

# New Scientist

WEEKLY February 11-17, 2017

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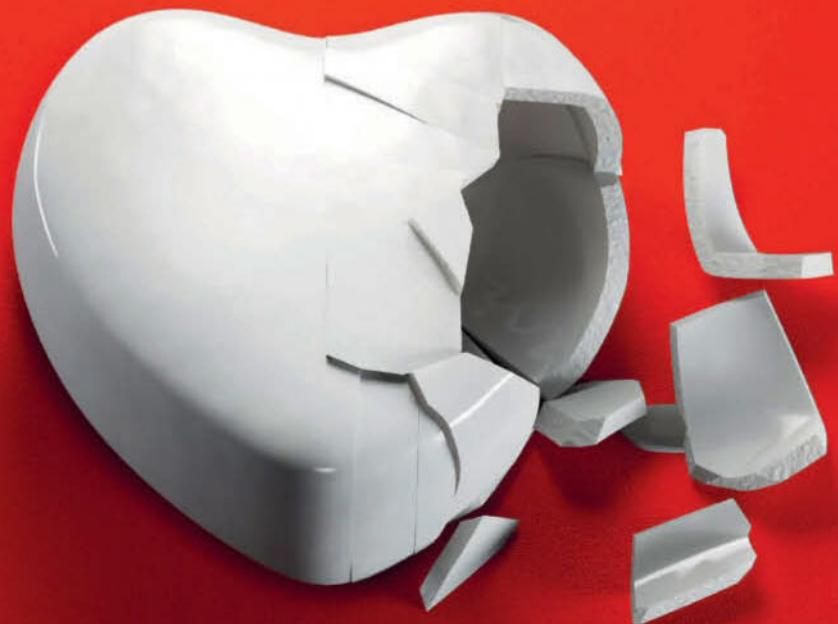
**QUANTUM CONSPIRACY**  
The universe has been  
weird for at least 600 years

**POISON CLOUDS**  
Mystery radiation threat  
to air travellers

**SOUNDING ROUGH**  
Computers that hear  
disease in your voice

## DOWN WITH CHOLESTEROL

Have we got the heart attack fat all wrong?



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# CONTENTS

## News

# 12

## Poison clouds

Mystery radiation hotspots could pose risk to travellers



ANDRE THIJSSEN/MILLIONN IMAGE UK

## On the cover

# 28

## Down with cholesterol

Have we got the heart attack fat all wrong?

Cover image  
Simon Danaher

- 7 Quantum conspiracy Our weird universe
- 12 Poison clouds Mystery radiation threat
- 10 Sounding rough Computers listen for disease in your voice
- 42 Digital dark age Daniel Dennett on perils of overcivilisation
- 38 Vertically challenged Where's sea level?

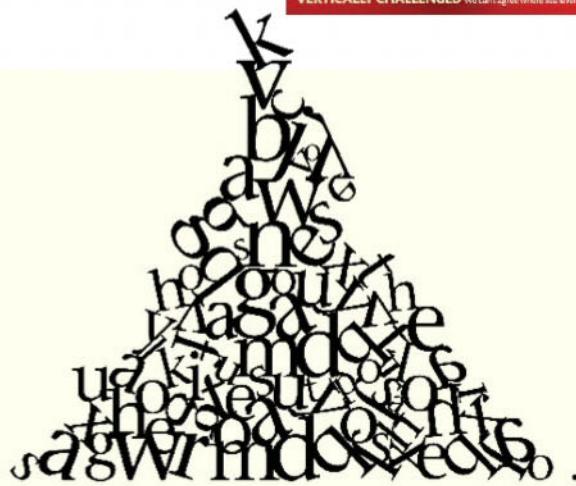


## Features

# 34

## Reading fast and slow

How to get the most out of the written word



## Coming next week...

### Hidden pattern

The strange symmetry that underlies reality

### Psychonauts

Harnessing the power of lucid dreams

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Volume 233 No 3112

### Leaders

- 3 Evidence-based medicine requires open data. What's the best way to read?

### News

#### UPFRONT

Tech firms turn against Trump. Vaquitas down to just 30 animals. E-cigarettes safer. Flies spread antibiotic resistance

#### NEWS & TECHNOLOGY

Gene editing to cut cholesterol. Hives have open-door policy in times of plenty. Weird quantum history of the universe. Algorithm seeks disease clues in your voice. Virtual illusion reduces pain. LIGO prepares to peer into strange stars. Playground for web tech. Neural net learns words like a child. Why loud chewing makes you angry. Clue to where antimatter is hiding. Friendly can be deadly for monkeys. Chemo side effects stopped

#### IN BRIEF

Moths held inside fruit prison for a year. Spacecraft to use starlight to park. Blood test to detect pancreatic cancer early

### Analysis

- 22 Release from the rubbers Can some people with HIV really ditch condoms?

