

New Scientist

WEEKLY May 13-19, 2017

READY FOR ANYTHING

How to train your brain
to survive disaster

ROBO-SHERLOCK

AI detective
hunts for clues

BY JUPITER!

Gas giant springs
some big surprises

WORKIN' NINE TO FOUR The surprising benefits of a 6-hour day

WHAT'S THE POINT OF CONSCIOUSNESS?

The accidental evolution of our unique minds

No 3125 US\$6.50 CAN\$6.50



Science and technology news
www.newscientist.com
US jobs in science

ODDS ON Ten unlikely breakthroughs that are worth a flutter

Intellectual indulgence

Subscribe and save up to 76%

Visit newscientist.com/9942 or call
1-888-822-3242 and quote 9942

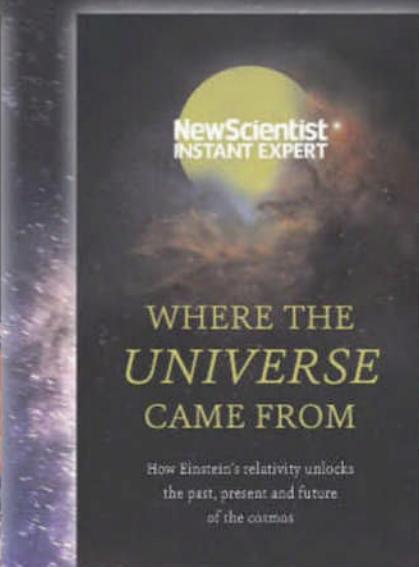
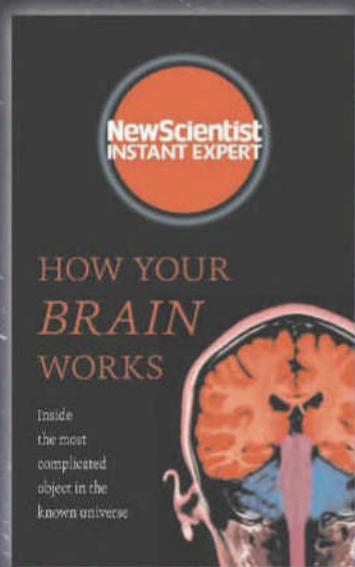


NewScientist
FEEDING MINDS FOR 60 YEARS

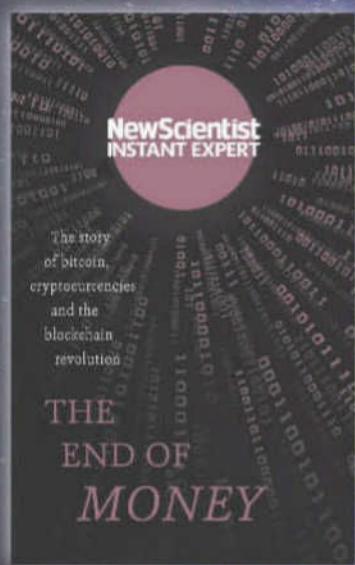


INTRODUCING THE New Scientist INSTANT EXPERT SERIES

DEFINITIVE, ENGAGING AND ACCESSIBLE GUIDES TO
THE MOST IMPORTANT SUBJECTS IN SCIENCE.



MARCH 2017



APRIL 2017



CONTENTS

News

8

RoboCop gets on the case

An AI is helping police hunt for clues in crime scene data



On the cover

28

What's the point of consciousness?

The accidental evolution of our unique minds

- 32 Ready for anything Disaster brain training
- 8 Robo-Sherlock AI turns detective
- 12 By Jupiter! Gas giant surprises
- 22 Workin' nine to four Benefits of a 6-hour day
- 36 Odds on Ten breakthroughs that are worth a flutter



Cover image
Credit is Richard Wilkinson

Features

32

Ready for anything

How to train your brain to survive disaster

PAOLO PELLEGRIN/MAGNUM PHOTOS



rbi reed business information

recycle

When you have finished with this magazine please recycle it.

Coming next week...

Concentrate!

Take control of your wandering mind

Zombie microbes

The life forms resurrected after millions of years

Volume 234 No 3125

This issue online

newscientist.com/issue/3125

Leaders

- 5 The stakes are growing for scientific wagers. Less work, more school?

News

UPFRONT

Measles outbreak. Rocket watches the sun. Citymapper bus. EPA's science sackings

NEWS & TECHNOLOGY

Do old brains get a boost from cannabis? Most complete *Homo naledi* skeleton found. Why we turn mean online. Turtle-riding robots. Nanofridge for quantum computers. New York rats on the pill. Jupiter's massive storms and magnetism. Synth proteins that work. Mini masterpieces pack in pixels. Atlas of the underworld. Robot bridge inspector. Radiotherapy colours man's dreams

IN BRIEF

Snowball Earth's freshwater seas. Eyeball fluke is fish controller. Baby mind reader

Analysis

- 22 The optimum working day Shorter hours are inevitable, but is that good?

COMMENT

Why SETI should look closer to home. Space-nuke terror talk more fiction than fact

INSIGHT

Can a small lawsuit stop an opioid epidemic?

Aperture

- 26 The gargoyle of the sea

Features

- 28 What's the point of consciousness? (see above left)

Ready for anything

(see left)

Odds on

Ten breakthroughs worth a flutter

PEOPLE

Shunichi Yamashita and Fukushima's psychological fallout

Culture

- 42 Real deal As millions queue to see art, will tech help or hinder access to originals?

Wall to end all walls

Ridiculing Trump's border plan might make it more likely

Regulars

- 52 LETTERS Light of our lives

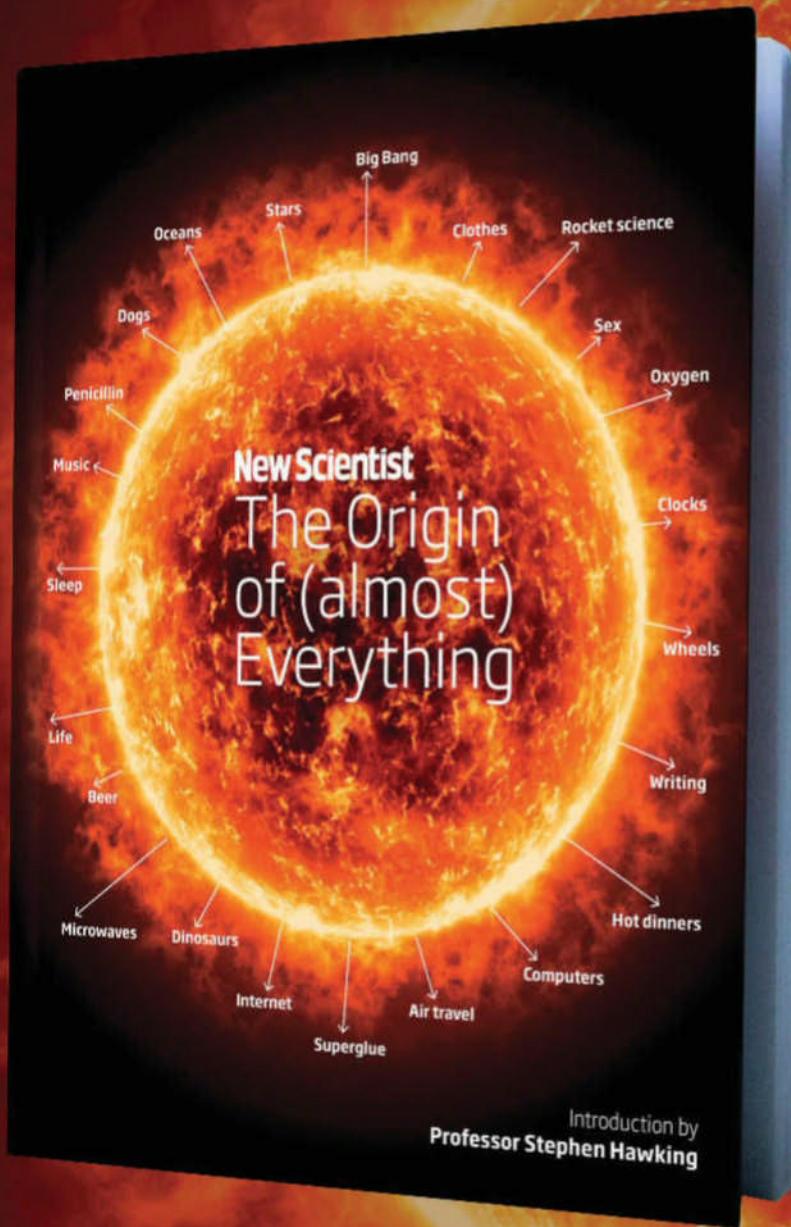
CROSSWORD

- 56 FEEDBACK Retronym, okay?

THE LAST WORD

Mossies with muscle

Where did we come from? How did it all begin?



And where does belly-button fluff come from?
Find the answers in our latest book. On sale now.



Introduction by **Professor Stephen Hawking**

**New
Scientist**

LOCATIONS

USA

45 Prospect St
Cambridge, MA 02139
Please direct telephone enquiries to our UK office +44 (0) 20 7611 1200

UK

110 High Holborn,
London, WC1V 6EU
Tel +44 (0) 20 7611 1200
Fax +44 (0) 20 7611 1250

Australia

Level 11, Suite 3,
100 Walker Street,
North Sydney, NSW 2060
Tel +61 2 9422 8559
Fax +61 2 9422 8552

SUBSCRIPTION SERVICE

For our latest subscription offers, visit newscientist.com/subscribe

Customer and subscription services are also available by:

Telephone 1-888-822-3242
Email subscribe@newscientist.com
Web newscientist.com/subscribe
Mail New Scientist, PO Box 3806, Chesterfield, MO 63006-9953 USA
One year subscription (51 issues) \$154

CONTACTS

Contact us
newscientist.com/contact

Who's who

newscientist.com/people

General & media enquiries
enquiries@newscientist.com

Editorial

Tel 781 734 8770
news@newscientist.com
features@newscientist.com
opinion@newscientist.com

Picture desk

Tel +44 (0) 20 7611 1268

Display advertising

Tel 781 734 8770
displaysales@newscientist.com

Recruitment advertising
Tel 781 734 8770
nssales@newscientist.com

Newsstand

Tel 212 237 7987
Distributed by Time/Warner Retail Sales and Marketing, 260 Cherry Hill Road, Parsippany, NJ 07054

Syndication

Tribune Content Agency
Tel 800 637 4082
tca-articlesales@tribpub.com

New Scientist Live
Tel +44 (0) 20 7611 1273
live@newscientist.com

© 2017 Reed Business Information Ltd, England.

New Scientist ISSN 0262 4079 is published weekly except for the last week in December by Reed Business Information Ltd, England.

New Scientist (Online) ISSN 2059 5387

New Scientist at Reed Business Information 360 Park Avenue South, 12th floor, New York, NY 10010.

Periodicals postage paid at New York, NY and other mailing offices.

Postmaster: Send address changes to New Scientist, PO Box 3806, Chesterfield, MO 63006-9953, USA.

Registered at the Post Office as a newspaper and printed in USA by Fry Communications Inc, Mechanicsburg, PA 17055



LUKE SHARRETT/BLOOMBERG VIA GETTY IMAGES

Care to make it interesting?

The stakes are rising for scientific wagers

THE Plataeans were besieged: walled in by their enemies, the Spartans. They could make ladders to climb out, but how tall should they be? Citizens were asked to guess the wall's height by counting its bricks, with the most popular estimate taken as correct. It worked: 212 duly escaped.

This episode from 428 BC is the first known use of the wisdom of crowds – collating estimates to arrive at an answer more accurate than any individual can manage. That lies at the heart of a variety of tools used to run our society, from opinion polls to financial markets. Adding an incentive – in other words, allowing people to bet on the outcome – encourages as much participation as possible.

Science has a long tradition of turning to wagers when facts are hard to come by: for example, Stephen Hawking has famously made several bets with his fellow theoretical physicists over various abstruse properties of black holes. Other celebrated (or notorious) wagers have been placed over artificial intelligence and the abundance of important metals.

The stakes are often pretty low in such bets. But the ethos of crowd wisdom still applies: the point is to encourage both bettors and onlookers to gather facts and hone arguments. It's in that spirit that we asked a bookie to quote odds on possible breakthroughs, ranging from a Martian colony to human cloning (see page 32).

Now others are raising the stakes for scientific wagers. The Long Now Foundation's Long Bets project, for instance, highlights issues that will resonate beyond our lifetimes. And researchers at hedge fund Winton Capital and the London School of Economics recently proposed that the UK host a "prediction market" in which bets could be placed on aspects of climate change. That could help gather information that's currently widely dispersed – and perhaps even build consensus around the most likely scenarios.

Given the frequent failures of gamblers, pollsters and traders to predict real outcomes, it's unclear how desirable or plausible that is. But would you bet against it? ■

Work smarter, not longer

HOW many hours a day do you work? For many of us, that's a surprisingly hard question to answer. Those employed in the so-called "gig economy", or on zero-hours contracts, may not know how much they will work (or get paid) from one day to the next.

Other employees may never really stop working, being tied to their jobs by phones and email. And highly paid jobs can be highly

pressurised too, demanding unhealthy amounts of overtime.

The quality of work has become a talking point: three quarters of those in a recent UK survey felt improving it should be a national priority. The good news is that serious efforts are now being made in that direction. We might even end up cutting working hours without harming productivity (see page 22).

In the longer term, however, the forces reshaping work today will be joined by another: longevity. Those working today can expect to work for decades longer than our predecessors, even as ongoing automation erodes the value of our skills. That's led to talk of lifelong training and multiple careers. So perhaps those shorter hours in work will be offset by hours spent back at school. That prospect will delight some and dismay others. But better homework than no work. ■

Measles after MMR 'scare'

THE state of Minnesota is in the throes of its biggest measles outbreak in 27 years. As of 5 May, 44 cases had been confirmed. Of these, 42 people were unvaccinated, and 38 belonged to the state's Somali-American community.

In 2008, some Somali parents raised concerns over what they perceived to be a high rate of autism in Somali-American children.

A subsequent study by the University of Minnesota, the Centers for Disease Control, and the National Institutes of Health found that autism rates among Somalis in Minneapolis were in fact similar to those of the city's white population.

Nevertheless, the concerns of the Somali community prompted anti-vaccination groups to begin

targeting Somalis in Minnesota. Former doctor Andrew Wakefield, who lives in Texas, visited Somali communities in Minnesota several times, speaking to parents. Wakefield's discredited 1998 study suggested a link between autism and the measles, mumps and rubella (MMR) vaccine.

Between 2004 and 2014, the MMR immunisation rate among 2-year-old Somali-Americans born in Minnesota dropped from 92 to 42 per cent.

State officials are now recommending that every Somali-born child across the state receives the MMR booster shot as soon as possible, and the same applies to all other unvaccinated children older than 1 year living in the affected counties.

Ripe for cancer

IMPROVING the worst environments in the US could prevent 39 in every 100,000 cancer deaths.

That's according to the first study to address the impact of cumulative exposure to environmental hazards on cancer incidence in the US, which found strong links between poor environmental quality and increased rates of cancer.

Our environment can influence biological processes such as hormone function and gene

increased alcohol consumption.

Jyotsna Jagai at the University of Illinois and her colleagues studied these links by comparing 2000 to 2005 data from the Environmental Quality Index – a measure of cumulative environmental exposures – with cancer incidence across the US from 2006 to 2010.

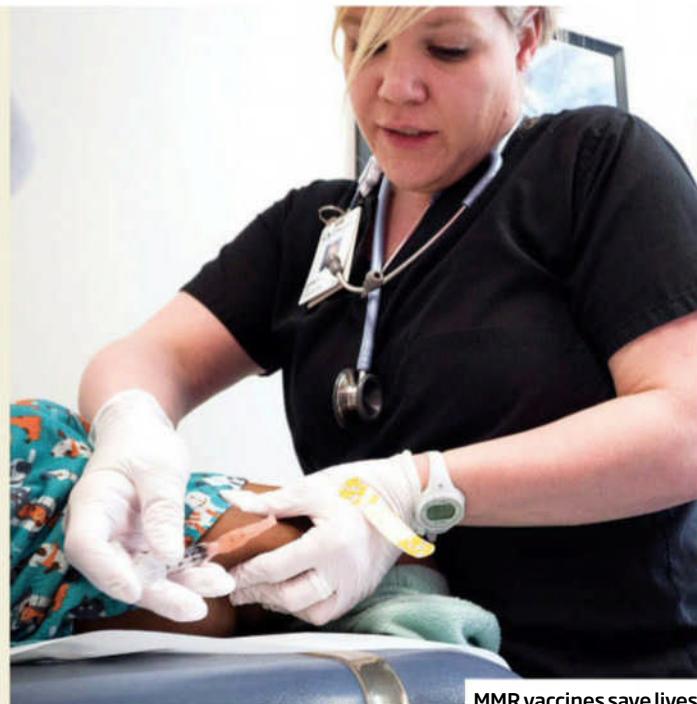
The results showed increases in cancer incidence with decreasing environmental quality. The link was clearest with prostate and breast cancer (*Cancer*, doi.org/b6v2).

The data compiled by Jagai's team may help identify which communities are most vulnerable to high cancer rates. But this could be hampered by legislative proposals put forward in January that seek to rein in the federal collection of local area data.

Jagai and her team also warn that a bill introduced in February to terminate the Environmental Protection Agency, which provided the environmental data used in the study, will severely harm researchers' ability to further investigate the factors that contribute to disease.

"Decreasing environmental quality was most strongly linked to prostate and breast cancer"

expression, or cause DNA damage – all of which can alter the risk of developing certain cancers. For instance, lung cancer incidence can rise because of chronic exposure to certain pesticides, diesel exhaust and the radioactive gas radon. Social factors also take their toll – poverty is linked to liver cancer, for example, due to



MMR vaccines save lives

COURTESY PERRY/FOR THE WASHINGTON POST/GETTY

Sun watcher

NASA has looked directly into the sun – but only for 5 minutes.

On 5 May, a small suborbital rocket used for the mission, called the Rapid Acquisition Imaging Spectrograph Experiment (RAISE), flew to an altitude of nearly 300 kilometres, where it took 1500 images of the sun in 5 minutes.

Several observatories constantly watch the sun, but their instruments are not quick enough to catch its most rapid changes. With a frame rate of five

images per second, RAISE can capture split-second changes in the sun's most active regions.

This is RAISE's third flight, and the first since its detectors were refurbished and its software upgraded. The rocket now carries a new diffraction grating, which separates the sun's light into its different wavelengths.

Measuring the strength of light at each wavelength can show how the sun's magnetic field moves energy and plasma around, causing solar flares and ejections of material into space.

Smart bus adjusts its route

CITYMAPPER, the firm behind an app that suggests public transport routes through 39 cities worldwide, has launched a bus service in London. Citymapper says its bus adjusts its route between stops depending on traffic and passenger demand.

As *New Scientist* went to press, the company was carrying out a two-day trial of a circular route through the centre of London from Blackfriars to Waterloo Bridge.

Tech companies like Uber and Lyft

have been taking on taxi services for the last few years but Citymapper will be the first to offer an upgrade to public bus services. Drivers of the 30-seater buses will stay up to date with traffic information using a tablet linked to Citymapper's data centre.

The company wants to offer a bus service that is more flexible than those currently in service. Transport for London will need to update its permits for private buses, however, as they don't allow for flexible routes.

60 SECONDS

Air pollution plans

THE UK government has finally published its plans to cut air pollution, after it lost a court case and was ordered to do so. But critics say the plans fall short of delivering real change.

"The UK government's long-delayed plans to cut air pollution now seem to lack scale and funding"

The plans suggest measures such as taking the most-polluting vehicles off the road, retrofitting local bus and lorry fleets to lower their emissions, removing road humps to improve traffic flow and encouraging more electric cars.

Air pollution is linked to an estimated 40,000 early deaths a year and 37 out of 43 areas across the UK are exceeding EU legal limits for nitrogen dioxide. A major source of this key pollutant is diesel engines, which the plans don't commit to scrap.

"A plan to help drivers swap polluting diesel for electric cars would be a good idea but the government's proposal lacks scale and detail," says Greenpeace UK's Doug Parr.

"The government is standing idly by while Britain chokes," says Caroline Lucas, co-leader of the Green Party. "This feeble plan won't go anywhere near far enough in tackling this public health emergency."

REUTERS/JOSHUA ROBERTS



Still protecting the environment?

EPA fires scientists

THE turmoil continues at the US Environmental Protection Agency. EPA administrator Scott Pruitt (pictured above) has dismissed half the members of the 18-strong Board of Scientific Counselors, an advisory panel for the agency's research arm.

The scientists were at the end of a three-year term and had been told by EPA staff that they

"Today, I was Trumped. My appointment at the EPA's science advisory board was terminated"

would be kept on for another term, as is common.

"Today, I was Trumped," tweeted Robert Richardson, an environmental economist at Michigan State University. "My appointment was terminated."

EPA spokesperson J. P. Freire told *The New York Times* that the agency may consider filling the now-vacant posts with members from industries affected by the EPA's regulations. "EPA received hundreds of nominations to serve on the board, and we want to ensure fair consideration of all the nominees – including those nominated who may have previously served on the panel – and carry out a competitive nomination

process," Freire told *New Scientist*.

Rush Holt, the CEO of the American Association for the Advancement of Science, said in a statement that the EPA should reconsider its decision. "Academic scientists play a critical role in informing policy with scientific research results at every level, including the federal government," Holt said.

UK coal subsidies

THE coal sector in the UK benefits from subsidies worth £356 million a year despite the government's pledge to phase out use of the highly polluting fossil fuel.

This is according to a report by the Overseas Development Institute, a think tank. It rates the UK as poor on transparency and on phasing out subsidies for coal mining and coal-fired power.

The UK support forms part of the wider £5.3 billion given to the coal industry each year by 10 European countries that together account for 84 per cent of the continent's carbon dioxide emissions, the report says.

"Our research shows governments are continuing to provide lifelines to coal by handing over new subsidies without which the coal industry would not be economically viable," says report co-author Shelagh Whitley of the ODI.

Macron hack?

Hackers who targeted the campaign of French president-elect Emmanuel Macron may be linked to the same Russian-affiliated groups who attacked the Democratic party in the run-up to the US election. The email leak has been blamed on the Fancy Bear hacking group, believed to have links to the Russian government.

Healthcare bill passes

The US House of Representatives has passed a bill to repeal and replace most of the Affordable Care Act, Barack Obama's signature healthcare law. The bill will now go to the Senate. If passed, it will remove protections for those with pre-existing conditions such as cancer or pregnancy, and bring about big cuts to Medicaid, which gives health insurance to people on low incomes.

