# New Scientist

**WEEKLY** June 3 - 9, 2017

**HEARD IT THROUGH THE SPACEVINE**
The plan to listen to Jupiter's moons

**MONKEY WITH MENACES**
Macaques steal your stuff then make you buy it back

**BLUE POOP**
Color-coded feces to diagnose diseases

**EDITING HUMANS** China marches ahead in the CRISPR revolution

# IRRESISTIBLE?

## Greed is in your genes – but you can beat it

No3128
US$6.99 CAN$6.99

Science and technology news
**www.newscientist.com**
Spring Diversity Issue

**GIFT OF THE GAB** How young children learn language so easily

# CONTENTS

Volume 234 No 3128

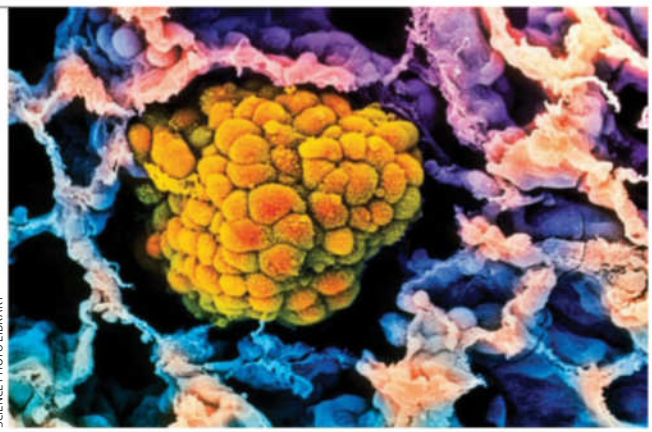
**This issue online**
newscientist.com/issue/3128

## News

# 6

### Editing humans

China forges ahead in the CRISPR gene-editing revolution



SCIENCE PHOTO LIBRARY

## On the cover

# 30

### Irresistible?

Greed is in your genes – but you can beat it




## Features

# 38

### Gift of the gab

How young children learn language so quickly

MARIE GENEL/PICTURETANK

## Coming next week...

**The particle that made the universe**
Why the Higgs is about more than just mass

**Fragrant stink**
Are perfumes damaging our health?

recycle
When you have finished with this magazine please recycle it.

## Leader



## News



## Analysis



## Aperture



## Features



## Culture



## Regulars


# Baja whale-watching expedition

**Witness the gathering of grey, blue, fin, sperm and humpback whales on an unforgettable 12-day sailing expedition around the Baja California Peninsula**

DEPARTURE:

**23 JANUARY 2018**

**11 days from £4895 per person**

## EXHILARATING WHALE WATCHING

Between December and April, grey whales migrate to the warm, calm waters of the Baja California Peninsula to calve and to nurture their young. Sail through this magical area to spot an abundance of marine life, including majestic grey whales, on small expedition vessel the Searcher.

## LEARN ABOUT MARINE CONSERVATION

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

## GET CLOSE TO BREATHTAKING MARINE WILDLIFE

From the decks of the Searcher, or in a smaller boat known as a panga, experience unparalleled whale watching from the waters. Be guided by the passion and knowledge of Art Taylor, owner and captain of the vessel, who has been navigating the peninsula for more than 30 years.

We've teamed up with Steppes Travel to offer readers a chance to get close to marine wildlife, with naturalists for company.

SPEAK TO OUR WILDLIFE TRAVEL EXPERTS TODAY

Visit **newscientist.com/Baja** or call **+(44) 01285 600 129**

SteppesTravel

NewScientist

**LOCATIONS**
**USA**
45 Prospect St
Cambridge, MA 02139
Tel +1 781 734 8773

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

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

**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 +1 781 734 8773
news@newscientist.com
features@newscientist.com
opinion@newscientist.com

**Picture desk**
Tel +44 (0) 20 7611 1268

**Display advertising**
Tel +1 781 734 8773
displaysales@newscientist.com

**Recruitment advertising**
Tel +1 781 734 8773
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



New Scientist ISSN 0262 4079 is published weekly except for the last week in December by New Scientist 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


JUTIN KASE/Z12Z/ALAMY

# A burden shared

## We can tackle obesity, but only through collective action

YOU can't be fat and fit. That was the take-home message of a big study published last month, which found that people with obesity are much more likely to develop cardiovascular diseases even if they don't have warning signs such as high blood pressure.

The busting of the "fat but fit" myth might be bad news for people who are already obese. But for society as a whole, it is good news. Over the past decade, obesity has gradually slipped off the health radar. It is now so commonplace that it has been normalised, and the idea that you can be obese without paying a heavy price has helped foster complacency.

In truth, the obesity epidemic is still a huge health issue. Every generation born since 1946 has been heavier than the previous one, and those at the extreme end of the spectrum are growing ever larger. Obesity puts people at risk of a long list of health problems, including heart disease, diabetes, cancer and mental health issues, and the fatter people get, the worse the prognosis.

At the same time, our approach to treating obesity has put too much emphasis on individual action – diet and exercise – and on pharmacological quick fixes that fail to materialise.

The more we learn about the drivers of obesity, the clearer it becomes that these fixes won't work. We now know, for example, that genetic differences make some people more prone to overeating than others, a fatal problem in today's obesogenic environment (see page 30). But there is also growing evidence that simple, common sense strategies can make a real difference to your waistline.

For example, making junk food less prominent in supermarkets or at buffets can make you less likely to eat it. Restricting the marketing of junk food limits its desirability, and borrowing food industry tactics – like putting cartoon characters on packets of raisins – makes healthy food more appealing to children. Paying people to eat better also works, at least in studies, as does taxing junk food. Tools like these have made obesity researchers cautiously confident that the tide can be turned.

**"Over the past decade or so, obesity has gradually slipped off the health radar"**

But showing that they work in clinical trials is one thing. Rolling them out more widely is another.

There are a few positives. Next April, for example, the UK will start taxing sugary drinks, which should reduce obesity. Unsurprisingly, the move is being resisted by the drinks industry, which argues that it would harm small businesses and cost jobs. They are not saying, note, that it wouldn't reduce obesity – surely an admission that it would.

Such corporate pressure often carries the day. In the US, the Food and Drug Administration wants menus to display calorie counts – a strategy that has been found to help people lose weight. The rule was supposed to come into force last month, but is being stalled by lobbyists.

The pattern is familiar from other public health debates that pit private interests against those of wider society, such as minimum alcohol pricing and plain cigarette packaging. Under these circumstances, corporations will always aim to privatise profits while socialising the risk.

Our new understanding of the causes of obesity makes it clear that we need to socialise the solution. The architects of today's food environment – and tomorrow's obese patients – need to decide whether protecting profits is really more important than sensible collective action. ■

DAVID SUCSY/GETTY

# Climate suing goes global

IF YOU can't beat them, sue them. Citizens are increasingly taking governments to court over climate change inaction, with financial lenders – and possibly big energy firms – next in the firing line.

Some 894 climate change cases have now been filed in 24 countries, according to a report published last month by the United Nations Environment Programme and Columbia University's Sabin Center for Climate Change Law in New York.

Most – 654 – have been in the US, followed by Australia (80) and the UK (49). The number of countries with climate cases has tripled since 2014. Citizens have filed nearly all of them against governments, with a handful lodged against fossil fuel companies.

Separately, campaign group ClientEarth wrote last month to energy giants BP and Glencore warning them they risked investor lawsuits because of over-optimistic statements about future fossil fuel demand in their reporting.

Some climate cases have already been won. But their success rate is likely to grow following the Paris Agreement, says the report. Under the accord, which entered into force last November, each country is committed to specific emissions targets. Although these aren't legally binding, they make it "possible for constituents to articulate more precisely and forcefully concerns about the gaps between current policy and the policy needed to achieve mitigation and adaptation objectives", say the report authors.

This is already starting to take effect. In March, Earthlife Africa Johannesburg successfully challenged the South African government's approval of a coal-fired power station. The high court ruling was partly based on the country's commitment to the Paris Agreement.

Banks and other firms who lend money to fossil fuel projects may also find themselves the subject of legal action, says Brendan Sydes at Environmental Justice Australia.

The growth of such litigation worldwide shows that many citizens hope courts can force governments and corporations to act on climate change, say Sydes. "People are increasingly turning to the courts to find [out] the duties and obligations of governments and corporations who are currently not acting sufficiently on climate change," he says. "This trend is likely to continue."

## Lost sea world seen

IT'S like going back in time. The US National Oceanic and Atmospheric Administration's Okeanos Explorer ship has spent three weeks exploring the Pacific between American Samoa and Hawaii. Some of the animal behaviour it recorded has previously been documented only in fossils hundreds of millions of years old.

"For all of the places we went, it was the first time we were getting to have eyes down in the deep sea," says Scott France at the University of Louisiana. Those eyes come in the form of remote submersibles that light up the sea floor and transmit live video.

**"We saw brittlestars capturing a squid and then there was a tussle over who got to eat it"**

"We saw brittlestars capturing a squid from the water column while it was swimming," says France. "I didn't know that was possible. And then there was a tussle among the brittlestars to see who got to have the squid."

The team also saw snails on sea lilies, a type of crinoid. "The snail seemed to be eating a crinoid. No one had seen this before," says Del Bohnenstiehl at North Carolina State University. This was only seen in the fossil record previously.

## Trump's ocean cuts

THE US Marine Mammal Commission, an organisation charged with restoring mammal populations in the world's oceans, is set for the chop in President Donald Trump's planned 2018 budget.

The proposal, released on 23 May, includes a 16 per cent cut to the bodies and agencies of the National Oceanic and Atmospheric Administration. This would close down the MMC, an independent federal agency that costs around

$3.4 million a year, or around 1 cent per US citizen.

The commission sees itself as a "one-stop shop" for marine mammal science and policies, says chairman Daryl Boness. It uses the latest science to ascertain the impact of human activities in the ocean, including shipping, military exercises and fossil fuel extraction.

"The commission's role as an oversight agency on all issues related to marine mammals is unique. No one else in the world meets this mandate," says Boness. So cutting its funding would end this service, he says.

## Space kiwis

NEW ZEALAND has lift-off. The nation launched its first rocket on 24 May, making it the 11th country with space launch capabilities. After a series of delays caused by inclement weather, the Electron rocket, made by California-based Rocket Lab, lifted off from the Mahia peninsula on New Zealand's North Island.

The company expects to perform three more test flights in New Zealand this year before starting to send satellites and other payloads into orbit 500 kilometres above Earth. Rocket Lab is using the New Zealand launch pad partly because the airspace there is far less crowded than that over the US.

The Electron rocket is relatively small, at 17 metres tall, so each launch only costs about $5 million. In comparison, SpaceX's Falcon 9 rocket is 70 metres tall, with launches costing upwards of $60 million. That would make Electron an inexpensive option for small satellites and CubeSats, which will be able to hitch a shared ride to space for just $77,000 apiece.

Rocket Lab already has contracts to ferry things into space for several organisations including NASA and US-based company Moon Express.

## Targeting cancer

A DRUG that finds and fights cancer wherever it is in the body has been approved in the US for the first time.

Pembrolizumab helps the body's immune system fight cancers that carry particular signatures on the surface of their cells, regardless of where the tumour is or where the cancer began. Last week, the US Food and Drug Administration approved the drug for treating people who test positive for either of two signatures.

"Until now, the FDA has approved cancer treatments based on where in the body the cancer started," says Richard Padzur of the FDA.

"This approval marks the start of a new era in how we think about cancer therapy," says Peter Johnson, chief clinician at the charity Cancer Research UK.

**"This approval marks the start of a new era in how we think about cancer therapy"**

Pembrolizumab has previously only been approved for cancers of known origin, such as lung cancer and metastatic melanoma.

## Jupiter's astonishing new look

SPECTACULAR pictures of Jupiter from NASA's Juno mission are helping to turn our ideas about the planet upside down.

Juno has revealed monstrous cyclones churning over Jupiter's poles that are more turbulent than scientists expected. The $1.1 billion spacecraft spotted the chaotic weather once it began skimming the poles' cloud tops last year, surprising researchers who assumed the giant gas planet would be relatively boring and uniform.

Finding dozens of huge cyclones hundreds of kilometres across means that the poles look nothing like Jupiter's equatorial region, which is recognisable by its stripes and Great Red Spot (*Science*, doi.org/b7s3).

"When you look from the pole, it looks totally different. I don't think anybody would have guessed this is Jupiter," says Juno's chief scientist Scott Bolton at the Southwest Research Institute in Texas.

Citizen scientists processed the images to reveal the impressive level of detail seen, although they don't give an accurate representation of what you would see with the naked eye from Juno's position.

Juno has also spotted white ice caps on Jupiter – frozen bits of ammonia and water. It has detected a vast abundance of ammonia deep down in the atmosphere, and a surprisingly strong magnetic field in places that is roughly 10 times greater than Earth's.

NASA/JPL

Swirls at the north pole

## 60 SECONDS

### US climate decision

President Donald Trump has said he will make a final decision this week on whether the US will stay in the Paris climate agreement. He made the surprise announcement on Twitter on 27 May after resisting pressure from European leaders at the G7 summit last week in Italy to commit to staying in the pact.

### AlphaGo's last victory

DeepMind's Go-playing artificial intelligence has trounced the world's top player, winning all three of its games against Ke Jie at a Go summit in Wuzhen, China. AlphaGo will now step back from competitive play and the researchers behind it will work on other projects, including using AI to seek cures for diseases, DeepMind said in a blog post.

### Antibiotic fightback

The crucial antibiotic vancomycin has been modified in a way that could make it far more powerful against some resistant bacteria. Experiments that repeatedly exposed bacteria to the drug suggest this altered compound may remain potent for many years (*PNAS*, DOI: 10.1073/pnas.1704125114).

### Shopping spies

Google wants to start tracking your offline purchases. Soon shops that collect email addresses will be able to import transactions into Google's AdWords system to see if online adverts convert into physical sales. The feature was announced at the Google Marketing Next conference in San Francisco last week.

### Mature vision

The part of the brain that processes vision seems to develop for decades longer than we thought. A study of post-mortem samples found evidence that the visual cortex only reaches maturity at about 36 (*The Journal of Neuroscience*, doi.org/b7sw). This means conditions such as "lazy eye" may still be treatable after the first few years of life.

# Boom in gene-editing clinical trials

A revolution in medicine is picking up pace, finds **Michael Le Page**

THE CRISPR genome editing revolution continues to advance at an astounding pace. As many as 20 human trials will be under way soon, mostly in China, *New Scientist* has learned.

One of these trials will involve the first-ever attempt to edit cells while they are inside the body. The aim is to prevent cervical cancers by using CRISPR to target and destroy the genes of the human papillomavirus (HPV) that cause tumour growth. This study is due to begin in July at the First Affiliated Hospital of Sun Yat-Sen University in China.

Gene therapy, which involves adding extra genes to cells, was first used to cure people in 1990, but it is mainly useful for treating rare genetic disorders. In contrast, gene-editing, which involves altering existing genes inside cells, promises to treat or cure a much wider range of conditions, from HIV infection to high blood cholesterol.

The first gene-editing trial in humans started in 2009. Doctors removed immune cells from people with HIV, disabled the gene for the CCR5 receptor – which the virus uses to get into cells – and returned the HIV-resistant cells to the body. The treatment appears to keep HIV in check.

**"One of these trials will involve the first-ever attempt to edit cells inside the body"**

But subsequent progress in gene editing was slow because developing a way to target each particular sequence is costly and time consuming. All that changed in 2012 when CRISPR genome editing was developed, making it cheap and easy to target almost any sequence.

The first clinical trial involving CRISPR began at the West China Hospital in Chengdu in October 2016. Doctors removed immune cells from the blood of a person with lung cancer, used CRISPR to disable a gene called *PD-1* and then returned the cells to the body.

*PD-1* codes for an immune cell "off" switch. Tumours can flip this switch to prevent immune cells attacking – so if immune cells lack the *PD-1* switch then cancer cells cannot manipulate them. However, there is a risk that the "always on" immune cells could begin attacking healthy cells.

The lung cancer trial isn't due to finish until 2018, but other teams are forging ahead. Clinical trial registries show that a dozen more trials that will disable *PD-1* with CRISPR are planned in China. These target conditions including breast, prostate, bladder, oesophageal, kidney, colorectal and Epstein-Barr virus-associated cancers.

## Breaking new ground

The HPV trial, meanwhile, will break new ground. Instead of editing cells outside the body, a gel containing DNA coding for the CRISPR machinery will be applied to the cervix. The CRISPR machinery should leave the DNA of normal cells untouched, but in cells infected by HPV, it should destroy the viral genes, preventing them from turning cancerous.

"Targeting HPVs seems a sensible approach if they can deliver the genome-editing components to sufficient numbers of cells," says Robin Lovell-Badge of the Crick Institute in the UK.

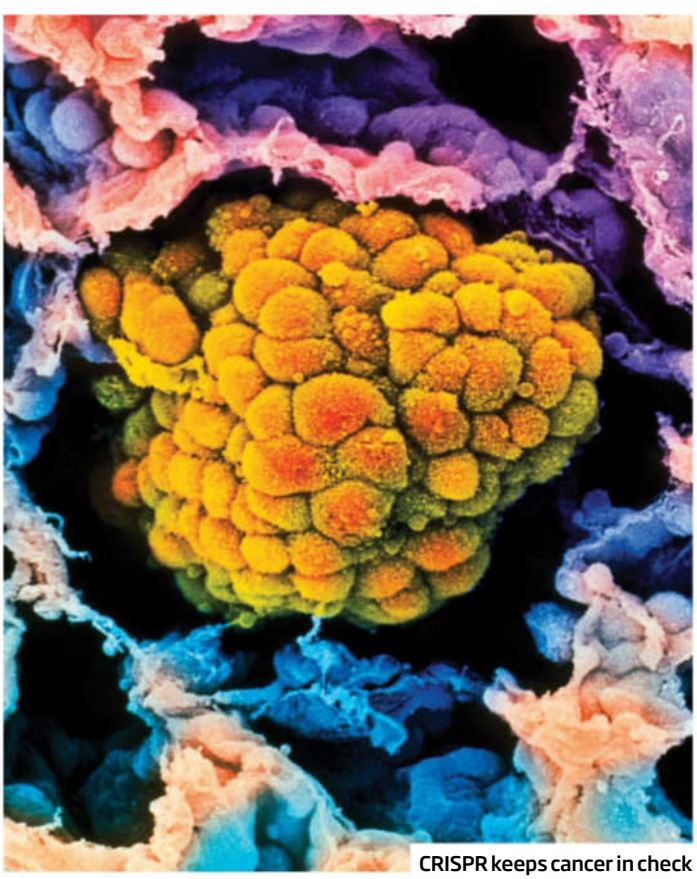
"It is tricky to do these experiments in animals as they are not infectable by HPV," says Bryan Cullen of Duke University Medical Center in North Carolina, whose group also hopes to use gene editing to get rid of HPV. But there is a risk of off-target mutations leading to cancer, he warns.

If these trials are successful, it could benefit millions of people. Vaccination against HPV is now possible, but there is no way to get rid of the virus in people who have it already. It can cause mouth, throat and anal cancers in both sexes, as well as being the main cause of cervical cancer.

A further four planned trials involve changing immune cells to make them better at killing cancers. First, a virus will be used to add a gene to immune cells that makes them attack specific tumours – creating so-called CAR-T cells. Then two or more genes – usually including *PD-1* – will be disabled with CRISPR to make the cells even more effective.

Such UCART19 cells have already saved the lives of two girls, but these cells were created with an older gene-editing method. Now a clinical trial is due to start in the UK. "Our lab is moving over to CRISPR," team leader Waseem Qasim of University College London told a meeting in February.

Two similar UCART19 trials are planned in China, with another in the US. Trials are also planned for Duchenne muscular dystrophy, says Lovell-Badge, but these are probably some way from starting. ■



SCIENCE PHOTO LIBRARY

CRISPR keeps cancer in check

# Is a big quake close? Time for a nowcast

EARTHQUAKES are nearly impossible to forecast, but a technique borrowed from economics and finance can now help us estimate the risk that a "big one" is nigh.

Seismic nowcasting, as it is called, assesses the current risk of a major earthquake in a given quake-prone area based on the area's history of smaller tremors. Nowcasting gives a snapshot of risk, whereas forecasting seeks to predict the date of a future event. It's akin to formulas that use the latest fluctuating data to evaluate whether there's a downturn looming in an economy or industry.

John Rundle at the University of California, Davis, and his colleagues have used the technique on data from the US Geological Survey's earthquake catalogue to calculate the "earthquake score" of 53 major cities around the world.

"If you have a high earthquake score, and then you start seeing more small earthquakes, I'd get worried. You're accumulating hazard, so to speak," says Rundle, who presented the team's results at an earth science conference in Chiba, Japan, on 22 May.

The researchers worked on the assumption that earthquakes occur over irregular cycles. They also assumed that some patterns are regular, though, given that an average number of small earthquakes strikes a region between the rarer big ones. This allows nowcasters to figure out what stage in a cycle a given city has reached based on how many small quakes have hit since the last big one.

Rundle's team says Los Angeles is halfway through its cycle for powerful earthquakes of magnitude 6.5 or above, as the area hasn't suffered many small quakes since the big one of 1994. Davao City, in the Philippines, had scored at the top of the list until a major offshore quake recently sent it to the bottom of updated rankings. Tokyo residents should be concerned: their city is 90 per cent of the way through its cycle. Ramin Skibba ■

BANKSPHOTOS/GETTY

Lending tools can be a saw point

# Charge your friends for the good of the group

Timothy Revell

WANT to borrow my tent? No problem, that will be £25 please. That might sound annoying, but it will be better for society in the long run. Surprisingly, this is the conclusion reached by a new game theory analysis of sharing goods.