#### COMMENT

Do we live in a hologram universe? European satnav system looks wise today

#### INSIGHT

Age verification for porn sites won't work

### Aperture

- 26 Refugees seen in the heat of the night

### Features

#### Down with cholesterol (see above left)

#### Reading fast and slow (see left)

- 38 Vertically challenged We can't agree where sea level is

#### PEOPLE

Daniel Dennett on the perils of overcivilisation

### Culture

- 44 Digital reckoning The loss of rights and freedoms in our post-privacy economy

#### VR Challenge Explain science to win £1000

- 46 Art of shape-shifting The centenary of D'Arcy Thompson's *On Growth and Form*

### Regulars

#### LETTERS Volcano's English impact

#### MAKE A digital Valentine's treasure hunt

#### FEEDBACK Mental probe of Jupiter

#### THE LAST WORD Offal way to die

New  
Scientist events

# INSTANT EXPERT: THE QUANTUM WORLD

SATURDAY MARCH 11, 2017

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# Hearts on our sleeves

We need transparent trials to maintain confidence in medicine

TENS of millions of people took Vioxx for their arthritis between 1999 and 2004. Tens of thousands probably had a heart attack as a result. It was a similar story with the anti-diabetes drug Avandia. In both cases, the drugs' makers were accused of withholding trial data that would have revealed the risks to doctors and patients.

Access to data is at the centre of many controversies in modern medicine – not just to do with the usefulness of drugs, but also of treatments (such as exercise for chronic fatigue syndrome) and screening programmes (for breast cancer in younger women, say). Big trials are hard to organise, and so researchers often keep a tight grip on the data they create.

As preventative medicine has become more common, concerns have risen that we may be missing key evidence about the effects of drugs given to huge numbers of people. Recently, statins – given to manage cholesterol levels in those deemed at risk of heart attacks – have come under scrutiny.

The trials run to assess statins' efficacy didn't focus on possible adverse effects. Those most worried about these – debilitating muscle pain is often cited – have so far been unable to assess the data for themselves. Other critics say there isn't strong enough evidence for mass prescription of statins (see page 28).

That has provoked a furious war of words with those who do have

access to the data. They say complex ownership and usage conditions mean it can't be released widely. That's a familiar problem: similar issues dogged the release of raw data from the 2011 PACE trial of chronic fatigue syndrome treatments, which a tribunal finally ordered to be released last year.

So the controversy over statins, whether well founded or not, rages on with no resolution in sight, damaging confidence in medicine. This simply isn't good enough. When it comes to treatments for millions, data should be gathered with a view to its eventual release. That won't be easy. But evidence-based medicine requires no less. ■

# On closer reading

HOW do you prefer to read *New Scientist*? Do you skim through it quickly to get the gist? Do you set aside an hour or so to read it from cover to cover? Or perhaps you scroll through it on screen, now and then pausing to follow a link to somewhere else, or to post your thoughts on its contents.

There's no right answer from our point of view. We know our readers use *New Scientist* for

many purposes – knowledgeable, pleasurable and sociable – and we welcome all of them and make our content available accordingly.

But perhaps you have a favourite approach. Most of us are deluged by words, many serving functional ends. That's reignited interest in speed-reading, and other ways of parsing text more efficiently. Screens are held by some to be superior for processing

information, for example – hence their wide adoption in schools, despite parents' anxieties about dwindling attention spans.

Until recently, we didn't know whether such claims had merit. But now we are finding that it really does matter how you read, and which medium you choose (see page 34). So being a "good" reader, however you define "good", requires attention not just to the text, but to the form it comes in. We'll keep providing them all, whichever you choose. ■



The EPA may have an unlikely boss

## Space junk flunk

IT'S a rubbish start. A cable designed to drag space junk out of orbit has failed to deploy from a Japanese spacecraft.

More than half a million pieces of debris are currently whizzing

### Clean-up solutions are designed to tug junk down into Earth's atmosphere, where it will burn up"

around our planet, including abandoned satellites and fragments of old spacecraft. They pose a danger to working satellites and new space vehicles.

A popular idea for getting rid of junk is to tug it down into Earth's atmosphere, where it will burn up.

On 28 January, the Japan Aerospace Exploration Agency (JAXA) started an in-space evaluation of a junk-removing cable technology.

Its uncrewed spacecraft, Kounotori 6, which had been fitted with a 700-metre-long metal cable, was on its way back to Earth after delivering supplies to the International Space Station.

The cable was meant to unfurl from the spacecraft, and an electric current along its length should have interacted with Earth's magnetic field to create a drag on nearby rubbish, bringing it to a lower orbit.

But Kounotori 6 was unable to release the cable, and JAXA could not fix the glitch before the spacecraft returned to Earth's atmosphere on 6 February.

"We think it is not because of the cable itself, but some other reasons," a spokesperson for JAXA told *New Scientist*. "A detailed analysis is underway."

PICTURE CREDIT



Public health concern

## US pollution rules at risk

### IS THE US Environmental Protection Agency at death's door?

Hundreds of former EPA employees and some current staff have urged Congress to reject President Donald Trump's nominee to run the agency, Oklahoma attorney general Scott Pruitt. In the past, Pruitt backed industry interests over those of the regulator and led many lawsuits against it. He could be confirmed by Congress as early as this week.

Some expect him to move forward on Trump's campaign promise to "get rid of" the agency, although critics predict him doing so in a piecemeal manner by making cuts and weakening the EPA's powers.

An overhaul of the agency's website since Trump took over has already seen the removal of federal

climate plans created under former president Barack Obama, along with the mention of carbon pollution as a cause of climate change.

In addition, a bill introduced by a Republican congressman on 3 February aims to axe the EPA altogether. But the move may be more of an anti-regulation rallying cry than a real harbinger of what's to come.