Hate posts takedown

An Austrian court has ordered Facebook to remove all hate posts about Green Party leader Eva Glawischnig – not just in Austria, but worldwide. The ruling is a victory for those who want the firm to fight trolling, and comes after Facebook said it was hiring an extra 3000 moderators to remove offensive posts.

Fake bone makes blood

A synthetic bone implant can host donor stem cells and make healthy blood, just like real bone marrow (*PNAS*, doi.org/b6vz). It has only been tested in mice, but could be a way to treat people with certain types of anaemia and autoimmune conditions, without the side effects of current bone marrow transplants.

Ancient pond life

Imprints of ancient air bubbles in 3.5-billion-year-old rocks in a hot, arid region of Australia are the oldest evidence of life on land. The finding also suggests life on Earth originated in ponds, not oceans (*Nature Communications*, DOI: 10.1038/ncomms15263).



CITYMAPPER

All aboard

Robot detective gets on the case

An AI is hunting for clues in crime scene data, finds **Timothy Revell**

MOVE over, Sherlock. UK police are trialling a computer system that can piece together what might have happened at a crime scene. The idea is that the system, called VALCRI, will be able to do the laborious parts of a crime analyst's job in seconds, freeing them to focus on the case, while also provoking new lines of enquiry and possible narratives that may have been missed.

"Everyone thinks policing is about connecting the dots, but that's the easy bit," says William Wong, who leads the project at Middlesex University London. "The hard part is working out which dots need to be connected."

VALCRI's main job is to help generate plausible ideas about how, when and why a crime was committed as well as who did it. It scans millions of police records, interviews, pictures, videos and more, to identify connections that it thinks are relevant. All of this is then presented on two large touchscreens for a crime analyst to interact with.

Spotting patterns

The system might spot that shell casings were found at several recent crime scenes including the one the police are focusing on now, for example. "An analyst can then say whether this is relevant or not and VALCRI will adjust the results," says Neesha Kodagoda, also at Middlesex. Thanks to machine learning, the system improves its searches on the basis of such interactions with analysts, who can raise or lower the importance of different sets of criteria with a swipe.

When an unsolved crime lands on an analyst's desk, one of the first things they have to do is search police databases for incidents that

could be related based on their location, time or modus operandi, and collect details of all of the people involved. "An experienced analyst needs 73 individual searches to gather all of this information, before manually putting it into an easily digestible form," says Kodagoda. "VALCRI can do this with a single click."

This is no mean feat. A lot of the information recorded in police reports is in side notes and descriptions, but the algorithms powering VALCRI can understand what is written – at a basic level.

For example, interviews with people at three different crime scenes may describe an untidy person nearby. One person might have used the word "scruffy", another "dishevelled" and the third "messy". A human would

have no trouble considering that all three might be describing the same person. Improvements in artificial intelligence mean VALCRI can make such links too. The system can also use face recognition software to identify people in CCTV footage or pictures taken at a scene.

West Midlands Police in the UK are currently testing VALCRI with three years' worth of real but anonymised data, totalling around 6.5 million records. Police in Antwerp, Belgium, are trialling a version of the system too.

The next stage is to let VALCRI loose on non-anonymised, new

"Everyone thinks policing is about connecting the dots. We have to work out which dots need to be connected"

data as crimes happen. This has been agreed in principle, but getting the final go ahead is a delicate process. Police techniques used during an investigation can be challenged in court, so deploying VALCRI too soon or incorrectly could cause cases to collapse. And laws vary between countries on how police data can be used.

An added complication is that many people would be uncomfortable with computers determining the probability of different narratives explaining a crime. "The data in a crime case is simply not good enough to do that, so VALCRI doesn't either," says team member Ifan Shepherd at Middlesex. "A human analyst always has to call the shots."

Having humans in charge won't solve everything. "Machine learning can help the police, but it will introduce new biases too," says Mark Riedl at Georgia Tech in Atlanta. It will be easy for analysts to think the system has identified all the relevant characteristics, but it is bound to miss some as well.

VALCRI tries to counteract this by making the whole process transparent. Results are never hidden, and every decision can be retraced. Overall, this could lead to increasingly detailed cases being put to juries, says Michael Young at the University of Utah in Salt Lake City. "Narratives could be constructed in a way that preserves provenance," he says.

In other words, things that would have been left out to make a case fit together can be included digitally, along with an explanation. This could be used by both the defence and the prosecution in court to make each side's assumptions more transparent, says Young. Sherlock Holmes might be edged out, but he'd approve. ■



The computer said we'd find a clue

ASHLEY COOPER/GETTY

In this section

- Why we turn mean online, page 10
- Jupiter's massive storms and magnetism, page 12
- Shorter hours are inevitable, but is that good?, page 22

Low cannabis dose may boost old brains

IN SOME cultures, it's traditional for elders to smoke grass, a practice said to help them pass on knowledge. They might just be onto something: low doses of the active ingredient in cannabis, THC, seem to reverse brain ageing in elderly mice.

Andreas Zimmer at the University of Bonn, Germany, and his team are studying the endocannabinoid system, which helps balance out our bodies' response to stress. THC mimics similar molecules in this system, calming us down.

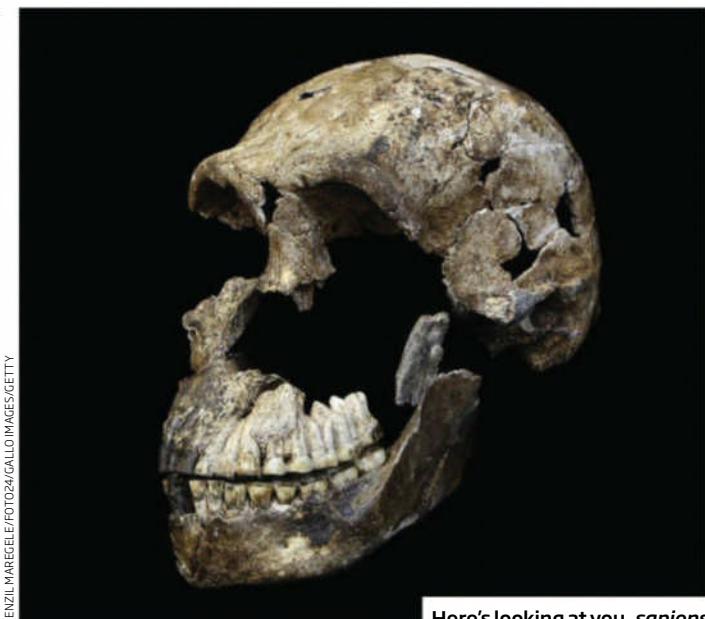
Mice whose endocannabinoid systems don't work properly age faster, which made Zimmer wonder if stimulating the system might have the opposite effect. To find out, his team gave young, middle-aged and elderly mice a steady but low dose of THC. After a month, the group tested the mice's cognitive abilities, such as how well they could navigate a maze or recognise other individuals.

Among the mice that received no THC, the middle-aged and elderly animals did far worse than the young ones. But the middle-aged and elderly mice given THC performed as well as the young mice in the control group (*Nature Medicine*, doi.org/b6vf). "It's a very robust and profound effect," says Zimmer.

The team's findings aren't that surprising, says David Nutt of Imperial College London. Animal studies have shown that the cannabinoids the body produces itself can be beneficial for the brain.

However, the young mice given THC performed worse in some tests than the controls. Zimmer thinks this is because the endocannabinoid system is most active in young mice (and people), so extra THC may overstimulate it. As this system is less active in older mice, a little THC may restore it to optimum levels.

Zimmer's team is now planning trials to see if older people benefit from low doses of THC and, if so, from what age. Michael Le Page ■



Here's looking at you, *sapiens*

Meet Neo, the most complete *Homo naledi*

IT'S the cave that keeps on giving. Almost four years ago, researchers recovered 1500 ancient hominin bones and teeth from a chamber in South Africa's Rising Star cave system, recognised as a new species of early human – *Homo naledi*. The team has now recovered 130 additional hominin bones and teeth from the cave.

They say the discoveries – and the first official confirmation of the specimens' age – could transform our understanding of how and where humans evolved.

Although the new *H. naledi* remains belong to at least three individuals overall, many of the bones and teeth belong to a single, remarkably complete adult skeleton, dubbed Neo (*eLife*, doi.org/b6wf). "It's one of the greatest fossil finds of the 21st century in its own right," says Lee Berger at the University of the Witwatersrand in South Africa, who led the team.

Judging by the size of the bones, Neo might have stood about 1.4 metres tall and weighed about 40 kilograms. The species has a strange mix of features: a small

brain like an early human, shoulders and pelvis more like those of other apes, but hands similar enough to those of modern humans that it may have been able to craft stone tools (*eLife*, doi: 10.7554/eLife.24234.001).

The team has also determined the age of the *H. naledi* remains. Isotope analysis of teeth and cave

"This is one of the greatest fossil finds of the century, and it could change our view of human evolution"

sediments indicate the enigmatic hominins are between 236,000 and 335,000 years old (*eLife*, doi.org/b6wg).

This falls in a time period with a poor hominin fossil record. We know that several species of hominin coexisted in Africa more than two million years ago, and that several species seemed to coexist across Eurasia in the last 100,000 years or so. "Now we see diversity at this time [236,000 to 335,000 years ago] too," says Carol Ward at the University of Missouri

in Columbia. "That's exciting."

It puts *H. naledi* on the southern African landscape not long before our species, *Homo sapiens*, had begun to appear elsewhere in Africa – and long after other small-brained hominins were thought to have vanished from the continent. "What makes this especially fascinating is that *H. naledi* was more different from modern humans than Neanderthals, another species with which modern humans co-existed," says Fred Spoor at University College London.

Bernard Wood at the George Washington University in Washington DC thinks *H. naledi* branched off from other humans relatively recently and then evolved to look more primitive. "Its primitive features might be misleading," he says.

For instance, southern Africa might have been relatively isolated from the rest of the continent, says Wood. Lack of competition from other humans could have relaxed the pressure on *H. naledi* to grow a large brain. If the skeleton no longer had to bear the weight of a heavy skull, features like the hips and shoulders might have reverted to become more like those of a small-brained hominin.

But others think it is a much earlier human – albeit one that survived until astonishingly recently. "It could lie close to the origin of the genus *Homo*," says Chris Stringer at the Natural History Museum in London.

"It could even be the most primitive early *Homo* we've ever discovered, with origins long before two million years," Berger says. He thinks that rather than being an isolated evolutionary cul-de-sac, southern Africa may have been the powerhouse of human evolution. "Subequatorial regions are the engines of biodiversity," he says.

Either way, the finds disrupt the neat tale of evolution steadily leading to ever larger brains and modern human anatomy.

Colin Barras ■

Others' behaviour makes you a troll

Sally Adee

THE internet can be a vicious place. Anonymity online has often been blamed for the web's abundance of trolls, but an experiment using a fake website shows the behaviour of others has the most influence.

Offline, people are more likely to behave antisocially when they can't be identified. A classic 1976 study found that masked trick-or-treaters stole more sweets. Some experiments have since suggested that stripping us of our names online gives us licence to unleash the inner animal.

But there's conflicting evidence. People still say aggressive things when using their real names. And a year after South Korea introduced a law in 2007 that required users of popular websites to register with proof of identity, abuse had fallen by only 0.9 percentage points.

To investigate further, Leonie Rösner and Nicole Krämer at the University of Duisburg-Essen in Germany created a fake website for football fans, and planted a false news story stating that people would no longer be allowed to stand at matches.

At the time, the idea of banning

standing terraces in stadiums was a hot topic in Germany.

The team then recruited users from a local university and let them loose on the site's forum. Half the participants could comment without registering, whereas the others had to use their Facebook accounts to do so. To some, all commenters appeared

anonymous, while others saw Facebook profiles for everyone.

The forum was also manipulated so that some saw a civil discussion, whereas others were greeted with an atmosphere rich in offensive words, sarcasm, insults and personal attacks – and many exclamation marks.

Rösner and Krämer found that people who were anonymous didn't necessarily use more aggressive language. Instead, they found that the tone set by other commenters was linked to the likelihood that a participant would use aggressive

language to support their points.

There's already evidence that social cues influence our online activity. For example, Facebook users tend to adopt the same patterns of behaviour as their contacts, such as sharing lots of news stories or photos. But the fresh findings are much more specific, says Adam Joinson at the University of Bath, UK. "We didn't know that social norms can exert such an effect on aggressive behaviour."

Anonymity isn't off the hook, however: the pair found that aggression in comments was highest when a forum was both hostile in tone and completely anonymous (*Social Media + Society*, doi.org/b6vh).

These findings suggest that Twitter was right to introduce a "report" button for flagging up offensive content. Rösner says any method for cutting out a thread that has descended into aggression should help stop other users from getting "infected" by mob rule.

Fortunately, the behaviour of others can affect us in good ways too. An experiment last year found that certain chatbots could chastise tweeters into using less racist language.

"If you create a social norm of increased civility, it becomes a virtuous cycle," says Joinson. "There's not necessarily an inbuilt tendency to be aggressive to other people or impolite." ■



Anonymity isn't the only problem

Robot riders hitch lifts on hungry turtles

WATCH out, humanity! You might be next. "Parasitic" robots are now riding turtles to get where they need to go.

Despite huge progress in recent years, robots find it hard to get around by themselves. But animals have no trouble at all. So it makes sense for robots to hitch a lift.

Dae-Gun Kim at the Korea

Advanced Institute of Science and Technology in Daejeon and his colleagues glued small box-like robots to the backs of five red-eared slider turtles. The robots included a frame that stuck out in front of the turtle's head holding five red LEDs spaced 30 degrees apart, and a food-delivery tube.

The robots had to ride their turtle through five checkpoints in a tank filled with water. The turtles were conditioned to associate a lit-up LED with food – so the robots simply guided it using the LEDs and fed it snacks as

a reward for going in the right direction. Using this process, five robot-turtle pairs successfully completed the course, and each sped up with practice (*Journal of Bionic Engineering*, doi.org/b6vd).

The researchers now want to harness electricity from the animal host's motion to provide the robot with power. "These robots could be used for

"If robots and animals were able to team up to explore a disaster area, it could be really useful"

surveillance, exploration, or anywhere it's difficult for humans or robots to reach on their own," says Nathan Lepora at the University of Bristol, UK.

Previously, insects have been controlled using electrodes connected to their nervous systems. This approach could let robots control their hosts directly.

"There are definitely ethical considerations, but if robots and animals were able to team up to explore a disaster area, it could be really useful," says Lepora.

Timothy Revell ■

Nanofridge keeps quantum computers cool

EVEN quantum computers need to keep their cool. Now, researchers have built a nanoscale refrigerator to keep qubits cold enough to function.

Instead of working with bits of information that can be either 0 or 1, as in a classical computer, a quantum computer relies on "qubits", which can be in both states simultaneously. The qubits must be shielded from external noise, since the slightest interference will destroy the delicate state. But well-isolated qubits heat up quickly.

Classical computers require things like built-in fans to dissipate heat, and quantum computers are no different. Also, unlike in a classical machine, qubits must start at low-temperature to run an algorithm. If you want to run several quantum algorithms one after the other, any cooling mechanism must be able to do its job quickly. A standard fan just won't cut it.

Now, Mikko Möttönen at Aalto University in Finland and colleagues have made the first standalone system to cool a quantum device. They built a circuit with an energy gap dividing two channels: a superconducting fast lane, where electrons zip along with zero resistance, and a slow non-superconducting lane. Only electrons with enough energy to jump the gap reach the superconductor highway; the rest are stuck in the slow lane.

If an electron falls short of having the energy to make the jump, it can get a boost by capturing a photon from a nearby resonator - a device that can function as a qubit. The resonator gradually cools down.

Over time this has a selective chilling effect on the electrons: hotter electrons jump the gap, while cooler ones are left behind. This removes heat much like how a refrigerator functions (*Nature Communications*, doi.org/b6vr).

The next step will be to build the device and cool actual qubits with it. "It's going to take some time, but I'm pretty sure we'll get there," Möttönen says. Jennifer Ouellette ■



RICHARD LEVINE/ALAMY

It works: no kidding

Bait gives New York rats early menopause

IT IS pest control without poison. A new type of bait that stops rats from having pups is helping to tackle infestations in several cities in the US.

The bait – called ContraPest – was approved by the US Environmental Protection Agency last August. It makes rats infertile by triggering early menopause in females and impairing sperm production in males. There are no known side effects and the rats eventually die of natural causes, so the technique is considered more benign than other control strategies being investigated.

The first field trial of ContraPest, conducted in the New York City Subway in 2013, halved the resident rat population in three months. Two more trials have now been completed in the US – one at a large-scale farm and another in an urban area – both in East Coast cities.

Rat numbers at the farm fell by one-third over three months. In the urban area, population growth was suppressed during the peak breeding season so the population expanded at only

one-third the expected rate.

"You'll never wipe out rats completely – they're too smart," says Brandy Pyzyna of SenesTech, the biotechnology company in Arizona that developed the bait.

"But if you think about it, one breeding pair of rats can produce 15,000 pups in a year," she says. "Even if you can reduce that by a third in a few months, you're

"One breeding pair of rats can produce 15,000 pups in a year. We'll never wipe them out completely"

already talking 5000 fewer rats, and the population will continue to go down."

ContraPest is more humane and effective than rat poison, says Pyzyna, who presented the latest results at the Australasian Vertebrate Pest Conference in Canberra, Australia, last week.

Killing rats also simply results in others moving in and taking their place, she says. Fertility control, on the other hand, maintains a small population of existing rats that guard their territory from newcomers.

The active ingredients in the bait – triptolide and -vinylcyclohexene diepoxide – can cause infertility in other animals, but not at the small doses used. The flavoured liquid is kept inside bait stations that are only accessible to rats. Once ingested, the chemicals are broken down by the rats' metabolism, preventing them from getting into predators' bodies or the wider environment.

Peter Banks at the University of Sydney says the approach looks promising, but needs more long-term research. Rats that don't take the bait may end up having bigger, healthier litters because there is less competition for food, he says. "It's really, really hard to eradicate pests," he says.

The bait may also be unsuited to places where there are native rodents that could eat it, says Banks. For example, in Australia, about one-quarter of native land mammals are rodents, many of which are endangered and require protection.

Pyzyna and her colleagues are continuing to research the effects of ContraPest in rat populations, while also adapting it to other pest species. They are working on reformulating the bait to target mice and feral pigs, but they also have their sights set on feral deer, dogs and cats. Alice Klein ■



Magnetic shocker: fluctuating field

Jupiter stormy with a fuzzy core

Andy Coghlan, Vienna, Austria

BIG planets come with big surprises. First results from the Juno spacecraft now orbiting Jupiter are already challenging assumptions about everything from the nature of the planet's atmosphere to its interior.

"The whole inside of Jupiter is just working differently than our models expected," says the mission's chief investigator Scott Bolton of the Southwest

Research Institute in Texas.

Launched on 5 August 2011, Juno reached Jupiter and began its first orbit on 4 July last year. It will make 33 circuits in all, covering the entire planet bit by bit.

The findings, presented last month at the European Geosciences Union meeting in Vienna, are from Juno's first five circuits, each lasting 53 Earth days, including a 6-hour scan of the planet from north to south.

Much of the excitement centres

on the discovery of a dense zone of ammonia around Jupiter's equator, along with gas-depleted regions elsewhere. Together these findings suggest an ammonia-based weather system. We already knew that Jupiter was completely shrouded in ammonia clouds, but the existence of such a deep gas "belt" is surprising.

The findings also challenge models of the planet's interior, pointing to a core that is not solid like Earth's, but is instead "fuzzy" and dilutely mingled with an overlying metallic hydrogen layer.

Another shock is that Jupiter's huge magnetic field is stronger and much more irregular than expected. That could be a sign that the dynamo driving it may

originate higher up in Jupiter's interior, perhaps from that same layer of metallic hydrogen.

"I didn't expect all the theories to be wrong, but there's motion going on in the planet we did not anticipate," Bolton says.

Jupiter's magnetic field also dwarfs Earth's by an even bigger margin than expected. Juno's readings on its closest approaches so far suggest Jupiter's magnetic field could be $8 \text{ to } 9 \times 10^{-4}$ tesla rather than the 5×10^{-4} predicted.

The first orbits have also produced new insights into the planet's atmosphere. The probe has already sent back pictures of hitherto unknown cyclones over the poles, probably composed of condensed ammonia.

"They're the size of Earth, or maybe half an Earth," says Glenn Orton of NASA's Jet Propulsion Laboratory in California.

Strange white ovals have been spotted, too, in belts south of Jupiter's equator. They could be clouds containing ammonia and hydrazine, a substance used as rocket fuel on Earth.

More data will arrive after the next closest approach on 19 May. Eventually, Juno will fly over Jupiter's famous Great Red Spot. Leigh Fletcher at the University of Leicester, UK, is excited about this. "It means that for the first time, we can go down deep and find out what's going on underneath," he says. ■

Weird random proteins work like real thing

ARTIFICIAL proteins, created from scratch with no particular design in mind, can do the work of a natural protein. The discovery may widen the toolkit of synthetic biologists trying to build bespoke organisms.

There are more proteins possible than there are atoms in the universe, and yet evolution has tested only a tiny fraction. No one knows whether

the vast, untried space of proteins includes some that could have biological uses.

Until now, most researchers assembling novel proteins have meticulously selected each amino acid building block so that the resulting protein folds precisely into a pre-planned shape that closely fits the molecule it is intended to interact with. Michael Hecht, a chemist at Princeton University, decided to try a much looser approach. "I was trying to see what the hell's out there," he says.

He generated a million different proteins and then inserted the genes

coding for them into *E. coli* bacteria that had other genes deleted (and hence, the proteins they coded for). The missing genes coded for proteins that catalyse biochemical reactions.

For four of the 80 gene deletions Hecht worked on, at least one - and in one case, hundreds - of the semi-random novel proteins restored the missing function. "We were ecstatic," says Hecht.

"These never-before-seen artificial proteins replaced natural ones in living cells - we were ecstatic"

They somehow "upregulated" other, related proteins in the bacteria so that they could take over for the absent ones, he recently told the Astrobiology Science Conference in Mesa, Arizona. The team hope this approach will eventually lead to a wide range of novel proteins.

So far, Hecht can't predict the function of his novel proteins, says Nicholas Hud at the Georgia Institute of Technology. That means a huge amount of trial and error is needed to find something useful. "De novo design of enzymes is still a bit beyond our reach," says Hud. Bob Holmes ■

Land of fire and ice

An amazing seven-day tour of the majestic landscape of Iceland. Discover how fire and ice shape the scenery and get a chance to see the Northern Lights

GEOTHERMAL POWERS

HVERAGERDI AND KRÝSUVÍK

Discover the might of the planet as you marvel at the sights, sounds and smells of erupting geysers and bubbling pools of mud. Soothe away your cares in the warm, mineral-rich waters of the Blue Lagoon in the middle of a black lava field. Enjoy food cooked by Earth's heat and visit the innovative greenhouses where tomatoes grow even in deepest winter.