With larger and more expensive items that are used infrequently, like power tools and hiking gear, people often face a choice between buying one themselves or borrowing from a friend. Assuming that this choice solely comes down to cost, Ariel Procaccia and his colleagues at Carnegie Melon University in Pennsylvania wanted to see what outcome these individual decisions have on society as a whole.

In their first simulation, people were able to borrow items for free from their friends. Considering overall wealth, "in this situation the cost for society was really bad", says Procaccia. "Everyone tried to optimise their own situation, but this was far from the optimum for society," he says.

To picture what goes wrong, imagine a town where people very occasionally want access to a circular saw. Most of the time the item remains unused, so anyone who owns one is happy to lend it to friends for free.

**"When you can borrow items for free, society suffers by buying more stuff than it needs"**

The optimum would be to have as few people as possible shell out for a circular saw, maximising the society's overall wealth. This is reached when the most popular people are the ones who purchase the gear. These people are able to do the most sharing as they have the largest friendship group, meaning fewer people in the village need to pay out themselves.

But when borrowing is free, there is no incentive for this to happen. The most popular people are also the people most likely to know someone with a circular saw, so why buy one? They might be friends with a hundred times more people in the village than a circular saw owner that they know, but the right individual decision is still to borrow, which will end up costing the village more overall.

Procaccia and his colleagues proved mathematically that when the two options are either buying an item or borrowing it for free, society always suffers by buying a lot more stuff than it really needs. To get out of this rut, you have to change the rules of the game.

In a second scenario, the researchers allowed people to charge for lending out their items. The most connected people then had an incentive to lend and were the ones who benefited most from purchasing an item. In this case, more friends means more money.

They found that in this situation, even when people made their decisions based purely on self-interest, the overall result would be much closer to the optimum result for society as a whole. In other words, the small cost of renting was balanced out by fewer people in the village needing to buy the item.

This suggests that the sharing economy is good for society too. Bike sharing schemes in cities, for example, mean that infrequent users of bicycles don't have to buy one themselves. But the city (which is of course friends with everyone) has an incentive to buy them and rent them out.

"While altruistic help is certainly commendable, we should not be afraid of asking our neighbours and colleagues for compensation," says Tomasz Michalak at the University of Oxford. "This will increase efficiency and benefit everybody in the long run." ■

# Narcolepsy drug suggests ADHD is a sleep disorder

A DRUG normally used to treat narcolepsy and excessive daytime sleepiness also seems to improve symptoms of attention deficit hyperactivity disorder (ADHD) symptoms. The finding supports the idea that ADHD might be a sleep disorder.

People who have been diagnosed with ADHD find it difficult to concentrate and are generally hyperactive. But many with the condition also find it difficult to fall asleep and stay asleep at night, and feel drowsy during the day.

Could this mean ADHD is a type of sleep disorder? After all, the brain pathways involved in paying attention have also been linked to sleep. And there's some evidence of similarly disrupted patterns of chemical signalling in the brains of people with sleep disorders and ADHD.

One suggestion is that the circadian rhythm that controls our sleep-wake cycle over each 24 hour period may be misaligned in people with ADHD, causing them to be sleepy or alert at the wrong times.

This idea inspired Eric Konofal at Robert-Debré Hospital in Paris to try using a drug for narcolepsy and excessive daytime sleepiness to treat ADHD.

Mazindol mimics the effects of a brain chemical called orexin, which modulates wakefulness and appetite. It works as a stimulant to keep us awake, and is lacking in people with narcolepsy, who tend to fall asleep at inappropriate times.

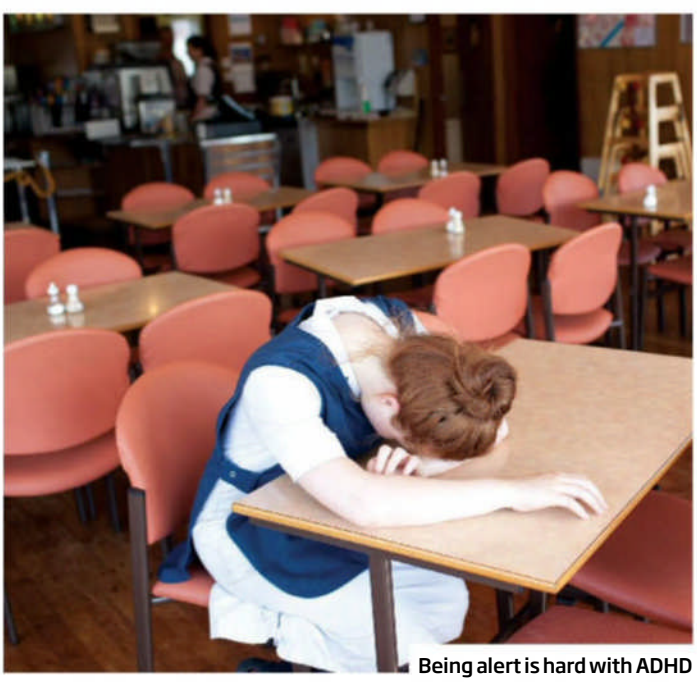
In their clinical trial, Konofal and his colleagues gave either mazindol or a placebo to 85 adults aged between 18 and 65, all of whom had previously been diagnosed with ADHD. Within two weeks, ADHD symptoms had reduced by more than 50 per cent in just over half of those who tried the drug.

These results are better than those in trials using conventional ADHD drugs, such as Ritalin and Adderall, says Daryl Efron at Murdoch Childrens Research Institute in Melbourne. Future trials should directly compare the effects of these drugs with mazindol, to see if it really is superior, says Efron. "But it does look like it could be a very promising additional treatment option for people with ADHD," he says.

Mazindol is the first new ADHD drug for decades to work in a novel way, says Efron. "Since mazindol acts on a different neurochemical pathway, it could be useful for those who don't respond to existing treatments."

The drug also appears to be safe, although some participants in the trial developed minor side effects such as constipation and nausea. These symptoms were most probably due to its effect on appetite – mazindol has previously been used as a weight loss drug because it reduces feelings of hunger.

However, although mazindol improved many ADHD symptoms, it did not boost the quality of the volunteers' sleep, nor reduce the daytime sleepiness they experienced. The team is planning larger trials and other experiments to better understand how the drug might be working. **Alice Klein** ■



ROBERT ORMEROD/MILLENNIUM IMAGES, UK

**Being alert is hard with ADHD**

# Curiosity saves the computer from death

**CURIOUS algorithms are teaching themselves to solve problems they haven't encountered before.**

**Faced with level one of *Super Mario Bros*, a curiosity-driven AI learned how to explore, avoid pits, and dodge and kill enemies. This might not sound impressive – algorithms have been beating humans at video games for a few years now – but this AI's skills were learned thanks to an inbuilt desire to discover more about the game's world.**

**Conventional AI algorithms learn through positive reinforcement. They are rewarded for achieving external goals, like increasing the score in a video game by one point. This encourages them to perform actions that increase their score – such as jumping on enemies in the case of *Mario* – and discourages them from performing actions that don't, like falling into a pit.**

**But humans learn through curiosity, says Deepak Pathak at the University of California, Berkeley. He set out to give his own reinforcement learning algorithm a sense of curiosity to see if it would do the same. The algorithm experienced a reward when it increased its understanding of its environment. So, rather than looking for a score-based reward in the game world, the algorithm was rewarded for mastering skills that led to it discovering more about that world.**

**This type of approach can speed up learning times and improve the efficiency of algorithms, says Max Jaderberg at Google's AI company DeepMind. The company used a similar technique last year to teach an AI to explore a virtual maze.**

**"Imbibed with curiosity, the AI learned to stomp on enemies and jump over pits in *Super Mario Bros*"**

**Imbibed with a sense of curiosity, Pathak's own AI learned to stomp on enemies and jump over pits in *Mario*, and also learned to explore faraway rooms and walk down hallways in another game. It could apply its new skills to further levels of *Mario* despite not seeing them before – but it did struggle to make it past some relatively simple obstacles (arxiv.org/abs/1705.05363).**

**Pathak now wants to see if robotic arms can learn through curiosity to grasp unfamiliar objects. He also plans to see whether a similar algorithm could be used in household robots like the Roomba vacuum cleaner.** Matt Reynolds ■

## Bacteria to turn your faeces blue if you're ill

CHECKING the hue of what you leave in the loo could soon reveal why you're feeling off colour. Gut bacteria in mice have been genetically modified to make pigments when they detect disease. If the mice have a gut disorder, microbes in their faeces turn blue.

A similar approach could be used to diagnose inflammatory bowel diseases or colon cancer in people.

Many gut disorders are diagnosed by putting a camera on a thin flexible tube up the rectum. "People often don't like that," says Pamela Silver of Harvard Medical School in Boston. An alternative could be to measure chemicals in the gut that are linked to disease.

Silver and her colleagues did this in mice using a harmless strain of *E. coli* bacteria. The team gave the bacteria genes that are sensitive to a chemical called tetrathionate, which is seen in higher levels in the guts of people with ulcerative colitis.

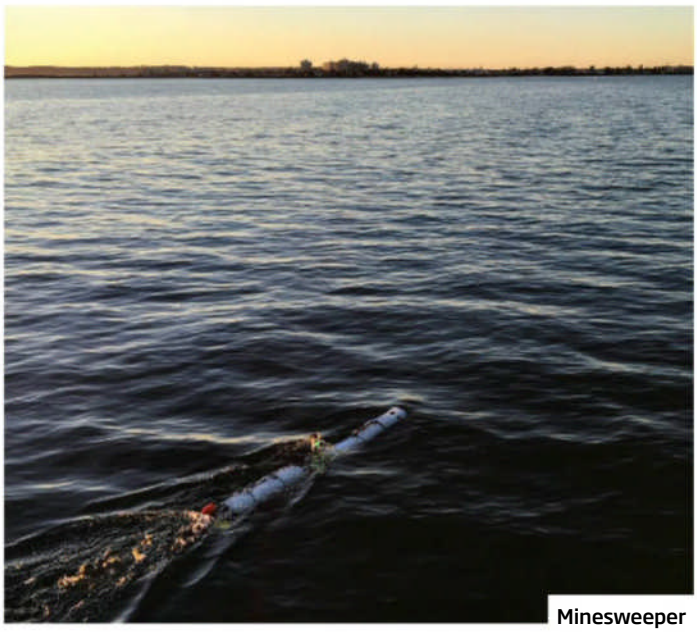
When the bacteria come across tetrathionate, they switch on a gene to make an enzyme, which is passed in faeces along with the bacteria. The enzyme can then be identified in lab tests, in which it changes colour.

Silver's team gave their modified bacteria to healthy mice and to mice that had gut inflammation, similar to that seen in ulcerative colitis.

Some gut bacteria are passed in faeces, and lab tests detected the colour-change enzyme only in samples from animals with gut inflammation. In these, the bacteria changed colour from white to blue (*Nature Biotechnology*, doi.org/b7s2).

The modified bacteria have to be grown in the lab for a day before they turn visibly blue. But Silver says that genes for different coloured pigments could be put into bacteria, including fluorescent ones that people will be able to see in their own excrement.

Silver's team hopes the method could diagnose other diseases linked to gut bacteria, such as Parkinson's disease and autism. Clare Wilson ■



OCEAN SERVER

Minesweeper

# Sea drones send images with sound

Matt Reynolds

DRONES are sending back snaps from the deep. Uncrewed vehicles that scour the ocean floor for submerged mines can now beam back images to human operators in close to real time.

The technology, developed by Canada's Department of National Defence, could also be used to autonomously map the locations of starfish colonies, for example, or study deep-sea hydrothermal vents.

The torpedo-shaped drones constantly scan the ocean floor using sonar, reaching speeds of around 2 metres per second. They use image recognition to search for shapes that look like a submerged mine. Once they spot something, they send a picture to a receiver up to 130 metres away. Humans can then review the images and send in a crewed or remote-controlled vehicle to check out the area in more detail.

Sending images is much more difficult to do underwater than it is on land, says Mae Seto, who led the research. Radio waves, which are often used to transmit data above ground, are distorted and blocked by seawater, which is hundreds of times more dense than air.

Instead, most underwater messages are sent using sound waves since they can travel longer distances in water. But they still get distorted, which means it is almost impossible to send large file sizes – such as images – without distortion becoming an issue. Once the data is too distorted, it becomes impossible to decipher the image when it reaches the surface.

To get around this problem, Seto turned to software that compresses images, making each transmitted image around 60 times smaller than the original. First, the original image is broken into 10,000 separate tiles. Then the software searches a database of sonar images to find a visually similar one that matches each tile in the image.

Each database tile is encoded as a number, and a sequence of those numbers is sent from the drone to a receiver, which could be mounted on a buoy or tethered below a ship. Here the process is reversed, with each number matched to the corresponding image from the database. The result is an image that is similar to the original but actually made up of tiny parts of thousands of other images.

Seto's team tested drones equipped with this software in the Bedford Basin on Canada's Atlantic coast, and off the north-west coast of Scotland. The drones managed to transmit images up to 130 metres, but beyond that the data loss was so high that images couldn't be accurately reconstructed. The work is due to be presented at a robotics conference in Cambridge, Massachusetts, next month.

Although the drones used in these trials only lasted for six hours before needing to be recharged, Seto says that much bigger drones could search the ocean for days at a time.

This technology could relieve humans from a lot of the grunt work involved in studying the ocean floor, says Jonathan Copley at the University of Southampton, UK. If autonomous drones were trained to recognise certain underwater features and flag their presence, they could help researchers mapping the ocean floor decide on which areas should be explored in greater detail.

**"The drones could help researchers mapping the ocean floor decide which areas to explore in detail"**

But Copley says that these drones still have a long way to go before they can help solve the mysteries of the deep. "To really make headway we need to be sending these drones out there for months at a time," he says. ■

# Ocean bugs may be eating plastics

Michael Le Page

THERE should be hundreds of thousands of tonnes of plastic floating in oceans. But much of it seems to be missing – perhaps because microbes have evolved the ability to break it down.

Plastic production is rising exponentially, so ever more of it should be ending up in the oceans, says Ricard Solé at Pompeu Fabra University in Barcelona, Spain. But surveys of areas where floating plastic accumulates, such as the North Atlantic gyre, are finding much less than expected.

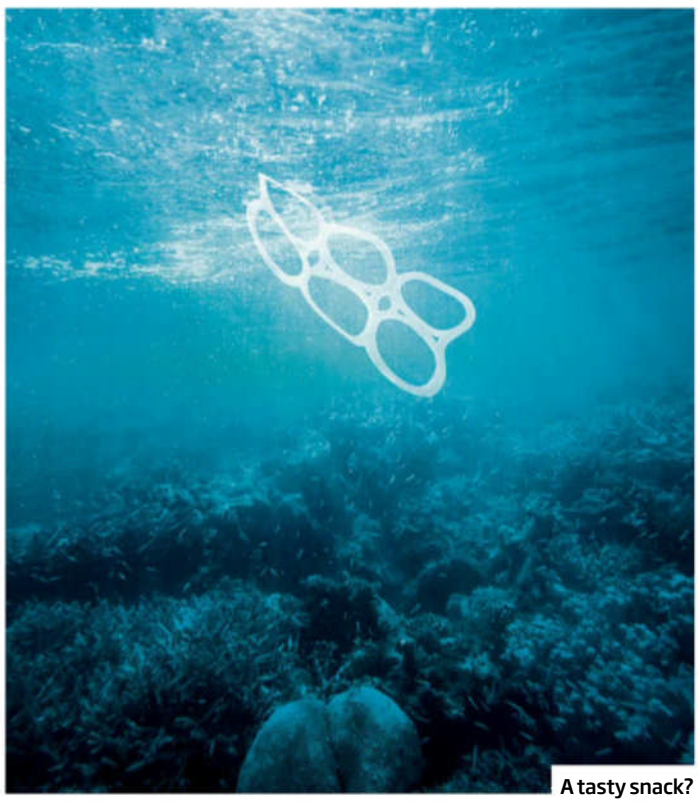
In fact, there is only a tenth to a hundredth as much plastic as anticipated – and the amount doesn't appear to be increasing. This constancy can't be explained by physical processes, according to the mathematical models Solé and his team used. Instead, they propose that there has been a population boom in microbes that have evolved the ability to biodegrade plastic (*bioRxiv*, doi.org/b7pc).

Other researchers agree that surveys are finding far less plastic in the oceans than expected. But they say there are several other possible explanations for this "missing plastic".

In theory, it is possible that some microbes have evolved the ability to break down plastics. Studies by Linda Amaral-Zettler of the Royal Netherlands Institute for Sea Research show that the microbes colonising floating plastic are quite distinct from those still in the water, and suggest some feed on those plastics. In effect, the plastic is creating a whole new ecosystem that Amaral-Zettler and colleagues call "the plastisphere".

But when environmental chemist Alexandra ter Halle of IMRCP laboratory in Toulouse, France, looked at the DNA of the organisms on floating plastic in the North Atlantic, she didn't find any microbes known to be capable of breaking down plastic. Of course, that might be because they have not yet been discovered: there could still be millions of unknown microbes.

Amaral-Zettler and ter Halle think it is more likely that floating plastic is simply sinking to the sea floor as colonising organisms weigh it down, or being physically broken into such microscopic pieces that it slips through the nets of research vessels. Plastic could also be being eaten by larger organisms or carried by currents to unexpected parts of the ocean.



MAARTEN WOUTERS/GETTY

A tasty snack?

The sinking explanation might also be compatible with his team's findings, says Solé. Their study doesn't prove that microbes are metabolising plastic, but the lack of an upward trend in how much there is in the oceans can only be explained by a biological response that can rise in proportion to the amount of plastic, he says.

And even if the plastic is being degraded faster than thought, this might not be a good thing. For instance, plastic contains potentially harmful additives that could be released and enter the food chain if the plastic biodegrades, says ter Halle. ■

# Early Earth was a molten doughnut

FOR a brief time during its infancy, Earth was a hot, doughnut-shaped blob called a synestia. Rocky worlds can be pulverised by collisions with each other, mushrooming into synestias before cooling off and becoming more familiar-looking celestial spheres, a new study says.

Worlds in our universe come in all shapes, from planetesimals to dwarf planets to giants with rings, but we don't fully understand how they change throughout their lifetimes, says Simon Lock at Harvard University.

In the early solar system, huge impacts would have been common as small bodies smashed together, broke apart, re-formed and smashed again. Previous studies found such impacts could pulverise part of a planet, leaving behind debris that coalesces into a moon or rings like Saturn has.

The most violent collisions can vaporise entire worlds into gas blobs that rotate so fast their edges spin at a higher rate than their inner core.

At a certain point, the planet takes on a new structure: an inner region rotating at a steady rate, loosely connected to a bulbous disc that rotates around it. The disc is not separated like a planet with rings, but sits at the edge of the planet's pull.

It resembles a puffy red blood cell, or a doughnut with a dented middle.

A synestia has an exterior region marked by clouds of molten rock and dust, all at a scorching 2000°C or hotter. These conditions only last for a cosmic blink. Earth would have been a synestia for just a century before cooling off enough to condense into a solid object again, Lock says.

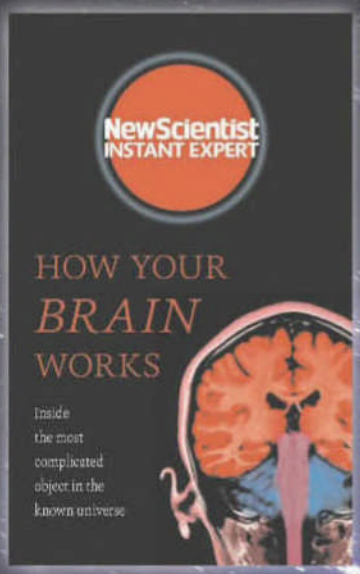
**"A synestia resembles a puffy red blood cell, or a doughnut with a dented middle"**

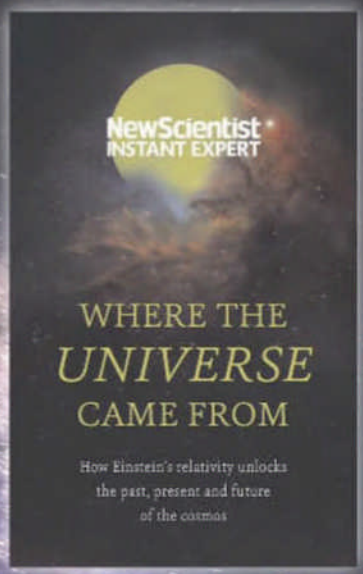
Most planets and even some stars might form synestias at some point in their lives, according to Stewart. She plans to look for evidence of them around young star systems, where the outer part of planets are hot and close to their stars.

"That keeps it poofy, and if it is rotating very fast, it could be a synestia," she says. Shannon Hall ■

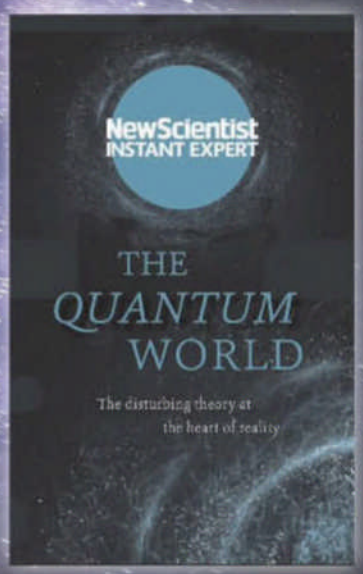
# INTRODUCING THE
# New Scientist
## INSTANT EXPERT SERIES

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




**MARCH 2017**


**APRIL 2017**

**NewScientist** newscientist.com/instant-expert-books

TERYOSHI/PLAINPICTURE

Time to case the joint?