"Given the overwhelming public support for clean air and water, it seems unlikely members of Congress would do away with the agency," says Michael Tubman of the Center for Climate and Energy Solutions. "If they did, they'd have to find or create an agency to implement all of the environmental protections Congress has approved over the past 50 years."

## Fall in HIV cases

NEW HIV infections in gay men appear to have dropped by nearly a third across England since 2015.

"Provisional data suggests that HIV diagnoses among gay and bisexual men in England have fallen, although it is not possible to confirm this at a national level until all data for 2016 has been received," says Valerie Delpech of Public Health England, who presented the stats at the HepHIV conference in Malta on 1 February.

A similar drop was reported by four London sexual health clinics

in December. One reason for this could be that people are taking medicines that slash their chances of catching HIV, known as pre-exposure prophylaxis.

These drugs aren't yet available on the National Health Service and cost around £400 a month if prescribed privately. So some gay men are buying cheaper, generic versions from online pharmacies in India and elsewhere, against mainstream medical advice.

The new figures for England are "great news", says Gus Cairns of HIV information charity NAM. "Something is working."

## Resistance in flies

GENES that enable bacteria to resist our most crucial antibiotics have been found in bacteria on farms in China, and are being spread by flies.

Carbapenem antibiotics are often used as a last resort for resistant bacterial infections. When these fail, one of the few options left is colistin. But carbapenem resistance is spreading, and colistin resistance was discovered in China in 2015.

## 60 SECONDS

Tonnes of antibiotics are used as growth promoters on farms in China. Now a study has found that a third of *Escherichia coli* bacteria sampled from chicken farms and meat in shops in China resisted carbapenems, and a quarter of those also resisted colistin.

The study also found such bacteria in flies at chicken farms. Bacterial DNA from farms, flies and human patients was similar enough to suggest flies are spreading resistance from farms to people (*Nature Microbiology*, doi.org/bzdx).

This is an immense public health concern, says the team.

## Vaping vs smoking

IS VAPING electronic cigarettes really safer than smoking? When it comes to carcinogens, it seems so.

"Less than half of current smokers in the UK believe that e-cigarettes are less harmful," says Lion Shahab of University College London. His team screened urine and saliva samples from 181 people, looking for chemicals linked to cancer. "We found using e-cigarettes alone results in very low exposure to toxins and carcinogens," he says.

Compared with current smokers, former smokers who

had been vaping for six months or more had very low levels of some of the worst carcinogens found in tobacco smoke (*Annals of Internal Medicine*, doi.org/bzdx).

The team says this provides reassurance that vaping is safer

**"Using e-cigarettes alone results in very low exposure to toxins and carcinogens"**

than smoking. But some are still sceptical. Last week, another study found vaping may raise the risk of heart disease (*JAMA Cardiology*, 10.1001/jamacardio.2016.5303).

## Vaquita down to 30

THE world's smallest porpoise is in dire straits. There are only 30 vaquitas left on the planet, according to a report by the International Committee for the Recovery of the Vaquita.

Vaquita numbers have plummeted by 90 per cent over the past five years. Between 2015 and 2016, almost half the remaining vaquitas died.

Vaquitas live exclusively in a small area in the Gulf of California, Mexico, where illegal fishing with gill nets is the main cause of their demise. Gill nets are commonly used to fish for the totoaba, an endangered species sought after in Asia for the supposed medicinal properties of its swim bladder.

"They're essentially taking out two endangered species in one fell swoop," says Kate O'Connell, a marine wildlife consultant at the Animal Welfare Institute. "We know what the problem is: it's gill nets. We've known for 30 years that gill nets kill vaquita and we have done nothing, and I find that heartbreaking."

Illegal fishing is still going on despite a ban, which ends in April. One hope is a mooted effort to place some of the vaquitas in a temporary sanctuary – but catching them might prove tricky.

## Tech turns on Trump

MORE than 100 technology firms have signed a legal brief opposing President Trump's immigration ban, arguing that it will harm the US economy.

Apple, Facebook, Google, Microsoft and Twitter are among the 127 signatories on the letter, which has been filed to a US appeals court in support of a lawsuit brought by the State of Washington.

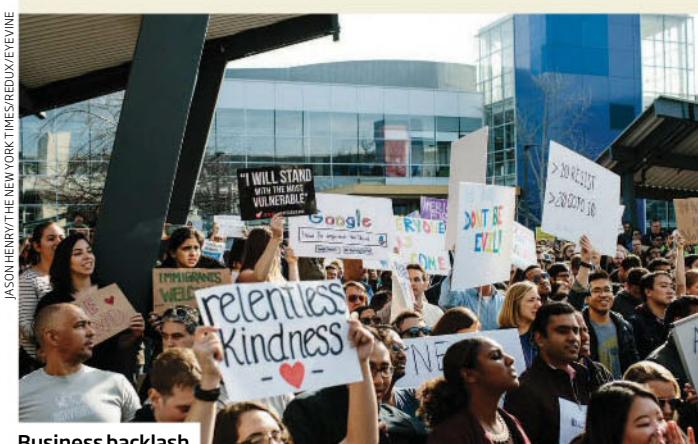
The lawsuit challenges Trump's executive order blocking nationals from seven Muslim-majority countries from entering the US. Last Friday, a federal judge put the order temporarily on hold.