ICE AND FIRE

BORGARFJORDUR AND SNAEFELLSNES PENINSULA

Drive across Europe's second largest glacier in an eight-wheel truck, and see shades of blue you never knew existed in Langjökull ice cave. Hike across the awe-inspiring Sólheimajökull glacier to discover how ice shapes the landscape. See how an eruption 8000 years ago sculpted beautiful shapes in Vatnshellir lava cave. Visit ice-capped volcano Eyjafjallajö.

MAGICAL LANDSCAPES

GOLDEN CIRCLE AND SOUTH SHORE

Our tour takes in Iceland's "Golden Circle", including the UNESCO-listed Thingvellir National Park, where the tectonic plates of Europe and North America separate to create a dramatic rift valley. Steeped in legend, Iceland's South Shore is famous for its sheer cliffs, picturesque villages and volcanic black sand overlooked by towering glaciers.

WHAT'S INCLUDED:

- › Six nights' accommodation, including breakfast
- › Private coach
- › Local expert guides
- › All entrance fees

DEPARTURE DATES:

18 OCT 2017, 15 NOV 2017

SEVEN DAYS

FROM £1790 PER PERSON

FIND OUT MORE

Call +44 020 3308 9763 or visit newscientist.com/travel/iceland

Mini masterpieces pack the pixels in

Matt Reynolds

EACH of these miniature masterpieces is the width of a human hair, but packs in more pixels per square centimetre than the highest resolution TV screen.

This level of detail is all down to a laser printing technique developed by Anders Kristensen and his team at the Technical University of Denmark in Copenhagen. By blasting lasers at a material made up of thousands of nanoscale plastic pillars covered with a thin layer of the element germanium, Kristensen has printed some of the highest resolution images ever made.

The laser heats up each pillar to more than 1000°C for a few nanoseconds, causing the germanium layer on its tip to change shape – which changes the colour of light it reflects and thus what colour it appears. Low intensity laser blasts cause it to reflect blue light, while ramping up the intensity shifts the colour towards reds and yellows. In this

way, the surface of the material can be tuned so that each pillar reflects a different colour, ultimately allowing different images to be printed (*Science Advances*, doi.org/b6tw).

The pillars are only a few tens of nanometres apart, which lets the team cram tens of thousands of spots of colour across every centimetre of the surface. The images are just 50 nanometres wide and were printed at a resolution of 127,000 DPI (dots per inch). The display on an iPhone 7, for comparison, is 326 DPI.

These are impressive results but don't plan on trading in your HDTV just yet, says Debasish Chanda at the University of Central Florida. To start with, the colour spectrum of these images is very limited – there are no greens, and the blues and reds are fairly dull.

Kristensen thinks one way to get around this could be to replace the germanium layer with silicon, which reflects a slightly different colour spectrum when deformed. Once he gets his material to reflect



The width of a human hair

green light, he hopes to tackle the full colour spectrum.

A bigger problem is turning the material into a screen that could display moving images. Adding the transistors and other electronics that make a display change colour would mean hugely increasing the size of the pixels in these images, Chanda says. As there is currently no way to keep such a high resolution and make

the screen dynamic, he suggests that the technique could be useful for printing security labels that are impossible to remove.

Laser printing could also make recycling easier, Kristensen says. Plastics often need to be sorted into similar colours before they can be processed. But when the new material melts it loses its colour, ready to be remoulded and printed on again. ■

First global map of Earth's underworld

THE road to hell may be paved with good intentions, but at least there's now a map to get you there.

The map is the first to show the whereabouts of almost 100 massive remnants of tectonic plates that long ago sank into the bowels of our planet through a process called subduction.

"We're pioneering the first map of the underworld," says Wim Spakman of Utrecht University in the Netherlands, who unveiled plans to launch the atlas at the annual meeting of the European Geosciences Union in

Vienna last month. Knowing the positions of huge, ancient slab remnants could prove invaluable for geological research and exploration, says Spakman – and could bring us closer to forecasting earthquakes.

So far, 98 slabs strewn throughout Earth's upper and lower mantles have been mapped. Some are found at depths of 2900 kilometres with ages of up to 350 million years.

Spakman and his colleagues detected the positions and sizes of the plates through an echolocation technology called seismic tomography. The slabs conduct sound faster than surrounding magma, and so give a telltale seismic signature of their existence.

The team combined their

measurements with extensive pre-existing research on subducted slabs to corroborate and chart the geological history of each slab found.

"We can build much tighter connections between how tectonic plates moved around the globe in relation to what was going on in the mantle," says Spakman. Until now, the main method of doing this has been to analyse ancient subducted rocks brought to the surface again by volcanic plumes.

"Now, we can add new information about what once occurred through

"Knowing where all the subducted crust has gone will allow us to play plate tectonics in reverse"

mapping the geological history of these subduction remnants," he says.

Knowing how subducted slabs might contribute to friction in the mantle could also help our understanding of and ability to forecast earthquakes, as well as how plate tectonics could raise sea level by lifting the sea floor. "It could also help us find huge mineral deposits," says Spakman.

Other geologists are enthusiastic about the atlas, too.

"Knowing where all the subducted oceanic crust has gone over the past 300 million years will allow us to play back the movie of plate tectonics in reverse," says Steve Jacobsen of Northwestern University in Illinois. Andy Coghlan ■



JAPAN: Land of reinvention

Explore cutting-edge Japan. Journey from buzzing Tokyo to snow-capped mountains; from hot springs to subtropical coral reefs

DEPARTURE:

5 NOVEMBER 2017

TOKYO ➤ HAKONE ➤ KYOTO ➤ OKINAWA

10 nights from £4795 per person

➤ TECHNOLOGY AND INNOVATION

Begin your adventure in futuristic Tokyo. Visit The University of Tokyo and enjoy a talk from a robotics designer on campus. Experience the awe-inspiring Miraikan, Japan's National Museum of Emerging Science and Innovation, before speeding west by bullet train to stunning Hakone.

➤ OUTSTANDING NATURAL BEAUTY

See Mount Fuji blanketed in white and visit the Owakudani valley, an active volcanic area. Walk the trails leading to steam vents and bubbling hot springs. Explore Kyoto's peaceful temples and lavish gardens where bamboo thickets crowd the skyline.

➤ GET INVOLVED WITH RESEARCH

Round your trip off with three days on the subtropical island of Okinawa. Get stuck in at the Okinawa Institute of Science and Technology where you'll trap insects for a research project, learn about how coral is being restored and visit their pioneering house for sustainable living.

This is a one-off itinerary exclusive to *New Scientist* readers, with special access to research facilities and institutions. As group size is limited, we advise early booking.

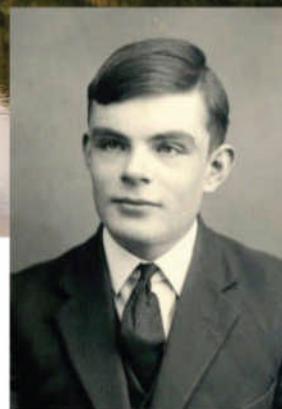
SPEAK TO OUR SPECIALIST TEAM AT STEPPES TRAVEL TO FIND OUT MORE.

Visit newscientist.com/travel/Japan or call (+44) 01285 600 129

SteppesTravel

The life and work of Alan Turing

Alan Turing is arguably one of the greatest scientists of the modern age. Join us as we explore his life, work and greatest achievements and learn more about this fascinating figure in 20th century science



20 – 22 OCTOBER 2017
From £465 per person

STUDENT DAYS Cambridge

Visit King's College where Turing studied mathematics and went on to lay the theoretical foundations for modern computers. Marvel at the chapel's famous Gothic architecture and medieval stained glass. Our guided tour of the city includes the American Cambridge cemetery and the Eagle pub, where Francis Crick first announced that he and James Watson had discovered the structure of DNA. After dinner, enjoy a talk by intelligence expert Mark Baldwin and a demonstration of a rare four-wheel Enigma machine.

CODE BREAKERS Bletchley Park

Soak up the atmosphere of the huts where Enigma messages sent by the German military were decrypted. Visit Turing's office to see how it would have looked during the second world war. Discover the ingenious mathematical techniques and devices that Turing and his colleagues designed to crack the Enigma code. At the nearby National Museum of Computing, see a rebuild of Colossus the world's first electronic computer. Reminisce over the museum's collection of home computers from the 1970s and 1980s.

WHAT'S INCLUDED

- Two nights' bed and breakfast
- Welcome reception, dinner and lecture
- Second night dinner with wine and talk
- Private coach
- Local expert guides
- All talks, admissions and guided tours



FIND OUT MORE
Call +44 (0)20 7251 0045
or visit newscientist.com/travel/turing

Robot bridge inspector looks for defects

WHEN the I-35W bridge over the Mississippi river collapsed in 2007, killing 13 people, it was because of defects in steel plates. Such tragedies might be avoided with the help of a robot that makes bridge checks easier.

Surveying a road bridge used to involve drilling to check the concrete and steel structures hidden underneath the road. Although radar has simplified the work since the 1980s, sending out teams of people to check bridges is still expensive and can require extended road closures.

So Spencer Gibb at the University of Nevada and his colleagues have built the first autonomous robot bridge inspector. It shuttles back and forth along the side of the road without getting in the way of traffic.

The four-wheeled, waterproof, battery-powered device uses ground-penetrating radar and electrical resistivity sensors to locate any corroded steel parts or deteriorating concrete inside the bridge. Surface cracks can be detected using the on-board camera.

A machine-learning algorithm converts the readings in real time into a colour-coded map of the bridge, highlighting any areas of weakness. The results are sent to human inspectors, who can keep tabs on the robot as it does its rounds.

The team tested the robot on the slow lane and the hard shoulder of four road bridges in Nevada, Maine, New Hampshire and Montana, where it proved speedier and more accurate than human inspectors. "The robot takes the same amount of time to physically scan the bridge as a human inspector but it processes the data in minutes instead of hours," says Gibb. The team is working on ways to cut down the robot's inspection time.

Another benefit is that one robot is cheaper than a team of people, says Gibb. When human inspectors check a bridge, other workers are needed to close it off to traffic and analyse the data. Alice Klein ■



DMITRY MARUK/EYEEM/GETTY

A technicolor dream

Radiotherapy turns dreams colourful

Alice Klein

A MAN has dreamed in colour for the first time after undergoing radiotherapy to treat a tumour on his eye.

The 59-year-old Australian previously dreamed exclusively in black and white. But when he received radiation therapy to the front and side of his head for four weeks, he began dreaming in vivid colour. Some of these dreams involved mentally flicking through coloured images of former girlfriends, cars, and fish he had caught (*Sleep Medicine*, doi.org/b6r3).

Why he had previously dreamed only in black and white is unclear, but it may be because of the type of television he grew

up with. People who see only black-and-white film and television as children seem more likely to dream in greyscale throughout their lives. Australia didn't fully convert to colour television until 1975.

His switch to colour dreaming may have been sparked by the radiation's effect on electrical brain activity, says radiation oncologist Michael McKay, who treated the man at the North Coast Cancer Institute in New South Wales.

There is some evidence that radiation can affect electrical activity in the brain. People exposed to radiation from the Chernobyl disaster, for instance, showed unusual electrical brain activity when given electroencephalography (EEG)

scans. More than a third also reported abnormal dreams.

Abnormal dreams have not previously been associated with radiotherapy treatment of the head, but this may be because of a lack of reporting, says McKay. In this case, the man had an easily curable eye tumour, whereas many others who

"If the radiation affected his brain's electrical activity, that could have changed the dream experience"

receive radiation to the head have terminal brain tumours. This could make them less likely to notice or remark on strange dreams.

The Australian man did not have EEG tests, so the effect of radiotherapy on his brain remains a mystery. "But if the radiation was affecting [EEG-detected] activity, then that could quite readily change the dream experience," says Simon Cropper at the University of Melbourne.

The man's dreams may have become more colourful in response to altered brain activity because colour is an easily modifiable component of perception, says Cropper. For example, hallucinogens – which also change the patterns seen on an EEG – almost always heighten the experience of colour.

But there could be a more banal explanation, says Robert Stickgold at Harvard University. The radiation may simply have caused the man to wake up more frequently in different stages of sleep, increasing the chance of noticing and remembering coloured dreams, he says.

The man's tumour was cured by radiotherapy and he reverted to black-and-white dreaming a few days after finishing treatment. McKay hopes that other people will come forward if they have had similar dream-altering experiences during radiotherapy, so the phenomenon can be studied further. ■



Snowball Earth melting led to freshwater oceans 2km deep

A LITTLE more than 600 million years ago, you could have drunk from the ocean. After an extreme ice age known as snowball Earth, in which glaciers extended to the tropics and ice up to a kilometre thick covered the oceans, the melted ice formed a thick freshwater layer that floated on the super-salty oceans.

Those freshwater surface seas lasted far longer than thought, according to research by Dorian Abbot, a geologist at the University of Chicago, and his colleagues. Their mathematical models showed that it took around 50,000 years for the two layers to fully mix.

"This is interesting because the modern ocean mixes on a timescale of only about 1000 years," says Abbot.

The much slower mixing was due to the huge density and temperature differences between the layers. During the snowball phase, half the oceans' water ended up as snow and ice. The remaining seas were twice as salty as today, and near their freezing point.

Once the ice melted, driven by a runaway greenhouse effect caused by volcanic eruptions, it formed a freshwater layer up to 2 kilometres thick. The extreme carbon dioxide concentrations in the atmosphere caused the layer's surface temperature to rise as high as 50°C. With such extreme differences, the winds and tides needed longer to mix the light, hot, freshwater layer with the dense, cold, salty layer (*Geology*, doi.org/b6tv).

Seeing hand makes things easy to grasp

AN ARTIFICIAL hand is using artificial intelligence to see with an artificial eye.

The prosthesis uses a built-in camera to take a picture of an object its wearer wants to grasp and then automatically picks one of four positions, including one similar to gripping a cup and one similar to grabbing a TV remote.

The idea is to make the hand easier to use. Existing controllable

prostheses work by converting electrical signals in a person's arm or leg into movement. But it can take a long time to learn to control such prostheses and the movements can be clumsy.

By giving the hand the ability to see what it is doing, the idea is that it can position itself accordingly without the wearer having to worry about making last-minute adjustments. The hand learns the

best way to grasp objects – that's the beauty of it, says Ghazal Ghazaei at Newcastle University, UK, who helped develop the device (*Journal of Neural Engineering*, doi.org/b6t7).

It is important that the technology helps assist grasping rather than fully taking over, says Dario Farina at Imperial College London. "It should be similar to brake assistance on a car: the driver decides when to brake but the car helps them brake better."

Mitochondria burn at high heat

YOUR body might not get much higher than 37°C on a normal day, but it turns out that the insides of our cells can reach close to 50°C.

The mitochondria in our cells burn food to produce energy. Unlike a fire, this is a controlled process involving several steps, but it still generates a lot of heat.

Now Pierre Rustin of INSERM in France and colleagues have used a protein that fluoresces less as the temperature rises to measure the temperature inside the mitochondria of human kidney and skin cells kept at 38°C.

They found that mitochondria operate at temperatures around 6 to 10°C higher than the rest of the cell (*bioRxiv*, doi.org/b6rw).

The finding makes sense, says Nick Lane at University College London. "Mitochondria are the main sources of heat, and they have to be hotter than the rest of the body," he says. "I'd never really thought of that before."

Earth's birth was from solar flare-up

A HYPERACTIVE young sun might be to thank for Earth's existence.

Standard lore says the planet-building process began when dust particles orbiting the newborn sun stuck together, forming rocks that built still larger objects. But those rocks aren't usually sticky enough for that to work.

Now, there is an intriguing solution. Alexander Hubbard at the American Museum of Natural History in New York suggests that if the sun had an early outburst – similar to the one that the infant star FU Orionis had starting in 1936 – it would have partially melted the orbiting dust, making it sticky enough to become the seeds of Mercury, Venus, Earth and Mars (*Astrophysical Journal Letters*, doi.org/b6sc).

Fluke controls fish from its eyeballs

A COMMON parasite that lives in fish eyeballs seems to guide its host's behaviour, pulling the strings from inside its eyes.

When the eye fluke *Diplostomum pseudospathaceum* is young, it keeps its host safe from predators. But once the parasite matures, it does everything it can to get the fish eaten by a bird and so continue its life cycle that goes from fish to birds to snails, and then back to fish.

Mikhail Gopko at the Severtsov Institute of Ecology and Evolution in Moscow and his colleagues have previously shown that fish infected with immature fluke larvae swim less actively than usual – making themselves less visible to predators – and are harder to catch.

Now, the same team has tested rainbow trout infected with mature eye flukes ready to move to bird hosts to reproduce. These trout swam more actively than uninfected fish and stayed closer to the surface, which would make them more conspicuous to birds.

When the team simulated a bird attack by passing a shadow over the tank, the fish froze – but infected fish resumed swimming sooner than uninfected ones.

Immature flukes “are too young and innocent to infect a next host”, Gopko says, so they protect their host (*Behavioral Ecology and Sociobiology*, doi.org/b6rr).



Fukushima radiation dose was equivalent to X-ray

THE results are in from the first global survey of how much extra radiation we all received from the meltdown of three nuclear reactors at the Fukushima Daiichi power plant in Japan in 2011. “We don’t need to worry,” says Nikolaos Evangelou at the Norwegian Institute for Air Research.

His team has calculated the approximate exposure of everyone on Earth to two radioactive isotopes of caesium, using all the data available so far. They estimate that most

individuals received a dose of 0.02 millisieverts. “What I found was that we got one extra X-ray each,” Evangelou told the annual meeting of the European Geosciences Union in Vienna, Austria, last month.

Even in Japan, the average radiation dose per person was low: 0.5 millisieverts. In comparison, the average annual exposure from background levels of radiation in the UK is around 2.7 millisieverts.

Unsurprisingly, residents of Fukushima and neighbouring

prefectures received higher doses in the first three months after the accident, ranging from 1 to 5 millisieverts. But such doses are still relatively low (see page 40).

Evangelou says that the effects on wildlife near the plant might be more severe. He says increased radiation levels around Fukushima have been linked to falls in bird populations.

But the overall hazards posed by fallout from the Chernobyl nuclear accident in Ukraine in 1986 are still much greater than those from Fukushima, he says.

No one's eating free food on Mars

IF LIFE exists on the Red Planet, it must be very rare – or so an unexploited energy source in the atmosphere suggests.

Mars’s atmosphere is unusually rich in carbon monoxide, which microbes on Earth can convert to carbon dioxide to yield energy.

“It’s a free lunch, just sitting in the atmosphere, that microbes could be eating,” says Steven Sholes at the University of Washington in Seattle. That suggests Martian life must be non-existent, or at least very rare.

Sholes has gathered estimates of how quickly solar radiation generates carbon monoxide in Mars’s atmosphere, and how fast it diffuses down to the planet’s surface and into subsurface rocks, where any Martian life would shelter from deadly radiation.

He has used these estimates to calculate the maximum microbial biomass that could be consuming carbon monoxide, yet still leave the observed amount of leftovers.

Mars could harbour no more than one billionth of Earth’s biomass, or less than one microbial cell per cubic centimetre of soil, Sholes told the Astrobiology Science Conference in Mesa, Arizona, in April.



Electrodes read babies' minds

WHEN a baby’s crying, it can be tricky knowing what’s wrong. But detecting brain signals may be a reliable way to tell if babies are in pain.

“Currently, doctors use facial grimaces and squints, but they could be caused by other factors, such as hunger or the desire for a cuddle,” says Rebeccah Slater at the University of Oxford.

Now Slater and her team have found that an electrode placed on the midline of the scalp can detect brainwave patterns associated with pain. They discovered this by analysing EEG readings taken from

18 babies as blood was collected during health screening. A distinctive signal appeared half a second after their heels were pricked.

The size of this pain signal correlated with how much the babies grimaced, and it was reduced in babies who had a painkilling gel applied to their heels before blood was taken (*Science Translational Medicine*, doi.org/b6rp).

If it proves reliable in further tests, the technique will assist the team’s research into how best to relieve a baby’s pain during procedures such as eye examinations.

T H E W O R L D ' S
M O S T E X C I T I N G F E S T I V A L
O F I D E A S R E T U R N S



E X P L O R E
E X P E R I E N C E
U N D E R S T A N D

SPONSORED BY



BEST
CONSUMER
SHOW



SHOW
OF THE
YEAR



28 September – 1 October 2017 ExCeL London

120+ TALKS...

100+ EXHIBITORS...