# Cannabis helps addicts quit crack

Andy Coghlan

COMPONENTS of cannabis might help those addicted to crack cocaine to quit. Such people may find it easier to curb their usage or give up entirely when they take some form of cannabis, suggests a small study that builds on similar results from research in rodents.

"This is a promising development that will provide more alternatives to those in need," says Ric Curtis at the City University of New York, who wasn't involved in the work.

Some of the first hints that cannabis might help curb crack cravings were anecdotal, says Curtis, who studied crack dealers in the 1980s. "They would wean themselves off crack by smoking it with marijuana."

To find out if this approach might work, Michael-John Milloy at the University of British Columbia in Vancouver assessed the findings from three long-term studies of drug users in the city. Across the studies, 3000 people with a history of drug use completed questionnaires detailing their habits, including whether they had started taking cannabis with the intention of reducing their crack cravings.

Milloy and his colleagues identified 122 crack users who started taking cannabis for this purpose. Over an average of 30 months, these individuals were 89 per cent more likely to have reduced their crack use when they were using cannabis, compared with when they were not using it.

**"People were 89 per cent more likely to reduce their crack use when they were taking cannabis"**

It also appeared to help some of them quit crack altogether or stay off it if they had already done so. "Before intentional cannabis use, 11 per cent were not using crack at all," says Milloy. "After intentional use, that increased to 28 per cent." His team presented the results at the Harm Reduction International Conference in Montreal last month.

The study wasn't a clinical trial, so the team can't be certain that the decline in crack use wasn't down to willpower or some other factor. Another flaw in the research is that the team didn't account for the form or amount of cannabis used.

Still, the results are intriguing and deserve further investigation, says Nora Volkow, director of the US National Institute on Drug Abuse in Maryland.

Milloy is currently planning a randomised and controlled trial, in which half the participants will receive a placebo. The other half will be given measured doses of medical-grade cannabis or specific components of cannabis that don't deliver a high.

It will be vital to learn which components might help most in treating drug addictions. Cannabis comes in various forms, which might explain why other studies have found that people who take cannabis find it harder to quit cocaine.

Animal studies suggest that a component called cannabidiol (CBD) might be the best bet. This compound is thought to interfere with reward pathways in the brain, potentially limiting the rewarding feeling of taking some addictive drugs, says Volkow. "From doing lots of studies in animals, CBD has been shown to be beneficial in reducing drug intake," she says. ■

# Neutron star is source of weird radio flash

**NEW images peg a neutron star in a stellar nursery as the source of the fast radio burst FRB 121102, coming from a dwarf galaxy 2.4 billion light years from Earth.**

**In the past decade, about two dozen radio bursts lasting mere milliseconds have been detected. Explanations for these signals have ranged from supermassive black holes to little green men.**

**Now Cees Bassa of the Netherlands Institute for Radio Astronomy in Dwingeloo and his colleagues have used the Hubble Space Telescope to study the galaxy in more detail (arXiv.org/abs/1705.07698).**

**"There is a very bright spot of star formation, and this FRB lies bang inside it," says team member Shriharsh Tendulkar at McGill University in Montreal, Canada.**

**Meanwhile, Mitsuru Kokubo of Tohoku University in Sendai has led a team using adaptive optics at the 8.2-metre Subaru Telescope in Hawaii to undo the usual blurring of the galaxy created by Earth's atmosphere (arXiv.org/abs/1705.04693).**

**The nursery is 6200 light years from the galaxy's centre and spans 4400 light years, far larger than any in the Milky Way, even though the galaxy itself is much smaller than ours.**

**"Relative to its small size, it's making stars at a prolific rate," says Dale Frail at the National Radio Astronomy Observatory in Socorro, New Mexico.**

**That points to neutron stars – which form when short-lived massive stars in stellar nurseries die – as the source of fast radio bursts. No one yet knows whether these stars produce all the fast bursts. FRB 121102 is unique: astronomers have seen it flash about 30 times but the others only once.**

**Jonathan Katz of Washington University in St Louis, Missouri, suspects they may all have the same cause, but Frail says he would be reluctant to draw broad conclusions based on one sample.** Ken Croswell ■

NEW SCIENTIST DISCOVERY

# Journeys of discovery

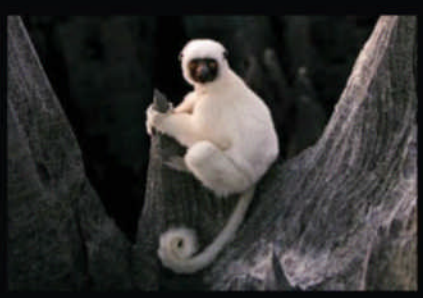
Climb high into the Himalayas, snorkel off the Galapagos or journey deep into the Madagascan forest for an expert look at wildlife conservation.

INDIA:

## TRACK SNOW LEOPARDS IN LADAKH

FEBRUARY 2018, 13 DAYS
FROM £5295

Rather than hunting these elusive, endangered creatures, Ladakh farmers are now protecting them. Find out why on an unforgettable expedition into the breathtaking Indian Himalayas with *New Scientist*. You'll take part in camera-trapping and hear from an expert geologist who has studied the Himalayan area for decades. In the company of the Snow Leopard Conservancy, spend five days tracking snow leopards and spot blue sheep and ibex along the way.



MADAGASCAR:

## LEMURS, BAOBABS AND THE TSINGY PARK

SEPTEMBER 2017, 13 DAYS
FROM £4995

Experience Madagascar's unique ecosystem by privately chartered plane. Visit the Durrell Wildlife Conservation Trust team and accompany community rangers on a daytime patrol. You'll learn how the endangered, cat-like fossa is being protected and listen out for the ear-splitting indri lemur. And we'll explore the mind-boggling Tsingy de Bemaraha National Park and take a walk through the iconic Avenue of Baobabs.

ECUADOR:

## DARWIN'S GALAPAGOS

APRIL 2018, 11 DAYS
FROM £5775

Jump on board our *New Scientist* charter for a one-off tour of this unique ecosystem, accompanied by naturalist and wildlife photographer Jonathan Green. Learn about the geology of the island, discover why the native creatures are so friendly and get the chance to quiz field researchers in an exclusive visit to the Charles Darwin Research Centre. See giant tortoises and sea lion colonies, spot the endemic waved albatross and get the chance to snorkel at sea then amble on shore.

We've teamed up with Steppes Travel to offer readers a chance to get close to geology and nature, with field experts and naturalists for company. Speak to our wildlife experts today.

Call now on **+44 (0)1285 600 129** or visit **newscientist.com/travel**

SteppesTravel

# Monkeys learn that crime pays

Brian Owens

MACAQUES living near an Indonesian temple have figured out how to run a ransom racket on visiting tourists.

The monkeys grab valuables, such as glasses, hats, cameras or, in one case, a wad of cash from the temple ticket booth, then wait for staff to offer them food before dropping their ill-gotten gains and dashing off with the prize.

This behaviour has been reported anecdotally at Uluwatu Temple on the island of Bali for years, but it had never been studied scientifically in the wild. So Fany Brotcorne, a primatologist at the University of Liège in Belgium, and her colleagues set out to discover how it has spread through the long-tailed macaque population.

"It's a unique behaviour. The Uluwatu Temple is the only place in Bali where it's found," she says, which suggests it is learned rather than being an innate ability.

Brotcorne wanted to see whether it was indeed cultural, which could help us better understand the species' cognitive abilities, and even our evolution.

She spent four months observing four different groups of the monkeys that live near the temple. The two groups that spent the most time around tourists had the highest rates of robbery and bartering, supporting the idea that they were learning the behaviour by watching each other. Groups with more young males, who are more prone to risky behaviour, also had higher rates than other groups.

Although this study is based on a small sample, Brotcorne believes it provides the first evidence that the behaviour is cultural, transmitted across generations as monkeys learn from each other (*Primates*, doi.org/b7n9).

In the years since these observations, she has gathered more evidence: members of a fifth group of macaques that moved into the area have started to learn that they can barter stolen goods for snacks.

Serge Wich, a primatologist at Liverpool John Moores University in the UK, says Brotcorne's work provides "a novel and quite spectacular example of flexibility in primate behaviour in response to environmental changes".

It is particularly interesting, he adds, because the same behaviour isn't seen in other places where it could occur.

Brotcorne says her work should help researchers learn more about the psychology of primates: how information is transmitted among groups, how much they understand their own actions and how they plan for the future.

It could even help answer questions about the evolution of our own cognitive abilities. "Bartering and trading skills are usually defined as exclusive to humans," she says. Seeing them in macaques could help us learn how early the behaviour might have arisen in the human lineage.

So did Brotcorne ever fall victim to her own thieving research subjects? "Oh, so many times," she says. "The monkeys were always trying to steal my hat, my pen, even my research data!" ■

KYLIE MCLAUGHLIN/GETTY

What's this worth?

# Learning to read and write rewires brain

LET'S hear it for the written word. Learning to read can have profound effects on the wiring of the adult brain – even in regions that aren't usually associated with reading and writing.

That's what Michael Skeide of the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, Germany, and his colleagues have found by teaching illiterate adults in rural India to read and write.

The team recruited 30 Hindi-speaking adults from two villages near the north Indian city of Lucknow, with an average age of about 31 years. Twenty-one people from this group were taught to read and write the Devanagari script, which is used in Hindi and other Indian languages. Nine people weren't taught anything. All of the volunteers had their brains scanned before and after a six-month learning period.

By the end of the study, the team saw an increase in brain activity in the cortex – the outermost layer of the brain, which is involved in learning – in the brains of those who had learned to read and write.

The thalamus and brainstem – brain regions that aren't typically involved in reading, writing or learning – also seemed more active after training (*Science Advances*, doi.org/b7pp).

These regions coordinate information from our senses and our movement, among other things. Both areas made stronger connections to the part of the brain that processes vision after learning to read.

The brainstem and thalamus are also known to control attention, so this may also be enhanced by learning to read and write. Such changes are probably happening in children as they learn to read and write, too, says team member Falk Huettig of the Max Planck Institute for Psycholinguistics in Nijmegen, Netherlands.

**"The thalamus and brainstem were more active after people had learned to read"**

The findings might help shed light on dyslexia. In people with the condition, the structure and function of the thalamus can be different from what is typical. If the wiring of the thalamus can change with an intensive literacy course, a lack of reading experience could explain these differences. The real cause of dyslexia may lie elsewhere, says Huettig. Anil Ananthaswamy ■

# 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

NEW SCIENTIST DISCOVERY

# 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 Germany 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

TRAVEL EDITIONS TOURS

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

JAMIE CULEBRAS

## This new see-through frog has visible beating heart

A NEWLY discovered glass frog species whose beating heart is visible through its chest is already feared to be in danger because of habitat destruction.

The frog, *Hyalinobatrachium yaku*, was identified through a combination of fieldwork in the Amazonian lowlands of Ecuador and DNA sequencing in the lab. It has unique physical and behavioural traits, such as the dark green spots on its back, its call and its reproductive behaviour (*ZooKeys*, doi.org/b7mg).

"I work with frogs every day and this is one of the most beautiful species I have ever seen," says Juan Guayasamin, of the Universidad San Francisco de Quito in Ecuador.

"Not all glass frogs have hearts that are visible through the chest," says Paul Hamilton, of US non-profit organisation the The Biodiversity Group. This frog will help us understand the evolutionary pattern that led to frogs being glass-like, he says.

Glass frogs need pristine streams to breed. "If the stream dries up or becomes polluted the frogs can't survive, and other more resilient creatures may be next," says Hamilton. We don't yet know enough about the new species to establish whether it would be officially deemed as threatened. "We do know, however, that its habitat is rapidly disappearing," he says. "Oil production has expanded greatly in this species' range, and road building is rampant."

## App lets crowds show their support

"3 – 2 – 1, GO!" shouts the announcer, and the spectators all hold up coloured cards pulled from under their seats. Such mass coordinated displays at sports events are impressive, but require a surprising amount of planning. An app from IBM now recreates the effect using smartphone screens.

Anyone who wants to join in an event indicates that they wish to participate on the app. Once enough people have joined, the app tells them to hold up their phone and starts flashing the message.

The app uses the phone's camera to work out where all the phones are in relation to each other. During an initial setup phase, each phone flashes a sequence of lights. Depending on the parts of the sequence a phone's camera picks up, it can work out where it is in relation to the other participating phones to an accuracy of around 15 centimetres. The app will be presented at the MobiSys conference in Niagara Falls next month.

So far, the team has tried out the system – named Card-stunt as a Service (CaaS) – with 49 participants and run a simulation of 40,000 people using it at once.

## Spiky penises lead to thick vaginas

EVER wondered what constitutes extreme sex? Cowpea seed beetles certainly know – their sexual act is brutal, and it also seems to encourage a rapid, evolutionary arms race between spiked penises and shielding tissue in females.

Once beetles become sexually mature after emerging from the beans in which they live as larvae, they have only one thing on their minds: procreation.

Liam Dougherty at the University of Western Australia and his colleagues have now found a correlation between the thickness of female reproductive tracts and the length of penis spikes in 13 independently bred populations of the cowpea seed beetle (*Callosobruchus maculatus*). This, they say, provides evidence that the spikes and tract-thickening are evolving in response to each other (*Proceedings of the Royal Society B*, doi.org/b7mr).

## Saturn's shattered moons reassemble

THE mid-sized moons of Saturn won't die: smash them into pieces and they stick back together to form new versions. This finding contradicts a theory that a major moon collision just 100 million years ago resulted in the debris that makes up the planet's rings.

Using modelling, Sébastien Charnoz and Ryuki Hyodo at the Paris Institute of Earth Physics found that if such a smash-up left behind big chunks of debris, these would form a new moon so fast that smaller fragments couldn't drift inwards to form rings (arXiv.org/abs/1705.07554).

"The process is so efficient that 20 to 30 generations of moons could have formed" since the solar system's birth, says Charnoz. "But it cannot form the rings."

## Waltzing bot gives dance lessons

TWO left feet? Not to worry – now you can take lessons with a robotic instructor designed to teach humans how to dance.

The wheeled 1.8-metre-tall robot has an upper body that moves like that of a human dancer to gently guide novices through routines while adapting to their skill level. A force sensor and two laser rangefinders track the student's movements, which are compared with motion-capture data from professional dancers.

As students progress, the robot gradually reduces the force used to lead them, so they become less reliant on its guidance. Its face displays real-time feedback to help pinpoint mistakes, as well as showing overall progress to provide encouragement.

In tests with volunteers who had never waltzed before, five out of six improved, according to results to be presented at the International Conference on Robotics and Automation in Singapore later this month. With another group, the robot was not programmed to adapt to students' progress, and four out of six showed no improvement.

Enabling robots to teach humans through physical interaction could be useful for physical rehabilitation or sports training, says the robot's creator Diego Felipe Paez Granados at Tohoku University in Japan.

SYSTEM ROBOTICS LABORATORY

## Bacteria may get hardier in space – and stay that way

SPACE might change *E. coli* cells permanently. The longest study yet of bacteria in simulated microgravity found that their adaptations remained even when researchers tried to erase them.

Astronauts may be more susceptible to infections in space, so if any bacteria that hitch a ride become more virulent or resilient, they could pose a risk.

Madhan Tirumalai at the University of Houston in Texas placed *E. coli* cells in a rotating vessel to simulate microgravity for 1000 bacterial generations, after which they had gained 16 genetic mutations. Some of these occurred on genes related to the bacteria's ability to form biofilms, colonies of cells embedded in protective slime. Biofilms can make bacteria hardier, which may present a problem if some were to form in a spacecraft.

After the cells adapted, they were combined with another strain of *E. coli* that had not been subjected to microgravity. The adapted cells outcompeted the normal ones and grew about three times as many colonies. Even after being out of microgravity for up to 30 generations, they kept 72 per cent of their advantage, pointing to permanent mutations rather than merely a temporary adjustment (*NPJ Microgravity*, doi.org/b7kq).

*E. coli* is fairly innocuous, but if microgravity also gives more dangerous bacteria, like salmonella, lasting adaptations to the environment, infection risk for astronauts could skyrocket.

Luckily, the mutated cells were just as susceptible to antibiotics as they would be in Earth's gravity.

## Losing sleep over global warming

AS THE planet warms, many will find it much harder to get a good night's sleep.

Research based on a survey of 750,000 people living in the US has found that when temperatures are high, people report getting less sleep. Elderly and poorer people find it particularly hard to sleep on hot nights. This may be partly because they cannot afford air conditioning, says Nick Obradovich at Harvard University.

Obradovich and his colleagues predict a big increase in sleep loss as the planet warms – not least because nights are warming faster than days. For every 100 people in the US, there will be six additional sleepless nights per year by 2050, if global warming continues at its current rate.

The impact will be much greater for people in hotter places like South East Asia, says Tom Matthews of Liverpool John Moores University in the UK.

We may already be losing sleep as a result of climate change, seeing as the planet has warmed by more than 1°C since pre-industrial times. If warming gets above 7°C, large parts of the planet will become too hot to inhabit.

IMAGEBROKER/REX/SHUTTERSTOCK

## Tree-climbing goats spit argan nuts

ACROBATIC goats climb argan trees to eat fruits and leaves in Morocco. Their widely overlooked habit of regurgitating and spitting out the nuts in the fruits may be important to the life of these forests.

Popular accounts say the goats defecate the nuts of argan fruits. But Miguel Delibes at Doñana Biological Station in Seville, Spain, and his team suspected the goats would have trouble passing the nuts, which are about 2.2 centimetres long.

They fed domestic goats various other types of fruit and found that the animals usually spit out seeds that are this large. More than 70 per cent could still grow after being spat out. That means spitting goats might help to scatter the seeds of plants they eat (*Frontiers in Ecology and the Environment*, doi.org/b7mt).

Ahmed El Aich of the Hassan II Agronomic and Veterinary Institute in Rabat, Morocco, says nuts spat out by goats represent up to 60 per cent of those used to make argan oil. "Farmers use goats on purpose to collect argan nuts, since some argan are very far from the habitations," he says. But this technique has risks: some goats fall and break their legs.


# COMPLETE YOUR COLLECTION

Missed a copy of *New Scientist: The Collection*? Past issues are available to buy through our online store: **newscientist.com/thecollection**

New Scientist

# THE WORLD'S MOST EXCITING FESTIVAL OF IDEAS RETURNS

## EXPLORE

## EXPERIENCE

## UNDERSTAND

SPONSORED BY

BT

esa

BAE SYSTEMS
INSPIRED WORK

EN WINNER
BEST CONSUMER SHOW

British Media Awards 2017
SHOW OF THE YEAR


New Scientist Live
28 September – 1 October 2017 ExCeL London
120+ TALKS...
100+ EXHIBITORS...
5 IMMERSIVE ZONES
BOOK NOW AT
newscientistlive.com

# Making a killing

Life-saving drugs are out of reach – even in the West. It's a damning indictment of pharmaceutical pricing, says **Clare Wilson**

PHANIE / ALAMY STOCK PHOTO

Not sick enough for pricey drugs?

FOR six years Paul Fleming was infected with the hepatitis C virus which, left untreated, often leads to liver failure or cancer. Recently, a medicine became available that can eradicate the virus within a few weeks, but doctors couldn't treat him because the £35,000 regimen was too costly for the UK's National Health Service (NHS).

Finally, late last year Fleming had had enough. "You have a contagious disease and it always preys on your mind," he says. So he took a radical step: with his doctor's help he bought a cheap version of the drugs from an Indian company, available for just £1200 thanks to differences in patent law. The package arrived three days later.

Fleming is one of a growing number of people using buyers' clubs, which facilitate the unofficial purchase of cheap generic versions of branded drugs, often with tacit help from doctors. Hepatitis C medicines are the newest addition to these grey markets, thanks to the recent development of safe and effective therapies – and the enormous prices they command. But while buyers' clubs may fill the gap for people like Fleming, is this any way to do medicine in the 21st century? Or is it a sign that we need to fundamentally rethink how we develop and fund new drugs?

Concerns over high drug prices have been growing for years. But with hepatitis C, it's the first time that such a large number of people with a potentially fatal condition have had a cure in sight and out of reach.

Viral hepatitis has recently jumped up the league table of the world's top health threats joining HIV, tuberculosis and malaria, according to the World Health Organization (see "The big four", right). The hepatitis C variant is especially deadly, accounting for half of deaths but has no vaccine.

**"Doctors helping patients get around patents is a direct assault on the global pharmaceutical industry"**

Everything changed in 2013, with the arrival of breakthrough compounds that, unlike previous treatments, act directly on the virus, stopping it from reproducing. Depending on which strain of the virus people have, treatment tends to be a two-drug regimen that includes sofosbuvir, made by US multinational Gilead.

When sofosbuvir was launched, jaws dropped at its price of $84,000 (£65,000) for a 12-week course in the US – $1000 per pill.

"To have drugs so powerful that so few people can access – it's almost the most extreme example of drug access that you can think of," says Andrew Hill of the University of Liverpool, UK.

In the past couple of years, the company has been moved a little by pressure to drop prices in Western countries, but the brand-name medicine still typically costs tens of thousands of pounds per person. In developing countries such as India, where health services cannot afford Western prices, Gilead lets manufacturers make a cheap generic for a small fee. This system leaves some middle-income countries such as Ukraine ineligible for the generic and too poor for the brand-name version. Even in countries like the UK, health services struggle to treat everyone.

