of Samara turned a lurid shade of pink.

While Russia is no stranger to toxic liquids turning up in unexpected places, the cause of the sudden burst of colour is unknown. An algal bloom, pollution or a chemical reaction with the underlying bedrock are all speculated. Suspicion has also fallen on local businesses, which include a concrete factory, a pig farm and a brewery. The last of which, at least, will ensure residents have something to drink until the water clears.

THE US Air Force is hunting for a kraken. Specifically, the 628th Force Support Squadron would like somebody to build them a kraken costume, as revealed in a tender posted to FedBizOpps.com.

The costume needs to be navy



blue, water-repellent, have between eight and 10 tentacles (arms optional), and ideally be machine washable.

Although we would like to believe that the outfit is part of an elaborate prank to spook navy divers during their next night-time exercise, the kraken will be deployed as a mascot at sporting events and parades.

Dressmakers should note that the costume must be delivered in 12 weeks. As the 628th should say from now on: “Let’s get kraken”.

We reported on the discovery of a 73,000-year-old drawing in red crayon, resembling a hashtag. Sadly the rest is missing, so the trending topic of the Middle Stone Age remains a mystery

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## Taking a bow

Recent strange weather conditions have led to a number of extraordinarily bright local rainbows. They contain extra colours inside the usual violet. There are as many as three additional bands: a narrow one of orange-yellow, a wider one the vivid green of nocellara olives and a narrow one of purple. These extra bands occupy about a third of the width of the rainbow itself. What am I seeing?



■ It sounds as if your questioner is seeing a supernumerary rainbow. This occurs when raindrops are relatively small and evenly sized. Light reflected inside the droplet can interfere with that reflecting off the outside, producing light and dark bands – just like the classic double slit experiment showing that light can behave as waves or particles.

Because different wavelengths of light are refracted by different degrees, the exact interference patterns vary according to colour. If the droplets are of even size, they all line up and produce more rainbows inside the main bow. The strange colours are probably caused by colours mixing where

the interference patterns overlap. If you photograph a rainbow and turn up the contrast, you might see many supernumerary bows. *Stephen Jorgenson-Murray*  
*Frankfurt, Germany*

■ This type of rainbow is known as a supernumerary rainbow. They are rare, so your questioner was lucky to see one. I saw one on 27 May 2016 at Great Shoddesden in Hampshire, UK. It is the only one I have noticed in 62 years of knowing what a rainbow is. I have enhanced the photo (left) to show the colours clearly.

The effect results from raindrops of a uniform size of 1 millimetre or less. It was recognised in the 19th century that this effect can't be explained by optics alone (as ordinary rainbows can), and is evidence of the wave nature of light.

*Brian Pollard*  
*Launceston, Cornwall, UK*

## Out cold

I read recently that turtles were being "cold-stunned" and sharks were freezing to death in the ocean off the north-eastern US coast. This was due to a cold spell with air temperatures of -12°C, rather than the average 1°C. Is this particularly cold or within the normal winter range, and how is it possible for animals to be affected in these ways? Also, why do we not see mass freezing of land animals before sea animals are affected, given the relative stability of ocean temperatures?

■ Sharks and turtles weren't really freezing to death in January 2018 when an "Arctic outbreak" of frigid air produced very low but not record-setting temperatures in the north-eastern US. For sharks to freeze, the coastal waters would have had to freeze too, and they didn't.

However, a few sharks and sea turtles were "cold-stunned" because they apparently

**"For sharks and turtles to actually freeze, the coastal waters would have to freeze too"**

remained too long in quickly cooling near-shore waters that had no layer of warmer water below them to buffer the rapid temperature drop.

They, along with most other fish, reptiles and amphibians, are ectotherms, animals whose body temperature closely follows the normal seasonal range of the water or air temperatures in which they live. Their metabolism is programmed to operate within this range, but if body temperature falls below it, some of the enzymes that control metabolic rate become inactive, partially stunning the animals.

However, if a shark or sea turtle can still breath and avoid predation or beaching during such an activity slump, normal metabolism and behaviour will soon return as the water temperature rises.

Mass freezing of land animals rarely occurs because any

ectotherms will retreat to burrows, deep rock crevices or caves where temperatures never fall below freezing.

Endothermic animals such as birds and mammals, whose metabolic rate supports their relatively constant body temperature, have a different problem. They usually require a constant food supply to drive their metabolism. If food becomes scarce in the winter habitats of large grazing mammals, their body temperature drops and mass freezing of entire herds may occur.

*Sam McGinnis*  
*Professor Emeritus*  
*Department of Biology*  
*California State University, US*

## This week's questions

### TIME DIFFERENCE

If we ever colonised a planet with a greater diurnal period, say 30 hours, how long would it take the circadian systems of humans and other species to adapt?

*Richard Hind*  
*York, UK*

### BEATS ME

When I was standing on the scales in my surgery today (I am a doctor), I noticed that the needle moved very slightly, exactly in time with my heartbeat. What could account for this fluctuation?

*Paul Jepson*  
*Manchester, UK*

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