The tech firms argue that the executive order violates the US constitution and "is inflicting

substantial harm on US companies". They say that the ban will prevent them from hiring the best talent and that "American workers and the economy will suffer as a result".

Uber has also signed the brief. The taxi firm faced a mass boycott after it was accused of profiting from a taxi driver strike at New York's JFK airport in protest at the ban. CEO Travis Kalanick stepped down from Trump's business council following the uproar.

SpaceX and Tesla, owned by Elon Musk, were not originally signatories, but signed the brief after it was released. Musk has been criticised for continuing to advise Trump, but has argued that "engaging on critical issues will on balance serve the greater good".



Business backlash

## SpaceX recycling

Private space flight firm SpaceX is getting ready to reuse a rocket. The Falcon 9 first stage booster first flew in April 2016, now the company has test-fired it to see if it's ready to fly again. That flight will be no earlier than March – but if it works, it's a step towards cheaper, more efficient space travel.

## Death by black hole

A black hole has been feasting on the same star for an entire decade. XJ1500+0154 was first spotted in July 2005 and is still giving off bright X-rays today as it continues its meal. Watching this so-called tidal disruption event in a galaxy 1.8 billion light years away will help explain how quickly supermassive black holes can grow (*Nature Astronomy*, doi.org/bzqz).

## Heart repair

Exercise doesn't just make your heart go faster – it might fix it too. After mice spent 30 minutes running on a treadmill, researchers saw changes in the gene activity in their hearts. Increased activity of genes involved in repairing DNA may help explain why exercise protects against heart disease (*Experimental Physiology*, doi.org/bzdg).

## Sea acidification boon

Tiny marine snails have challenged assumptions that ocean acidification driven by carbon emissions will make the oceans sterile. One species of snail living near carbon dioxide-rich ocean vents thrives there – the CO<sub>2</sub> fuels the growth of the algae it feeds on (*Current Biology*, doi.org/bzd5).

## Thought control

Sensors have let people control virtual arms using their thoughts alone. Implanted in the spine, the sensor interprets signals directly from a person's motor neurons, and could one day let amputees have finer control over prosthetic limbs (*Nature Biomedical Engineering*, DOI: 10.1038/s41551-016-0025).

# Lower your cholesterol - for good

Gene editing could bring the benefits of natural DNA mutations to all

**Michael Le Page**

A SINGLE injection could one day lower your cholesterol levels for the rest of your life.

People born with natural mutations that disable a specific gene have a lower risk of heart disease, with no apparent side effects. Now a one-off injection has successfully disabled this same gene in animal tests for the first time.

This potential treatment would involve permanently altering the DNA inside some of the cells of a person's body, so doctors will have to be sure it is safe before trying it in people. But the benefits could be enormous. In theory, it could help millions live longer and healthier lives.

The results of the animal study were described by Lorenz Mayr, of pharmaceutical firm AstraZeneca, at a genomics meeting in London on 1 February. Mayr, who leads the company's research into a DNA editing technique called CRISPR, wouldn't say whether AstraZeneca plans to pursue this approach, but he was clearly excited as he presented the findings.

"The idea would be to do it as a one-off," he later told *New Scientist*. "It should be permanent."

Heart attacks and strokes kill a quarter of people living in rich nations, and having high levels of "bad" LDL cholesterol in the blood greatly increases the risk. For this reason, millions of people now take statins to lower their LDL cholesterol levels. While statins undoubtedly extend the lives of many people, some experience side effects such as muscle pain (see page 28), leading drug companies to look for alternative treatments.

In 2005, a few people were

found to have naturally very low cholesterol levels, thanks to mutations that stop their livers making a protein called PCSK9. "They have a lower incidence of cardiovascular disease and no apparent side effects whatsoever," says Gilles Lambert at the University of Réunion Island, who studies the protein.

PCSK9 normally circulates in the blood, where it degrades a protein found on the surface of blood vessels. This second protein removes LDL cholesterol from the blood: the faster it is degraded by PCSK9, the higher a person's cholesterol levels. People who lack PCSK9 due to genetic mutations have more of this LDL-removal protein, and therefore less cholesterol in their blood.

To mimic this effect, two companies have developed approved antibodies that remove

the PCSK9 protein from the blood. These are very effective at lowering cholesterol and no serious side effects have been reported so far, Lambert says. It is yet to be shown if they reduce the risk of cardiovascular disease, but the first trial results are due to be announced in March.

However, the antibody drugs are extremely expensive and need

**"The approach mimics what happens in people born with certain mutations and could be really productive"**

to be injected every two to four weeks, so even if the antibodies work as well as hoped, they cannot be dished out to millions like statins. All attempts to develop conventional drugs to block PCSK9 have failed.

But gene editing provides

a radical alternative. Using the CRISPR technique, the team at AstraZeneca have disabled human versions of the *PCSK9* gene in mice.

They did this by injecting the CRISPR Cas9 protein and a guiding RNA sequence into the animals. The RNA guide helps the Cas9 protein bind to a specific site in the gene. The protein then cuts the gene at that point, the idea being that when the break is repaired, errors that disable the gene are likely to be introduced.