UK hospitals are given quotas for how many patients can be treated each month, and they prioritise the sickest. People without symptoms, like Fleming,

stand no chance. Despite regular monitoring, he worried that the potentially deadly infection would progress and damage his liver, or that he might pass the virus on through sex.

He was able to take matters into his own hands because, as a gay man, he had heard about buyers' clubs for medicines that stop people catching HIV. These are not offered by the NHS, but the health service will often support people who have obtained the drugs by checking the medicines' levels in their blood.

## Ethical issues

Although it's not official NHS policy, Fleming also got help from his hospital. He couldn't have done it without his doctor, who directed him to a buyers' website called FixHepC and provided the test results that indicated the correct drug combination, then monitored him during treatment.

After 12 weeks, Fleming's blood tests for the virus were negative. "I've no regrets," he says. "I'm cured of hep. C."

But while many hospitals are now helping patients in this way, not all are. "Some doctors don't want to take the responsibility of something going wrong," says Hill. "Some doctors say this is crazy, I have no idea of the quality of this medicine."

"Medicines purchased in this way could have the wrong active ingredient, no active ingredient, or an incorrect dosage," says a spokesperson for the UK Medicines Healthcare and Regulatory Agency.

Such fears may abate given recent figures presented at the International Liver Congress, showing that cure rates in people self-treating through buyers' clubs generics are as high as in people who get the brand-name versions.

But buyers' clubs raise other ethical questions. Some doctors think "patients [are] queue-jumping by buying their own treatment and being monitored on the NHS," says Graham Cooke of Imperial College London. On the other hand, he says, "they're saving the NHS money."

It's not just doctors raising their eyebrows. Developing countries are allowed to make the generics for their own people because their health systems can't afford the brand name versions. Westerners aren't supposed to buy from them. Some think this phenomenon of doctors helping patients to import their own generics, happening first with HIV and now with hepatitis C, is nothing less than an assault on the global pharmaceutical industry.

Big pharma's usual defence of its eye-watering prices is that they are justified by the high cost of developing the medicines. "The revenue that comes in funds the advances of the future," says Julian Cole of Gilead.

But Melissa Barber, also at the University of Liverpool, says this is flawed reasoning. Most of the initial basic research in drug development goes on at universities, funded by public money. Big pharma enters the picture only in the final stages of clinical trials. By some estimates, private money is only a third of the total spending on medical research. "It's a small contribution," says Barber.

What's the alternative? Some, including Barber, are calling for a revolution in the way drug development is funded. Options include changing medical patent laws or giving governments and public bodies more rights over any medicines that arise from research they pay for. "I don't think it's inflammatory to say people should not die from preventable diseases because they can't afford the medicines," says Barber.

The latter step is already being considered for research into new antibiotics, partly because antibiotics are unprofitable, which makes drug firms reluctant to invest their own money.

If it seems idealistic to expect governments to take on big pharma, perhaps others will. A group of charities led by Médecins Sans Frontières is challenging Gilead's patent on sofosbuvir at the European Patent Office. The patent has already been revoked by several other countries.

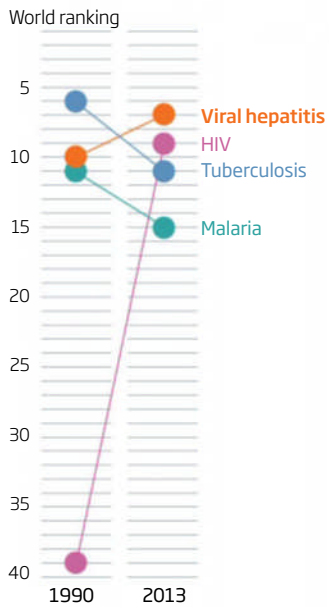
At the very least, the existence of generics is giving Western governments more bargaining power when it comes to agreeing prices with big pharma. Although it's still secret, the Australian government is said to have achieved a substantial discount on sofosbuvir.

"There's no reason why governments can't negotiate harder with drug companies," says Barber. She predicts people are going to start demanding they do just that when they see there are medicines widely available in other countries but not their own. "They need to hold their government accountable."

"Something needs to be done about the drug companies," says Fleming. "What is a reasonable profit margin?" ■

### The big four

Viral hepatitis has climbed the ranks of deadly communicable diseases, now claiming more lives than tuberculosis, HIV and malaria

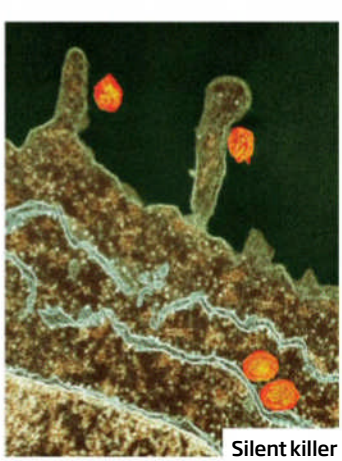



## INFECTED BY DOCTORS

**The hepatitis C virus was spreading unchecked for much of the 20th century, but we only discovered it in 1989. Like HIV, it is a microbe that can be spread through sex – especially anal sex – and through sharing drug and tattoo needles. But in the past, the most common way to catch it was from medical injections.**

**That's the insight from a study of people in the US in their 60s and 70s, who are surprisingly more likely than average to carry the virus. When they were children in the mid-20th century, vaccinations were becoming common, but reusable syringes were not yet known to be dangerous – they were only phased out after the discovery of HIV in the 1980s. Contaminated syringes meant "most of the hep. C patients who are baby boomers were given the virus by doctors," says James Freeman, a doctor in Hobart, Australia.**

**Contaminated syringes and blood transfusions may also be why rates are so high in developing countries. Egypt is thought to have the highest infection rate, with estimates as high as 20 per cent of the population – probably due to mass injections to treat parasitic worms in the mid-20th century.**



THOMAS DEERINCK, NCMIR/SCIENCE PHOTO LIBRARY

Silent killer

# In need of a helping hand

Stare into the demographic crystal ball and you'll see elderly care is a crisis in urgent need of a solution, says **James Bloodworth**

SINCE 1975, the UK has changed a lot. Now it is leaving the European Union, whereas 42 years ago it was reaffirming its membership of the European Economic Community. It is also considerably older as a nation.

Back then, 14.1 per cent of the UK population were 65 or older. Now that figure is 18 per cent. By 2045, nearly a quarter of UK people are expected to be over 65.

This will have big implications for health and social care, and soon. A study in *The Lancet* now predicts that numbers of over-65s needing care for age-related disability will hit 2.8 million by 2025 in England and Wales – 25 per cent more than in 2015.

It found that a growing elderly population more than wipes out any reductions from expected drops in incidence of dementia and cardiovascular disease. The authors say the "shortage of caregivers and the precarious state" of care need addressing urgently.

At long last the parlous state of social care in the UK, the real Cinderella of health provision, is making headlines and attracting political attention. It's about time. Last year, I witnessed the struggles of this corner of our system working undercover in social care while researching a book.

There I met staff treated by care firms as glorified cleaners. They were mostly women, underpaid, undervalued and getting minimal training before being sent out to the homes of vulnerable people.

Much of this is down to money. Since the 2008 recession and government spending cuts, council budgets have been squeezed. As a result, care companies that change the most catheters and wipe the most bums for the lowest price tend to win contracts.

# Two tribes

It is high time we closed the gulf between science and politics, says **David Willetts**

ELECTIONS can be a frustrating reminder of how deep the mutual incomprehension is between scientists and politicians.

Researchers don't like how politicians appeal to instinct and revere as "intuitive wisdom" what scientists see as ignorance and prejudice, or their use of creative ambiguity rather than precision to reconcile conflicting views. On the other hand, scientists can seem to politicians like a pressure group after funds, one with a patronising assumption of superiority.

Politicians are meant to get on and do things, choosing how to act with limited information and time. Scientists' standards can be so stringent that anything other than peer-reviewed empirical analysis is dismissed as opinion.

But the pace of technological advance we are now seeing creates an imperative to do something about reconnecting science, politics and our wider culture. Questions are coming thick and fast: at what point does genetic modification challenge our ideas of identity? How does society cope with a new wave of automation?

Every edition of *New Scientist* brings fresh examples of such dilemmas. Even the most self-confident scientist cannot claim that all the answers can be found in the physical and life sciences. Politics ultimately gets involved. The next parliament could see legislation to set a framework for driverless cars; Brexit could reopen the debate on GM crops.

**"Every major policy review should now include a consideration of relevant technological advances"**

Increasingly, UK chief scientific advisers will need to make their voices heard and ministers will need to see the value they bring. Every major policy review should now include a consideration of relevant technological advances.

There is another thing we must do. Incomprehension is worsened by early academic specialisation,

It means a bargain basement service and an unattractive job with huge staff turnover.

The most obvious solution is more cash. Going into the general election, most parties have acknowledged this to a degree, and are for the most part arguing over who should foot the bill.

But the care sector – and by extension the government – must also start valuing those doing the work. Paying them peanuts on zero-hours contracts is a recipe for poor care and staff shortages.

Vulnerable people's health is at risk. "Clockwatch care" is rife, as staff rush through appointments stuffed into rotas like sardines in a tin. More than half a million visits between 2010 and 2013 lasted 5 minutes or less.

Changing this will improve the treatment received by an ageing population. But it will also make it easier to recruit the many carers the country is going to need.

With Brexit's immigration clampdown set to deplete the labour force, turning care into a well-funded part of our health system that people want to work in will be a matter of urgency, whichever party is in power. ■

James Bloodworth is a London-based writer and author of *The Myth of Meritocracy* (Biteback Publishing)

with 16-year-olds under pressure to opt for arts or sciences. UK degrees also lack the flexibility of US ones, where students pick a major and a minor subject. The result? British politicians may be ignorant of physics, but the country's physicists know too little political history.

This is the moment for both camps to recognise that we need each other like never before, and for whoever forms the next government on 8 June to do all they can to narrow the divide. ■

David Willetts was the UK's science minister from 2010 to 2014. He chairs the British Science Association

INSIGHT World Health Organization

SAMEER AL-DOUMY/AFP/GETTY IMAGES

It takes a global village

# WHO needs a global emergency service?

**Debora MacKenzie**

DISEASE is coming back. This week alone, emergencies in five countries – Iraq, Nigeria, South Sudan, Syria and Yemen – reached the highest grade on the World Health Organization's scale. That means they have the potential for "substantial public health consequences" – international ones.

But no international agency can yet step in and fix these crises, never mind prevent them. So far even the WHO hasn't been able to. It was not designed for handling emergencies, but to provide nations with technical health advice. It is a global agency, but until recently most disease outbreaks were not global threats.

Now that they are, the agency is rushing to reinvent itself as the global disease response service the world increasingly needs. But that requires "predictable, multi-year financing", says Peter Salama, director of the Health Emergencies Programme. Without that certainty, it is hard to plan, and to recruit staff with emergency management experience.

The question now is: will the member states foot the bill?

The wake-up call that the world was missing a vital global caretaker came in 2014 with the Ebola epidemic in Africa. After its disastrously slow response almost let the epidemic spin out of control, the WHO began trying to ramp up its ability to respond to such emergencies. Last year it set up its emergencies programme to coordinate responses to outbreaks. This year the world finds out if it works.

Ensuring it does is left to Tedros Adhanom Ghebreyesus, the former health and foreign minister of Ethiopia, who was elected last week as the WHO's new director general. In his first

**"This week, emergencies in five countries could bring substantial international consequences"**

press conference after the election, Tedros reaffirmed this programme as a priority. During his campaign, he said, he found member states agreed.

However, a report presented in Geneva last week found that members haven't backed their concerns with money. The programme's core budget is so far only 70 per cent funded. An additional "appeals" budget for humanitarian emergencies has $67 million of its $523 million target, and a contingency fund for fast response to crises like Ebola has a third of its planned $100 million.

Even this insufficient funding may soon be cut. A mere fifth of the WHO budget comes from member countries' regular dues, the rest from rich countries' voluntary contributions.

So it was bad news last week when the US – the source of some 16 per cent of WHO funds, more than any other country – proposed a national budget that cuts funding for global health and for UN agencies. The Trump administration plans to eliminate the voluntary contributions so vital to the WHO. It will allocate what is left to agencies that "most directly support US national security interests and American prosperity".

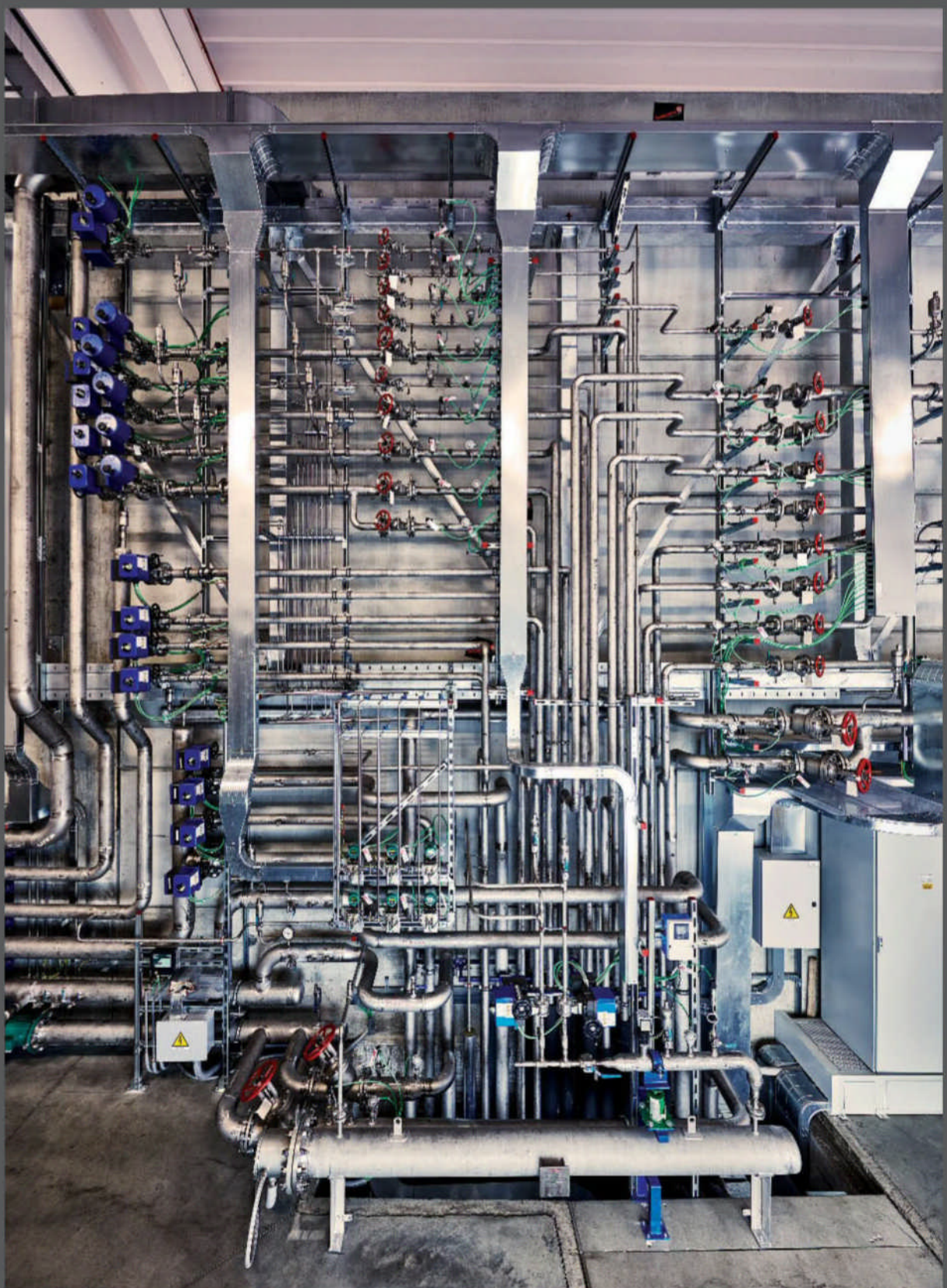
That should have meant the WHO is safe, given that prosperity depends on averting potential pandemics. Trump's team doesn't see it that way, slashing other global programmes that fight diseases like HIV.

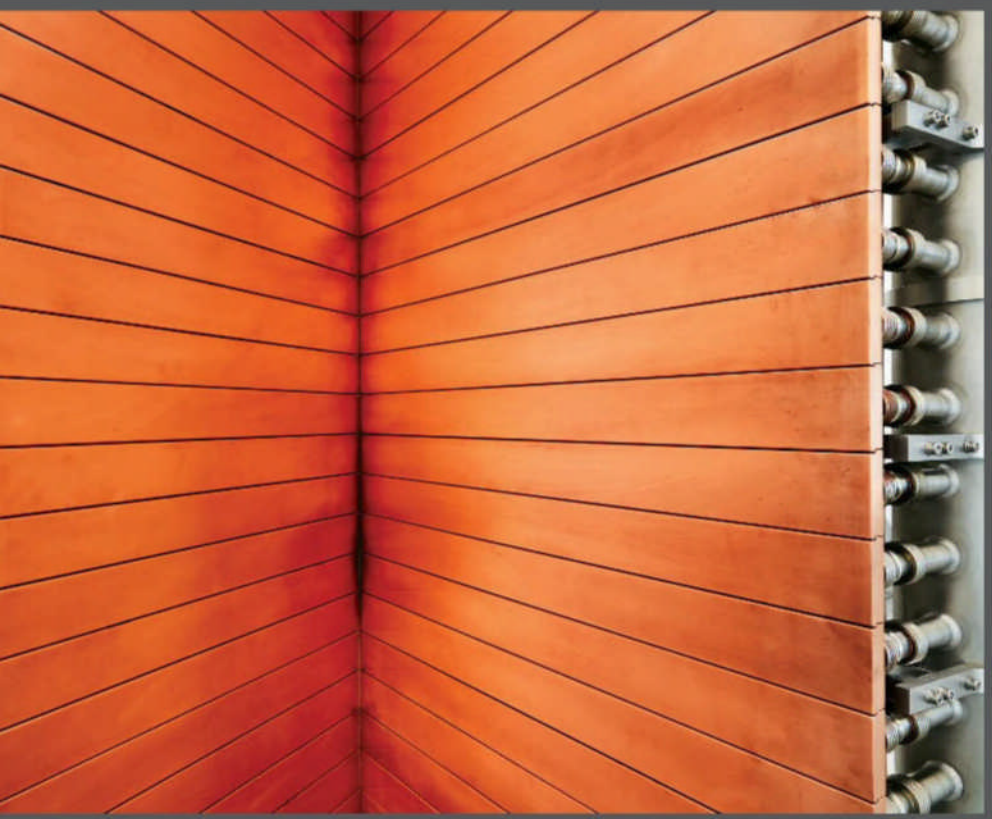
Can Tedros squeeze blood from these stones? He predicts the US proposal is likely to change. And he said in Geneva that the WHO should get funds from a "broader base" of contributors, and boost its fundraising staff and skills.

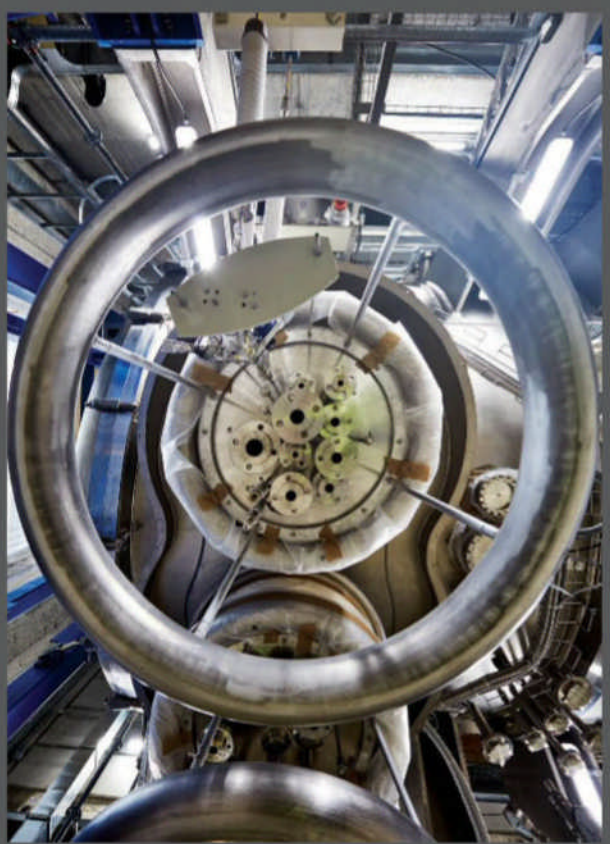
Wish him luck. He'll need it, to save the world's best hope of fighting an increasingly global threat. ■



New Scientist
Live Smarter







## More than a pipe dream

THIS may resemble a distillery, but what it will generate isn't for drinking. It will serve up streams of atoms and ions to make the energy of the sun right here on Earth through nuclear fusion.

Called SPIDER and due for completion next year, this facility in Padua, Italy, will help fine-tune what will become the key heating source for ITER, the world's first experimental fusion reactor. ITER is under construction in southern France and due to be ready in 2025.

Within the ITER tokamak reactor – a reaction chamber shaped like a doughnut – two forms of hydrogen – deuterium and tritium – will be smashed together in a plasma to fuse and form helium atoms as "ash", plus high-energy neutrons that can be harnessed to drive turbines.

To create the plasma, the temperature within the tokamak must be raised to 300 million°C – about 10 times the temperature of the sun – and the heat for that will come from two high-energy beams of deuterium fired simultaneously into the tokamak.