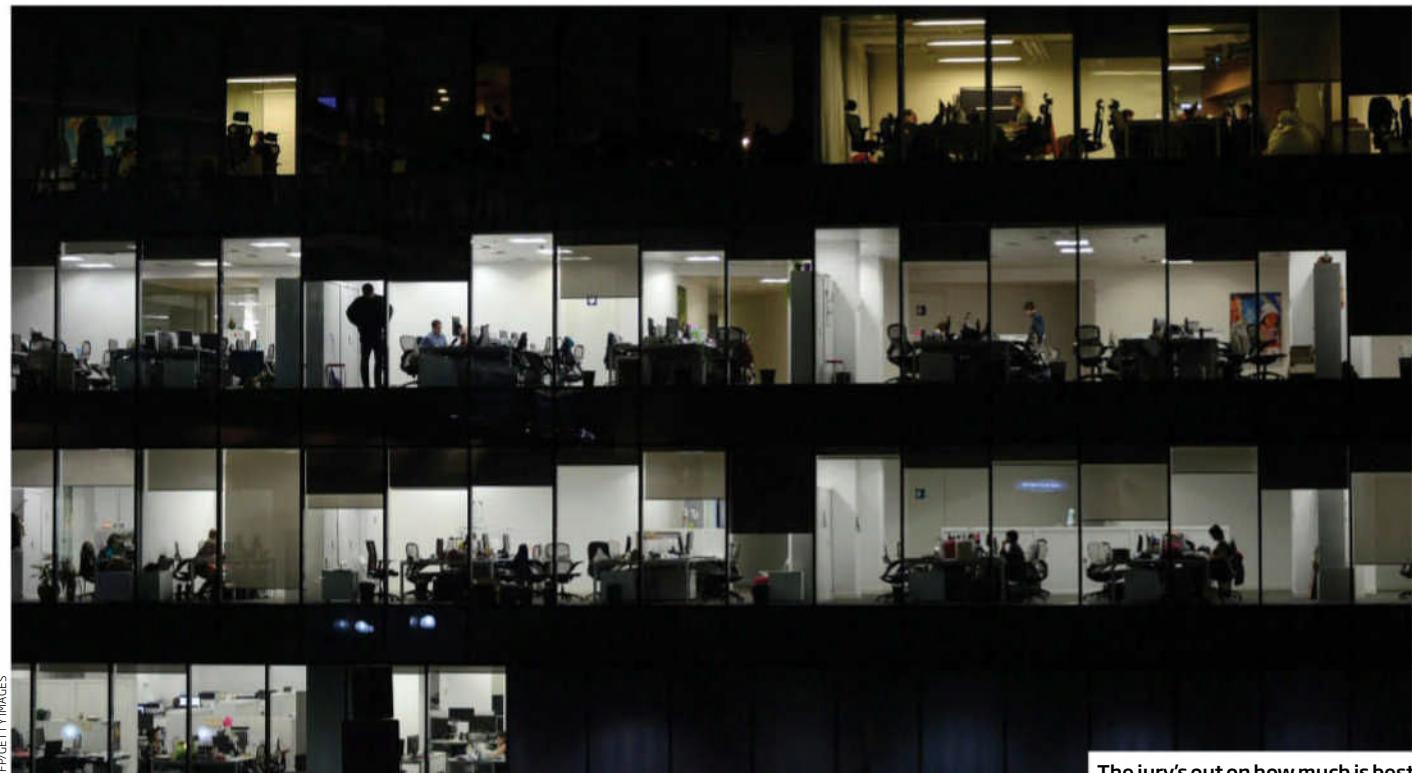
5 IMMERSIVE ZONES

BOOK NOW AT

newscientistlive.com

Be careful what you wish for

Rising prosperity may lead to a 15-hour week. If we're still on course to fulfil this old prediction, is it good news or bad, asks **Timothy Revell**



The jury's out on how much is best

AP/GETTY IMAGES

THERE'S nothing quite like a three-day weekend to get us pondering the benefits of working less. What if every working week had four days? You'd get more sleep, more time with your family and friends or just to yourself: what's not to love?

Working stiffs aren't the only ones asking the question. A high-level conversation has gathered pace in recent years about how long we should be working. Advocates of shortening the standard 8-hour day have long argued that doing so could lead to happier, healthier and maybe even more productive lives.

Some research has cast doubt on the idea that fewer hours would make us better able to maintain productivity, but a

newly completed study has reopened the case. If we are on the verge of another historic drop in hours, is that a good thing?

History is full of fights over working hours. During the industrial revolution, factory owners maximised profit by keeping plants open as long as possible, leading to Dickensian 60-hour working weeks.

But in the last century, hours gradually fell away as workers negotiated better terms of employment. By the turn of the millennium, hours were averaging around 40 a week, where they have pretty much plateaued since (see graph, right).

As long ago as the 1930s, the economist John Maynard Keynes was predicting that as living

standards rose in rich countries, working hours would fall. We should expect a 15-hour week within a hundred years, he said.

That clearly hasn't happened, despite proposals by respected organisations like the New Economics Foundation, a think tank based in London.

"Working less has made us more productive than ever before - could fewer hours make us even more so?"

In 2010, it began advocating a gradual transition to a 21-hour working week.

Such a short week might not be a disaster for productivity, if history is our guide. Going from 60 to 40 hours a week had no ill

effects on productivity (whereas working more than 10 hours a day does). By the most important measures, we are more productive today than at any time in history. The question is whether shortening the working week further would boost productivity even more.

Ten years ago, the Swedish National Institute of Working Life tried to find out, using a randomised controlled trial involving more than 500 public-sector workers. For 18 months, half the group went from working 8 hours a day to 6, with a corresponding cut in workload – although they remained on full pay. The other half stuck with their normal 8-hour shifts. To make sure that jealousy didn't

influence outcomes, whole workplaces were put into one or the other group.

At the end of the trial, the people working shorter hours said they felt happier and less stressed. Productivity, however, was a different story: the researchers couldn't find the evidence to reach a conclusion.

When most people worked in factories, it was much easier to quantify productivity in terms of, say, the number of cars made or the number of books bound. Measuring productivity in office-based or service-sector jobs is far less straightforward. "It's almost impossible to get any useful data," says Torbjörn Åkerstedt at the Stress Research Institute in Sweden, who was part of the team behind the study.

No benefits

So they had to look for other measurable benefits. Here the news was disappointing for fans of leisure time: reducing working hours had no discernible effect on empirical indicators of stress like levels of the hormone cortisol. And people were no less likely to take sick days. "That was pretty surprising," Åkerstedt says.

So much for the idea that a 6-hour day improves productivity or health.

That Swedish study closed the case for a decade, but over the past couple of years, with renewed interest in the subject, a few high-profile trials have been looking again.

Last year, a trial in the northern Swedish town of Umeå came to the same conclusions, finding that sick leave increased when working hours were lowered. But these results were contradicted by a longer trial, one that followed medical staff at a retirement home in Gothenburg for two years. This time, researchers found that the 6-hour working day reduced sick leave by 10 per cent.

This study also did a slightly

better job of specifying measures of productivity, and identified some improvements. "There was a big increase in the number of activities organised for patients," says Daniel Bernmar, the councillor in charge of the care of elderly people in Gothenburg.

The study gave insight into better measures of not only productivity but also satisfaction. "People came to work happier and did a better job," says Bernmar. This became especially salient when one company took up the 6-hour working day on a trial basis last year.

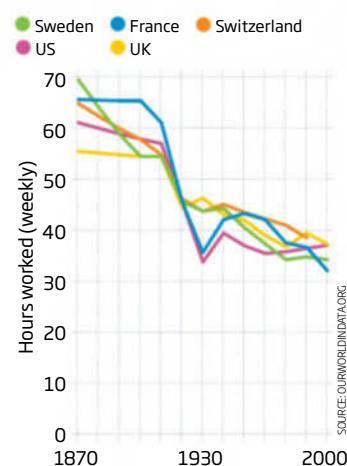
Agent Marketing, based in Liverpool, UK, thought everyone's jobs would be improved by 6-hour days and mandatory lunch breaks. But after two months, staff voted against keeping the new hours. The verdict: it was just too stressful. "Six hours just wasn't enough time to get their work done," says Jeanette Gill, one of the employees who took part in the trial.

But that didn't mean they went back to the old system at the end of the trial. People did want more time off – they just wanted more control over it as well. Now, every employee finishes a couple of hours early on Fridays and on one other day of their choosing.

So the latest research is

The shrinking week

Working hours have been falling since the industrial revolution, although they have plateaued lately



beginning to suggest that under the right conditions, a shorter working week is the way forward. Is this the future? Maybe, but the potential for implementing it varies considerably. People at a marketing agency can feasibly go home a bit early one day, but you can't just do the same at, say, a hospital that needs to be properly staffed around the clock.

Even where a 6-hour working day is easily introduced, it might be little more than an illusion.

Technology tempts us to be

always-on, with smartphones instantly notifying us of work emails and even letting us access remote desktops.

There have been nascent efforts to rein in this virtual overwork. This year, employees in France gained the right to

"After two months of 6-hour working days, staff voted to stop. It was just too stressful"

disconnect, to completely ignore their smartphones outside office hours.

But whether you like the idea of a 6-hour day or not, soon you might have no choice. The reason is automation.

"Some people say that robotics and artificial intelligence will completely replace humans in the job market," says Lesley Giles at the Lancaster University Management School, UK. A third of US business leaders and managers already feel that way, according to a survey published last week by the Pew Research Center. If AI doesn't replace you, it is sure to reduce control over your employment, courtesy of the rise of the gig economy and companies like Uber and Taskrabbit.

For now, most people still prefer to work in more traditional types of employment, says Giles: jobs, not gigs. The next big fight in the world of work may not be for shorter hours, but the right to a stable job. Because although some have argued for replacing employment with universal basic income, the benefits of working go far beyond paying the bills.

"If we think as a society that everyone should have a good job, we need to take steps to make that happen," says Sarah Lyall at the New Economics Foundation.

The future of work is still up for grabs, but we should not assume it will take care of itself. Keynes's prediction of a 15-hour work week will be as good or as bad as we make it. ■

WHAT HAPPENS WHEN WE WORK TOO MUCH

The jury is still out on whether reducing working hours leads to health benefits (see main story), but in the other direction the case is long settled. As employees labour beyond 50 hours a week, the risk of coronary heart disease and stroke goes up.

One meta-analysis of studies covering more than half a million people in total found that those who work 55 hours a week are 13 per cent more likely to develop coronary heart disease and 33 per cent more likely to have a stroke, compared with those working between 35 and 40 hours.

"There is also some evidence of a link between long working hours and poor mental health, although

these studies are not as conclusive as those related to heart disease and stroke," says Mikko Härmä at the Finnish Institute of Occupational Health.

We know what happens when people are pushed to the limit. In Japan, *karoshi* – death by overwork – is at an all-time high, with 1456 cases last year.

The term covers death by cardiovascular illness or stroke, as well as suicide. It is possible for family members to claim compensation, but only if their deceased relative had clocked up at least 160 hours overtime in one month, or 100 hours overtime for three successive months.

ET is home

There is logic to the idea that alien civilisations rose and fell in our own solar system, says **Geraint Lewis**

"WHERE is everybody?" wondered physicist Enrico Fermi when ruminating on the question of life in the cosmos. He reasoned that, if life's genesis is not too hard, the universe could be teeming with little green creatures on the many trillions of planets out there.

It's been nearly 14 billion years since the big bang, so if some of these alien societies had become technologically advanced and spacefaring, evidence of their existence should be obvious. Why do we see no sign of them?

This apparent absence of evidence is known as the Fermi paradox. It has led to considerable head-scratching for more than half a century. Now, US astronomer Jason Wright has a new twist on it, rephrasing Fermi's question to: "Where was everybody?" One answer could be in our own solar system. He wonders if "prior indigenous



technological species" arose here, and what trace they might have left behind.

The Fermi paradox has many proposed solutions: that we are truly alone in the cosmos, for example, or that Earth is somehow kept isolated from the interstellar community until it becomes a responsible galactic citizen. The scariest possibility is the idea of a Great Filter, some inevitable sticking point that means all civilisations have a relatively short shelf life. In which case, on cosmic timescales, the chances of two coexisting in close proximity would approach zero, and they would always appear to be alone.

So the universe could be littered with the debris and detritus of dead civilisations. Rather than contemplating extinct life "out there", which would be hard to detect, Wright is contemplating the possibility of technologically

Blast of fiction

Talk of North Korea devastating the US with a space nuke are fantasy, says **Jeffrey Lewis**

THERE is no shame in enjoying dystopian science fiction – it helps us contemplate the ways in which civilisation might fail.

But it is dangerous to take the genre's allegorical warnings literally, as too many people do when talk turns to a possible electromagnetic pulse (EMP) attack. There have been repeated

recent claims that North Korea could use a nuclear bomb in space to produce an EMP to ruin US infrastructure and cause societal collapse. This is silly.

We know a nuclear explosion can cause an EMP – a burst of energy that can interfere with electrical systems – because of a 1962 US test called Starfish Prime.

US nuclear weaponeers wanted to see if it was capable of blacking out military equipment. A bomb was launched to 400 kilometres above the Pacific before exploding with the force of 1.5 megatons of TNT. But it was a let-down for those hoping such blasts could knock out Soviet radar and radio.

The most notable thing on the ground were the visuals. Journalist Dick Stolley, in Hawaii, said the sky turned "a bright bilious green".

Yet over the years, the effects of

"A 1962 nuclear test was a let-down for those hoping electromagnetic pulses could disable Soviet radar"

this test have been exaggerated. The US Congress was told that it "unexpectedly turned off the lights over a few million square miles in the mid-Pacific. This EMP also shut down radio stations, turned off cars, burned out telephone systems, and wreaked other mischief throughout the Hawaiian Islands, nearly 1,000 miles distant from ground zero."

It didn't. That was clear from the light-hearted tone of Stolley's report. Immediate ground effects were limited to a string of street lights in Honolulu failing. But no one knows if the test was to blame.

Of course, we rely on electronics more today. Those warning of the

advanced life that rose in the early solar system, and fell victim to the Great Filter many hundreds of millions, if not billions, of years before humans walked the earth.

If they existed here what signs should we look for and where? In the crushing environment of Venus and the churning plate tectonics of Earth, buildings and monuments would be destroyed on such long timescales. But on slow-changing Mars, our moon and possibly the frozen satellites of the outer planets, the tunnels and cities of ancient lost civilisations could survive buried under the soil and ice.

Other signatures would be even more durable, with nuclear power sources detectable for billions of years via distinct mixtures of elements and radioactivity.

This is pure speculation. But remember our space probes have barely scratched the surface of any planet, and when we really start digging into the dirt of other nearby worlds, we may find signs that someone else was there first.

That someone may not have crossed the depths of space, as SETI usually assumes, but might have been there all along. ■

Geraint Lewis is a professor of astrophysics at the University of Sydney, Australia

EMP threat say it would lead to “planes falling from the sky, cars stalling on the roadways, electrical networks failing, food rotting”.

But evidence to back up such claims is lacking. A commission set up by the US Congress exposed 55 vehicles to EMP in a lab. Even at peak exposures, only six had to be restarted. A few more showed “nuisance” damage, like blinking dashboard displays. This is a far cry from the fantasies being aired as tensions with North Korea rise.

Nuclear weapons are scary enough without the fiction. ■

Jeffrey Lewis is a US expert in nuclear non-proliferation and geopolitics



INSIGHT Opioid addiction

TRIBUNE CONTENT AGENCY LLC/ALAMY STOCK PHOTO

Can lawsuits stop the US opioid epidemic?

Chelsea Whyte

PURDUE PHARMA, the maker of painkiller OxyContin, last week settled a \$20 million lawsuit brought against it by a Canadian province. It is a relatively trivial amount for a firm worth billions, but it could be part of a death by a thousand cuts.

Since Purdue released OxyContin just over 20 years ago, the company has made more than \$31 billion from it. But the drug has been linked to an opioid addiction epidemic that has swept Canada and the US. And there have been claims Purdue didn't accurately describe the addictive potential of the opioid analgesic, which also induces euphoria and reduces anxiety.

In 2007, Purdue pleaded guilty to US federal charges of misbranding the drug and was ordered to pay \$600 million. The company still sells a version of it, and as the medicine is out of patent in the US, it is also sold by other firms in generic form as oxycodone. Purdue's owners are also eyeing other markets through firms in Central and South America, the Middle East, Africa and South-East Asia.

However, the settlement last week

might be a key turning point. The suit was launched 10 years ago by 2000 Canadians who claimed to be addicted to OxyContin after prescriptions from doctors, and sued the company for not disclosing that it knew the product was addictive and would lead to withdrawal symptoms if patients stopped using it. The payout includes \$2 million for Canadian provincial governments, which spent \$93 million on public programmes to combat drug addiction in 2014 alone.

The company hasn't admitted any wrongdoing as part of the settlement. But, says Ray Wagner, the lawyer who

“It’s a relatively trivial amount for a firm worth billions, but it could be a death by a thousand cuts”

prosecuted the class action suit in Canada against Purdue, similar cases brought against it by other Canadian provinces and parts of the US could stem the sales of OxyContin, and maybe stall international expansion.

Municipalities in the US are getting on board. The city of Everett in Washington is suing Purdue for

“intentional, reckless, and/or negligent misconduct”, claiming its product fuelled a spike in heroin-related deaths in the area. Some research suggests that prescription painkiller use can lead to heroin use.

Purdue says it is “troubled by the abuse and misuse” of its medication, and that the “lawsuit paints a completely flawed and inaccurate portrayal of events that led to the crisis in Everett”.

Nonetheless, other regions are reportedly considering suits. If enough copycat lawsuits end in settlements, the money begins to add up.

Additional lawsuits broaden the range of possible defendants to include distributors of generic versions of the drug. In West Virginia, where six of the 55 counties in the state have the highest opioid-related death rates in the US, lawmakers in the city of Huntington are suing three drug distributors – Amerisource Bergen, McKesson and Cardinal Health – for bringing millions of opioid painkillers into the state between 2007 and 2012. Thousands have overdosed in those counties, and the city is seeking restraining orders for the companies and punitive damages for what it claims amounted to flooding a small market with drugs that can cause addiction. These challenges are being defended.

With oxycodone now being marketed worldwide, the outcome of such lawsuits will do a lot to ensure the drug's reputation precedes it. ■

APERTURE





Gargoyle of the sea

A BLENNY fish pokes its head out of a coral reef off the Caribbean island of St Lucia. Blennies aren't known for their looks. They tend to be small, dull-coloured and slimy - hence their name, which means "mucus" in Greek.

Most of the 800 known blenny species live in warm, shallow waters. They slither along the seabed using their comb-like teeth to nibble algae and detritus off rocks and coral.

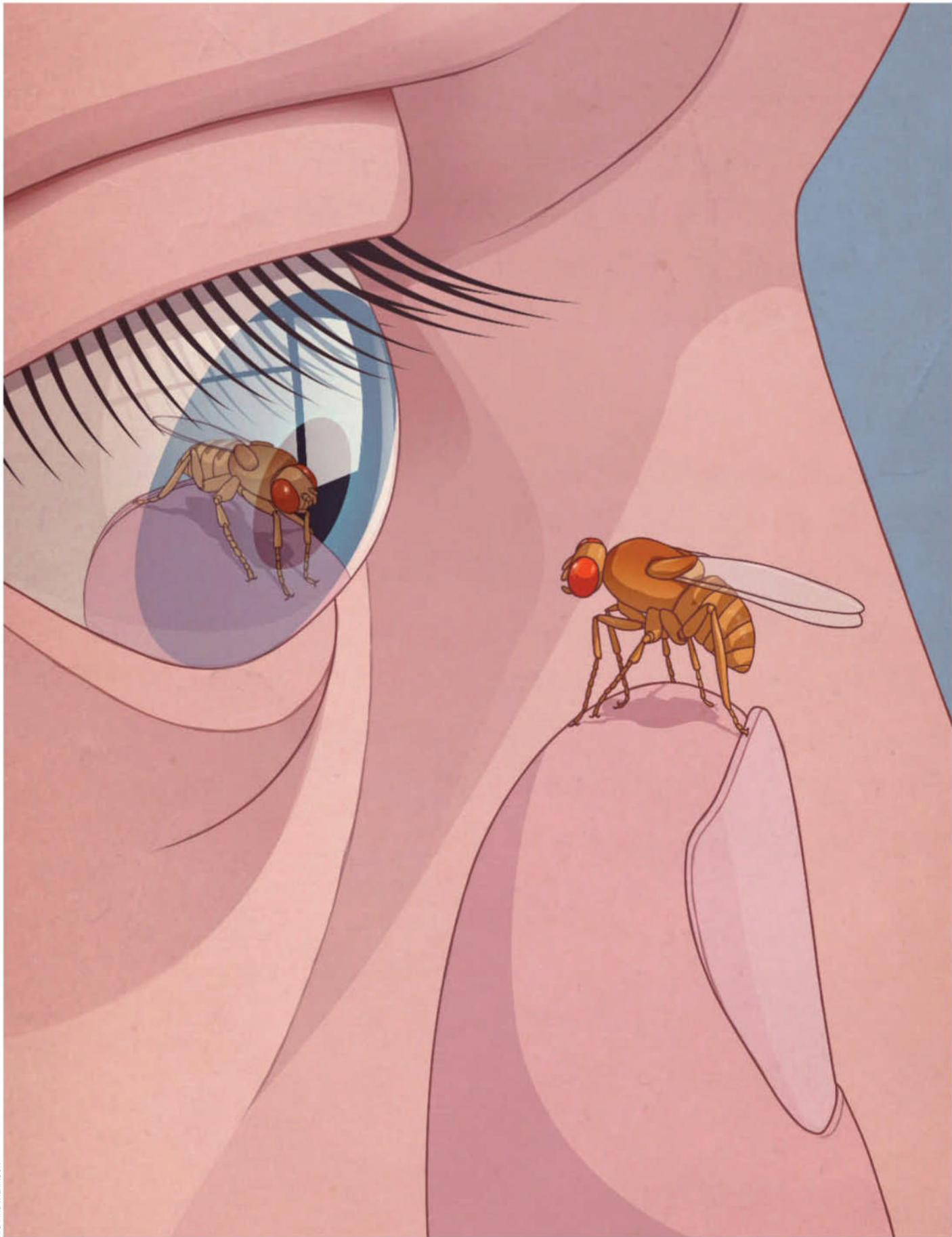
Because of the constant threat of being eaten by larger fish, blennies are generally found camouflaged against rubble patches or lurking behind coral. Here, the fish is propping itself up on its pelvic fins to scan for danger.

Photographer Jade Hoksbergen says she became fascinated with blennies after moving to St Lucia last year and getting her hands on an underwater camera for the first time. "I thought they made extremely interesting subjects due to the range in their facial expression, sometimes akin to the grimaces one would associate with gargoyles," she says.

This shot captures the shy, wary nature of blennies, Hoksbergen says. "I wanted to illustrate their intricate detail whilst showing how their colour and texture blends seamlessly with the environment," she says. Alice Klein

Photographer

Jade Hoksbergen



Why be conscious?

The hunt for the first conscious beings is revealing the improbable origins of our unique mind, finds Bob Holmes

YOU know that you are conscious. Hopefully, you believe me when I tell you that I am, too. But is your pet dog or cat conscious? What about a tool-making crow, or a "clairvoyant" octopus or a worm? You might think it is impossible to find out. There is no distinctive pattern of brain activity that indicates consciousness, and we can't exactly ask animals about their experiences. We don't even fully understand what consciousness is.

But maybe there's a way to get a handle on it. What if we tracked consciousness to its origins? Then, instead of asking what consciousness is, we ask why it evolved – in other words, what is it for? Until recently, that question has been largely ignored. But now biologists are starting to feel their way around the tree of life to consider where, when and why something resembling consciousness emerged. Their research is proving surprisingly fruitful. It's not just shedding light on animal minds, it is also providing insights into the very nature of consciousness.

This approach has its own difficulties. "Consciousness doesn't leave any fossil record," says Anil Seth, a neuroscientist at the University of Sussex, UK. So we have to infer its evolutionary history by comparing animals alive today and working back to what their common ancestor might have been able to do. And, because we don't really know what we are looking for, we have to grope our way blindly around the evolutionary tree, with only our own experience of consciousness as a guide. Then, as we observe how consciousness is, or

might be, expressed in other animals, we can gradually refine our notion of what we are talking about.