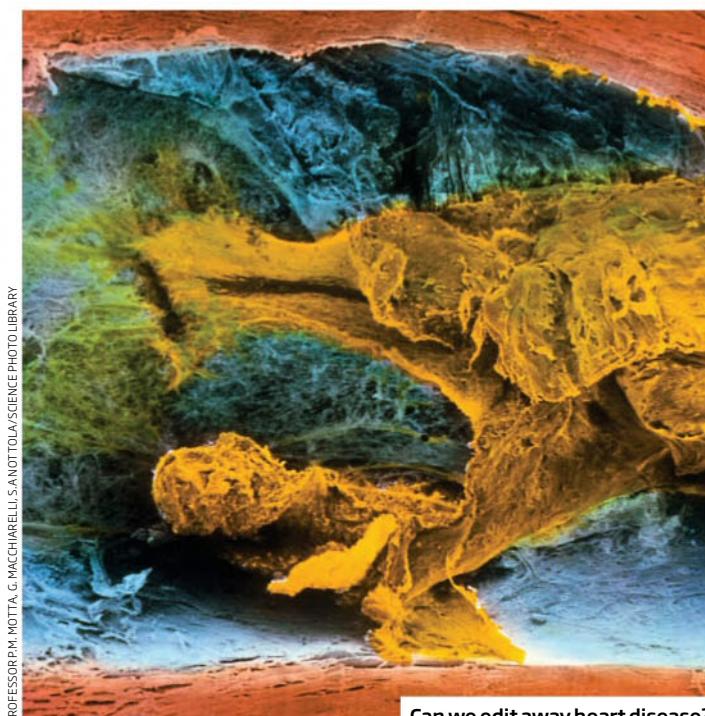
The team found that mice given the CRISPR treatment had an even bigger fall in cholesterol levels than those injected with the antibody drugs.

This gene-editing approach would be a closer mimic of what happens in people born with PCSK9-disabling mutations than injecting antibodies, says Patricia McGettigan at Queen Mary University of London, who has looked at the safety of PCSK9 therapies. "That might actually be really productive," she says.

The big worry about using gene editing to alter DNA inside the body is that it could cause unintended "off-target" mutations. In the worst case, these could turn cells cancerous.

Mayr says the team have tested for off-target effects in 26 different tissues in the mice, and that the results will be published soon. "It's very promising in terms of safety," he told *New Scientist*.

What's more, the CRISPR method is constantly being improved. Other teams have developed modified versions of the CRISPR protein that are so precise off-target effects occur no more often than natural mutations in cells. Even so, Lambert thinks human trials are at least a decade away. "For now it's very far-fetched," he says. ■



Can we edit away heart disease?

PROFESSOR P.M. MOTTI, G. MACCHARELLI, S. ANTONI/SCIENCE PHOTO LIBRARY

## In this section

- LIGO prepares to peer into strange stars, page 11
- Mystery radiation hotspots could pose risk to air travellers, page 12
- Can some people with HIV really ditch condoms?, page 22

# Beehives take in drifters in times of plenty

HONEYBEES may have a unique system for accepting migrants. "Drifting" bees that wander into a hive may stay - if the guard bees see fit.

Such drift is common in apiaries, where hives are placed close together. A bee that drifts essentially migrates from its own hive to another, probably unintentionally.

Morgane Nouvian and her team at the University of Queensland in Brisbane, Australia, reviewed 161 papers on how honeybees defend their hives to get an overview of the phenomenon. They report that 10 to 15 per cent of honeybees take on nest-guarding roles, usually when 2 to 3 weeks old. Their main role involves detecting and dealing with predators, but they are also the first point of contact when drifting bees arrive.

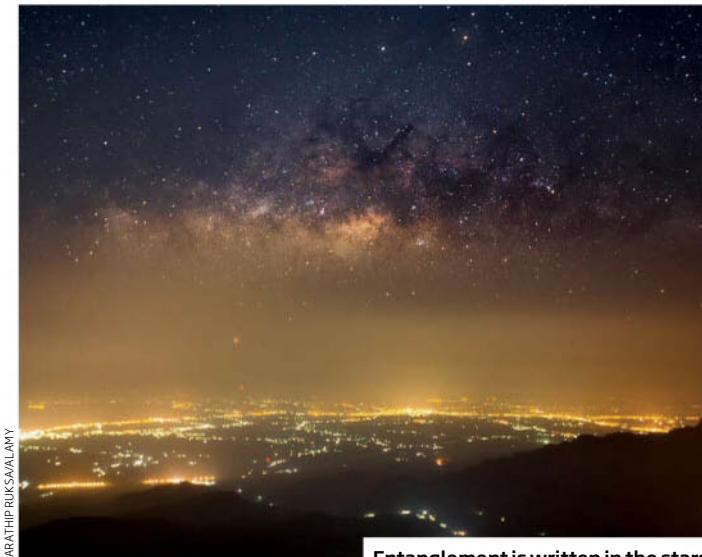
In an inspection that can last half a minute, the guards check out chemical cues on the newcomer - typically hydrocarbons - that depend on hive-specific genetic factors and comb wax. If this profile matches or nearly matches that of their own hive, the guards will let the drifter in. Around 30 per cent of drifting bees are allowed to stay (*Journal of Experimental Biology*, doi.org/bx8q).

A hive that is thriving is more welcoming, too. "It's interesting that when there are enough resources, for instance nectar near the hive, and fewer empty combs, guards allow in more non-nestmates," Nouvian says. There may not even be guards at the entrance in these circumstances.