SPIDER will test how beams of deuterium atoms behave in a smaller, experimental reaction chamber, how much heat they generate and how to control the temperature within the reactor.

Pictured on the far left is the labyrinthine piping network supplying the cooling system for the reactor. The brown panels resembling a sauna, in the picture at the top, are tiles for soaking up surplus energy from the beams. Made from an alloy of chromium, copper and zirconium, the tiles are themselves cooled by water fed through pipes visible behind the panels.

The reactor, left, is here viewed from underneath through the circular structure, and the power for the whole facility is supplied from within the gleaming silver Faraday cage seen in the picture next to it. If all goes to plan, ITER will use this technology to produce a lot of energy. It might not be drinkable, but it will be consumable.

Andy Coghlan

### Photographer

**Enrico Sacchetti**

www.es-photography.com

# You know you want to...

Subtle differences in how we respond to food are what truly determine who's fat and who's thin, finds Elie Dolgin

YOU'VE just finished an indulgent meal, the plates have been cleared and you sit back in your seat, stuffed. You couldn't possibly manage another bite. But then it turns out they have sticky toffee pudding, your favourite dessert. Oh go on then, you can make room.

We all succumb to temptation. And it's no secret that people have big differences in appetite – some eat like birds, others like horses. But only some of these differences reflect our energy needs.

The driving factors for weight gain tend to get oversimplified: studies show that most people still think obesity is down to laziness and gluttony. Others tend to shrug and blame "big bones" or "bad genes".

Genes play a part: they may be responsible for as much as two-thirds of our variation in weight. But they aren't betraying us in the way many assume. Some slow down our metabolic rate, leading to a build-up of fat, but they are the exception. Instead, most make people chubby in a more insidious way: by subtly affecting how appealing food seems to us, and how quickly we feel full.

Not only that, but these genetic effects kick in even from the first weeks of life. In other words, the deck may be stacked against you right from the start. Understand that, and we may each have the key to maintaining a healthy weight – and might finally make inroads against the obesity epidemic.

Measuring how our response to appealing food and to feelings of fullness can influence weight is something that can be traced back to 2007. That's when the late British health psychologist Jane Wardle first proposed the idea that genetic differences in appetite raise the risk of overeating in food-rich conditions. This "behavioural susceptibility theory" offered an explanation for why weight gain can be both highly heritable and highly responsive to environmental influences.

To identify innate differences in appetite and disentangle the impact of genes from all the other factors that can alter our food choices – from social pressures to comfort eating – Wardle and her colleagues turned to twins. Specifically, the Twins Early Development Study, a UK survey of more than 15,000 pairs of identical and fraternal twins.

The beauty of such twin studies is that siblings grow up in the same circumstances. That's important, says Jed Friedman, a molecular nutrition researcher at the University of Colorado, Denver, because babies get all sorts of nutritional cues from their mums, both in the womb and during the first months of life, that can have "a profound effect on developmental systems that regulate appetite".

At around age 11, children in the study were weighed and parents filled in questionnaires about their eating behaviours, ranking statements such as "My child is always asking for food" and "My child gets full up easily".

That snapshot in eating behaviours ›

MARTIN BARRAUD/GETTY

## ARE THE KIDS ALRIGHT?

More than half of parents now fail to recognise when their children are overweight. A recent US study led by Jian Zhang at Georgia Southern University found that parents' ability to identify excess weight in their preschool kids has declined by 30 per cent over the past 20 years.

Part of the problem is a shift in attitudes about what's "about right". Packing a few extra pounds is "just a social norm now", says Connie Tompkins, a childhood obesity researcher at the University of Vermont. If a child's peers are all the same size, parents won't see a problem.

To counteract such perceptions, in 2005 the UK Department of Health established a National Childhood Measurement Programme, through which all children in England are weighed and measured as they enter and leave primary school. Parents of overweight or obese children receive a letter informing them of their child's weight and its potential health implications.

"Without recognition, there's not going to be any behavioural change," says Hayley Syrad at University College London.

But knowing doesn't necessarily mean things will change for the better. Eric Robinson, a behavioural psychologist at the University of Liverpool, UK, and his colleagues have shown that children's weight trajectories align with their parents' perceptions, and kids correctly identified as overweight tended to gain more, not less, than peers with oblivious parents.

Robinson suspects the shame attached to being heavyset is to blame. "If you think about the world we live in and how we stigmatise and point fun at people who are fat, who would want to identify as overweight? You're not going to feel good about yourself," he says.

But that doesn't mean parents should wilfully ignore how their children tip the scales. You just need to face weight problems in a more covert way, Robinson says. Perhaps with smaller plates that can't hold quite as much mac-n-cheese.

showed Wardle and her team that appetite and weight were linked: children who were more responsive to food and slower to feel full were more likely to carry excess weight. But the researchers couldn't tell if the eating traits caused the weight gain or if being overweight was changing kids' habits around food.

### Back to the start

"If we wanted to try and get any kind of causal grip on the relationship between appetite and weight," says Clare Llewellyn, who worked with Wardle and studies behavioural obesity at University College London, "we had to go right back to the beginning of life, when these things first started to emerge."

They needed a new kind of study. So for the past decade, Llewellyn has helped run Gemini, the largest-ever twin study of childhood weight and appetite, which involves more than 2400 pairs of twins born in England and Wales in 2007. She and her colleagues have found that genetic differences in how we respond to food are apparent from the first weeks of life, and can influence our weight for the rest of our lives.

"Weight gain is deceptively simple really," says Llewellyn. "Small differences in appetite on a regular basis can catch up with you."

By just a few months of age, the twin study found that babies show clear differences in how they react to milk and how soon they'll stop feeding once they feel full. By 15 months, twins with strongly divergent eating traits can show as much as a 1-kilogram difference in body weight. That is about 10 per cent of each child's weight. Project that into adulthood, and deep-rooted dining habits may be adding centimetres to your girth.

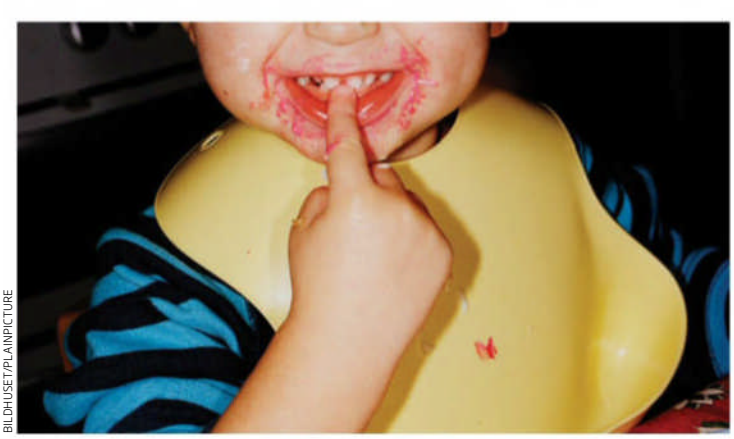
Gemini revealed that a heartier appetite during the first three months of life fuelled early weight gain into toddlerhood, not the other way around. "This is the only study to show us that the genetic influences of appetite are visible right from birth," says Susan Carnell, a behavioural scientist now at Johns Hopkins University School of Medicine in Baltimore, Maryland, who developed behavioural susceptibility theory with Wardle.

By the time the Gemini twins turned 2, there was also a distinct divergence in consumption: if you compared two children at opposite extremes of satiety responsiveness, there was a difference of about 37 calories per meal, the equivalent of half a digestive biscuit. Those extra bites quickly add up to more than five extra days' worth of food consumption per month.

So it's not that overweight children are eating fattier or more sugary foods. They just eat a little bit more at each meal or snack. The same appears true for grown-ups. "It's not just what you eat, but how you eat," says Llewellyn.

This work changed thinking in the field of obesity research, says Jason Halford, a health psychologist at the University of Liverpool, UK. "Everyone now knows that the

CAVAN IMAGES/PLAINPICTURE



BILDHUSET/PLAINPICTURE

**Little by little: just a few extra mouthfuls at each meal can quickly add up**

## RUN OFF THOSE EXTRA CALORIES

**If your genes put you at risk of overeating (see main story), you should be able to cancel out those extra calories by hitting the treadmill or going for a bike ride, right? It's not so simple.**

**"Most people can't do enough exercise to offset their calorie surplus," says Todd Miller, director of the weight management and human performance lab at George Washington University in Washington DC.**

**An analysis of more than 10,000 people in the US who lost at least 14 kilograms and kept the weight off for a year or more shows that just 2 per cent shed the pounds solely through exercise.**

**Part of the reason why physical activity alone isn't effective has to do with "metabolic compensation": the more energy you burn from exercise, the less energy your body needs for basic functioning while at rest. In fact, some research indicates that energy expenditure can reach an upper limit and then plateau.**

**But the main culprit could be hunger, says Diana Thomas, an obesity researcher at the West Point military academy in New York state. Those who up their exercise respond to their body's increased energy needs by eating more, often without even realising they're doing it. "It's really easy to rack up those calories by just licking a spoon of peanut butter one more time," Thomas says.**

environment is very much driving obesity," Halford says. The work of Wardle and her collaborators showed that, while by no means the only factor, genetic weaknesses or genetic protections put people on developmental trajectories from birth that influence their appetite.

With calorie-rich fare now abundant in kitchens and supermarkets throughout much of the world, people whose genes put them at risk of overeating will consume to excess in a way that wouldn't have been possible in earlier times (see "In your genes", page 34). "We're past the days when we had to be vigilant about plate-cleaning," Llewellyn says. "But unfortunately, that seems to have remained in the culture around eating."

And unless we take action to counteract our genetic predilections, waistlines will continue to grow where food is plentiful – and so will the attendant health problems.

This fact has an increasing number of people seeking out a more high-tech solution to their weight problem: DNA tests. Numerous companies sell tests that promise diet and lifestyle recommendations purportedly informed by your personal genetic make-up. Tests usually include a sample of the 200 to 300 gene regions tied to weight in some way.

But even if you add up all the known genetic risk factors, they collectively account for maybe 5 per cent of the variation in body weight. How can that be, if, as twin studies have shown, up to two-thirds of this difference may be down to heritable factors? It's either

**"Weight gain is deceptively simple – small differences in appetite on a regular basis can catch up with you"**

that we haven't identified all the genes at play yet or that they affect behaviour in a more complicated way than we understand.

*FTO*, for instance, is perhaps the most extensively studied gene thought to affect appetite. But recent efforts to confirm findings that *FTO* increases food intake, instead found that the "skinny" and "fat" variants of the gene influenced how people store or burn calories. The effect on appetite seems to be more subtle and indirect.

The trouble is, while we can identify and measure differences in food and satiety responsiveness, see how they relate to changes in weight and know that these effects are down to our genes, it is harder to pin down precisely which genes, or combinations of them, are responsible. There may be a lesson here from attempts to use drugs to govern appetite. For years, it was hoped that drugs targeting chemical pathways critical to appetite would be the key to tackling obesity. But it turns out that if you block one pathway, the body will find a workaround. The same may be true with expression of the various genes that affect appetite.

## Extreme hunger

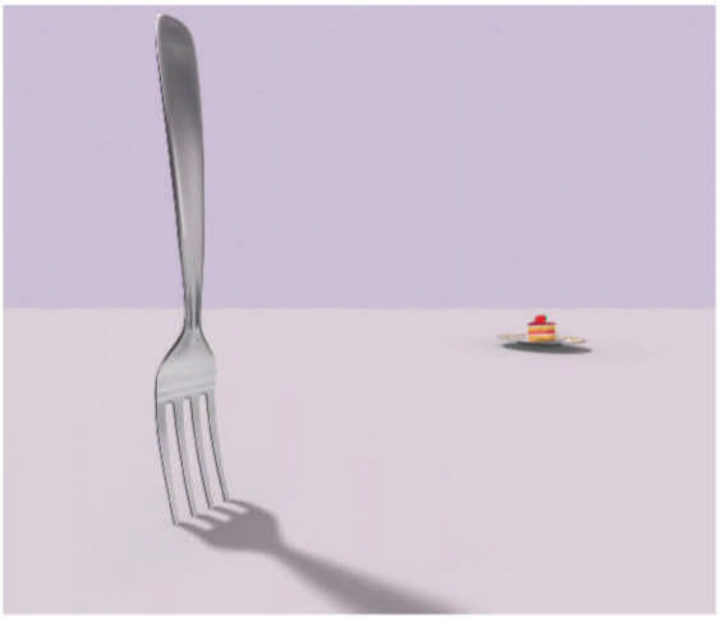
There are some rare disorders, such as congenital leptin deficiency, in which a single-gene defect is responsible for extreme hunger and obesity. In these cases, genetic testing is warranted. For everyone else, the tests are all "bullshit", says Ruth Loos, director of the Genetics of Obesity and Related Metabolic Traits Program at Icahn School of Medicine at Mount Sinai in New York City.

Loos worries about the pendulum swinging away from the misconception that overweight people lack willpower to a deterministic fatalism that there's nothing to be done as the problem lies in your genes. The truth, she says, is harder to swallow. It's not a level playing field. "Some people just have to work harder not to gain weight."

That brings us to the big question. If our genes predispose us to eat more than our body needs, what can we do about it?

Pay close attention to the ways you respond to food, says Llewellyn. Do you always go back for seconds? Do you leave food on your plate if you feel too full? Llewellyn says her "trigger food" is spaghetti bolognese. "I just go absolutely mad for it and I can't control myself," she says. So she never cooks more than a single portion's worth of pasta. And as soon as her food is plated, she sticks any leftover sauce in the fridge. Otherwise, she says, "I will invariably go back and eat more until I feel physically sick."

There might be a way to nudge overweight individuals in the right direction, without explicitly lecturing them about eating habits, says Claudia Hunot, a dietician at the University of Guadalajara in Mexico. She gave adults a questionnaire about their eating habits, and then offered email tips tailored ›



YAGI STUDIO/GETTY

**Some people are slower to register feelings of fullness**

to participants' food-related foibles – be it emotional eating, eating too quickly or feasting past the point of fullness. "We could give them accessible and simple information that spoke to their own personal traits," Hunot says. If the results suggested someone was very responsive to food, for instance, she might suggest keeping certain foods out of the house or avoiding the table of treats at work. Another strategy is to build up resistance over time: if chocolate is a weakness, buy a small bar and carry it around but don't eat it. The idea is that over time you will become less tempted to indulge.

Feedback from the 32 people who've tried the intervention so far has been positive, says Rebecca Beeken, an obesity researcher at University College London who collaborated with Hunot. "People felt empowered by the knowledge that they could be genetically predisposed to find it harder," she says.

But to truly tackle a proclivity for pigging out, the twin studies seem to suggest that interventions have to start much earlier – perhaps even during the first months of life. A common refrain in parenting books and even on government websites is that you can't overfeed a breastfed baby, but, says Llewellyn, "our data suggest that's not completely true".

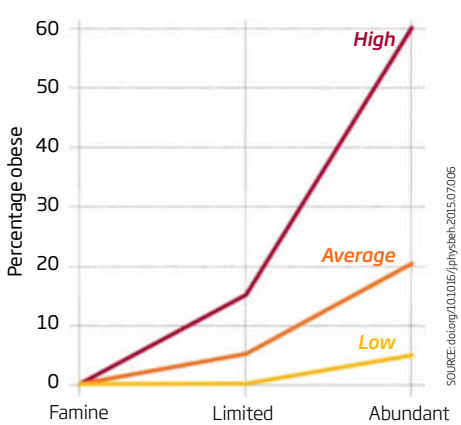
Ian Paul, a paediatrician at Penn State Children's Hospital, advocates "responsive parenting". This basically involves paying attention to your child's needs and learning the difference between cries of hunger, overstimulation and tiredness, for instance, and then tailoring your responses accordingly – instead of turning to food as a default solution. Paul and his colleagues studied about 300 first-time mothers, half of whom were trained in responsive parenting, the other half on infant safety. Those in the first group were half as likely to have an overweight 1-year-old and one-tenth as likely to have an obese 2-year-old.

"Part of responsive parenting is limit-setting," says Paul. That simply means being sensible about portion sizes if you have a child who will overeat given the chance (see "Are the kids alright?", page 32).

This might sound simple, but it's "a lot harder to do in practice" when your baby is crying, says Carnell. "It's a very tricky topic," Llewellyn says. "No parent wants to be told what to do." Maybe this is why some believe that less of the burden of addressing the obesity crisis should be placed on the individual. Theresa Marteau, director of the Behaviour and Health Research Unit at the University of Cambridge, thinks the UK government should start placing restrictions on the portion sizes of unhealthy foods.

## In your genes

The amount of available food influences whether people become obese, but models show that a more important factor could be whether you have a **high**, **average** or **low** genetic susceptibility to obesity, which affects what and how much you want to eat




SOURCE: doi.org/10.1016/j.physbeh.2015.07.006

**"People with genes to savour the 'sensory loveliness' of food may take those extra bites after they feel full"**

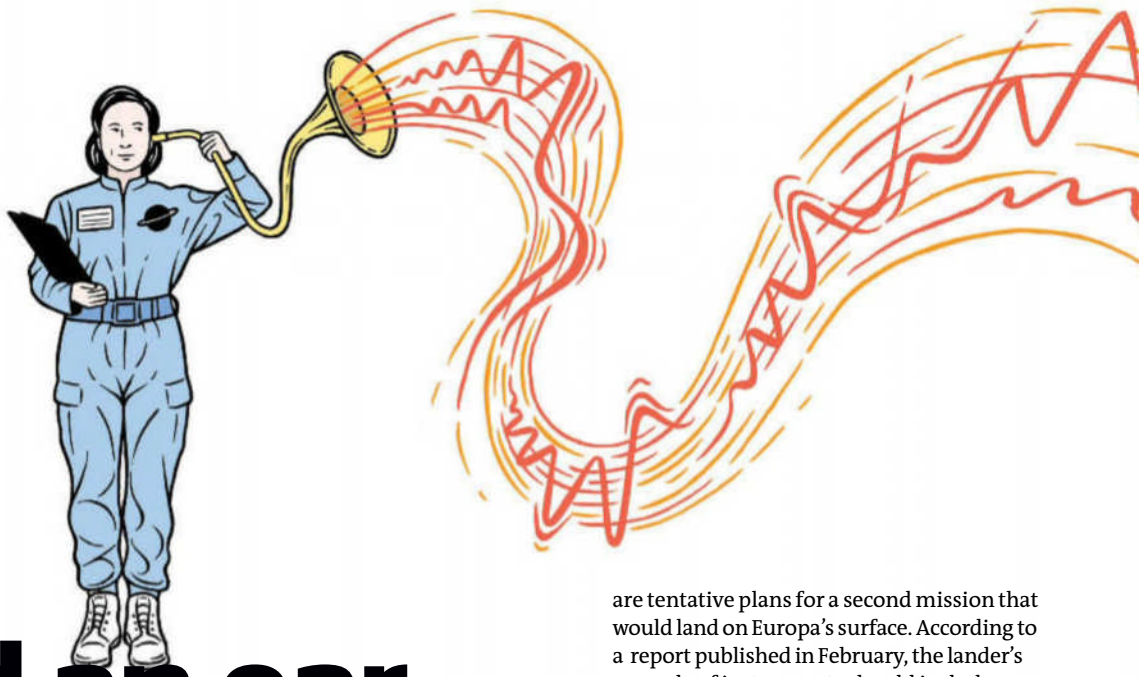
Economic analyses suggest that this would make a massive dent in the country's public health burden from obesity. "Smaller portions, packages and tableware could reduce daily energy intake by significant amounts," Marteau says.

Yet few governments are willing to implement such heavy-handed legislation. New York City perhaps came closest when it tried to introduce a ban on large soda containers in 2013. The move caused a public outcry and met fierce opposition from the beverage industry. It was eventually struck down by the courts.

So, for now at least, we are on our own. But acknowledging that it might be more difficult for you than for others to turn down that tempting yet unneeded pudding doesn't have to prompt feelings of helplessness. Instead, knowing there is a reason for your powerful urge can provide a sense of relief, says Beeken. "There is a lot of stigma around weight and ability to lose weight," she says. "People know that they find it hard, and knowing that there is a reason they find it hard takes some of that blame and guilt away."

And perhaps there are reasons to celebrate these differences. Danielle Reed at the Monell Chemical Senses Center in Philadelphia, Pennsylvania, likens the propensity for overeating to genetic differences in vision. Just as someone who sees more colours might linger longer at the Louvre than someone who is colour-blind, so someone who has the genes to savour the "sensory loveliness of food" might take those extra bites even after they're full. If you struggle to refuse that extra slice, perhaps it is some consolation that you might be able to taste in technicolour and better appreciate all the glorious flavours. ■

**Elie Dolgin** is a writer based in Somerville, Massachusetts



STUART PATIENCE

# Send an ear

Future probes will eavesdrop on moons to listen for sounds of life, finds **Stephen Battersby**

YOU are entering an alien soundscape. The first thing you notice is a chorus of curious pings – or perhaps you'd call them chirps. Underneath their bright staccato is an almost ominous roar. And faintly, in the distance, could that be the whistle of a railway train?

In a few years, sounds like these might be proclaiming good news for life on Europa, the pale moon of Jupiter that may be one of the most hospitable spots in the solar system. Although its surface is an airless landscape of cracked ice, all the evidence says that beneath that bleak shell is a liquid water ocean stretching hundreds of kilometres down to the rocky mantle below. If life can thrive on Earth's ocean floors, feeding on the chemicals that gush from the rocks, why not on Europa too?