Some signs seem obvious. Chimpanzees recognise themselves in the mirror. Scrub jays will sneak back and re-cache food if another bird watched them hide it the first time – unless the watcher is their mate. Rats that push the wrong lever and fail to get a food reward gaze regretfully at the lever they should have pushed. In these cases, we can infer some sort of awareness of self, of others, and of what might have been, which looks a lot like what we recognise in ourselves as

"Consciousness comes with drawbacks. It may be less helpful than we think"

consciousness. If this were the sole criterion, however, there would be precious few non-human animals that cleared the bar.

There's reason to consider a broader benchmark: not every conscious experience is that complex, even for us. "If you ask yourself, what are you conscious of... you see colours, you smell coffee, you feel your aches and pains," says Jesse Prinz, a philosopher at the CUNY Graduate Center in New York. "Consciousness looks like it's largely about perception and emotion: it's not about thought or higher more human capacities." These basic components of conscious

experience could be widespread, even in animals that lack our mental sophistication and brainpower. Let's push a little deeper into the family tree, to see if we can find them.

Consider emotion, or "hedonic valuation" to use a less anthropocentric term. As Prinz points out, much of our conscious experience consists of perceptions with shades of feeling – objects are comforting or scary, sounds are pleasing or annoying, our body feels good or bad. And such evaluations play a crucial role in guiding our behaviour.

"Behaviour is about moving toward what is beneficial or moving away from what isn't. Feelings are meant to guide us by offering positive and negative rewards," says evolutionary biologist Bjørn Grinde at the Norwegian Institute of Public Health in Oslo. That makes hedonic valuation a useful evolutionary tool.

Grinde believes this sensation – the awareness that something good (or bad) is happening to me – may represent the dawn of consciousness. So, which animals have it? Surveying the vertebrate family tree, he sees a clear pattern: mammals, birds and reptiles all show signs of emotional responses, such as an increased heart rate and elevated body temperature when handled, while fish and amphibians do not. The brains of higher vertebrates are also much richer in receptors for dopamine, the neurotransmitter most closely associated with reward pathways. He believes this is evidence that the ability to assign value to an experience arose around ➤

300 million years ago in the common ancestor of modern reptiles, birds, and mammals – the first fully terrestrial vertebrate.

It makes sense. This ancestor would have faced challenges that its aquatic cousins did not, like temperature regulation and water conservation. Simple animals have reflex responses, and even a worm can learn a fixed behaviour pattern by trial and error, but an individual with hedonic valuation is capable of much more flexible behaviour. In this new environment, such adaptability would have been a big advantage. However, as Grinde points out, consciousness also has drawbacks. Compared with unconscious processing, it is slow and energy intensive, and can only do one thing at a time. What's more, it can lead to behaviours that are capricious or even detrimental to the individual – for example, there would be no self-harm without conscious thought. So the evolution of consciousness may be less helpful than we tend to think, leading Grinde to speculate that it emerged just once.

Do fish have feelings?

Other researchers agree that land vertebrates have something special, but many believe consciousness is found elsewhere in the animal kingdom too. They point out that the signs of emotion become harder to discern the further we get from ourselves. Would we recognise the expression of feelings in a fish, let alone a fruit fly? Instead, many researchers are converging on another indicator: an animal is conscious, they propose, if it experiences the world subjectively. This captures the distinctive “me, here, now” element of our own experience. Like hedonic valuation, subjective experience allows behavioural flexibility that goes beyond mere reflex responses. But it doesn't necessarily involve any of our more sophisticated abilities like emotion, reason or imagination.

That sounds like a plausible basis for consciousness, but how can you measure an animal's subjective experience? Bruno van Swinderen thinks he has found a way. A neuroscientist at the University of Queensland in Brisbane, Australia, he believes the essence of subjectivity is selective attention – focusing on just a few elements among all the sensory information available – because it indicates an individual is taking control of its perception. “I'm not sure there's really much difference between subjective experience and selective attention,” he says.

I'm probably conscious, me, and have been for around 290 million years

10 signs of consciousness

Not sure whether an animal is conscious? Here are some clues to look out for:

- Recognises itself in a mirror
- Has insight into the minds of others
- Displays regret having made a bad decision
- Heart races in stressful situations
- Has many dopamine receptors in its brain to sense reward
- Highly flexible in making decisions
- Has ability to focus attention (subjective experience)
- Needs to sleep
- Sensitive to anaesthetics
- Displays unlimited associative learning

To discover whether fruit flies are capable of selective attention, van Swinderen trained them to walk on a trackball suspended on a cushion of air, in front of a virtual scene projected onto a wrap-around wall of LEDs. By rotating the trackball, the flies could shift the scene and choose which of two objects to pay attention to. The images flickered at different rates, so that when a fly was paying attention to a particular object, it produced telltale frequencies in its neural activity, recorded by probes implanted in its brain. The results were remarkable. “It's like a spotlight. There's a dynamic window of attention that's moving around, and other competing objects are being suppressed,” he says. “The small fly brain really has a capacity for attention. That is, to me, the dawn of consciousness.”

Measuring attention like this is very labour-intensive. But van Swinderen thinks there may be a rough-and-ready way to separate animals that pay attention from those that cannot. “An easier experiment might be to see which organisms need to sleep,” he says. “So far, it really seems like the animals that pay



GEOGETTE DOUWMA/NATURE PL

attention are also the ones that need to sleep.” These include vertebrates, insects, crustaceans and octopuses, but probably not more lumpen animals such as starfish, worms, and jellyfish. Intriguingly, van Swinderen has also found that insects and vertebrates respond almost identically to general anaesthetics. “The concentration to knock out a fly is pretty much the same as the concentration to knock out an elephant,” hinting that the two lose consciousness in a similar way, he says. By contrast, nematode worms, which are unlikely to have selective attention or anything approaching consciousness, require 10 times as much anaesthetic before they stop moving.

The hunt for selective attention suggests that something like consciousness occurs in vertebrates, insects and octopuses at the very least. We know that the common ancestor of these three groups was a very simple organism that resembled a flatworm. Modern flatworms show few, if any, signs of rudimentary consciousness, so it seems a safe bet that the common ancestor also lacked consciousness. If so, that means consciousness evolved separately in the three groups. This runs counter to Grinde’s proposal, but does reinforce his idea about the function of consciousness. “When you step back and start to reflect on why these systems arise where they do, the story seems to make sense,” says Prinz. All three groups feature nimble, fast-moving animals that encountered rapidly changing conditions as they moved. That puts a premium on flexible decision-making.

However, not everyone is convinced that being able to direct focus is a signifier of consciousness. Selective attention is about data handling, says Michael Graziano, a neuroscientist at Princeton University in New Jersey. To act on that data, an animal needs a

“The animal kingdom is suffused with other kinds of consciousness”

mental model of that attention, for much the same reasons it needs a mental model of its body. “It’s fine for me to say ‘arm, go here,’ says Graziano. “But something in my brain needs to have a model of what an arm is, its possible motions, and so on.” Similarly, a model of attention would recognise that you are focusing on something and understand how quickly you can shift focus and so forth. This model – not selective attention per se – is responsible for our conscious awareness of the world, according to Graziano. And he speculates that such a level of mental sophistication

may only be found in vertebrates.

Evolutionary biologist Eva Jablonka at Tel Aviv University, Israel, also thinks there is more to consciousness than selective attention. She believes we should be looking for “unlimited associative learning” as a marker for the origin of consciousness. This is the ability to knit multiple cues into a single perception that is more than the sum of its parts, and then use that compound cue to drive behaviour. It’s what allows us to learn that a growling dog may be playful in one context but threatening in another. “That marks the beginning of minimal consciousness,” she says.

Explosive talent

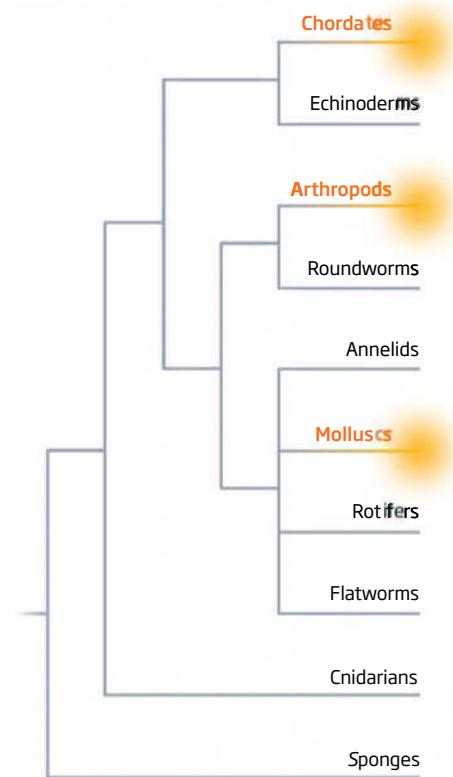
Unlimited associative learning requires an array of brain functions, not only selective attention, but also the ability to combine sensations into one perception, perform compound action patterns and distinguish between self and environment. Scientists have found evidence that this complex learning is surprisingly widespread throughout the animal kingdom. Already, researchers have documented it in almost every vertebrate (except, possibly, lampreys), some arthropods such as insects and crustaceans, a few molluscs including octopuses and, perhaps, some snails. The jury is out on other groups, such as worms, since we don’t have enough evidence to be sure. “There are huge gaps in our knowledge,” says Jablonka.

Nevertheless, what we already know has led Jablonka to suspect that consciousness evolved in early vertebrates and early arthropods during the Cambrian explosion, about 540 million years ago, when these groups diversified rapidly. (Consciousness in octopuses probably evolved about 250 million years later, after their lineage diverged from other, less intellectually gifted molluscs such as clams and snails.) This origin is interesting. The Cambrian explosion saw the emergence of most of the major animal groups alive today, and Jablonka suggests that consciousness – driven by selection for powerful learning ability – might have helped drive that rapid evolution. “I can’t think of many things that could change adaptability that dramatically,” she says.

It’s early days when it comes to considering consciousness in an evolutionary context. While researchers have yet to reach a consensus on when it arose and which animals possess it, they have already enriched our understanding of what consciousness is. There’s no doubt that human consciousness is special. Whether it is unique in some way or

The enlightened ones

Signs of consciousness have been found in animals from at least three different **phyla**, suggesting it evolved more than once and is far more common than most people think



simply richer than that of other animals is still up for debate. However, it is becoming clear that the rudiments of consciousness are all around us. That comes as a surprise to many. “When I started, I was really sure we would find it in mammals. I was pretty convinced we wouldn’t find it elsewhere,” says Prinz. “I have been absolutely convinced that the contrary is true. The basic mechanisms can be found in creatures of an enormous variety.”

Another lesson we can draw from this approach is that consciousness is not clear-cut. “I don’t think we’re ever going to find a single dividing line between those species that enjoy the glow of an inner universe and those that don’t,” says Seth. “There is not just one single way of being conscious. The animal kingdom is going to be suffused with other kinds of minds and other kinds of consciousness, and they’re not going to be just mini versions of human consciousness. We’re not the centre of the universe.” ■

Bob Holmes is a consultant for *New Scientist* based in Edmonton, Canada



IN THE FACE OF DANGER

In a crisis, your brain powers down. Michael Bond learns what to do to keep yourself safe

**FIND
MORE
FREE
MAGAZINES**

FREEMAGS.CC

EVERY journalist in Gaza knew the rule: one strike usually means two, so stay well away until you hear the next hit. But the cameraman staying in my hotel forgot, and that night he didn't return. It was 2002, the second intifada had been raging for 18 months, and hundreds had died on both sides. Intent on capturing the story, he rushed to the scene of an Israeli attack without waiting for the second missile. "He made a big mistake," said his colleague.

It was an epic misjudgement – fortunately, not a fatal one. But you couldn't put it down to stupidity. Many psychological studies have shown that under high stress, when your life is threatened or you have witnessed something terrible, it can be difficult to remember what to do. Or, if you do remember, to actually do it.

This helps explain why so many people caught in building fires and ferry disasters do nothing to save themselves; why people struggle to dial the emergency services in their moment of need; why 11 per cent of sky-diving deaths are due to parachutists failing to pull their reserve chutes.

"No one becomes smarter under stress," says Charles Morgan, a forensic psychiatrist at the University of New Haven, Connecticut.

"The question really is who gets dumb faster."

So what befuddles our brains when the unthinkable happens, and can we do anything about it? That question has long obsessed the emergency services, military and others who regularly put themselves in danger. But we can all benefit from understanding what happens in our heads during a fire, mugging or terrorist attack – and we can use that knowledge to give ourselves the best shot at surviving.

It has become standard procedure for companies and governments to put employees through hostile environment awareness training (HEAT) before sending them to high-risk areas. But is it really possible to prepare for something so unpredictable? "Training for emergencies certainly works, there's no doubt about that," says John Leach, a former military survival instructor who

studies survival psychology at the University of Portsmouth, UK. "How people respond depends very much on what they know."

Prior knowledge is crucial, because when disaster strikes, your brain is in no state for rational deliberation. It takes just seconds for adrenaline to flood into your bloodstream, pushing your heart rate up from about 70 beats per minute to over 200. Then the body's central stress system releases the hormone cortisol, boosting blood sugar levels and suppressing non-essential functions such as digestion.

This evolved fight or flight mechanism prepares us for physical action, but inhibits areas of the brain that govern working memory and process new information.

"No one gets smarter under stress. The question really is who gets dumb faster"

In other words, it primes us to act but not to think. With our cognitive faculties hobbled, if the threatening situation is one we have never been in before, there's little chance of figuring out a solution.

One consequence is that most people neither fight nor flee: they freeze. Leach estimates that in mass disasters such as ferry sinkings and aircraft fires, about 75 per cent of people suffer cognitive paralysis, resulting in complete inaction. "Our brains build up a model of the world, and for the most part that model is accurate," he says. "But in a threat situation, the model in our head no longer represents the truth on the ground."

Because it would be unethical to conduct experiments that risk traumatising the participants, most studies of survival behaviour involve elite military recruits who opt in to extreme scenarios as part of their training. Even in this self-selecting group, highly stressful situations can have a big effect on performance.

In 2006, Morgan looked at how an intense mock capture and interrogation affected the cognition of pilots and aircrew at a US military survival school. He used a test of visuo-spatial processing and working memory that involves copying out a complex line figure, and then reproducing it from memory. Compared with controls, the recruits who attempted this in captivity not only had great difficulty reproducing the drawing from memory, they also copied it with a piecemeal approach generally used only by children under 10. It was akin to "seeing the trees rather than the forest", says Morgan, and is likely to result in impaired decision-making, particularly if time is short. "It approximates what most of us would do under really high stress." The only way to guard against such decision-making errors, he says, is to have a checklist of actions that you have practised and can follow when you can't think straight.

To get an idea of how preparing for unexpected threats might increase our survival chances, I enrolled on a three-day HEAT course with Hostile Environment Training in Andover, UK. On the course with me are representatives of two UK government agencies and an international aid charity. Most of our instructors are former special forces soldiers, although they seem to have their fingers in a lot of hot pies: Andy, our lead instructor, is also a hostage negotiator. His aim this week, he says, is to make us absorb his lessons so that we don't have to think about them, because "the thinking part of your brain is the part that is likely to get you killed".

Given our instructors' badass backgrounds, I half expect to spend the first day learning how to dodge a bullet or take cover from an exploding grenade – that comes later. But they are primarily concerned with reducing the risk of us ever having to face that kind of situation. We learn things like the safest seat on an aircraft and the importance of learning a ➤

Left: In a crisis like the Lebanon war of 2006, overcoming the urge to freeze can be critical

TIPS TO KEEP YOUR WITS

Prepare

- When you enter an unfamiliar building, note the nearest fire exit and how you would reach it. In an emergency, you'll be able to fall back on this mental shortcut despite being highly stressed.
- Always listen to the safety briefings on aircraft, boats and trains and go through the motions of escape in your head. If you don't, you are likely to just freeze up if you have to evacuate fast.
- In a taxi, the safest seat is directly behind the driver. In a crash, the driver will instinctively try to protect their part of the car; if they have ill-intentions towards you, you will be harder to reach if you're behind them.
- The safest seat on an aircraft is by the wing one row behind the exit. You will be close to an escape route and find it easier to remain anonymous in the event of a hijacking.
- The safest room in a hotel is at the back, between the first and fourth floors, furthest from harm during terrorist attack and within reach of a quick exit during a fire.

Act

- In an emergency, do not wait for others to act; most people's first reaction will be to do nothing.
- If the fire alarm goes off unannounced in your office, leave immediately. If you're worried about looking foolish, say you're going to grab the opportunity to take a walk.
- If someone attacks or tries to kidnap you in the street, shout "bomb" or "gun" and run towards other people. Your attacker won't expect this and won't like the risk of attention.
- If you are taken hostage, try to humanise yourself but don't be their friend; drink and eat anything they offer. Try to blend in: hostage-takers may treat troublemakers more harshly.
- If you're caught up in a riot or terrorist attack, the basic default advice is: "Head down, run fast."

fire escape route and rehearsing it in your head, so you won't have to do that under stress (see "Tips to keep your wits", left).

Day two is kidnap day. We know it's coming but it's still a shock. We're in an abandoned farmyard learning how to crawl through a minefield when we hear gunshots and shouting. Six men in balaclavas come running at us from the bushes. One of them "shoots" Andy in the face (with blanks, but even so), meaning he's out. Then they turn on the rest of us. They bind our wrists, blindfold us, make us lie in the mud, kneel, stand and lie again. We're marched around in a pitiful column then forced onto the floor of a revving van. Instructions are shouted at me a few centimetres in front of my face. Eventually they hustle us into a barn, pull hoods over our heads and subject us to a surprisingly abusive interrogation. They make it personal: one of our group sounds upset and they abuse her for that; another they perceive to be overweight and abuse him for that; I'm abused for being a journalist, given a new name – something unprintable.

Somewhere in our rational minds we know that these men aren't going to shoot us or beat us, but when the hoods are removed and we are finally released we all feel pretty shaken. Later, during the debriefing, it's clear the stress has affected our memories. We disagree on just about everything: the sequence of events, what was said, how long it lasted. To me it felt like 15 minutes, someone else says an hour – Andy says 45 minutes. None of us can recall what our kidnappers were wearing even though we saw them clearly enough. Apparently this is normal. The crucial thing, says Andy, is that we have learned what it feels like to be a hostage, which makes it more likely that some of the advice he has given us – don't stand out, drink and eat anything they offer – will stick in mind should it happen for real.

Later, I ask the director of Hostile Environment Training if he has any evidence that the training works. He shows me a letter from a former client who endured a violent kidnapping and robbery at his home in Kenya during which one of his friends was killed. He wrote: "Immediately, I saw the situation for what it was and remembering the training I had received, I dropped my gaze, put my hands up, and felt an inexplicable sense of calm – there was no way I could fight, so what was the point in resisting?" He describes being forced to beg for his life with a gun to his head and a machete to his neck. Clearly not everything can be replicated in training.



The main purpose of such training, apart from increasing confidence, is to create a "procedural memory" to guide your actions when your thinking powers are crippled. It doesn't happen quickly, says Sarita Robinson at the University of Central Lancashire, UK. She has been studying people who undergo helicopter underwater evacuation training,





Hostile environment training mimics the hostage experience

THOMAS DWORZAK / MAGNUM PHOTOS

which is mandatory for oil rig workers, search and rescue pilots and others who regularly fly over the sea. It involves being strapped into a mock-up of a helicopter that is then plunged at speed into a pool.

On their first trial, says Robinson, most people behave in one of three ways. Either they freeze and don't attempt to escape; or they make a sequential error, like trying to get out of a window before undoing their harness; or, most commonly, they revert to a familiar yet inappropriate action, such as trying to release their four-point harness as if it's a car seatbelt. "In that very high pressure environment, they can't inhibit that behaviour or they can't think about a new one." But by the time they've been dropped into the pool five or six times, the behaviours they have been taught kick in automatically. "They just activate the script and do the action. No need for working memory."

Robinson, Leach and others are convinced that training increases your chance of surviving an emergency, and that if you have coped well once you are likely to do so the next time. However, because procedural memories are chains of context-specific actions, memorising your office fire drill won't help you escape a burning cinema. And a helicopter ditching course won't keep

you calm during a kidnapping.

This applies as much to trained professionals as the rest of us. On the final day of my HEAT course, Andy puts on a video from the headcam of a US soldier in Afghanistan. It shows two soldiers just after a mine has exploded. One is lying on the ground, the lower part of his left leg blown off. The other is struggling to fix a tourniquet. Usually this is one simple movement, but this time he first has to thread the end of the strap through the tourniquet's buckle – something

"The thinking part of your brain is the part that is likely to get you killed"

he has never practised under pressure because tourniquets are usually threaded before they go out. Stressed, his fine motor skills shot, it takes him 2 minutes and several attempts to do it.

People without training differ in how they respond to disasters. This is partly due to differences in working memory capacity and how well we can direct our attention. Anxious people do worse, says Robinson, because "their working memory is basically being

eaten up with the thought, 'I'm going to die, I'm going to die.'" Although as Naz Derakhshan at Birkbeck, University of London, points out, anxious people do have one advantage: "They are more vigilant towards threats, so they'll be faster to notice danger and faster to want to act on it."

Running into danger

Even highly trained soldiers differ considerably in their response to threats, and Morgan has found a strong biological component to this. Soldiers who perform best in military survival school, and suffer fewer working-memory deficits, express higher levels of certain stress-regulating chemicals in their central nervous system. For example, compared with regular recruits, special forces soldiers – selected for their "stress hardiness" – were found to have significantly higher levels of the neurotransmitter neuropeptide Y during a stressful "prisoner of war" exercise. "They can tolerate more stress without becoming impaired," Morgan says.

There are efforts to develop drugs that mimic these effects – and some researchers have even proposed their use for the police – but for the rest of us, nothing beats learning from those who know the drill. Anthropologist Scott Atran, whose research into terrorists and religious fundamentalists has landed him "in a few very bad situations", recalls occasions when "the ordered reactions of trained people around me clearly helped me pretty calmly control my own reactions".

The value of training for the unexpected became clear in the aftermath of the terrorist attack in London on 22 March. Five people were killed, and more than 50 were injured, when a man drove a car at high speed onto the pavement of Westminster Bridge and then fatally stabbed a policeman. Most of us would have found such carnage overwhelming, but the medics and other emergency responders have won praise for the calm and efficient way they assessed the scene and treated the injured, despite having little idea what they were heading into. London's Air Ambulance crew thought they had been called to a road traffic collision. Paramedics from St Thomas' Hospital didn't know if the attack was still in progress when they ran towards the bridge to help. Yet when they got there, they knew exactly what to do: they had done it hundreds of times before. ■

Michael Bond is a writer based in London. His most recent book is *The Power of Others*.