Scarcity can shut these "open borders" quickly. Guards not only reject newcomers at these times, but may even kill them, perhaps agitated by lack of food.

The guards are also adept at spotting bees that aim to steal honey. "We know now that these robber bees are detected by their flight patterns and speed," says Nouvian. "Guards can detect an incoming robber and sting it before it even reaches the nest."

Amitha Kalaiachandran ■



NARATHIP RUKSALAMY

Entanglement is written in the stars

# Stellar proof of 600 years of quantum law

OUR universe has been ruled by weirdness for at least six centuries. If the quantum effects in a new experiment aren't genuine, but are somehow caused by past meddling, then that is how long ago it must have happened - a finding that makes would-be alternatives to quantum theory even more unlikely.

Two qualities seem to describe our everyday world: realism, the idea that things have properties which don't vanish when we're not looking; and locality, which means no influence can travel faster than the speed of light.

But the quantum effects we see on tiny scales defy these descriptions. The properties of particles aren't set in stone until we measure them, and their states can be entangled - such that altering one affects the other much faster than light can travel between the two.

There are loopholes in quantum theory, though. David Kaiser at the Massachusetts Institute of Technology and his colleagues are trying to close them down - aided by starlight.

Their experiment exploits a

standard test for locality: Bell's inequality. It sets a limit on how often two entangled particles can end up in the same state just by chance - without quantum mechanics or some unknown "hidden variables" to guide them.

The first step is to create a pair of entangled particles - often photons of light - then fire them off in different directions. Usually, a random number generator determines at the very last moment which property of each particle to measure. The detectors used are far enough apart that

**"These experiments make alternative theories to quantum mechanics far more implausible"**

the arriving particles can't "cheat" and coordinate their states - unless they can signal each other faster than light.

If the measurements tally more often than allowed by Bell's rule, then the particles aren't governed by locality. Previous experiments have shown this consistently, and so backed quantum mechanics.

But it's still dimly possible that

some unknown influence is allowing the particles to affect each other without breaking the principle of locality. To rule this out, Kaiser and his colleagues didn't use any old random number generator to decide what to measure. After all, it's even possible that the hidden variables could be tampering with the number generation itself.

Instead, after the photons were shot towards the detectors, the researchers made a measurement of light from a randomly chosen star in the Milky Way. Its colour was what determined which photon property to measure.

"If any physical mechanism were to somehow jigger with the questions that get asked of each particle, those would have to have been put in motion at that star when it was about to emit that light that we measured," Kaiser says. Light from the closest star they used takes 600 years to reach us, so any hidden variables would have needed to be in play since then.

As in previous tests, Kaiser's team found that their photons ended up correlated far too often, violating Bell's inequality and supporting the non-local, quantum notion of reality (*Physical Review Letters*, doi.org/bzfh).

Of course, this loophole can never really be closed. Maybe the outcomes of these experiments were determined by hidden variables 700 years ago, or at the birth of the universe. But Kaiser and his colleagues plan to keep using larger telescopes and more distant astronomical events to rule out the loophole as far back as they can.

"They're making alternative theories to quantum mechanics far more implausible - and they were already implausible to start with," says Krister Shalm at the National Institute of Standards and Technologies in Boulder, Colorado. "This is just going that extra step of pushing things back." Leah Crane ■

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## Voice calls combed for signs of disease

DID your voice give it away? US start-up Canary Speech is developing deep-learning algorithms to detect if people have neurological conditions like Parkinson's or Alzheimer's disease just by listening to their voice. And it has found a controversial source of data to train them on: phone calls to a health insurer.

The insurer – which Canary Speech wouldn't name but says is "a very large American healthcare and insurance provider" – has provided hundreds of millions of phone calls that have been collected over 15 years and are labelled with information about each speaker's medical history and demographic background.

Using this data, Canary Speech says its algorithms will pick up on vocal cues that distinguish someone with a particular condition from someone without it. Co-founder Jeff Adams says the company could have an algorithm designed to detect vocal indicators of Alzheimer's disease ready within two months. It also aims to find vocal markers for depression, stress and dyslexia.

How the technology is used will ultimately be down to Canary Speech's customers, says CEO Henry O'Connell. The insurer providing the call data also runs US health clinics, he says, and discussions have so far related to using the technology in a clinical setting, for example to help diagnose these conditions. When asked if the technology

**"It doesn't require medical intuition, it requires signal processing and machine learning"**

could be used to screen callers or influence insurance premiums, he responded that such an application "may be regulated".

"This is the type of thing where we'd want to make sure patient privacy is protected," says Caitlin Donovan at the US National Patient Advocate Foundation. "I would be worried that this could be used to either track or diagnose a condition that the patient may not be aware they have."

The US Affordable Care Act (ACA) prevents insurers from

**It's how you say it, not what you say**

denying benefits or raising costs because of a pre-existing condition, but that could change under the new administration of Donald Trump. Before the ACA took effect, people with Parkinson's and Alzheimer's were often denied coverage by insurers.

We have known about vocal indicators of neurological conditions for a long time, says Sandy Schneider at Saint Mary's College in Notre Dame, Indiana. For example, Parkinson's often results in a softness of speech called hypophonia. But only recently have people started to explore how machine learning could aid diagnoses.