NASA is already putting together a mission to this intriguing world. Europa Clipper should launch in the early 2020s, and when it arrives in orbit around Jupiter it will repeatedly swoop over the moon, picking up valuable magnetic and gravitational information about its structure. And there are tentative plans for a second mission that would land on Europa's surface. According to a report published in February, the lander's panoply of instruments should include a small seismometer – a simple device that would give scientists an ear on Europa's inner workings. This could enable them to learn more about its ice crust, work out the chemistry of the ocean and the rocks beneath, and perhaps pick up the music of active geysers on the surface and volcanoes erupting on the sea floor. Put it all together, and we could get a much better idea of whether Europa is a healthy spot for life.

"So now we need to know what we'll be listening for," says Mark Panning, a member of the mission team based at the University of Florida in Gainesville. To help them make the most of any data sent back, Panning and his colleagues have simulated the vibrations a seismometer might pick up on Europa, and turned the result into sound files.

"Previous studies tried to do detailed modelling," says Panning. "A lot of it was very dependent on assumptions about how the ice behaves – a lot of unknowns thrown together." His team chose instead to focus on the big picture, by working out how much energy was likely to go into the seismic processes that shake Europa's crust.

It all starts with the tide. Just as our moon exerts a pull on Earth, Jupiter's gravity stretches out Europa. Because the moon's orbit is slightly elongated, and it wobbles from side to side as it travels round Jupiter, this tidal distortion is constantly shifting, repeatedly stretching and squeezing Europa in different directions. These contortions heat up the moon enough to keep its inner ocean from freezing solid. They should also create cracks in the ice shell, or icequakes, a process ›

whose total energy can be worked out without too many assumptions.

Panning and his collaborators assumed that Europa's icequakes follow a similar pattern to tremors on our planet and moon. As seismometers on Earth and those left behind by the Apollo missions have shown, quakes on both bodies have the same

**"Cracks in Europa's icy crust would sound like pebbles thrown on a frozen lake"**

probability distribution, with those one notch higher on the magnitude scale happening one-tenth as often. This relationship meant the team could divide the total tidal energy felt by Europa into a plausible set of icequakes.

Team member Simon Stähler at the Ludwig Maximilian University of Munich in Germany then modelled how vibrations from each quake travel through the ice crust and ocean before being picked up by a seismometer. Finally, he speeded up the recording 500 times, to shift low, slow quake vibrations up into the audible range. This last step wasn't strictly necessary for science purposes, says Panning. "Making it audible was just fun."

The resulting audio file consists of a series of pings, like the sound of pebbles being thrown onto a frozen lake. This is no coincidence. Europa's ice crust is kilometres thick, but it vibrates in roughly the same way as ice on a lake, by bending. Bending waves of this type move faster when they have higher frequency, so the high-pitched sounds reach the seismometer before the lower notes – resulting in that characteristic ping.

Listen to the sound of our own planet and you'd hear something quite different. Earth's rocky crust doesn't sit on a liquid layer, but instead on a thick, rocky mantle. This solid sandwich won't bend, so the energy released by earthquakes takes the form of waves that either travel deep through the planet or cling close to the surface. The upshot is that when the seismic waves from a cluster of earthquakes are sped up, you hear a series of percussive cracks from fast-travelling deeper body waves, each followed by the boom of slower surface waves, which then rise in pitch.

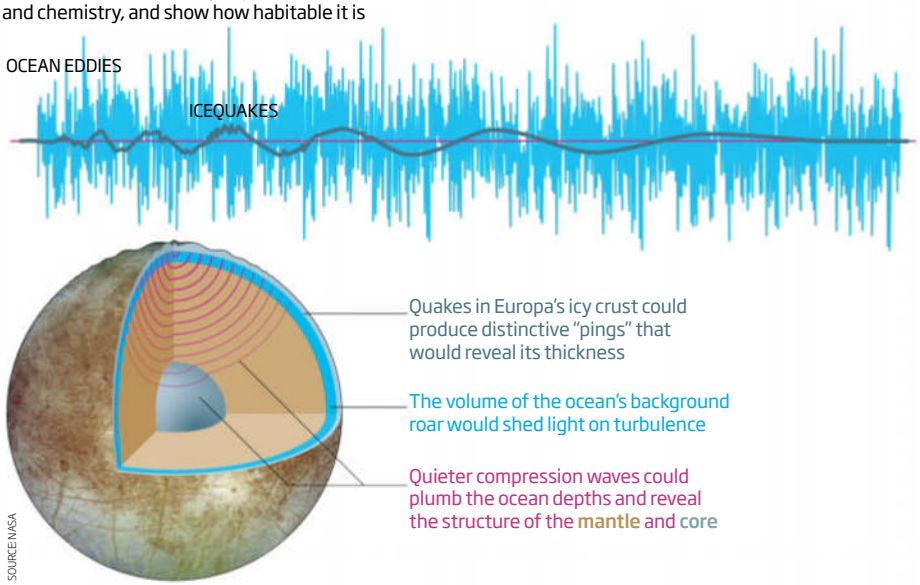
Because we don't know exactly how thick Europa's ice crust is, the team ran simulations for icequakes travelling through layers either 5 or 20 kilometres deep. "The pings in the thinner ice shell are more dispersed," says Panning, with each one lasting longer.

And while the ice cracks, Europa's dark ocean roars. Simulations show that its currents are probably turbulent, with eddies moving at up to 2 metres per second. These would push up against the crust, sending out seismic waves of their own. The team has now added this effect, resulting in a distant, deep rushing sound.

STUART PATIENCE

## Lunar tune

The characteristic melody of Jupiter's moon Europa could reveal valuable infomation about its structure and chemistry, and show how habitable it is




SOURCE NASA

Hidden under these sounds will be subtler signals that can be used to work out Europa's structure. As well as the pings produced by the bending ice sheets, each icequake sends out two other types of wave. There are compression waves, like sound in air, and shear waves – a side-to-side shaking. These are much lower in amplitude than the bending waves, making them inaudible on the sound files, but their reflection at boundaries within the moon could give measures of crust

thickness and ocean depth. Oil companies use similar principles – though relying on explosives rather than cracking ice – to look for promising spots to drill, says Panning. Without a seismometer in place at present, we can only get a hazy view inside Europa and other moons, by measuring their magnetic and gravitational fields from a distance. Unlike seismology, these methods can't clearly identify sharp boundaries within a body.

Seismic data could also reveal whether Europa's seabed is smooth or rough and rugged. And combined with gravity and magnetic measurements, they could give us a taste of how salty the ocean is, because sound travels faster in saltier water.

## Audio guide

Planting a seismometer on Europa's surface may even make it possible to look deeper. Some of the sound of an icequake will penetrate the mantle, reach the metal core that may exist within and bounce back. If the mission is lucky, there might even be a big quake way down in the mantle, which would set the whole moon ringing and reveal its deep structure more clearly.

In the absence of that, or an unlikely large cometary impact, icequakes will probably be the loudest thing the proposed lander will hear during the few weeks of its battery-powered life. But some fainter, more intriguing voices might also make themselves heard. The Hubble Space Telescope has spotted plumes of water vapour rising from Europa, similar to those puffed out by geysers on Saturn's moon Enceladus. Geysers on Earth have a characteristic sound, with a base note overlaid by a series of harmonics. "When you speed it up, it sounds like a train whistle," says Panning. His colleague Steven Vance, at the Jet Propulsion Laboratory in Pasadena, California, says that capturing this sound with a seismometer should allow us to work out the size of the water chambers that feed these plumes, and gain some insight into how the geysers work.

And if all the other noise doesn't drown it out, any volcano on the sea floor could add its own whistling to the choir, suggesting a steady flow of hydrogen and methane into the ocean. That would be encouraging news for Europa's habitability, because bacteria on Earth eat these substances. Hydrogen and methane might be created when hot fluids chemically alter rocks in the mantle, leaving behind less dense minerals with a distinct seismological signature.

Although these chemical morsels could power life as we know it, they won't be enough on their own. Hydrogen and methane can only be digested if there is also a supply of oxygen, which is scarce on most worlds. Oxygen is abundant on Earth only because of our long history of photosynthesis. While plant life on Europa is a slim possibility, this moon has another source of the element: charged particles from Jupiter's radiation belts generate free oxygen by breaking up water molecules on Europa's icy surface.

A big question is how much of this life-giving gas would find its way to the ocean below. Again, a seismometer could help to give us an answer. For a start, the thickness of the icy crust matters, because a thinner layer of ice should be relatively permeable. Seismology should also reveal whether water is seeping through the ice and whether the bottom bit of the crust consists of convecting slush. Both these things would affect how rapidly the crust's structure changes, and how long it takes oxygen formed at the surface to reach the sea. "There might also be plate-tectonic-like behaviour on Europa," says Vance. That would be a direct route for oxygen to ride down into the ocean on subducting plates of ice.

With all the deep knowledge on offer from such a small device, future missions to other outer moons might want to include a seismometer too. Enceladus would be a good target, says Vance. "We know it's seismically active and we know where to land."

He is also interested in the biggest ice moons, including Jupiter's Ganymede and Callisto. His calculations suggest these objects could resemble multi-decker sandwiches, with oceans stacked beneath oceans, separated by exotic forms of ice that only exist at high pressure. "You could only find these with seismology," says Vance.

**"When you speed the geysers up, they sound like train whistles"**

Saturn's biggest moon may be especially appealing from a sonic point of view. "We know Titan should be seismically active, from the methane atmosphere," says Vance. "We could also hear water sloshing around the lakes."

The Europa lander has yet to be approved, and missions to other icy moons are even more distant prospects, but a seismometer will soon be en route to a slightly closer target. An instrument called SEIS is due to launch on the InSight mission to Mars next year, aiming to show us the deep structure of the Red Planet. Astronomers are all ears. ■

**Stephen Battersby** is a consultant for *New Scientist*.
To listen to the audio files mentioned in the feature, see the online version at newscientist.com/issue/3128

# Spoken rules

How children learn language is one of the biggest and oldest debates in linguistics. A new take on an old idea may finally provide the answer, say psychologists

Freddy Jackson Brown and Nic Hooper


SIXTY years ago, renowned Harvard psychologist B. F. Skinner published one of the most important books ever written about language. *Verbal Behavior* offered a comprehensive account of our unique capacity for symbolic communication, arguing forcefully over nearly 500 pages that it was learned rather than innate. The culmination of years of work, it was certainly influential – although not in the way Skinner anticipated. Rather than propelling his ideas into the limelight, it sparked a counter-revolution that catapulted a rival theory to worldwide acclaim.

Now, though, that rival theory is in decline and some of Skinner's ideas are making an unexpected comeback. In recent years, psychologists have discovered that language really is learned, emerging from some general skills that are taught to children in the first few years of life. Surprisingly, these are not grand intellectual feats. Rather they can appear almost trivial – as simple as grasping the relationships between things, such as a large ball and a small one.

The debate over the extent to which language is learned or innate is one of the most enduring in linguistics. Most children start to speak around age 2, and within a few short years are proficient, often prolific, users of language. Do they simply listen and learn, or are they born with some language facility that is filled in by the specifics of their native tongue? Learning is obviously involved – children pick up the language(s) they are brought up with. But can this alone account for the complexity and creativity of language?

That was the question Skinner set out to answer in the 1940s. As a behaviourist, he championed the idea that much of human behaviour, including language, could be explained by learning theory. He was especially interested in operant learning, which holds that our actions are shaped by their consequences. In a nutshell, behaviour is shaped by environmental feedback in the form of reinforcement or punishment.

As an approach to language, it was highly original. Linguists typically study form and structure – grammar, syntax and so on. But Skinner was interested in function: under what circumstances is language produced, and to what effect? He developed a system that grouped very different behaviours according to their function. For example, saying "hello" or "hi", nodding, and writing the word "hello" can all have the same function, so they can be grouped into a single unit called an operant.

The parallel with evolution was clear. Skinner saw operant learning as the process by which organisms adapted to their environments within their lifetimes. In much the same way that natural selection can lead to biological complexity, selection of behaviour can shape increasingly novel and complex repertoires, including language. Successful

MARIE GENEL/PICTURETANK

What's the relationship between this truck and that truck?

behaviours are selected, the operant evolves, and this is the basis of linguistic complexity.

*Verbal Behavior* was conceptually bold, but was almost immediately on the back foot. In 1959, a young linguist called Noam Chomsky published a highly critical review that laid the foundations for an alternative explanation of language – possibly the most influential book review in the history of science.

Chomsky's main critique was that Skinner hadn't accounted for a feature of language called "generativity". That is, our ability to produce and understand sentences we've never heard before. He pointed out that a lot of what we say has not been directly learned or prompted by our immediate environment. To use Chomsky's own example, "colourless green ideas sleep furiously" is a grammatically correct but meaningless sentence that nobody had ever thought to utter before. If language was learned, how could he have come up with it? He explained away this "poverty of stimulus" by positing that humans are born with innate language skills called universal grammar.

Another classic example comes from an anecdote recounted by Skinner in *Verbal Behavior*. In 1934, as a young scholar, he attended a Harvard fellows' dinner where he found himself sitting next to the philosopher Alfred North Whitehead. After a discussion about behaviourism, Whitehead issued Skinner with a challenge: "Your behaviourism works except with verbal behaviour. How can you explain my sitting here saying something like, 'No black scorpion is falling on this table'?" His point was that he had never said it before and nothing in the room had prompted him. The challenge set Skinner on an intellectual journey that culminated with his book; in it he suggested that the black scorpion was a metaphor for behaviourism, thus accounting for Whitehead's words within his framework.

**"Do children just listen and learn, or are they born with an innate language ability?"**

But Chomsky's ideas proved the more persuasive and his star began to rise. Within a decade universal grammar was the dominant idea in linguistics. But some psychologists remained unconvinced. Although there were gaps in Skinner's account, this did not mean that a functional analysis of language was not worth pursuing – indeed a small number of researchers continued this pursuit.

In the 1970s and 1980s, Murray Sidman at Northeastern University in Boston led a small research group aiming to understand how we learn to read. In various experiments they used a simple procedure called "matching to sample", teaching young children to select one stimulus in the presence of another. For example, when presented with the letters "D-O-G", they were taught to choose a ›

picture of a dog. This is how most people learn the names of things and it is a core component of learning to read.

Sidman noticed something interesting: after learning one relationship, the children automatically understood others that they had not been taught. In one experiment he taught children aged 5 to 7 to match the names of Greek letters to their upper and lower case symbols. When they heard the word "gamma", they learned to select the symbols Γ and γ. They also learned the words and symbols for xi (Ξ and ξ) and lambda (Λ and λ).

PETER MARLOW/MAGNUM PHOTOS

**Learning to link words and pictures is a key part of language development**

## All Greek to me

During later tests, Sidman found that the children also knew relationships that they had not learned: when presented with γ they could select Γ and vice versa, even though they hadn't explicitly been taught that relationship. They were also able to say the names of the Greek letters when presented with their symbols, again without any training. Sidman called this phenomenon "stimulus equivalence".

These findings prompted a great deal of interest in behavioural science at the time because they could not be explained by the children's learning history, further challenging Skinner's original account. Perhaps more importantly they provided experimental demonstrations of people uttering things they had never said or heard before, opening up new ways to explore language generativity.

Over the past 30 years research led by Steven C. Hayes of the University of Nevada, Reno, and Dermot Barnes-Holmes at the University of Ghent in Belgium has shown Sidman's equivalence to be just one type of stimulus relationship. There are lots of others, like opposition (up versus down) comparison (an elephant is bigger than a mouse) and hierarchy (cheese is a type of diary product). All can be learned and then generalised.

We now know that young children learn to link all sorts of different stimuli together using these relationships and then effortlessly generalise them to novel stimuli – a skill called generalised relational responding.

Having learned the relation "bigger", for example, they find it easy to identify the larger object in other pairs, like two trees, two chairs, or indeed two unlike objects, such as a book and a chair, or a dog and a cat. Even though they might never have seen the stimuli before, they can generalise.

At first sight, this can appear almost trivial. How hard can it be to learn that one thing is bigger than another, then generalise that relationship? However, it turns out to be a uniquely human skill. While children can effortlessly do it from the age of 16 months, no other animal has shown a similar aptitude.

Many species can learn the basics. For instance, a pigeon can be taught to select the larger of two balls by presenting it with both and rewarding it when it pecks the right one. After a few successes it learns to peck the correct ball every time. But it cannot generalise this relationship to other objects that do not look similar to the ones it was trained with.

Our closest living relatives can't do it either. In 2000, psychologists Neil Dugdale and Fergus Lowe of Bangor University, UK, published the results of their research with three chimpanzees, Sherman, Austin and Lana. They taught the chimps to respond to the letter Y by selecting the letter G and not R. Once they had learned this relation, the chimps were shown the letter G to see if they would reverse it and choose Y. They failed. This was despite having lived with the primatologist Susan Savage-Rumbaugh for years and receiving extensive language training – probably more than any other non-human animals in history.

Another key feature of generalised relational responding is that it requires learning. Almost from birth, infants are given intensive training in the relationship between stimuli. Parents or caregivers might pick up a ball and say "ball" and then moments later say "ball" and point to a ball, or a picture of a ball. Over time the child will be exposed to many objects and words, in many different settings

**"Children can eventually ask abstract questions like 'who has the bigger ego?'"**

## SAME, DIFFERENT AND THE REST

Objects and events are related to each other in nine basic ways. According to an emerging theory of language called relational frame theory (see main text), networks of these relations are the building blocks of symbolic thought and language

1. **COORDINATION**
   dog is the same as hound
2. **DISTINCTION**
   a white dog is not the same as a brown dog
3. **OPPOSITION**
   a black dog versus a white cat
4. **COMPARISON**
   this dog is bigger than that dog
5. **SPATIAL**
   that dog is on the left, the other dog is on the right
6. **DEICTIC** (similar to spatial but in terms of the perspective of the speaker)
   I am in front of that dog but behind the other
7. **TEMPORAL**
   I fed the dog before I fed the cat
8. **HIERARCHICAL**
   a dog is a sort of mammal, which is a type of animal
9. **CAUSAL**
   if the dog bites me, I will punish it

and with different people, but in each case the equivalence relationship remains constant. After sufficient training the child is able to abstract out the relation and use it with any stimuli in any situation. The same happens with other relationships such as bigger/smaller, higher/lower or same/opposite.

With time and practice the stimuli can become more abstract and context-independent, enabling children to compare arbitrary symbols and even concepts. Eventually, they can ask and answer questions such as: which country has the stronger economy? Who has the bigger ego? What is more important, time or money?

This turns out to have far-reaching implications. It explains, among other things, how we are able to link together arbitrary symbols such as written and spoken words – the essence of symbolic language. It also enables us to combine symbols in novel ways, to extend our language use beyond our direct learning histories. Sound familiar?

As experimental evidence accumulated, the researchers began to ask themselves the same question: is generalised relational responding the key to language?

## In the frame

The research programme begun by Sidman has been synthesised into a comprehensive model of language called Relational Frame Theory (RFT), which is now vying to replace Chomsky's increasingly unfashionable ideas as the dominant theory in linguistics.

A relational frame is a specific type of relational responding with three defining features – the ability to reverse and combine stimulus relations, and what is called the "transfer of stimulus function". The "frame" refers to the nature of the relationship between two stimuli – sameness, for example, or opposition. Once two stimuli are framed together, their relationship can be reversed and/or combined, and the function of one stimulus is transferred to the other. In that way an arbitrary symbol like a written word can acquire a meaning.

As a very simple example, once the arbitrary sound "dog" has been linked to actual dogs in a "sameness" frame, they end up having the same function. A child with a fear of dogs will experience fear if told that there is a "dog" in the next room. The function of an arbitrary stimulus, "dog", has been transformed to have the same meaning as an actual dog. This transfer can then continue onto other stimuli. For example, if the child learns that "chien" is the French word for "dog", then they would have a similar fear response on hearing a "chien" is in the next room.

To date RFT has identified nine types of stimulus relation and how they are learned in early childhood (see "Same, different and the rest", left). It also describes how they can be built into networks of relations. Each and any of these relations can connect stimuli together, allowing us to link anything to anything. In this way RFT describes how we are able to create a richly symbolic, dynamic network of relations between arbitrary stimuli – in other words, language.

Admittedly, it can sometimes be hard to see how a skill as apparently simple as relational framing can give rise to something as rich and complex as language. In this respect RFT has similarities with natural selection. The idea that life evolves as the environment selects variations from the gene pool is quite straightforward, but what makes the mind boggle is how it can account for the huge diversity of living things on our planet.

Nonetheless, RFT's big claim is that our ability to reverse and combine relations and transfer stimulus functions answers the big question that motivated Skinner and Chomsky: what are the origins of language?

If RFT is correct, Skinner was right after all – sort of. Language is learned, although not quite as he originally conceived it. We don't need innate abilities such as universal grammar to account for language generativity. Instead, it is the product of a learned, generalised – and uniquely human – ability to respond to simple relationships between stimuli. We take it for granted, but it is arguably what makes us human. ■

**Freddy Jackson Brown** is a clinical psychologist and associate fellow at the University of Warwick, UK. **Nic Hooper** is a lecturer at University of the West of England in Bristol

# Endgame? It's just the beginning

Chess legend **Garry Kasparov** knows first-hand how it feels to lose out to AI. Now he says we need to stop worrying and learn to love it

HE WAS fiery, flamboyant and merciless, and people loved him for it. It was 1985 when Garry Kasparov became the youngest ever world chess champion at just 22. He remained at the top for 20 years, but it was his epic battles with IBM's supercomputer Deep Blue in 1996 and 1997 that catapulted him into the stratosphere. Billed as the ultimate Human vs Machine challenge, the first six-game match began badly for Kasparov, but he fought back to win 4-2. But in the second game of the rematch a year later, a flustered Kasparov needlessly resigned when he could have forced a draw. He never recovered psychologically, and lost 2½ to 3½. It has taken Kasparov 20 years to get over his defeat – and to embrace his former adversary, artificial intelligence.