A MARS COLONY

It's all go. Stephen Hawking has declared that we should start colonising other planets as soon as possible, and last year billionaire venture capitalist Elon Musk announced plans to establish a Mars colony in the 2020s.

That's possibly a little ambitious, says Lewis Dartnell, an astrobiologist based at the University of Leicester, UK. Mars is a brutal and unforgiving environment. A quick land and return is one thing, but it's quite another to set up a self-governing human colony largely independent in terms of food and energy, and 18 months' travel time from Earth. "I'd hope for a colony within 50 years, but even that is probably verging on 1950s levels of credulous optimism," he says. So don't bet your house.

BOOKIE'S ODDS

33/1

A permanent Mars colony by 2027

Bookie's odds are for the stated breakthrough to occur within 10 years, and were calculated by bookmaker PaddyPower

ODDS ON

Human clones, a Mars colony, perpetual motion: what implausible developments might soon happen? Michael Brooks asked the experts – and the bookies – to take a punt on the next scientific breakthroughs

NON-DARWINIAN EVOLUTION

The giraffe stretches its neck to reach the most succulent treetop leaves. Over time, as it repeats the action, it acquires a longer neck – an advantageous adaptation the giraffe passes on to its offspring.

Such developments are often called Lamarckian evolution, after French biologist Jean-Baptiste Lamarck, who developed a “theory of inheritance of acquired characteristics” around 1801. Today’s mainstream evolutionary theory, based on Darwin’s later ideas of natural selection, says it doesn’t work like this. Adaptations arise through the accumulation of random genetic mutations that we pass on if we reproduce. Stretching our necks has no effect on the necks of later generations.

Not so fast. We have recently discovered that the environment and our behaviour may indeed influence our biochemical inheritance. Pollution, smoking, stress and diet can all cause some genes to be expressed and others to remain dormant in non-random ways. In some organisms, these changes seem to be “epigenetic”, cascading down the generations. They might even speed up evolution purely by natural selection.

You can debate whether to call such effects Lamarckian evolution, says biologist Douglas Ruden of Wayne State University in Detroit, but for him, their existence is a closed book. “I don’t think that we have to wait until 2025 before most evolutionary biologists appreciate the role of epigenetics in evolution,” he says.

Massimo Pigliucci of the City University of New York broadly agrees. There are probably multiple layers of inheritance, some genetic and some epigenetic, he says. “What remains to be seen is just how widespread and evolutionarily relevant the additional layers are compared with the genetic one.” Bet against Darwin at your peril – but a flutter on Lamarck might be an advantageous adaptation to evolving circumstances say the bookies, too.

BOOKIE’S ODDS

5/1
Lamarckian evolution confirmed

PROOF THAT ACUPUNCTURE WORKS

LEFT: ALAMY/PLAINPICTURE/CAVANIMAGES



Acupuncture is undoubtedly popular. But does sticking needles into your skin at designated points actually cure pain, or do people merely think it does? Felicity Bishop, a health psychologist at the University of Southampton, UK, is relatively confident. “I would be willing to place a sizeable bet that acupuncture is better than a placebo pill for pain,” she says. “I would also bet that, in a properly designed and powered trial, acupuncture is better than so-called ‘sham’ acupuncture for pain” – where a stage-dagger needle prods the skin but doesn’t pierce it.

Such tests have yet to be done to everyone’s satisfaction. But they might not be persuasive enough on their own anyway. Acupuncturists engage strongly with their patients, showing empathy and interest that is likely to elicit positive mental and emotional responses. They also recommend lifestyle changes that could account for a reduction in pain. It’s hard to control for such a “super placebo” effect, Bishop admits. So while the bookie’s odds on this one are relatively short, evidence that will convince them to pay out may be hard to find.

BOOKIE’S ODDS

5/1

Conclusive proof that acupuncture works universally as a treatment for pain relief

HUMAN CLONES

In the past few decades we have cloned cows, mice, chickens and, most famously, sheep: we have extracted the DNA from a living animal and inserted it into an egg with its nucleus removed, to make an identical copy of the animal. So are humans next?

Some argue human cloning could “resurrect” a lost child, or be a source of organs or tissue for someone with an incurable illness. Ethically speaking, it’s a minefield, but there are many technical hurdles, too. Cloning is hard to perfect and live births are elusive. Dolly was the first success in a batch of 277 attempts to clone a sheep that lived to adulthood. She mated and gave birth to lambs normally, but developed osteoarthritis and died from a lung condition relatively young, aged 6. That might just have been bad luck: other sheep cloned later from the same source lived to ripe old ages.

Subtleties with humans make things more complicated. In primates, spindle proteins, structures vital for cell division, sit very close to the nucleus. These tend to get damaged when the original cell nucleus is extracted, diminishing the chance of cells dividing without catastrophic errors. Alison Murdoch of Newcastle University is one of only two researchers in the UK with a licence to clone human embryos. She says she’s not aware of any serious scientific, ethically approved programme working on human cloning. To her eyes, the bookie’s assessment seems rather optimistic. “As a scientist, I can’t ever say never but I estimate the odds being close to zero.”

BOOKIE’S ODDS

10/1

A viable human clone by 2027

PSYCHEDELICS LICENSED AS PHARMACEUTICALS

The evidence is piling up: mind-altering drugs help people with stress disorders and depression, or those with a terminal illness. So how do you lock ravers up for taking ecstasy while simultaneously condoning its use in traumatised soldiers?

The dilemma has made it difficult to research substances such as MDMA, aka ecstasy, and psilocybin, the active ingredient of magic mushrooms. Getting hold of and storing the drugs requires expensive licences, secure storage facilities, not to say laborious access and accounting procedures. Still, things are only moving one way, says Robin Carhart-Harris of Imperial College London, who last year conducted the first clinical trial of psilocybin as a treatment for depression. "I think it's quite heavily odds on that a government somewhere will approve psilocybin as a therapeutic by 2025," says Carhart-Harris. "If I could get evens, I'd put most of my savings on it."

BOOKIE'S ODDS

14/1

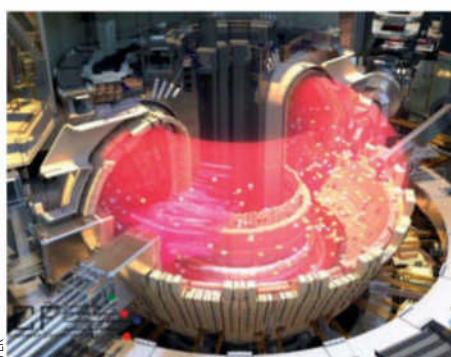
All Class A drugs to be licensed for medical use in the UK

ODDS OFF?

Disagree with the odds here? Feel free, but if you're one of many those odds will shorten, says Féilim Mac An Iomaire of bookmakers PaddyPower. "If lots of people like our price, we got it wrong." With something like alien contact, odds can fall drastically with every supposed sighting, adds Graham Sharpe of William Hill. "People may scoff at you, but it's a liability you just don't want."

Alien contact at least has a protocol: it must be confirmed by the US President or UK Prime Minister. Policing more recondite bets can be tough, though. "Say we were to take a bet on there being more to evolution than genetics," says Sharpe. "Who's going to chair that debate?"

COMMERCIAL NUCLEAR FUSION



A huge doughnut-shaped reactor under construction in the south of France represents humanity's best hope of taming the power of the sun. But there's an old joke about nuclear fusion: it's four decades away, and always has been. "Fusion is a difficult business," says Thomas Klinger of the Max Planck Institute for Plasma Physics in Germany.

ITER, the French project, isn't exactly breeding confidence. The internationally funded "tokamak" reactor is 11 years behind schedule, and is now due to start up properly in 2027. Despite its \$20 billion price tag, it's only a demonstration model, not generating enough power to be connected to the grid. Nuclear fusion as a significant energy source within 10 years seems a long shot.

Unless one of ITER's rivals can strike gold. Klinger works on the billion-Euro Wendelstein 7-X "stellarator", a doughnut with added twists and turns. Its plan is to achieve 30 minutes' continuous operation in 2021, but it too is just a demonstration model. The immediate prospects of any of the numerous smaller fusion start-ups seems similarly doubtful. "The so-called 'alternative schemes' have no scientific basis to be faster than tokamak or stellarator," says Klinger.

For Klinger, the lack of progress has a simple explanation: lack of funding, over the past four decades to be precise. For this bet to come off, someone will need to punt a few billion.

BOOKIE'S ODDS

20/1

Nuclear fusion power to be the predominant source for electricity worldwide

PERPETUAL MOTION MACHINES

Roger Shawyer is not shy of making predictions for his invention, the EmDrive. "If you are asking what is the probability of a commercial EmDrive by 2025, I can tell you with absolute certainty that it is 100 per cent," he says. His confidence comes from "knowledge of existing commercial projects".

Many people would wager against that: they claim the EmDrive is nothing but a perpetual motion machine. It consists of a cone-shaped chamber where bouncing microwaves generate a small thrust that pushes the narrow end of the cone away from the wider end – movement from nothing according to the critics, in contravention of all known laws of physics.

A NASA evaluation of the EmDrive published last year did find a net force acting, albeit only around 1.2 millinewtons per kilowatt of electricity, far less than conventional electrically-driven thrusters can produce. One suggestion made in the report is that an as-yet unsubstantiated hidden process in quantum theory (see "Proof there's no quantum weirdness", right) might offer an explanation.

That is somewhat reminiscent of the "law of conservation of mysteries": explaining one mystery by invoking another completely unproven phenomenon. John Baez, a mathematical physicist at the University of California, Riverside, is unconvinced: the idea the EmDrive can work as claimed is "graduate-level baloney", he says. That's certainly the bookies' take on perpetual motion machines.

BOOKIE'S ODDS

5000/1

Construction of a perpetual motion machine

PROOF THERE'S NO QUANTUM WEIRDNESS

Quantum theory is a bookie's theory: it never tells you what's going to happen, only what the odds are. That's a bit of a downer for a theory that, mathematically at least, is meant to explain the fundamentals of our world, where things definitely happen and causes have definite effects, or so it seems.

There are various unsatisfactory explanations for quantum theory's vagueness. The dominant "Copenhagen" interpretation, for example, says there is no meaningful physical reality until we make an observation or measurement. In the "many worlds" interpretation, by contrast, all possible states of reality actually do occur, and what we see is a manifestation of interference between these parallel universes.

An alternative is that there is a more concrete, physical explanation for quantum weirdness – some "hidden variable" that we can't yet see and that calls reality's shots. Almost since quantum theory's beginnings, a small band of physicists, notably Einstein and exiled American David Bohm, have championed this view, albeit with a notable lack of success so far.

Might we ever make such a breakthrough? Basil Hiley of Birkbeck, University of London, who worked with Bohm, says we're not there yet. "I know of no hidden variable theory that provides a completely satisfactory account of quantum phenomena," he says. And the odds that might change any time soon? "I cannot answer with a one-liner." We may yearn for a theory we understand a little better, but it seems we need to learn to live with it for now.

BOOKIE'S ODDS

50/1

Proof of a "realistic" interpretation of quantum theory

A BETTER THEORY OF GRAVITY



We invented dark matter, an unseen substance that outweighs normal matter by more than four to one, to explain why gravity doesn't work – why, for example, galaxies and galaxy clusters whirl around far faster than they would if there were only visible matter there.

Yet despite decades of searching, we have found no peep of the stuff. Perhaps our understanding of gravity is wrong instead?

Dark-matter sceptic Stacy McGaugh of Case Western Reserve University in Ohio, is wary of getting any bets to stick. "I've been down this road before," he says. In 1999, he publicly wagered that close analysis of features in the cosmic microwave background, the radiation left over from the big bang, would disprove the then-standard model of dark matter. It did – then the model changed. "Free parameters were pulled out of the bag, knobs were dialled, data were fitted," he says.

McGaugh has published various further tests of his ideas, but still no one has bitten. His latest wager is that he can predict the distribution of individual stars' velocities within a dwarf galaxy "without any reference to a fictitious dark matter component". But, he says, "The trick is finding someone who will take the contrary bet, and actually stick to it."

BOOKIE'S ODDS

66/1

Proof dark matter doesn't exist

ALIEN CONTACT

In Hollywood, aliens are all over the place: here to take over the planet, save us from ourselves, or just passing by.

In the real world, not so much. We have yet to get a convincing signal from extraterrestrials, despite several telescopes looking. The closest thing was the Wow! signal, spotted by Ohio State University's Big Ear radio telescope in 1977. A continuous radio signal observed over 72 seconds, Wow! is still to be explained, although last year, Antonio Paris of St Petersburg College in Florida suggested it came from a comet.

That doesn't deter Seth Shostak of the SETI (Search for Extraterrestrial Intelligence) Institute in California. SETI experiments are gaining in power and number, he says, and by 2030 we should be well set up to receive alien broadcasts. "By that date, assuming that funding to do the work can be found, we'll have checked out roughly a million stellar systems for signals," he says. He is personally willing to stake only a cup of coffee on a discovery, though.

Milan Cirovic, a SETI researcher at the Astronomical Observatory of Belgrade, is similarly sceptical in the short term. He puts the odds of detection at no more than 5 per cent by 2030 – although "by the end of the century, I would give the odds no less than 50 per cent – barring nuclear winter, pandemics or abuse of nanotechnology which could destroy civilisation on Earth," he says. So if we don't get us, the aliens still might. ■

BOOKIE'S ODDS

100/1

Verified communication between humans and intelligent aliens

Michael Brooks is a consultant for New Scientist

An epidemic of fear

People expect a surge in cancer cases after nuclear disasters like Chernobyl and Fukushima. But that is far from the biggest danger, says **Shunichi Yamashita**

FUKUSHIMA wasn't just a nuclear disaster. It was also an information disaster.

Before the 2011 earthquake, tsunami and meltdown of three nuclear reactors, there was a myth in Japan about how nuclear power was completely safe. Ever since, we have had a new myth: everybody thought Fukushima was a second coming of Chernobyl, and that they would all get cancer.

I went to the prefecture to give radiation safety advice. I recognise people's fears about radiation. It is human nature. You can't smell or see or touch it – it is like a ghost. Radiophobia has become a big public health problem. And it is made worse because, especially here in Japan, people have lost trust in experts. I am one of those experts.

I have studied the health effects of radiation for most of my adult life. I know about it personally too: I was born in Nagasaki seven years after the Americans dropped the atomic bomb on the city. My mother was 16 years old when it fell, and she was just 3 kilometres away. A third of the population died, but she survived. Now she's 88 and lives in my house. She has had lots of diseases, including tumours and cardiovascular diseases that may have been caused by the radiation, but she has a strong heart and is still going.

Perhaps this background led me to study medicine. I was a professor at Nagasaki University when I was asked to go to Chernobyl in 1990, four years after the nuclear accident there. People had received high doses of radioactive iodine because milk from cows grazing radioactive pastures wasn't removed from the food supply. More than 5 million people were exposed. Thousands were diagnosed with cancer of the thyroid, a gland that takes up iodine.

We started a screening programme among the Chernobyl evacuees. It continues and I go



ANTONIO PAGNOTTA/COSMOS/EYEVINE

PROFILE

Shunichi Yamashita is radiation health management adviser for Fukushima prefecture and vice-president of Nagasaki University, Japan

there regularly. New cases are still emerging. Apart from the radiation sickness power plant workers experienced after being exposed to massive doses during the accident, thyroid cancers have turned out to be the main health impact. Many people expected a big surge in other cancers and genetic effects on the next generation. They haven't happened, but I have seen how people live in fear of these things.

Fear can be very damaging. After Fukushima, I saw part of my role as being an intermediary between the government and the public. But I got into trouble for telling people to smile. I said it at a public meeting 10 days after the accident. Everybody was very stressed and in the middle of chaos. Many had been forced to evacuate. I said it was bad to worry so much. They should try to be at ease with themselves.

My audience, I think, understood. Almost nobody reacted badly at the time. But later my words were posted – out of context – by a lot of people online. Some opposed the advice I was giving and used it to attack me. I had difficulty working as a government adviser because of it.

Many people thought even a tiny amount of radiation was dangerous, despite the natural background radiation we are all exposed to. Some 110,000 people living within 20 kilometres of the Fukushima plant had been evacuated. I said publicly that there should be

Decontamination in Fukushima prefecture. Thousands of people are yet to return

no apparent health effects when exposure was below 100 millisieverts a year. This is the lowest dose linked to rising cancer rates in studies such as those following the survivors of Hiroshima and Nagasaki. And it is in line with recommendations by the International Commission on Radiological Protection – an independent body of scientists. Some people wanted the official safety limit set as low as 1 mSv, but that is below the natural background level. The government decided on 20 mSv.

This caused confusion. Many people thought I wanted them to live in dangerous places. This is totally wrong. I felt that any small risks from radiation were much less than the psychological effects of being in evacuation camps or unable to return to normal life. I had seen this in Chernobyl.

The confusion was made worse by the chaos after the accident. When I went to Fukushima, I was shocked to discover that 60 people had died. This was not from radiation. Old people died during the evacuation, and some were even left behind in nursing homes or at home without medication.





JEREMIE SOUTER/LUZ/EYEVINE

Ironically, just three weeks before the accident, I had helped organise a World Health Organization meeting in Nagasaki, to discuss how to prepare for a nuclear accident. But these desk plans weren't put into practice. Instead, the medical system collapsed. The Red Cross pulled out all its staff. Nurses left because they were frightened. And nobody knew how bad the radiation was because the

"Many people thought even a tiny amount of radiation was dangerous"

government wasn't issuing timely information. In the end, scientists at the local universities decided to take radiation readings themselves and produce their own maps.

It is now clear that, thanks to the evacuations and food safety controls, dose levels for the public were far below 100 millisieverts. We think that during the accident more than 99 per cent of people in the area received below 5 mSv, and the highest exposure was only 25 mSv.

In most places, radiation was soon back below the government's safe level, but plans for the return of people didn't get going for a long time. I had told the government that people could start to return after a month. The delay fed the fears.

One of the big concerns people had was that children would get thyroid cancer, as happened at Chernobyl. But here, with milk and other foodstuffs swiftly banned, children received thyroid doses of just a few mSv at most, whereas in Chernobyl they often received hundreds.

Nevertheless, we decided to do a mass thyroid screening using ultrasound, repeated every two years. We knew from Chernobyl that no cases were likely for four years, and we did an initial baseline survey to compare future rates against. We screened more than 300,000 children between 2011 and 2015.

We hoped this would reassure people. But the problem is a mass screening is bound to show up cancers that wouldn't otherwise have been diagnosed. They had nothing to do with radiation, but the public and the media didn't

understand this. So when we published our first baseline results, showing we had found 113 thyroid cancers, all the headlines were about a "skyrocketing" 30-fold increase.

But you see the same "skyrocketing" whenever you do mass thyroid screening. And the rates we found were no different between areas with higher and lower radiation doses. There hasn't been an epidemic of cancer, but there has been an epidemic of fear. The psychological effects from the trauma of evacuation and the fear of radiation are now the biggest health consequence of Fukushima.

Many people remain in an uncertain situation, frightened that they or their children will get sick, and unable to resume their lives. Adults are experiencing depression, sleep loss and anxiety. Their children are also anxious and school performance has suffered.

There have been more than 80 suicides linked to the accident and the evacuation. But there have been no deaths or sickness from direct exposure to radiation. ■

As told to Fred Pearce

It's an original...

Will tech help or hinder access to famous art, asks **Simon Ings**

Prints in Paris 1900: From elite to the street, to 11 June, Van Gogh Museum, Amsterdam

IMPRESSIONISM, the movement that shaped a generation of European artists, was concerned above all with light, colour and the mechanics of visual perception. Only one of its leading lights concerned himself, without apology, to the business of fame – Vincent van Gogh. He got what was coming to him: absolutely nothing. Dealers failed to sell a single canvas in his lifetime.

Tastes change. On 2 June 1973, in a park behind the Rijksmuseum in Amsterdam, a museum dedicated to van Gogh's work opened to an ever-swelling crowd of admirers. In 2014, 1.6 million people visited. Last year it was 2.1 million – 20 times the number the museum was designed to accommodate – all there to see just 250 paintings and 700 drawings and letters.

At what point does a practical problem become an existential one? When do we have to admit that not everyone can experience everything – and what do we do about that? Forgery is no solution because good forgeries are, by definition, as exclusive as originals: if the original turns up, the forgery loses all value.

What if we undermined cultural norms to the point where fakery was the norm? This is the state of affairs dreamed up by Polish writer Stanislaw Lem in his 1976 novel *The Futurological Congress*, which features this diary entry: "Spent a few free hours... in the city. Could hardly control my horror as I looked at all the

displays of wealth... An art gallery in Manhattan practically giving away original Rembrandts and Matisse... The fiendishness is that part of this mass deception is open and voluntary, letting people think they can draw the line between fiction and fact. And since no one any longer responds to things spontaneously – you take drugs to study, drugs to love,

"Stock market-style tracker software reduced peak visits by 60 per cent, yet visitor numbers increased"

drugs to rise up in revolt, drugs to forget – the distinction between manipulated and natural feelings has ceased to exist."

Doubtless the curators at the Van Gogh Museum have no such nefarious plans. But, faced with those queues, they are resorting to technology, even virtual reality.

Their most innocent-looking intervention is a dedicated location-based app by Marjolein

Fennis that will entertain those waiting to enter, turning potentially fractious hordes into ad hoc communities of gamers.

In an effort to avoid delays and bottlenecks, museum designers scrape eye-tracking studies and video footage for insights. Some 85 per cent of the museum's visitors are tourists, which means they get up late and roll up to the museum at the same time, 11 am.

A computer program developed with Erasmus University in Rotterdam uses algorithms more usually found in stock market trackers to predict visitor behaviour. Thus armed, the museum has come up with incentives to reduce peak time visits by around 60 per cent, even while visitor numbers have increased by nearly half.

"We don't want as many visitors as possible, we want each visitor to have the best experience as possible," says Milou Halbesma, the Van Gogh Museum's director of public affairs.

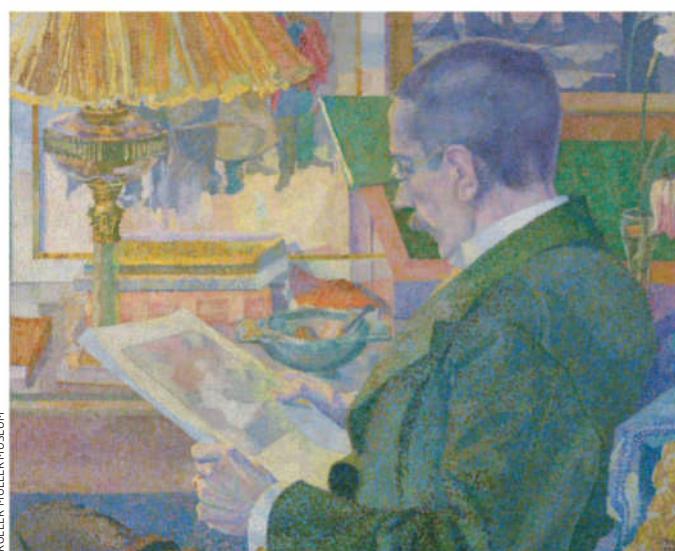


LONELY PLANET/GETTY

Amsterdam, also badly bottlenecked, is planning to adopt similar technology later this year to get tourists out of the city and into the rest of the country.