Canary Speech is coming at the problem from a big data perspective rather than a medical one. "We have a large collection of audio files of people with and without [conditions], and we just have to find in those files what are the differences in the audio, in the waves," says Adams. "It doesn't require medical intuition to do that, it requires signal processing and machine learning."

But not everyone is convinced by the approach. Max Little at Aston University in Birmingham, UK, says: "I'm deeply sceptical of efforts that naively believe you can simply accumulate more data and that will do the job." **Matt Reynolds** ■

## Seeing a virtual body raises your pain threshold

LOOKING at a virtual body may be a useful way to relieve pain.

We've known since 2009 that looking at your own body has an analgesic effect, although it's unclear why. Now Maria Sanchez-Vives at the University of Barcelona, Spain, and her team have found that, if you get the position right, looking at a virtual representation of your body can also reduce pain.

The team used a variation on the classic rubber hand illusion, in which a person's real hand is hidden and a rubber hand is placed next to it. Stroking both the real and rubber hands with paint brushes convinces the person that the rubber hand is their own. This works with a virtual hand, seen through a VR headset, too.

The researchers attached thermal electrodes to volunteers' hands to make them feel heat. The virtual hand appeared to be attached to virtual electrodes too. The team then stepped up the heat in small increments, asking volunteers to tell them when the heat started to feel painful – a measure of their thermal pain threshold. They found that, provided the virtual hand was located close to the participant's real hand, they had a higher pain threshold (*Journal of Pain*, doi.org/bzcj).

"If you look at a virtual body, it is analgesic, but it's important that it's co-located," says Sanchez-Vives.

The researchers think virtual reality can be used as a therapeutic tool. In an earlier study, the team found that looking at a virtual arm that's reddish in colour lowers your pain threshold, while a bluish arm increases it. Viewing such images during a painful procedure might ease discomfort.

"This research is very useful and quite promising because it opens a route to how we could therapeutically dampen down pain using virtual reality," says Thomas Metzinger at the Johannes Gutenberg University in Mainz, Germany. Anil Ananthaswamy ■

# LIGO gears up to peer inside exploded stars

PREPARE for a big wave – a wave of gravitational waves. A mass of predictions from the latest meeting of the American Physical Society in Washington DC is shedding light on what's next for the LIGO experiment.

With two sets of colliding black holes in its net and another possible pair in its second run, LIGO, the world's first successful gravitational wave detector, is ready to see the unexpected.

Like insects on the surface of a pond, masses create ripples in space-time when they move. When massive objects like black holes accelerate, those ripples – gravitational waves – are powerful enough that we can detect the contractions in space-time using LIGO's twin detectors in Washington and Louisiana.

The detectors use lasers to measure the distance down two perpendicular tunnels. When a wave goes by, one tunnel shrinks and the other stretches by less than the width of a proton. Almost exactly a year ago, the team announced its first detection, from a pair of black holes about 30 times the mass of the sun crashing together.

Now, a few months into the detector's second "advanced" run,

team members are scrambling to predict what signals will look like from even weirder things, so we can recognise what we see.

"We're playing this taxonomy game," Shane Larson of Northwestern University in Illinois told *New Scientist* at the APS meeting at the end of last month. "We go through all the

phenomena in space that people have looked at, and we ask, 'Could we get a gravitational wave signal from that? Sure! This is what it might look like. This is what we could learn.'

First up will probably be more waves from merging black holes. This will boost our understanding of the holes and how stars evolve, and test whether Einstein's theory of general relativity holds true.

Next may be neutron stars. At the meeting, the LIGO team presented results from its first

search for gravitational waves from pulsars – spinning, radiating neutron stars. None of the 200 pulsars surveyed emitted waves LIGO could detect, but that let the team put limits on the shapes and magnetic fields of the pulsars, revealing that some are incredibly round.

When we do catch waves from neutron stars in binary systems, it will help us learn about their mysterious insides. Their cores are probably superfluid, made of neutrons packed so close together that they start to flow without any viscosity or friction. The closer the star gets to its partner, the faster its interior tides will come and go. This motion could cause standing waves that we would never be able to observe with visible light – but we could get a look at them with LIGO. They lie right in LIGO's detection "sweet spot," said Hang Yu, a member of MIT's LIGO Laboratory.

Even things we can see with telescopes hold mysteries. Dust and the chaos of an explosion can stop us getting a clear picture of supernovae. But energetic core collapse supernovae should produce gravitational waves that LIGO can detect.

Those waves may let us peek inside supernovae, watching the cores of stars fold under the force of gravity and the shock waves, explosions and baby neutron stars that result. Leah Crane ■



LIGO LABORATORY

Lying in wait in Louisiana

## Internet 'playground' to test new tech

INTERNET need an upgrade? An "internet playground" is being set up in the UK to try out new communications tech on a huge scale.

"We know the internet needs reinventing," says Dimitra Simeonidou at the University of Bristol. "It was originally designed for basic communication like email and now we want 4K video available

to us standing on the street."

The Initiate project will test technologies to make connections faster and more secure, and lay the groundwork for smart cities and new internet of things applications.

"I work with a surgeon who takes a train to Leeds once a week to perform robotic surgery, but he wouldn't need to go there if the internet was better," says Toktam Mahmoodi at King's College London. "He could do the same procedure remotely, saving lots of time and effort."