**You've have just published a book in which you explore your defeat by Deep Blue. Was writing it a cathartic experience?**
Yes, absolutely. There were many questions about my rematch with Deep Blue that I had avoided asking and the answers weren't always pleasant. Even though it was 20 years ago, writing about it was a very painful experience. I'd never analysed those six games in depth using modern chess computers. I discovered that Deep Blue didn't play very well either – at least not as well as we all believed at the time – and this made me feel even worse about how my terrible psychological state during the match led to my loss. Of course, it was only a matter of time before Deep Blue or another machine defeated me, but I played embarrassingly below my level.

**If you could go back in time and take the draw in the second game of the rematch, would you?**
Once a move is made it cannot be retracted, and if I had a time machine, I'm sure I could think of better uses for it. That match was such an anomaly, it has taken years for me to even attempt to draw lessons from it.

**What are the broader lessons from your defeat?**
As the proverbial man in man-versus-machine I feel obligated to defend humanity's honour, but I'm also a realist. History has spoken: for nearly any discrete task, including playing chess, machines will inevitably outstrip even human-plus-machine. AI is hitting us in a huge wave, so it is time to embrace it and to stop trying to hold on to a dying status quo.

**What did you make of the Go match between DeepMind's AlphaGo and top player Lee Sedol?**
I understand that AlphaGo played some genuinely unusual moves, strong moves that a top human would never consider. It doesn't surprise me that there is room for this in a game as long and subtle as Go, where an individual move is worth less than in chess. It's even possible that entirely new ways of playing Go will be discovered as the machine gets stronger. It's also likely that humans won't be able to imitate these new strategies, since they depend on the machine's unique capabilities.

**You called Deep Blue the end and AlphaGo the beginning. What did you mean?**
Chess was considered a perfect test bed for cognition research but it turned out the world chess champion could be beaten while barely scratching the surface of artificial intelligence. I'm sure some things were learned about parallel processing and the other technologies Deep Blue used, but the real science was known by the time of the 1997 rematch. Not to downplay the Deep Blue team's achievement, but AlphaGo is an entirely different thing. Deep Blue's chess algorithms were good for playing chess very well. The machine-learning methods AlphaGo uses are applicable to practically anything.

**What does that mean for the wider world?**
AI is clearly booming as a technology, but there's no way to know what part of the curve we are in. Periods of rapid change are turbulent and confusing, and we are seeing the social apprehension that comes with a wave of automation, even more so because robots and algorithms are moving in on jobs that require college degrees. Of course, real dangers and human anguish come with the AI wave, and we can't be callous toward those caught in the turbulence. But it's easy to focus on the negative things because we see their impact much more clearly, while the new jobs and industries of the future can't be imagined

JOEL SAGET/AFP/GETTY IMAGES

so easily. I think we'll be surprised, as we have been throughout history, by the bright future that all these amazing tools will help us build, and how many new positive trends appear.

**Computer scientist Larry Tesler once said "intelligence is whatever machines haven't done yet". Where are the next targets?**
Where aren't they? The biggest public impact might be felt in medical diagnosis. This is an area that doesn't require 100 per cent or even 99.99 per cent accuracy to be an improvement on human results. You wouldn't trust a self-driving car if it was only 99 per cent accurate. But human doctors are only 60 or 70 per cent accurate in diagnosing many things, so machine or human-plus-machine hitting 90 or 99 per cent will be a huge improvement. As soon as this is standard and successful, people will say it's just a fancy tool, not AI at all, as Tesler predicted.

**"The world champion could be beaten while barely scratching AI's surface"**

**What happens if AI, high-tech surveillance, military tech, and communications are sewn up by the ruling class?**
Ruling class? Sounds like Soviet propaganda! New tech is always expensive and employed by the wealthy and powerful even as it provides benefits and trickles down into every part of society. But it seems fanciful – or dystopian – to think there will be a harmful monopoly. AI isn't a nuclear weapon that can or should be under lock and key; it's a million different things that will be an important part of both new and existing technology. Like the internet, created by the US military, AI won't be kept in a box. It's already out.

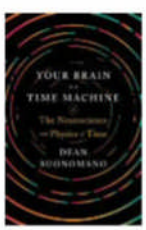
**Will handing off ever more decisions to AI result in intellectual stagnation?**
Technology doesn't cause intellectual stagnation, but it enables new forms of it if we are complacent. Technology empowers intellectual enrichment and our ability to indulge and act on our curiosity. With a smartphone, for example, you have the sum total of human knowledge in your pocket and can reach practically any person on the planet. What will you do with that incredible power? Entertain yourself or change the world? ■

Interview by Sean O'Neill.
*Deep Thinking: Where machine intelligence ends and human creativity begins* by Garry Kasparov is published by Hodder & Stoughton

# All the time in the world...

Grappling with all the ways we see time is a revolutionary act, especially for a neuroscientist, says **Anil Ananthaswamy**

*Your Brain Is a Time Machine: The neuroscience and physics of time*
by Dean Buonomano, W. W. Norton




"TIME is a road without any bifurcations, intersections, exits, or turnarounds." With that, neuroscientist Dean Buonomano sets up the meat of his new book, *Your Brain is a Time Machine* – and an intriguing difference between the way we animals navigate time as opposed to space.

Not that contrasting time and space makes the task of understanding time any easier, as Buonomano illustrates later: "The physicist's talk on the nature of time ended on time, but it seemed to drag on for a long time." This captures various notions of time: natural time, clock time and subjective time.

Natural time is what physicists fuss about. Is time real? Or is the passage of time an illusion, and do all moments in time exist in much the same way that all coordinates of space exist? Neuroscientists, on the other hand, fuss about clock time and subjective time.

To explain natural time, physicists and philosophers back eternalism, according to which the past, present and future are all equally real. "There is absolutely nothing particularly special about the present: under eternalism now is to time as here is to space," writes Buonomano.

The other main explanation of natural time is presentism, according to which only the present moment is real – a view that tallies with our sense of subjective time. The past is gone, the future hasn't happened yet. "Neuroscientists are implicitly presentists," says Buonomano. "But despite its intuitive appeal, presentism is the underdog... in physics and philosophy."

Buonomano decides it is time to simultaneously tackle the physics and the neuroscience of time. The title of the book is derived from the now well-regarded idea that our brains are prediction machines. Whenever we perceive something, theory says that what we perceive is not objective reality, but rather the brain's best guess as to what's causing the sensations impinging on the body. But popular accounts of the theory often ignore one dimension of the prediction machinery: time.

**"Mental time travel is a human capacity. But to do it, biology first had to figure out how to keep time"**

Buonomano points out that the brain is continuously making real-time predictions, not just of "what will happen next" but also of "when it will happen". To do so, the brain needs complicated machinery for keeping time – to predict not just what will happen within microseconds, but what might happen in seconds, minutes, hours, even days, weeks, months and years.

This ability to predict the long-term future is reliant on memory. In fact, that's really the main evolutionary use for memory, as a storehouse of the information needed to predict the future. With memory and cognition, our brains became time machines – we could travel back and forth in time. This mental time travel is a human capacity, distinguishing us from other animals, hence the book's title. Scrub jays, oddly, seem to demonstrate similar abilities, but proof of mental time travel in animals is hard to come by as yet.

To indulge in mental time travel, biology first had to figure out how to keep time, not unlike how scientists in the 17th century invented the pendulum clock. Christiaan Huygens's high-quality pendulum clocks were the first to keep time more accurately than clocks within the human brain.

Buonomano's book is full of delicious details about the myriad ways in which cells – neurons and other types – tell the time. For example, there's the complicated sounding suprachiasmatic nucleus, a cluster of neurons at the base of the hypothalamus that acts as a master circadian clock. Circadian clocks depend on pendulum-like oscillations of the levels of specific proteins. One of which is aptly named period.

But unlike our clocks, which can tell time over a vast range of intervals, the brain has no single clock. For example, lesions in the suprachiasmatic nucleus don't alter the brain's ability to discern temporal patterns at the scale of seconds: there are different clocks for that. If there's one clear message about the neuroscience of timekeeping, it's that neural circuits can wire themselves in response to regular external

HERBERT LIST/MAGNUM

stimuli. In other words, they can keep time, all sorts of time.

Reading Buonomano's book, it's hard not to marvel at how time and timekeeping pervade our existence – whether in the form of the clocks and instruments we build or through the mechanisms inherent in our brains. Buonomano creates a sense of wonder about just how complex the temporal brain is and about what a spectacular job it does of timekeeping.

Buonomano writes lucidly, in an almost matter-of-fact fashion, choosing crystalline clarity over flowery prose. So the occasional

**Neural circuits wire themselves to external stimuli to keep time**

writerly sentences stand out, for example, when he writes: "The duration of the beat of a hummingbird's wing is as concealed to our sensory organs as is the drifting of the continents."

Buonomano's clear writing is most apparent when he writes about the physics of time. Given that his expertise is neuroscience, this is no small feat. His explanation for why Einstein's special theory of relativity implies the existence a block universe – a 4D manifold of space-time in which here, there and everywhere exist alongside the past, present and future – makes a masterful case for eternalism.

Special relativity destroys the notion of simultaneity – the idea that two observers moving with respect to each other could agree on the timing of events. When speeds get close to the speed of light, the temporal order of events can be perceived differently by different observers.

Buonomano writes: "If we assume that all events that ave ever or will ever occur are permanently located at some point in the block universe… then the relativity of simultaneity becomes no more puzzling than the fact that two objects in space can appear to be aligned or not depending on where you are standing. Two telephone poles along a highway appear aligned if you are standing on the side f the road, but not if you are in the middle of the road – it is a question of perspective." And so it is with time.

But eternalism clashes with our subjective experience of the flow of time: in other words, physics clashes with neuroscience. While it's true that we feel the passing of time, and thus instinctively favour presentism, Buonomano points out that our notions of subjective time are intricately linked to our notions of space. He shows this with the metaphors we use to talk about time: "That was a refreshingly SHORT commercial. We have been studying time for a LONG time… I'm looking FORWARD to your reply; in HINDSIGHT that was a terrible idea." For timekeeping, the brain co-opts the neural circuits that are used to represent space, thus treating time and space similarly, in a curious analogy to special relativity.

This leads to one of the most intriguing questions raised in the book: could our theories about physics be informed by the very architecture of our brain? "Now that we know that the brain itself spatializes time, it is also worth asking if the acceptance of eternalism has benefited from the fact that it resonates with the architecture of the organ responsible for choosing between eternalism and presentism," writes Buonomano.

**"Could our theories about physics be informed by the very architecture of our brain?"**

The state of scientific knowledge about time is such that no straight answers are forthcoming. The book, a compelling read for the most part, somewhat peters out towards the end, with more questions raised than answers. Understandably so. "Our subjective sense of time sits at the center of a perfect storm of unsolved scientific mysteries: consciousness, free will, relativity, quantum mechanics, and the nature of time," writes Buonomano.

*Your Brain Is a Time Machine* can be disquieting, as the implications settle in, for example, of inhabiting a universe in which all moments exist. But the book ultimately leads to an internal quieting, as one realises that all the profound scientific discoveries of the past century or so are struggling with a common enemy: time. ■

**Anil Ananthaswamy** is a consultant for *New Scientist*

# Braving the future

A bold robot show toughs out tricky questions about coming disruptions, says **Simon Ings**

**Hello, Robot: Design between human and machine,** a touring exhibition at MAK, Vienna, 21 June to 1 October

STEPHAN BOGNER, PHILIPP SCHMITT & JONAS VOIGT, RAISING ROBOTIC NATIVES, 2016 © JONAS VOIG

***Raising Robotic Natives*: will we warm to this exhibit's message?**

ABOVE the exhibits in the first room of Hello, Robot, a large sign asks: "Have you ever met a robot?" Easy enough. But the questions keep on coming, and by the end of the exhibition, we're definitely not in Kansas any more: "Do you believe in the death and rebirth of things?" is not a question you want to answer in a hurry. Nor is my favourite, the wonderfully loaded "Do you want to become better than nature intended?"

That we get from start to finish of the show in good order, not just informed but positively exhilarated, is a testament to the wiliness of the three curating institutions: the Vitra Design Museum in Germany, the Design Museum Ghent in Belgium, and MAK in Austria.

One of the show's advisors, architect Carlo Ratti, head of the MIT Senseable City Lab, nails the trouble with such shows: "Any environment, any city, any landscape can become a robot when it is equipped with sensors, actuators and intelligence." By the time robots do useful work, they have vanished. Once, we called traffic lights "robots", now, we barely see them.

Robots, an exhibition currently at London's Science Museum, gets caught in this bind. By following a "science fiction becomes science fact" trajectory, it creates a show that gets more boring as you work your way through it. Hello, Robot is much cannier: it knows that while science fiction may spin off real artefacts now and again, it never becomes science fact. Does writing down a dream stop you dreaming? Of course not.

Hello, Robot is about design. Its curators explore not only what we have made, but also what we have dreamed. Fine art, speculative designs, commercial products, comic books and movie clips are arranged together to create a glimpse of the robot's place in our lives and imaginations. Far from

**"The longings and anxieties that robots are meant to address are as ancient as they are unrealisable"**

disappearing, robots seem more likely to be preparing a jail-break.

The longings, fantasies and anxieties that robots are meant to address are as ancient as they are unrealisable. The robot exists to do what we can imagine doing, but would rather not do. They were going to mow our lawns, now we're glad of the exercise and we might prefer to have them feed our babies – or look after much older people, as Dan Chen's 2012 *End of Life Care Machine* envisions.

This robot mechanically strokes a dying patient – a rather dystopian provocation, or so Chen thought until some visitors asked to buy one. Exhibited here, Chen's piece is accompanied by a note he wrote: should he encourage people to leave family members alone in their final hours or deny them the comfort of a machine?

Hello, Robot asks difficult questions in a thrillingly designed setting. It is a show to take the children to (just try not to let them see your face in Room 3 as you check on a computer to see if your job's about to be automated).

There's a deep seriousness about this show; if design teaches us anything, it is that no one is ever in charge of the future. "The question of whether we need, or even like [robots] is not really ours to ask," a wallboard opines. "Do we actually need smartphones? Ten years ago, most people would probably have answered no." Our roles in this "lifeworld" of the future are still to be defined.

Catching the exhibition in Germany, I go round three times until it's late. I adore industrial robot YuMi's efforts to roll a ball up a steep incline, and I grin as I walk past a clip of the automated kitchen in Jacques Tati's 1958 film *Mon Oncle*. Still, I can't quite take my eyes off a 2005 photograph of a Chinese factory by Edward Burtynsky, who visited China's shipyards and industrial plants. Identical figures performing identical actions remind me of iconic British newspaper sketches of weaving machines from the industrial revolution.

We have not outgrown the need for human regimentation – we simply outsource it to cheaper humans. Whether robots become cheap enough to undercut poor people, and what happens if they do, are big questions. But this show can bear them. ■

## Spring Diversity Advertising Feature

NIH NATIONAL CANCER INSTITUTE
Cancer Prevention Fellowship Program

### National Cancer Institute (NCI) Postdoc: Cancer Prevention Fellowship Program

The National Cancer Institute (NCI) Cancer Prevention Fellowship Program (CPFP) is now accepting applications for Cancer Prevention Fellows. This is a unique postdoctoral training opportunity for scientists and clinicians in the fields of cancer prevention and control.

The CPFP is multidisciplinary by nature, as we select fellows from a variety of disciplines and backgrounds to include basic science, epidemiology, health services research, medicine, behavioral science, nursing, social science, nutrition, health education/health promotion, law, dentistry, statistics, geography, exercise science, and engineering. Unlike some postdoctoral programs, our fellows have the opportunity to select their own preceptors, and develop and lead research activities based on their own interests.

**The Program provides**

- Up to 4 years of financial support
- Master of Public Health (MPH) or an equivalent degree at any one-year accredited university program, if needed depending on prior training
- Mentored research opportunities at the National Cancer Institute (NCI) and Food and Drug Administration (FDA)
- Dedicated training to build scientific and leadership skills
- Competitive stipends, relocation expenses, travel allowances, and more

**Duration**

The typical duration in the CPFP is 4 years (year 1: master's degree; years 2-4: NCI Summer Curriculum in Cancer Prevention and mentored research).

**To be considered for the CPFP, you must meet the following eligibility requirements**

*Doctoral degree*

You must have an MD, PhD, JD or other doctoral degree in a related discipline (e.g., basic science, epidemiology, health services research, medicine, behavioral science, nursing, social science, nutrition, health education/health promotion, law, dentistry, statistics, geography, exercise science, or engineering).
Applicants currently enrolled in accredited doctoral degree programs that have not yet fulfilled all degree requirements are welcome to apply with the understanding that all requirements will be completed before the start of the CPFP. Assurance to this effect must be supplied in writing by the chair of the dissertation committee (e.g., Ph.D. candidates) or the dean of the school (e.g., M.D. candidates).
Foreign education must be comparable to that received in the United States.

*Prior postdoctoral experience*

You must have less than five years of relevant postdoctoral research experience at the time of appointment.

*Citizenship*

You must be a citizen or permanent resident of the United States at the time of application OR You must be applying through the Ireland-Northern Ireland-NCI Cancer Consortium.

**How to Apply**

The application deadline is **August 25, 2017**. To be considered, applicants must submit application via the CPFP website. To learn more about eligibility requirements and to apply, please visit our website **https://cpfp.cancer.gov/** or contact **cpfpcoordinator@mail.nih.gov**.

**Contact**

Program Coordinator
Cancer Prevention Fellowship Program
National Cancer Institute, NIH
9609 Medical Center Drive, Bethesda, MD 20892
Phone: **240-276-5626**
Email: **cpfpcoordinator@mail.nih.gov**
**https://cpfp.cancer.gov/**

NIH National Institute on Aging
*Intramural Research Program*

### Department of Health and Human Services
### National Institutes of Health
### National Institute on Aging

The National Institute on Aging (NIA), a major research component of the National Institutes of Health (NIH) and the Department of Health and Human Services (DHHS), is recruiting for a postdoctoral position in The Section on DNA Helicases, Laboratory of Molecular Gerontology. Research in the Laboratory of Molecular Gerontology involves the study of genomic stability maintenance. The focus of our group is to investigate the functions of DNA helicases defective in premature aging and cancer disorders. The objective of this research is to understand the molecular and cellular roles of human DNA helicases in pathways that are important for the maintenance of genome stability. Genetic and biochemical approaches are used to characterize the roles of helicases in cellular DNA metabolic pathways and the mechanisms of unwinding by human DNA helicases.

Interested candidates must have a Ph.D. or M.D. with less than five years of postdoctoral experience and research experience in molecular biology, and training in mammalian cell culture techniques. Salary is commensurate with experience and accomplishments. Submit letter of interest, curriculum vitae, and references to:

Robert M. Brosh, Jr., Ph.D., Senior Investigator NIA-NIH,
Laboratory of Molecular Gerontology,
251 Bayview Blvd., Suite 100, Baltimore, MD 21224 USA.

Phone: **410-558-8578**, or E-mail: **BroshR@mail.nih.gov**

For additional information on this position, visit
**https://www.irp.nia.nih.gov/branches/lmg/rbrosh.htm**

HHS and NIH are Equal Opportunity Employers

THE UNIVERSITY OF TENNESSEE
HEALTH SCIENCE CENTER

### 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 $Ca^{2+}$ 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.** Jaggar, Maury Bronstein Endowed Professor of Physiology, Department of Physiology, University of Tennessee Health Science Center, 894 Union Avenue, Memphis, TN 38163, USA.
email : **jjaggar@uthsc.edu.**
Website : **http://physio1.uthsc.edu/~jaggarj/index.php**

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


MY WORK IS A
STORY OF
FLOURISHING.
I'm helping children avoid asthma attacks. We produce a blood test that identifies allergens that can cause breathing problems—giving people around the world vital information to avoid asthma triggers. As an avid runner myself, I have a particular interest in helping all of us to breathe well. I've made it my mission to encourage pediatricians to order our tests for their young asthma patients. I'm grateful that I can use my position to make a difference for children in my community—and beyond
Cherise
Clinical Sales Consultant, Immuno Diagnostics Division
What story will you tell?
ThermoFisher
SCIENTIFIC
Explore opportunities at jobs.thermofisher.com
Thermo Fisher Scientific is an Equal Employment Opportunity/Affirmative Action employer and a VEVRAA Federal Contractor.

# Together, we make the difference.

At Bristol-Myers Squibb, we're creating innovative medicines for patients like Vincent 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 Immuno-Oncology career opportunities.**

Join us. **bms.com/careers**

model is not an actual patient

*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.



Bristol-Myers Squibb

# Diversity drives discovery.

## Become an NPP Fellow. Propel NASA's missions.

NASA
POSTDOCTORAL PROGRAM

administered by

USRA

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

EDITOR'S PICK

## Sense and security require digital maturity


*From Harold Thimbleby, Swansea, UK*

You suggest that the US National Security Agency was part of the problem that caused the wildfire spread of malware across the UK National Health Service and beyond (20 May, p 3). But not having an adequate plan for malware is the real problem. Blaming the NSA is like blaming the tree when you crash your car into it. If the tree had not been there, you would not have hit it; but the usual reason you hit a tree is that your driving skills are inadequate.