Technology can also satisfy demand, especially in Asia, by bringing van Gogh's art to the people. To this end, the museum has produced a digitally enhanced immersive experience, *Meet Vincent van Gogh*. It sounds hokey: visitors can wander with Vincent from rural Netherlands to the streets of Paris, pull up a seat at *The Potato Eaters*' table, and step into a life-sized *Yellow House*. In reality, the exhibition stimulates genuine interest, without leaving the visitor feeling cheated that they haven't been in contact with the real work.

The museum's limited run of Relievo reproductions take the opposite tack. Based on 3D scans of the paintings, including cracks in the paint and traces of paint



KRÖLLER-MÜLLER MUSEUM

Jan Toorop's *The Print Lover* helped make art accessible by the 1890s



layers, these surreally accurate reproductions took the museum and Fujifilm Belgium seven years to achieve. If you ever wanted to run your hand down the thick, impasto brushstrokes of van Gogh's *Sunflowers*, now is your chance. This approach was also targeted at the overseas market, especially Hong Kong. A Dubai hotel exhibited them in 2015.

The only downside is that these strategies increase the number of people who want to see van Gogh's real work. An exhibition currently at the Van Gogh Museum, Prints in Paris 1900, explores another very successful way of dealing with the sheer popularity of art and the celebrity of individual artists.

The fad for prints at the end of the 19th century not only decorated the hoardings and walls of Paris with colourful public art in the form of adverts, it also let everyone with a half-decent salary

own an "original". No two prints were identical – the imprimatur of the artist was visible and even, depending on the inks used, tangible. And the private nature of collections meant darker, more intimate themes could be explored by artist and collector.

Producing art ordinary people could own was a cultural as well as a technological breakthrough. But there is a snag, felt more sharply now than at the time these prints were produced. The low lighting at the Prints show reveals the vulnerability of works on paper. Unless these pieces are endlessly reproduced, dissolving their connection with the artist, they will have to spend almost all their life in storage, out of the public gaze.

The original is the gallery-goer's holy grail. When Mark Rothko's badly faded murals, painted for a Harvard University dining room, were rehung in 2014, an expensive

lighting system was used to restore their colour. Over-painting them would have been an act of sacrilege. No one thinks this way about buildings. St John's Cathedral, in the Dutch city of 's-Hertogenbosch, for example, had whole pinnacles reinstalled and some statues recarved from scratch. This process began in the 19th century, using easily weathered limestone, which

"Unless artworks on paper are endlessly reproduced, they spend their life in storage, out of public gaze"

means some of the most recently reinstalled figures are actually copies of copies.

Gallery-goers are less forgiving. "I think it should always be very clear for the audience what you are looking at," says Halbesma. "That is why we shall never show copies in our museum – because

Demand to see the original art of van Gogh increases every year

this is the moment when you meet Vincent and his work."

And the posters and prints upstairs? "They are all originals," Halbesma says. "But we have big problems because of the light and their vulnerability. A lot of museums are already working with facsimile." The implication is clear: catch this while you can.

Perhaps we should leave it to artists to determine what role provenance plays in their work. Van Gogh, desperate for that elusive sale, embraced the idea of reproduction. A letter to his brother Theo in December 1882 reads: "What I wrote to you in my last letter about a plan for making prints for the people is something to which I hope you'll give some thought one day. I don't have a fixed plan about this myself as yet... But I don't doubt the possibility of doing something like this, nor its usefulness."

The nearby Stedelijk Museum's recent show of kinetic sculpture by 20th-century Swiss artist, showman and mischief-maker Jean Tinguely shows a rather different attitude. Tinguely was no ordinary mechanic, and some of his work, such as *Hommage to New York*, was designed to burst apart in showers of sparks. His less self-destructive work is hardly more stable; the Stedelijk show had 42 moving pieces, rigged to timers to eke out the fun between the inevitable repairs.

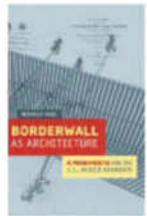
It reminded me of a story told by Midas Dekkers in his book *The Way of All Flesh* – and an important part of the story of provenance. The Stedelijk once had a piece of Tinguely's called *Gismo*. Tinguely insisted it should run constantly so the noise would lead people to it from wherever they were. A curator took him at his word, and for a brief, happy while, everyone got to see *Gismo*.

That's the trouble with art: if you want it to live, you may have to let it die. ■

A wall to end all walls

Making fun of Trump's border wall only makes its construction more likely, argues **Bruce Sterling**

Borderwall As Architecture: A manifesto for the US-Mexico Boundary by Ronald Rael, University of California Press



I HAVE the kindliest feelings for a wily academic who can create a 3D-printed teapot out of powdered tea. Better yet, Ronald Rael, a visionary architecture professor at the University of California's beautiful Berkeley campus, made that fine object into a "Utah teapot", the archetype of 3D printing that every student of the field admires.

Rael has an architect's morality, believing you should design and construct well-built structures that are sturdy, useful and pleasing to the senses. Like many architects – Rem Koolhaas in cold war Berlin, for instance – he is alarmed by the oppression and ugliness of border walls. Scholars don't get more inventive than Rael and I wanted to like his book rather more than I did.

Border walls exist to intimidate, discommode, exploit or even kill people. The Great Wall of China may have grown into a national icon, but working walls are ramshackle and ugly and they commonly fail: remember the Maginot Line, which failed to prevent the German invasion of France in the second world war?

Borderwall As Architecture goes into keen scholarly detail on the walls at the US-Mexico border. Rael is particularly upset about those in the San Diego-Tijuana border region. I have been there myself, and he is right, there is plenty to complain about.



MIKE BLAKE/REUTERS

If you have never heard how many migrants die of thirst in the deserts of the south-west US, or about the huge cost of the wall per metre, or how walls harm desert wildlife, or what a drag it is to be a US Border Patrol officer, you will learn a lot from this book.

The part of the book I should have most enjoyed is a series of

"Walls are ramshackle and ugly and they commonly fail: remember the legendary Maginot Line?"

paper-architecture interventions that might make the wall more humane. I quite like "architecture fiction", and, being a science-fiction writer, I'm quite happy to see someone ignore budget constraints in pursuit of the sense of wonder. So when Rael proposes turning the US-Mexican wall into a long, narrow marijuana farm, I get the joke. The cannabis

trade is obviously a major issue at the Mexican border. If the wall itself was the peaceful source of all that marijuana it could pay for itself!

Rael offers many such concepts in the book, which often have a whimsy about them that reminds me of Italo Calvino's *Invisible Cities*. But they don't advance the debate in the way that I suspect Rael imagines they will. If you are an anti-narco, pro-wall person and you are presented with a subversive conundrum of this kind, the mockery hardens your position. From a wall enthusiast, you become a polarised wall fundamentalist. You will build new walls just to spite humanistic Californian intellectuals like Rael.

Rael is too decorative. He is riffing on architectural solutions when planet-wide dynamics of terror, resentment and depression have, to take another example, already created a brand-new

The US-Mexico barrier in Jacumba, California, remains controversial

border wall around part of the French port town of Calais to keep migrants out of the UK.

Rael ends his book by expressing his dismayed astonishment that Donald Trump was elected US president on a pro-wall campaign. Before that election Rael's book might have felt prescient, liberating and forward-looking. Now it is hard not to read it as the relic of an kinder bygone era.

A manifesto is commonly a sheet of paper glued to a wall. As the walls multiply, many more manifestos will be needed, and they are going to have to engage people on a practical level. You would be surprised how long such a manifesto can last, and how fast a wall can crumble. ■

Bruce Sterling is a writer and critic based in Austin, Texas



A LIBRARY OF KNOWLEDGE... POCKET SIZED

GET UNLIMITED ACCESS TO
THE NEW SCIENTIST APP

Visit newscientist.com/app or call
1-888-822-3242 and quote offer 9055

FREE!
SAMPLE ISSUES
IN-APP



**New
Scientist**
Live Smarter

NewScientist Jobs

Incorporating ScienceJobs.com

To apply online visit newscientistjobs.com

East Coast Office
50 Hampshire Street
Cambridge, MA 02142
Email NSSales@NewScientist.com
Phone 781 734 8771

Calls may be monitored or recorded for staff training purposes



POSTDOCTORAL POSITION

Vascular smooth muscle and endothelial cell ion channels

Postdoctoral position immediately available to study physiological functions and pathological alterations in arterial smooth muscle and endothelial cell ion channels. Projects include studying blood pressure regulation by ion channels and regulation of trafficking, signaling and functions of TRP, BK_{Ca}, Kv and voltage-dependent Ca²⁺ channels, similar to studies we have recently published (Leo et al PNAS 2014, Kidd et al Science Signaling 2015).

Techniques in the laboratory include, RT-PCR, Western blotting, biotinylation, immunofluorescence, FRET, patch-clamp electrophysiology, calcium imaging, pressurized artery myography and blood pressure telemetry. Experience with molecular biology, ion channel biochemistry, electrophysiology, and cardiovascular physiology preferred.

Required qualifications include a PhD or MD in Physiology or a related field.

Send curriculum vitae and names and addresses of three references to Dr. Jonathan H. Jaggard, Maury Bronstein Endowed Professor of Physiology, Department of Physiology, University of Tennessee Health Science Center, 894 Union Avenue, Memphis, TN 38163, USA.

email : jjaggard@uthsc.edu.

Website : <http://physio1.uthsc.edu/~jaggard/index.php>

The University of Tennessee is an
EEO/AA/Title VI/Title IX/Section 504/ADA/ADEA employer.



Postdoctoral Position

Postdoctoral position for an extremely motivated researcher to study the role of urinary bladder smooth muscle ion channels (K+ and TRP channels) and their regulatory mechanisms is available at the Department of Pharmaceutical Sciences, College of Pharmacy, University of Tennessee Health Science Center (UTHSC) at Memphis, TN in the Laboratory of Dr. Georgi V. Petkov (E-mail: petkov@cop.sc.edu).

Applicants should have a PhD degree with a strong background in physiology, pharmacology, electrophysiology (patch-clamp and/or sharp microelectrodes), cell and molecular biology, bladder cystometry, and experience in animal handling and rodent surgery. A good background in urinary bladder smooth muscle function and regulation is strongly required. Applicants should be very skillful in setting up, care and use of laboratory equipment and have ability to develop new and improved methodology. Good communication and organizational skills, and excellent knowledge of English (both oral and written) are required.

Applicants should have demonstrated scientific productivity, have a strong publication record, be able to design and execute scientific experiments independently, write manuscripts, prepare and submit competitive fellowship applications, and assist with grant writing. Team player spirit and a dedicated attitude toward scientific progress are an absolute must. This position starts August 1, 2017 or thereafter. Please send a CV, letter of interest explaining relevant work experience, statement of research interests and career goals, and contact information for 3-5 referees to: Georgi V. Petkov, PhD, Professor and Chair, Department of Pharmaceutical Sciences, College of Pharmacy, University of Tennessee Health Science Center (UTHSC), Memphis, TN (E-mail: petkov@cop.sc.edu).



Postdoctoral Fellows:

Cancer Genetics, Epigenetics and Biomarkers

Multiple Postdoctoral Fellow positions are available for immediate recruitment for highly motivated candidates to join a team of researchers at the Baylor Scott & White Research Institute and Charles A Sammons Cancer Center, Dallas, TX, USA.

Research Description:

The laboratory headed by Ajay Goel, PhD focuses on understanding the interplay between genetic and epigenetic alterations in colorectal, pancreatic, gastric and esophageal cancers. We are a multidisciplinary research group, undertaking a number of collaborative projects involving large international consortia.

Job Description:

An ideal candidate should have a strong background in biochemistry and/or molecular biology, and relevant experience in cancer genetics and epigenetics. The candidates with prior hands-on experience in sequencing-based platforms (Ion Torrent PGM sequencer, MiSeq/HiSeq, RRBS, ChIP-Seq, MeDip and RNASeq etc.) and other array-based platforms will be given preference.

Under general supervision of the Director of the Center, the Post-Doctoral Fellow will continue to expand upon his/her previous research project. The position will continue to focus on developing the skills necessary to obtain grants and scientific publications and become an independent Investigator.

Qualifications:

Minimum Requirements: The candidate should possess the following criteria:

1. PhD and/or MD/PhD
2. Evidence of first author peer-reviewed publications
3. Prior molecular and/or cancer biology experience and evidence of project development
4. Excellent communication and writing skills.

Prospective candidates should be highly motivated, enthusiastic about science, with an ability to think creatively and independently.

Eligible and interested candidates can apply by sending a C.V. and Cover letter to the hiring recruiter **Dr. Amar Desai** amar.desai@sciunite.com



ARE YOU A PROBLEM SOLVER? COME GROW WITH US

We invest heavily in research and development that:

- Engineers stronger, longer-lasting, safer roads
- Produces better quality fertilizer to feed the world
- Optimizes the recovery of minerals needed for everyday products

Simply put, we strive to improve quality of life.

WE ARE GROWING AND NEED CREATIVE,
DISCIPLINED AND FUN-LOVING SCIENTISTS
TO GROW WITH US



THIS IS WHAT BETTER LOOKS LIKE

JOBS@ARRMAZ.COM

+1-863-578-1206

ARRMAZ.COM/NS



Together, we make the difference.

At Bristol-Myers Squibb, we're creating innovative medicines for patients like Grant who are fighting serious diseases. We're also nurturing our own team with inspiring work and challenging career options. No matter our role, each of us makes a contribution. And that makes all the difference.

**Visit us at the
2017 ASCO Annual
Meeting to learn
more about our
unique career
opportunities.**

Not an official event of the
2017 ASCO Annual Meeting.
Not sponsored or endorsed by
ASCO or the Conquer Cancer
Foundation.

Bristol-Myers Squibb is an equal opportunity employer. Qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability or protected veteran status.

© 2017 Bristol-Myers Squibb Company. Printed in USA.
All rights reserved. 4/17

models are not actual patients

Join us. bms.com/job-seekers



Bristol-Myers Squibb



Diversity drives discovery.

Become an NPP Fellow. Propel NASA's missions.



Fields of study include:

- Aeronautics and Engineering
- Astrobiology
- Astrophysics
- Biological Sciences
- Cosmochemistry
- Earth Science
- Heliophysics Science
- Planetary Science
- Technology Development
- Science Management

Image: Philip Lange/
Shutterstock.com

Apply now: npp.usra.edu

MY WORK IS A STORY OF PROGRESS.

What I do at Thermo Fisher sometimes makes an impact on the biggest news stories in the world. During the Ebola outbreak, our team developed a fast, flexible screening kit, and helped to train professionals in Africa to use the kits in monitoring the disease and controlling its spread.

When I first started at Thermo Fisher, I was part of the team that developed the world's first commercial instrument that detects and analyzes microorganisms in real time—ushering in the era of rapid molecular diagnostics. What's next? Our team is working to detect pathogens that cause black fever, among other diseases. At Thermo Fisher, I'm at the forefront of technology and innovation. Our work helps our customers create vaccines, speed diagnostics and monitor the spread of diseases—impacting the lives of millions of people around the world. If you're ready to make advancements in the world and in your career, you'll discover that at Thermo Fisher Scientific, each one of our 55,000 extraordinary minds has a unique story to tell. And we all contribute to a singular mission—enabling our customers to make the world healthier, cleaner and safer.

Junko

Senior Director, R&D

What story will you tell?



ThermoFisher
SCIENTIFIC

Explore opportunities at jobs.thermofisher.com

IMPACT TOMORROW, TODAY

As a leading, research-intensive biopharmaceutical company, Merck is on a quest to overcome some of the world's most serious health challenges. And today, we're investing in this vision with two future-focused exploratory science centers in both Cambridge, MA, and South San Francisco.

Right now, we're composing a team of scientifically-diverse individuals. Those inspired to invent with relentless curiosity and spirited collaboration.

Could this be you?

How will you invent for the future?

The world needs you.
Join us on our mission of invention at our MRL facilities:

SAN FRANCISCO

MRL San Francisco is built upon Merck's proven discovery capabilities and world-class expertise in small-molecules and biologics in R&D. This center focuses on breakthrough invention that radically changes how we approach and treat serious diseases in the following fields:
**Discovery Biology/Pharmacology/
Preclinical Development/
Translational Medicine**

CAMBRIDGE

At its Cambridge, Massachusetts facility, MRL is working to fuel early discovery research and pursue the most promising emerging science in the following fields:
**Microbiome/Bioinformatics/
Immuno-Biology/Host-Pathogen/
Molecular Innovation/
Chemical Biology**

merck.com/careers



Learn more about current opportunities with MRL Cambridge and San Francisco today.
Merck is proud to embrace diversity in all its manifestations EOE/M/F/D/V



MAKE A DIFFERENCE. TEACH NOW.

"I want my students to know that they are capable of success no matter their background or what anyone else may have told them."

-EnCorps Fellow Tyran Richards



Join a Fellowship of more than 600 EnCorps leaders across California making a profound impact by passing on their knowledge in science, technology, engineering and math to inspire the next generation. The EnCorps STEM Teachers Program empowers STEM industry experts to become exceptional teachers, tutors, and educators for the students who need them most.

Final application deadline: May 15, 2017


EnCorps
STEM TEACHERS PROGRAM
www.encorps.org

EDITOR'S PICK

Religion and motivation without gods



From Gregory Sams, London, UK

Someone from another planet reading Graham Lawton's article on faith and atheism might easily think the three Abrahamic religions and atheism are the only belief systems on the planet (15 April, p 32). Buddhists and Taoists do well without any creator god. The most worshipped deity in history, one

that even atheists can recognise, is our local star, which actually is the light of our life.

*From Robert Cailliau,
Prévessin-Moëns, France*

You quote David Sloan Wilson asking whether atheism can "motivate people to prosocial action, can it get you out of bed?" It probably motivates me indirectly: the aberrations of many religions make me, and others, work for a more just world with more people aware of reality.

*From Frank Aquino,
West Leederville, Western Australia*

The first human to realise they were going to die pretended gods would make a comfy afterlife. Atheism is the absence of self-delusion. All babies are born atheists; then the trouble starts.

Fossils... if only they could actually talk

*From Tony Waldron,
London, UK*

Whether *Homo naledi* could talk or not we will never know (29 April, p 6). We will certainly not be helped much by the study of brain casts that, at best, provides an imperfect picture of the anatomy of the brain.

Several other areas of the brain are important for talking and the comprehension of speech. Functional PET scanning confirms that connections are important in all aspects of brain function. We are certainly not going to be able to map out any of these in fossils, and so whether they could talk or not will have to remain a mystery.

It is understandable that anthropologists want to wring as much information as possible from the generally scanty remains

at their disposal. But they would do well to remember it is unwise to speculate if you can't validate.

At last, an explanation of simultaneous lightning

*From Ed Prior,
Poquoson, Virginia, US*

When I worked at NASA Langley Research Center in Hampton, Virginia, a number of astronauts on the International Space Station reported a huge number of lightning flashes happening simultaneously all over the planet. Some of them thought the flashes were somehow communicating with each other.

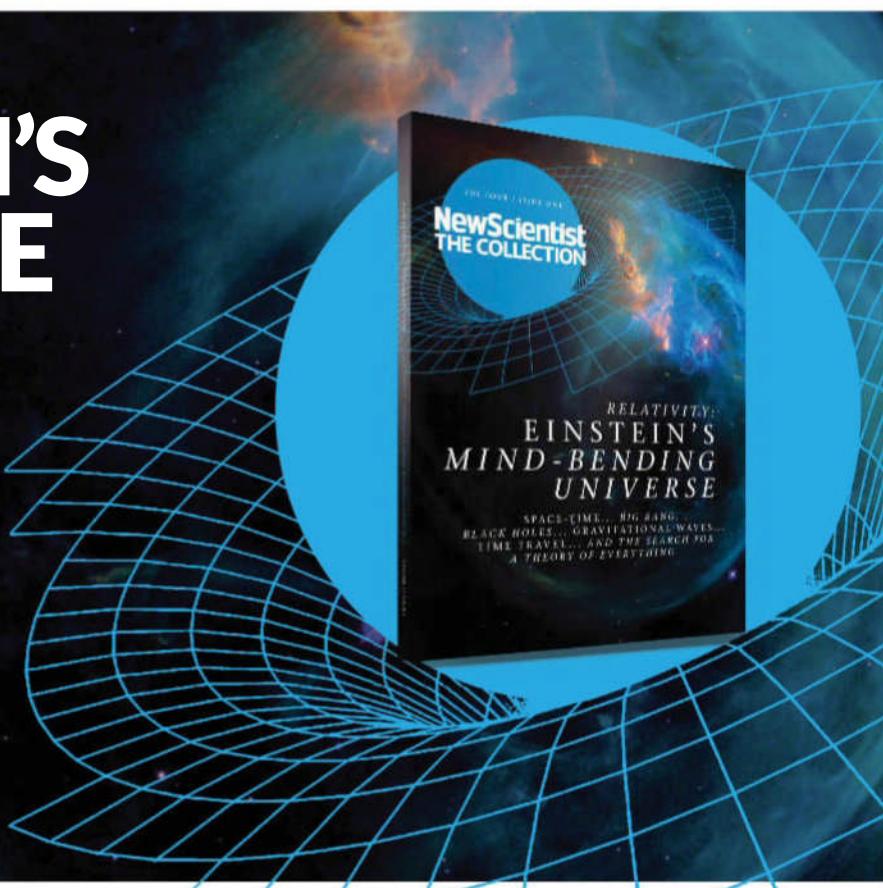
Shannon Hall discusses the billions of high-energy cosmic rays that crash into our atmosphere and their effect on thunderstorms (15 April, p 37). These could well be the worldwide trigger for lightning strikes.

EINSTEIN'S UNIVERSE

Get to grips with space-time, the Big Bang, black holes, gravitational waves, time travel and the search for a theory of everything.

Buy your copy from all good magazine retailers or digitally. Find out more at newscientist.com/thecollection

NewScientist





"We could use an extra dimension or two now – humanity is laying waste to what we know"

Maggi Carter is strangely heartened by the news that gravitational waves could show hints of extra dimensions (6 May, p 8).

How do other apes see us watching them?

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK
You accompanied Sam Wong's article on research suggesting that other great apes have a "theory of mind" with a rather provocative picture caption: "I know what you're thinking" (8 April, p 10). This prompted me to question further whether and how the apes may analyse us.

Do they see us as hairless and more intelligent versions of themselves, mirroring the way we might describe them as less bright, hairy versions of us? Do they comprehend the difference from their perspective as we comprehend it from ours?

Are they sufficiently aware of our potential that they should be afraid of us as, for example, the humans in the film *2001* came to

fear the computer Hal? And as far as they are concerned (with more than a casual nod to novelist Douglas Adams's concept of white mice running an experiment on us) exactly who is studying whom?

Carbon pricing: is this a cunning plan?

From Chris deSilva, Dianella, Western Australia
Michael Le Page describes the international community implementing a global carbon pricing scheme and imposing carbon tariffs on goods produced in the US (8 April, p 22). But may this be what President Trump wants to boost American manufacturing? If the rest of the world imposes tariffs on the US, it could impose retaliatory and punitive tariffs, protecting US manufacturers from foreign

competition. American industry would have the further advantage of lower energy costs as it would not have to pay for its emissions, or bear the costs of complying with a carbon trading scheme.

Compulsory consumption: you have been warned

From Peter Davey, Bournemouth, Dorset, UK
Roger Denison asks who will buy all the goods produced in automated factories (Letters, 29 April). Back in 1954, the American science fiction writer Frederik Pohl produced the novelette *The Midas Plague*, set in a future society in which the automated factories produce so much in the way of goods that, to prevent economic catastrophe, every citizen is required by law to consume so much food, drink, clothing, and so on, every day.

In a later story, the humans attempt to shut off the factories by blowing up their supply lines...

I hope that this is a case of "forewarned is forearmed".

Always look on the bright side of nuclear war

From Jocelyn Penny Small, New Brunswick, New Jersey, US
You warn us about the perils of a "local" nuclear war that would result "in a nuclear winter that would lower global temperatures for years" (22 April, p 5). Wouldn't that solve another problem, that of climate change?

The dreadful prospect of having been right

From Bruce Denness, Whitwell, Isle of Wight, UK
You say oceans could rise by 3 metres by 2100, topping the ➤

GALAXY ON GLASS



Spectacular wall art from astro photographer Chris Baker
Available as frameless acrylic mix or
framed backlit up to 1.2 metres wide.
A big impact in any room. All limited editions.

www.cosmologychris.co.uk

or call Chris now on +44 (0)7814 181647

www.facebook.com/galaxyonglass

2013 IPCC estimate by 2 metres (8 April, p 7). Thirty-odd years ago I pointed out that, at the end of the last ice age, sea levels rose by about 50 millimetres per year, equivalent to about 4 metres by 2100 starting now (13 February 1986, p 59). Yet, in so many ways, I hope I am proved wrong.

Understanding chemical bonds and energy stores

From Keith Ross,
Villembits, France

Anna Azvolinsky reports work on artificial photosynthesis (15 April, p 28). She writes that plants "store their energy... in chemical bonds. In other words they make fuel". This risks reinforcing the common misconception that energy is stored in bonds.

The point – counter-intuitive to some – is that strong chemical bonds are strong because they have lower energy than others, and more energy must be added to break them. Photosynthesis breaks strong bonds in water and carbon dioxide using energy from sunlight. The new bonds that form are weaker. The bonds in

carbohydrates, and indeed fossil fuels, are quite strong – it is the very reactive gas oxygen that has the weak bonds.

The problem with saying that energy is stored "in the fuel" is that people then think there are "energy-rich" bonds in the fuel, where the energy is somehow stored. In fact the energy is stored because oxygen and fuel have been separated, and it is the replacement of weak bonds in oxygen by strong bonds in the oxides that actually packs the punch. It takes energy to break bonds – they do not store energy.

Whale stranding and valued remnants

From Brian Collins,
Wellington, New Zealand

I enjoyed Geoffrey Patton's story of rescuing whales on the US eastern seaboard (Letters, 18 March). There are many more whale strandings in one part of Aotearoa or New Zealand – "Farewell Spit" in the north of the South Island.

I call this hook-shaped spit "the scythe of death". Once stranded

there, the magnificent mammals stay stranded. Volunteers assist workers from the Department of Conservation to refloat them but, as happens in Florida, the whales appear to have a death wish and head back to shore, to be refloated again. When they are exhausted they are euthanised.

Maori people consider much of their carcasses to be *taonga* – an object or natural resource that is highly prized. The teeth of some of these whales are used for carving. When I was teething, I was given either a whale or a shark tooth that had been rubbed smooth to bite on and encourage my milk teeth to push through my gums.

Clues to brain size from coding knowledge

From Chris Reynolds,
Tring, Hertfordshire, UK
Carl Zetie discusses why we have never filled up a brain (Letters, 22 April). Since 1970 I have worked on CODIL, an unconventional computer programming or information language to handle poorly structured information. The original research looked at

how humans and computers might work together on complex tasks. I now see a relationship between the brain's neural nets, language and intelligence.

It seems to me that initially, brain size is related to the time spent on trial-and-error learning in a single lifetime. The invention of a self-modifying language is a major tipping point. One generation can pass information to the next as abstract concepts, reducing trial-and-error learning times. High-level generalisations need less storage space and the savings increased as language became more sophisticated.

Further, civilisation allows us to call on shared knowledge and books so we no longer need brains as big as those of our pre-language ancestors in order to survive, and are actually left with some spare capacity to enjoy science, the arts, and the world around us.

Maybe that's not such a knotty problem

From Steve Dalton,
Chipstead, Kent, UK
You report researcher Christine Gregg jogging on a treadmill to capture details of her shoelaces unravelling (22 April, p 19). I suspect a major contributor to loose laces is the difference between kinds of knot. After a friend pointed this out to me I spend a lot less time seeking low walls and high steps.

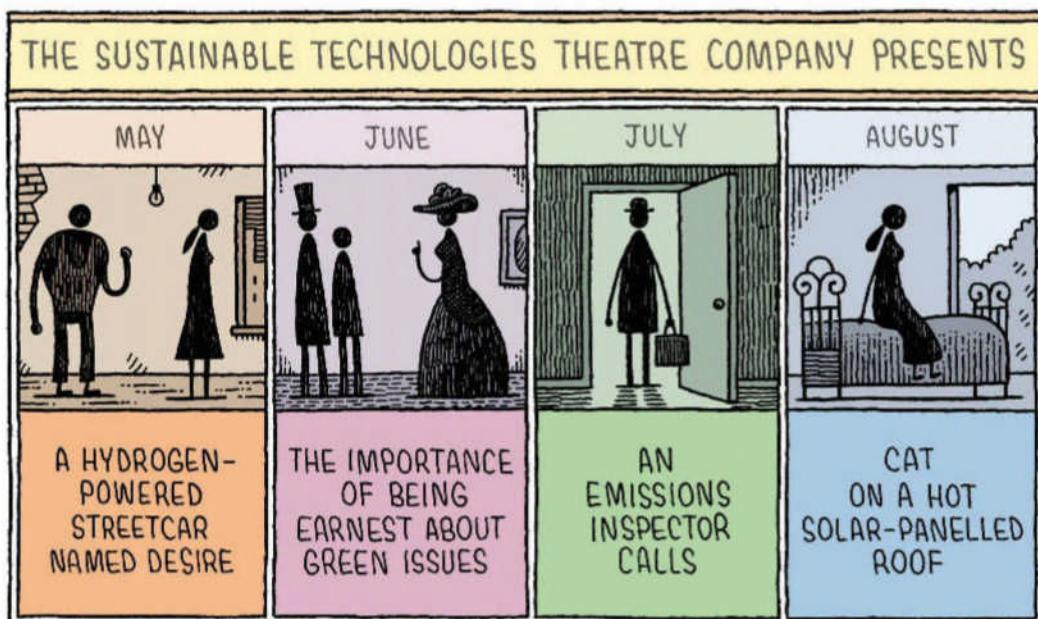
For the record

■ The haddock hanging out around 85° North were 550 kilometres from the Pole (8 April, p 32).

Letters should be sent to:
Letters to the Editor, New Scientist,
110 High Holborn, London WC1V 6EU
Email: letters@newscientist.com

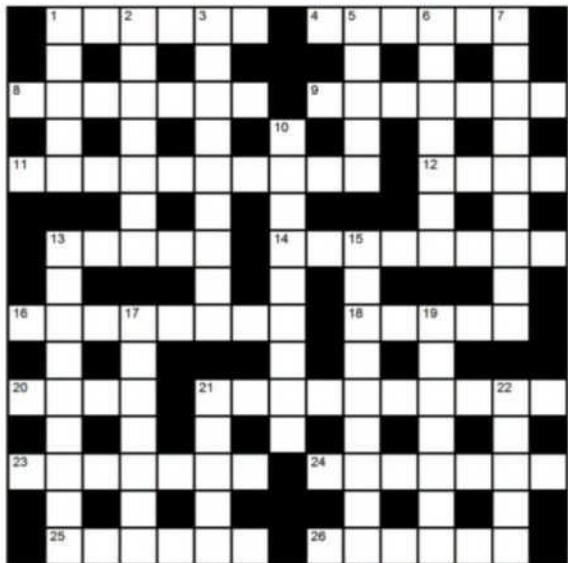
Include your full postal address and telephone number, and a reference (issue, page number, title) to articles. We reserve the right to edit letters. Reed Business Information reserves the right to use any submissions sent to the letters column of *New Scientist* magazine, in any other format.

TOM GAULD



CROSSWORD

Compiled by Richard Smyth



Crossword No6

ACROSS

- 1 Lamp used to produce rapid, regular flashes of light (6)
4 Genus of long-lived deciduous trees with barrel-like trunks (6)
8 Lise ___ (1878-1968), Austrian-born physicist (7)
9 Type of organic compound used in certain superglues and polymers (7)
11 Rock formation suspended from a cave ceiling (10)
12 *A Brief History of ___*, 1988 work by Stephen Hawking (4)
13 Relating to the kidneys (5)
14 Camillo ___ (1868-1943), electrical engineer, founder of a firm known for typewriters and other office technology (8)
16 The genetic constitution of ___
an organism (8)
- 18 Alfred ___ (1833-1896), Swedish chemist, engineer and inventor of dynamite (5)
20 Noxious form of urban air pollution (4)
21 Timepiece also known as a clepsydra (5,5)
23 Descriptive term for a compound that contains tin (7)
24 In anatomy, a protective covering, as found in human hair follicles and nails (7)
25 Missile or aircraft such as the German V-2 or the American Saturn V (6)
26 In medicine, the exit of an organ through the body's cavity wall (6)

DOWN

- 1 Small fish related to the salmon (5)
2 Proprietary drug used in the treatment of attention deficit hyperactivity disorder (7)
3 ___ Park, UK WW2 code-breaking centre (9)
5 Organic compound with a six-membered aromatic heterocycle (5)
6 Laboratory glassware for delivering known quantities of liquid (7)
7 Hard alloy of copper and tin used in the manufacture of resonant percussion instruments (4,5)
- 10 Unit that may be written as 10^3 Hz (9)
13 Instrument for measuring viscous stress in a liquid (9)
15 Component of a pneumatic tyre (5,4)
17 Of a chemical compound, containing carbon (7)
19 1,000,000,000 (7)
21 Colour perceived when light stimulates the eye's three types of cone cell in equal amounts (5)
22 Hair-like organelles projecting from a cell body (5)

Answers to Crossword No5

ACROSS: 1 NANOTECHNOLOGY, 10 OKAPI, 11 GEODESIST, 12 FLOW NET, 13 BACILLI, 14 ENEMA, 16 OPERCULUM, 19 METHYLENE, 20 DEBUG, 22 DECAPOD, 25 TORNADO, 27 CARBONADO, 28 BRINE, 29 LARGE INTESTINE. **DOWN:** 2 AHA MOMENT, 3 ORION, 4 EIGHTY ONE, 5 H-BOMB, 6 OLEIC ACID, 7 ORIEL, 8 YTTRIUM, 9 COFFEE, 15 ASYMPTOTE, 17 ELECTRODE, 18 LIBRATION, 19 MEDICAL, 21 GEODES, 23 CORER, 24 DRAIN, 26 ROBOT.

NewScientist Connect

LOOK FOR YOUR HERO ON NEW SCIENTIST CONNECT

Find your hero (or heroine) on New Scientist Connect – there are plenty to choose from.

Meet like-minded people who share similar interests to you – whether you're looking for love, or just to meet someone on the same wavelength, no matter where you are in the world.

Start your search now at:

<http://dating.newscientist.com>

Join now
**FOR
FREE**





IAN FRENNEY appealed to readers for examples of "retronyms" - words made by sounding out the individual letters of an acronym (22 April). He offered emcee, okay and kayo, to which we added Jeep, from the US army's General Purpose vehicle.

"There are many more examples of retronyms in common use, quite a number relating to military vehicles or aircraft," writes Cedric Lynch.

"The successor to the Jeep, the High Mobility Military Wheeled Vehicle (HMMWV), is usually called the Humvee." He also cites the Iroquois Utility Helicopter, whose original designation HU-1 lent it the nickname Huey.

PUTTING a tiger in our retronym tank, Jake Burger suggests the petroleum brand Esso, "which takes its name from the phoneticised initials for Standard Oil, as the company was known prior to 1911".

And a few minutes with Chambers has Douglas Woodall delivering a patter of retronyms,

"I've just started using a bottle of what Tesco describes as 'Ocean Bleach,'" says Tony Compton. "I hope it doesn't affect corals."

PAUL MCDEVITT

including deejay, veejay, jaycee (a member of the junior chamber of commerce), tee-tee (a teetotaller), and "veep, for vice-president".

AND how could we forget fraternal falsetto pop trio the Bee Gees? They took their stage name from the shorthand for Brothers Gibb, Bryn Glover - a B.G. himself - reminds us. And that a BBC channel devoted to children's programming goes by the somewhat fractured retronym CBeebies.

Bryn also offers a rare single letter retronym - pee - which he suggests might be derived from the truncation of a less-savoury word for the act.

DELVING into foreign tongues for retronyms, Stuart Arnold remarks "I thought German would have a lot of them, as Germans love making words from contractions of others." The most obvious one, he says, is the supermarket chain Edeka "which is the German pronunciation of EDK, for the company *Einkaufsgenossenschaft*

der Kolonialwarenhändler". Another "is Kadewe, KDW, the *Kaufhaus des Westens*." All in all, a great start. Are there any more?

AUSTRALIAN chiropractor Bernard Nadolny is in the doghouse after being prosecuted for treating animals for reward without a veterinary licence. The bone-knocker saw cats and dogs at his practice, diagnosing diseases such as cancer and arthritis.

"I've treated racehorses, ponies, foals, llamas, alpacas, birds, chooks," Nadolny boasted to Australia's *The Sunday Mail* in 2006, "Their structure is almost the same as ours." Take that, medical specialism!

Over at ReasonableHank.com, you can see a collection of chiropractors performing their manipulations on the furry and feathered (pictures garnered from their own websites). This includes a photo of one attempting to adjust the spine of a turtle. Baffling, perhaps. Just don't call it turtle-y bogus.

AMID all the bad news, something shines. *The Guardian* reports that scientists at the Hebrew University of Jerusalem in Israel have developed pellets loaded with genetically engineered bacteria that glow in the presence of explosives. This allows them to identify the location of hidden landmines.

Feedback is also excited by the possibility that the technology might one day be used in other areas where you might need to watch your step: could we see paving slabs that light up in the presence of dog mess? Until that comes to pass, we must renew our campaign to have glow-in-the-dark glitter added to pet food as standard.

JON LULY sends news of a kind of fruitloopyery that he worries may be self-correcting. He is talking about the healing stones known as green zebra jasper, dragon scale stone, or chrysotile.

Online retailer Raven Crystals tells us the green and white banded rock is "an excellent stone for supporting

honesty and sincerity", and "the visual patterns may provide a link to ancient knowledge".

Indeed, those powdery stripes running through the stone should prompt any good geologist to draw on their ancient knowledge and call this mineral by its other name: white asbestos.

Earlier this year, the Queensland government issued a safety alert over the sale of chrysotile, which had appeared in shops as finished pendants and as "raw rock for carving", and reminded citizens that the import, manufacture, supply and sale of asbestos-containing products was banned in 2003.

We admit the stone does seem to be working its honesty and sincerity powers on the proprietor of Howl at the Moon Gems, who opts not to sell the poisonous product and informs customers "if you want a great stone for working with the



Crown or Heart Chakra, it is my personal opinion that you could make much wiser choices than this particular one".

WATCH the pennies, and the pounds will look after themselves, the saying goes. John Culver finds Virgin Mobile doing just that, as he tells us: "My latest phone bill has a card processing fee that has been calculated to 16 decimal places." Every little helps!

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

Blood sausage

A full mosquito must be much heavier than an empty one – and they can consume a lot of blood. What is it about the mosquito that allows it to carry such a heavy load? And what is the percentage increase in body weight between a mosquito that hasn't had a meal of blood and one that has? How does its pro rata load-carrying ability compare with that of, say, a buzzard or vulture, which must also gorge when the opportunity presents itself?

Only female mosquitoes consume blood, because they need a source of protein and iron to ensure their eggs develop properly. After feeding, a female digests the blood for several days before laying her eggs and setting out to locate another meal. Following each of these, her weight can increase by as much as 300 per cent. In contrast, a vulture can only eat about 10 per cent of its body mass in carrion (up to around 1 kilogram).

Both mosquitoes and vultures must gorge themselves when they get the chance. However, both also need to fly to escape predators, find food and so on, so they can't be totally weighed down by what they eat. The difference between their respective food-carrying abilities comes down to size, and particularly the ratio between muscle strength and body mass.

A muscle's strength is proportional to its cross-sectional area, and an animal's mass is proportional to its volume. The

volume of an animal decreases more sharply than the muscle cross-sectional area as the animal under consideration gets smaller, so a mosquito is "stronger" than the much larger vulture and can take on a greater pro rata load. This also explains why other insects, such as ants, can lift objects that are many times their own body mass.

If a vulture ate three times its own body mass – as a mosquito does – it wouldn't have the strength to lift itself off the ground. In fact, some vultures vomit from their crop (a special food storage sac near their throat) when threatened by a predator to enable them to make a speedier getaway.

*Sam Buckton
Chipperfield, Hertfordshire, UK*

Hamsterverse

Whenever I read a description of the multiverse, it always talks about human decisions causing branches. What about animals and the decisions they make? Does my hamster deciding to eat the apple first rather than the pea cause a new branch?

The idea that human decisions cause branches is a literary rather than a scientific one (perhaps due to the idea that time travellers can create a new timeline through their actions in the past).

The scientific view, put forward by Hugh Everett III in 1956, is that quantum events cause branching. This was an attempt to explain

why the Schrödinger wave equation describes the probabilities of various outcomes rather than one fixed outcome, as occurs in classical physics. For example, when a photon hits a semi-silvered mirror, the equation describes a 50 per cent chance of reflection and a 50 per cent chance of transmission. Various ideas had been proposed, but Everett suggested taking the equation at face value.

If it describes two outcomes, that's because there are two outcomes and both occur – they just occur in different branches of the multiverse. This has the advantage of not needing any new physics, but the disadvantage of having to explain exactly how the probabilities give rise to branches (this is still being argued over).

In addition, it posits a vast number of almost undetectable parallel universes. But the existence of unseen infinities has never put scientists off – at least it hasn't since they recovered from Giordano Bruno being convicted of heresy for suggesting something very similar 400 years ago.

*Charles Goodwin
Auckland, New Zealand*

Hugh Everett III's relative state formulation of quantum mechanics is the basis of the "many worlds" interpretation (you can see his original PhD thesis at to.pbs.org/2mxiOqx).

This makes no reference to conscious decision-making and doesn't need to invoke the

concept of mind or free will at all. Instead, Everett imagined purely physical objects interacting, such as machines and recording devices – indeed any physical interaction that leaves a trace.

Each of these interactions then "causes" a branching of the universe. So you interacting with your environment, or your hamster with its surroundings, or even a single photon scattering off a macroscopic mote of dust, will lead to branching in the many worlds picture.

Although this appears to give rise to a dizzying infinity of branches (worlds), all observers can only ever be aware of one world: the one associated with all the recorded outcomes of all the interactions they themselves could, in principle, go and check. All the other possible worlds with different outcomes don't interact with, or have any influence on or observable consequences for, the observed world.

*Nick Canning
Coleraine, Co. Londonderry, UK*

This week's question

SKY HIGH

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

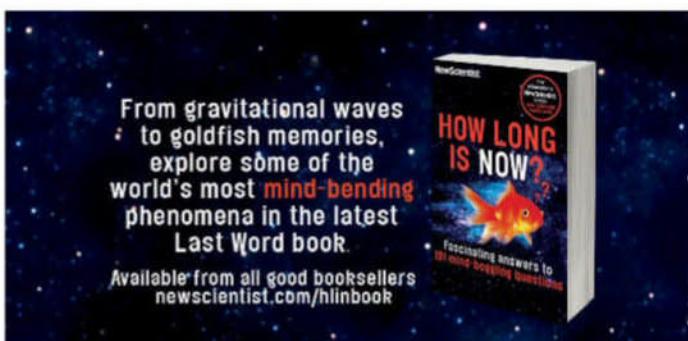
*Nick Ewans
London, UK*

The writers of answers that are published in the magazine will receive a cheque for £25 (or US\$ equivalent). Answers should be concise. We reserve the right to edit items for clarity and style. Please include a daytime telephone number and an email address if you have one. New Scientist retains total editorial control over the published content.

Reed Business Information Ltd reserves all rights to reuse all question and answer material that has been

submitted by readers in any medium or in any format and at any time in the future.

Send questions and answers to The Last Word, New Scientist, 110 High Holborn, London WC1V 6EU, UK, by email to lastword@newscientist.com or visit www.newscientist.com/topic/lastword (please include a postal address in order to receive payment for answers). Unanswered questions can also be found at this URL.





Professor Dame Carol Robinson

2015 Laureate for United Kingdom

By Brigitte Lacombe



Science needs women

**L'ORÉAL
UNESCO
AWARDS**

Dame Carol Robinson, Professor of Chemistry at Oxford University, invented a ground-breaking method for studying how membrane proteins function, which play a critical role in the human body.

Throughout the world, exceptional women are at the heart of major scientific advances.

For 17 years, L'Oréal has been running the L'Oréal-UNESCO For Women In Science programme, honouring exceptional women from around the world. Over 2000 women from over 100 countries have received our support to continue to move science forward and inspire future generations.

JOIN US ON [FACEBOOK.COM/FORWOMENINSCIENCE](https://www.facebook.com/forwomenninscience)