You say that a chronic problem is the underfunding of the NHS. Of course. But just as buying a new car won't improve your driving skills, we need to think clearly about how the NHS should use its resources. Low digital maturity across our political systems explains the low funding and low priority that dependable IT has.

If the NHS fixes its Windows systems and keeps using other kit that depends on old versions of software this won't stop the next malware. What will is digital maturity.

The simplest solution is much stricter procurement, with enforced service standards. How can hospitals have let their suppliers walk away from a safety-critical service without support? The next part of the solution is to require IT people in healthcare to have decent computer science qualifications. Computer science and criminal understanding of computers are changing too fast for the NHS to have anything less than lots of PhDs to keep up. That will require funding to make these jobs attractive to appropriate graduates. It would probably be cheaper than the recent fiasco and the next one. Blaming the NSA is not terribly helpful.

*The editor writes:*

■ There is plenty of blame to go round, as our leader made clear. But the NSA, uniquely, could have stopped this problem before it started.

## Why consciousness may require sleep and dreams

*From Roger Kistruck, Sudbury, Suffolk, UK*

Bob Holmes's discussion of the point of consciousness is a refreshing new take on the theme (13 May, p 28). He reports Bruno van Swinderen's suggestion that selective attention is correlated with sleep behaviour: animals that show selective attention appear to need sleep. This is an interesting hypothesis for testing, but there are good reasons to expect that it may be largely true.

Selective attention is valuable to help animals respond to incoming sense data. Perception depends on pattern recognition, and pattern recognition depends on some pre-existing prototype patterns or weightings in a neural network. Natural neural networks are bound to be self-training.

**"So the use of sleep deprivation on detainees has long-term harm? Asking for a friend"**

**D'ericka Henrie** considers implications of the brain "eating itself" after chronic sleep deprivation (27 May, p 8)

In the early 1990s, Geoffrey Hinton and others constructed artificial networks for pattern recognition that were capable of training themselves. These depended on a "wake" phase to create a "representation" of the pattern and a "sleep" phase producing "fantasies" of possible sense data. The result was a system that trained itself very successfully to recognise handwritten characters and digits.

The key to the process was the alternation between sleep and waking, with different (and complementary) adjustments being made in the two phases. This seems to support the idea that sleep is essential behaviour for intelligence.

*From Robert Jasper, Stourbridge, West Midlands, UK*

Thank you for a very thought-provoking and long-overdue insight into consciousness.

The fact that we are not unique in having consciousness makes it plain that our consciousness is an emergent property of neuronal activity and so puts to rest the idea that we have a spirit separate from our bodies. It also gives us a different way to think about artificial intelligence and whether we should fear robots taking us over. Computers or robots may be logical, fast and "intelligent", but they have a long way to go before they even approach rudimentary consciousness. Perhaps someone should devise a new Turing test for consciousness in AI.

## We can expect hostile artificial intelligence

*From Perry Bebbington, Kimberley, Nottinghamshire, UK*

Will future artificial intelligences turn against us, beyond taking our jobs (20 May, p 7)? I think last month's attack on the UK National Health Service and other organisations gives a clear answer.

While this was instigated by criminal humans, it gives a clue about what a hostile AI system could easily do in future. Once we have self-motivated and self-aware AI, cybercriminals and rogue states will not hesitate to adapt and use it to their own ends. Once loose on the internet with its own motivations and goals, it will cause unprecedented damage.

## Forget ETs, where are their robot probes?

*From Bob Cory, Altrincham, Cheshire, UK*

Never mind the little green creatures who are unaccountably absent (13 May, p 24). Where are the automated probes?

Any intelligent civilisation should be able to produce a self-replicating intelligent probe for every planet in its galaxy within a few million years. There should be thousands of them watching over Earth, even if only one planet in a hundred million produces intelligent life that persists. So, sadly, Geraint Lewis may be right that most civilisations die out before they reach the stage of building such probes.

## Dreaming in colour by the waters of Alph

*From Anne Hardwick, London, UK*

Alice Klein reports that people who grow up without colour television cannot easily dream in colour (13 May, p 17). What, neither the painter Titian, nor the poet Samuel Taylor Coleridge – who didn't quite write "In Xanadu did Kubla Khan / A stately pleasure- ›

dome decree: / He dreamed it up in black and white / Because they didn't have TV"? How did they see the world?

One can dream without specifying colours, just as a writer telling a story may or may not choose to describe what the characters are wearing, or the weather. That is not the same as dreaming in black and white.

## Don't interrupt me, my daydreaming is vital

*From Brian Horton, West Launceston, Tasmania, Australia*
I was horrified to read of stop lights in offices warning staff not to interrupt colleagues who are typing at high speed, and a green light encouraging them to talk when typing slows (6 May, p 9).

When I am typing at high speed, I am doing routine stuff that can easily be stopped and restarted, but a slower speed means I need to think carefully and should be left alone. So I was relieved to read of the benefits of daydreaming for creativity (20 May, p 26). My co-workers know that if I am staring blankly out of the window, I am solving some complex problem and must not be disturbed. Maybe I should just swap those red and green lights.

## Name the problem with our air quality

*From Bernard Stay, St Albans, Hertfordshire, UK*
Much recent coverage of our problematic air quality fails to mention that the World Health Organization recently stated that evidence shows that diesel exhaust causes cancer (for example 6 May, p 35). Its carcinogenicity is attributable largely to particulates depositing free radicals in the lungs. The transport and other special lobbies are much happier to talk about nitrogen oxides – which are probably less dangerous and certainly more easily reduced.

## The lack-of-opioid crisis hurts people too

*From Marilyn Lott, Front Royal, Virginia, US*
Suing the manufacturers of opioid drugs is no help with the problem of abuse (13 May, p 25). While everybody gets their knickers in a twist about this, take a moment to shed a tear for those caught up in another crisis – the non-opioid crisis.

This is the crisis affecting those who are suffering from long-term, intractable pain for which there is no apparent relief. Opioids work, but physicians aren't prescribing them out of fear of the US Drug Enforcement Administration.

In the meantime, people commit suicide in order to end the pain.

## An unexpected culinary twist to knot theory

*From Bob Mehew, Southport, Merseyside, UK*
Steve Dalton suggests loose laces are due to the difference between kinds of knots (Letters, 13 May). Piotr Pieranski and his colleagues have calculated the theoretical breaking strength of various knotted strands and suggested that another component of shoelaces' breaking is the degree to which the knot is pulled tight. In 2001, they verified that work using high-speed camera studies of knots – and since their initial choice of fishing line broke too quickly, ended up using knots tied in spaghetti.

## Theory robs me of entertaining plots

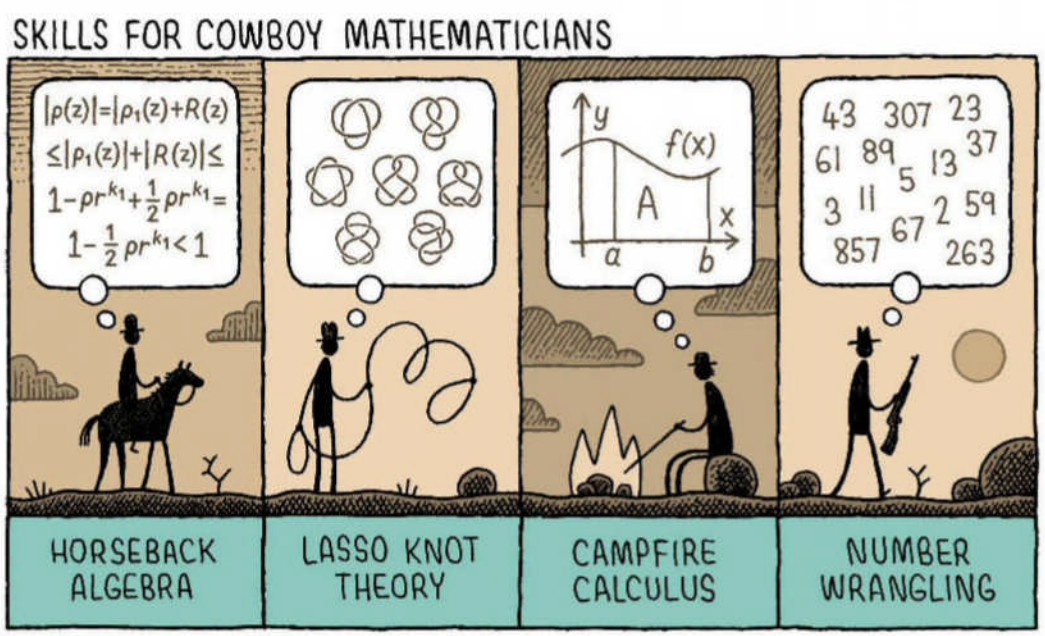
*From Ken Wallace, Mount Evelyn, Victoria, Australia*
As an amateur science-fiction writer, I was excited to read that the difficulty in detecting dark matter may be due to it – or gravity – being an emergent phenomenon of a suite of particles (18 March, p 28). Could that mean dark chemistry? Dark life? A dark intelligence thinking: "I wonder if these gravitational anomalies are caused by a suite of 'phantom' particles we cannot yet detect? I wonder if there is 'phantom' chemistry? I wonder if..."?

Modified Newtonian dynamics would kill these great possibilities, although it does seem to be the winning theory to me. Darn.

## The Arctic has been warmer than this

*From Eric Kvaalen, Les Essarts-le-Roi, France*
Fred Pearce writes that a new Arctic is being created – "perhaps the most profound change to the look of our planet for millions of years..." (8 April, p 33). But what about the Holocene thermal maximum 10,000 years ago, when Arctic temperatures were about 1.6°C warmer than now on average? Or the Eemian interglacial period 125,000 years ago, when there were forests where we have tundra, and hippos in the Thames?

TOM GAULD




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. New Scientist Ltd reserves the right to use any submissions sent to the letters column of *New Scientist* magazine, in any other format.

# OLD SCIENTIST

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

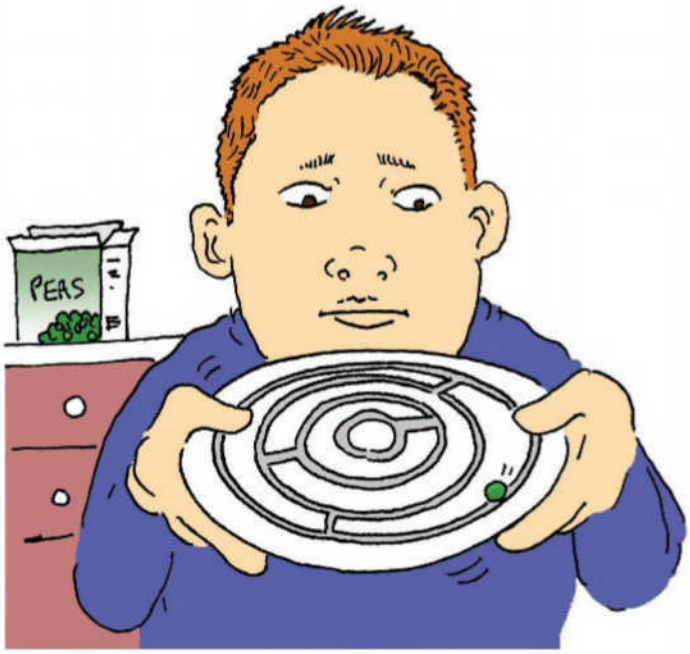
NASA


WE TRY never to be naive. We know that ideology, not technology, dictates trends in space travel. In 1961, *New Scientist* was actually calling for a halt to the moon race, driven as it was by cold war rivalry. Nobody at that point knew how to reach the finish line, but both the Soviet Union and the US had launched satellites, and Yuri Gagarin had orbited Earth. In our 8 June issue, we lamented that the superpowers were squandering resources better spent on earthbound problems. With imperious aplomb, our US correspondent wrote, "I trust it is not too much to expect the British people to act, as they have in other instances in the past, as a brake on an over-impetuous Moon race that could easily become a losing bet for free men everywhere." One suspects that the leaders of the US and USSR were little troubled by the Brits' delusions of superiority.

The cold war was still raging in 1972, but by now Europe was starting to flex its limited political muscle in space too. Our 22 June issue announced that the forerunner of the European Space Agency had been invited to play a role in the US space shuttle programme. Jokes abounded about Britain providing the astronauts' teabags, but once again *New Scientist* was more preoccupied with bang for bucks. Instead of hitching our horses to the US space wagon, we suggested spending the money on "new commercial transport projects such as the [vertical take-off] airliner". As we now know, the shuttle flew, the airliner did not.

By 1997, the Berlin Wall had fallen and the world was starting to rely on private enterprise to fulfil its spacefaring ambitions. Numerous companies were working on engines to power a spacecraft to Mars, though most of the planned ships could only carry enough fuel for a one-way journey. Our 29 June edition suggested using a chemical reactor on Mars to make fuel from hydrogen and carbon dioxide. That some of the raw materials for the reactor are already available on the Red Planet certainly gladdened the heart of thrifty *New Scientist*. **Mick O'Hare** ■

To delve more into the *New Scientist* archives, go to **newscientist.com/article-type/old-scientist/**




PAUL MCDEVITT

**NEWS that mathematicians may find a little hard to digest. Shane Bennison finds the *i* newspaper, among others, reporting the invention of a rippled, Frisbee-like plate for dieters. The *i* explains that "the plate has ridges and troughs that reduce its overall surface area therefore cutting down the amount of food that can be piled on it".**

**If this technology is transferable, says Shane, "I assume slimmers can reduce their own surface area by folding any spare skin as they lose weight." We're not sure if hyperbolic tableware would help us shed the kilos, though return trips to the kitchen to replenish the dish might burn some calories. If not, you could always use the plate as a handy 3D prop for explaining gravitational waves, an inevitable byproduct of shifting mass.**

SOMETHING smells fishy about the bottle of perfume John Boyle discovered. The "holistic fragrance" from Josie Maran is an eau de parfum named Love, which proclaims itself to be unscented and contain no alcohol. That's love in the sense of zero, then, Feedback presumes.

**ADVENTURES in multiple dimensions: "Hilary Johnson's 7D submarine experience has a long way to go before it beats the record," says Ian Simmons (20 May). "One of my film suppliers told me of a 36D ride he'd encountered in Korea. Apparently, they got there by counting every single special effect as an extra dimension, as well as each axis of movement of the seats."**

OUR inbox continues to be peppered with retronyms – words made by attempts to sound out the letters of acronyms. "One Dutch example that springs to mind is the word elpee, pronounced el-pay," says Govert Schilling. "It is the Dutch pronunciation of the letters LP, a 12-inch vinyl record."

"Alcohol purchased in M&S cannot be consumed anywhere inside or outside these premises," says a sign spotted by Juliet Casey. Aimed at responsible alcohol consumption, she presumes

**HOWEVER, as our readers giveth, they also taketh away. "Jeep is not really a retronym," says Martin van Raay, "as contrary to popular belief, there was no US Army acronym GP for 'general purpose' vehicle" (13 May).**

**He provides two overlapping alternative ideas: first that the word jeep stems from Army slang for a new recruit, and second, "the *Popeye* cartoon character Eugene the Jeep, which could do all kinds of tricks."**

**Martin says that during development, Ford did refer to the car as GP (G for "government", P, incomprehensibly, for "reconnaissance vehicle with an 80-inch wheelbase"). "After the first press presentation of the new vehicle, the soldier driving it replied to a reporter's question 'What is it?' with the words: 'It's a jeep!' Probably meaning it's a new vehicle, and also likely referring to Popeye, because the new car really could do wondrous things off-road."**

STAYING with military terms, Peter Norton writes that during the second world war, the US Navy construction battalions were referred to as Seabees.

He also uncovers a strange exile from the world of abbreviations: "the dual medical specialty of obstetrics and gynaecology is often abbreviated to Ob-Gyn. But instead of being pronounced that way in the US, it is spoken out as 'oh-bee-gee-wy-en'." In the UK, the same department is often referred to as Obs and Gynae. A touch inelegant, perhaps, but when it comes to contractions, who are we to argue with the experts?

**PREVIOUSLY Feedback puzzled over the attention to detail displayed by Virgin Mobile's accounting team, which calculated John Culver's bill to 16 decimal places (13 May). "Global annual GDP is almost US$80 trillion, which means it is approaching $10^{16}$ US cents," says Hillary Shaw. "So if Virgin Mobile has ambitions to produce everything in the world, for everybody, it will indeed need 16 decimal places in its accounting to be accurate to the last cent."**

**Feedback suspects the UK Competition and Markets Authority might have something to say about this, if Virgin doesn't take it over as well.**

YOU can pre-order the latest invention from Tony Stark cosplayer Elon Musk, a solar roof tile that generates electricity (the ideal peripheral for anyone who bought one of his electric roadsters). "We offer the best warranty in the industry," proclaims the website, "the lifetime of your house, or infinity, whichever comes first."

Michael Zehse, perhaps planning to put this guarantee to the test, says: "I wonder how they define house. You could keep replacing bits of the house and adding stuff until there's nothing left of the original, would one still be living in the same house?"

And if you could find suppliers

willing to offer the same guarantee for walls, tiles, roof frames and so on, would your house survive to the heat death of the universe?

**READERS may recall Feedback's campaign to have glow-in-the-dark glitter added to dog food to make walking the streets less hazardous (13 May). We may have been scooped, says Tony Donaldson. "Looking for glow-worms in dark places in Devon, I found glowing patches, which I identified as bird poo."**

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.

## Sleep tight

**How do people in polar regions, where there can be up to 24 hours of daylight or night, cope physiologically? (Continued)**

From 1969, I spent a year as a radar officer at a US Air Force ballistic missile warning site in Greenland. At almost 77° north, we had roughly three months of no direct sunlight in winter and vice versa in summer. We used aluminium foil to cover our dormitory windows during the light season, but no similar strategy was available for the dark season. There was no way to be unaware of the 24-hour darkness, and no real way to fool the brain into thinking it was night when it was never dark. The result was time disorientation.

On top of this, those operating the radar site worked 8-hour shifts, with crews spending three days on one of the three shift phases (day, evening, night) before moving to the next and then the final one, followed by three days off. As is now known from studies of sleep cycles and disturbances, and their effects on alertness and judgement, a worse schedule could hardly have been designed.

**"Arctic diurnal cycles and our shifts were perfect for generating insomnia, fatigue and depression"**

The combination of Arctic diurnal cycles and three-day shift work phases was the perfect storm for generating insomnia, fatigue, depression, inattention, sleepiness bordering on narcolepsy, depression and overindulgence in alcohol. I often wonder whether the US Air Force learned anything from this and has now implemented rational, physiologically based scheduling.

*Howard Ritter Jr*
*USAF Medical Corps (retired)*
*Fuquay-Varina, North Carolina, US*

## Salvaging Hubble

**The illustrious Hubble Space Telescope will eventually re-enter Earth's atmosphere and be destroyed – or so I understand. Could it be returned to Earth safely and put in a museum? If so, what would be the cheapest way to do it?**

The Hubble design requirements dictated that the telescope be capable of surviving a return trip to Earth via the space shuttle. This was a driving factor in some of the design considerations, particularly regarding the 450-kilogram primary mirror and its mounts.

If someone had the means to capture the telescope and return it to Earth, they might decide to jettison the five science instruments (360 kilograms or so each) and the three fine guidance sensors at 250 kilograms each, as well as some of the hardware such as inertia wheels, gyros and electronics. The solar panels could, I believe, also be jettisoned. This weight reduction should ease the problem.

*Sam Palasciano*
*Retired engineer*
*Oceanside, California, US*

## No stone unthrown

**Personal experience suggests that if you put human males beside a body of water with a supply of stones to hand, they will soon start throwing them into the water. What drives them to do this, and is the same true of human females? Is this unique to humans, or has it been observed in other primates? What purpose can it possibly serve? (Continued)**

As a former baseball player, the mechanics of throwing has always interested me. It is one of the few skills – along with endurance running and extraordinary manual dexterity – in which humans exceed all other mammals. Only apes and some monkeys can throw at all, with humans throwing far harder, faster, farther and more accurately than anything else.

This is because we use leg thrust and the rotation and torsion of our bodies, only possible with an upright posture. We also have a modified shoulder joint, giving greater mobility compared with other apes. All this can more than double the power of a throw.

This means humans can throw objects well over 100 metres and at more than 160 kilometres per hour. It seems likely that this was crucial in our evolution. For tens, if not hundreds, of thousands of years, the *Homo* genus hunted and fought by throwing things, having the ability to cause damage at a distance. Fine-tuning this skill may even have led to *Homo sapiens* gaining ascendancy over Neanderthals because they mainly thrust with spears, while we threw them.

So evolution may have built throwing into our genes, which may also explain the urge to throw stones into water. I have it.

*Stuart Leslie*
*Dorrigo, New South Wales, Australia*

## This week's questions

**HUMAN ATTRACTION**

How small would something need to be for the gravitational field of a human to significantly affect it? At what point would something be attracted to someone or able to establish an orbit?

*Andrew Twyman*
*Cardiff, UK*

**SURVIVAL OF THE FITTEST**

The more physically attractive you are, the more likely you are to have lots of sex, reproduce and pass these traits on to the next generation. Or so the theory goes. So how come we don't all look like movie stars and supermodels? Or so it seems from looking round the train this morning.

*Dave Dee*
*Joondalup, Western Australia*

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.


Providing educational funding for women in STEM since 1888
Scientist
Leader
Innovator
AAUW CAN HELP GET YOU THERE
www.aauw.org
AAUW
empowering women since 1881