But testing internet tech is hard, as you can't just start messing with

infrastructure that millions rely on. With a test bed network, it doesn't matter if researchers break things.

It is all based on a server in the town of Slough. High-speed fibre-optic cables link it to researchers at the universities of Bristol, Edinburgh, Lancaster and King's College London.

The researchers got access to the server on 1 February and are starting to test various technologies. A team

**"We will be connecting everything from smart cities to 5G mobile internet"**

from Bristol will connect thousands of real-life "smart city" sensors, which detect everything from air quality and traffic flow to energy use. A group at Edinburgh will test a light-based alternative to Wi-Fi called Li-Fi, which uses LEDs to transfer data at speed.

"We will be connecting everything from smart cities to 5G mobile internet," says Simeonidou.

Many of these technologies already exist, says Polina Bayvel at University College London, but the project will allow them to be tested at a national scale and in a real-world environment. Timothy Revell ■

# New radiation hazard to flights

David Hambling

MYSTERY radiation hotspots high up in the air could pose an unrecognised health hazard. Airliners may have to avoid these in future, just as they do with volcanic ash clouds, to minimise any risk to travellers and crew.

High-altitude flight exposes us to cosmic rays: the radiation dose on a flight from London to Tokyo is roughly equivalent to a chest X-ray. Now research flights, made under the NASA-funded Automated Radiation Measurements for Aerospace Safety (ARMAS) programme, have revealed the existence of zones where radiation levels can be double the usual level.

In 265 flights, the radiation levels detected generally followed the expected pattern, but in at least six instances they surged, as though the aircraft was flying through a radiation cloud (*Space Weather*, doi.org/bx8r).

"We have seen several cases where the exposure is doubled

while flying through the cloud," says ARMAS principal investigator W. Kent Tobiska, of Space Environment Technologies in Los Angeles. Some even higher spikes have been recorded, but those results remain unpublished while the team considers alternative explanations for the data.

Tobiska says the two main

sources of radiation, cosmic rays and the solar wind, can't account for the surges. "Our new measurements show a third component."

The surges coincided with geomagnetic storms. Tobiska believes these events can liberate energetic electrons from the outer Van Allen radiation belts, regions of Earth's magnetosphere where charged particles – mostly from the solar wind – get trapped.

"Those electrons are driven into the upper atmosphere, collide with nitrogen and oxygen atoms and molecules, and then create a

spray of secondary and tertiary radiation, likely in the form of gamma rays," Tobiska says. He thinks this radiation is what the ARMAS flights are detecting across a wide area.

Daniel Baker of the University of Colorado's Laboratory for Atmospheric and Space Physics says that's feasible. "It is plausible that the ARMAS results are related to enhanced loss of radiation belt particles from the magnetosphere into the middle and lower atmosphere," he says.

The absolute risk this poses may be low – a chest X-ray only increases the risk of a fatal cancer by 1 in 200,000 – but it must be balanced against the large number of flights, and whether the risk is avoidable.

Although no set standards exist for radiation safety in US aviation, Tobiska says regulations are likely in the next few years. "This is mainly for crew members," he says, "but would certainly benefit frequent flyers and even fetuses in their first trimester."

A combination of airborne measurements and space weather data from satellites may allow the radiation "clouds" to be tracked. Tobiska says that in future, flights may be diverted or directed to a lower altitude to avoid them. ■



Seat belts won't help

## Neural net learns words like a child

OCEAN, castle, train. It's not exactly Shakespeare, but it's a start. A neural network has cobbled together a rudimentary vocabulary in a way similar to how a child learns to speak, by learning to associate images with spoken descriptions.

David Harwath and Jim Glass at the Massachusetts Institute of Technology wanted to see if a machine could learn words without ever seeing them written down. They presented a neural net with more than 200,000 images and corresponding

audio captions, and then tested it on a fresh set of 1000 images.

It learned to pair sounds from the captions with objects in the images. For example, it learned to associate images that featured lighthouses with the word "lighthouse".

This method is closer to how we attain speech than standard learning algorithms, says Grzegorz Chrupala at Tilburg University in the Netherlands. "[Children] listen to what people say and at the same time perceive the world and the situation in which these references are made, and correlate those things together," he says.

The neural net learned to name hundreds of things that recurred across the set of images, including the sky, trucks and trees. It picked up

some adjectives too, for instance learning that the word "wooden" could be applied to photos of both attic rafters and desks (arxiv.org/abs/1701.07481).

The technology could make it easier to build speech recognition programs for less common languages.

Conventional speech recognition algorithms, like those behind Apple's Siri and Amazon's Alexa personal assistants, are taught by comparing huge data sets of spoken and written words. "You have to train these systems with thousands or even

tens of thousands of hours of people speaking, and you have to have someone manually go in and transcribe that data," says Harwath.

As it is expensive and time-consuming to create these data sets, voice assistants usually only work in a limited number of languages. Siri offers 21 so far, while Alexa has only got to grips with English and German.

But Harwath and Glass's neural net only needs audio captions and images, so it could help develop speech recognition for languages that lack large bodies of transcribed spoken data. It's even possible, says Harwath, that a neural net could use images as a reference point to translate from one language to another. Matt Reynolds ■

**"The system could make it easier to build speech recognition programs for less common languages"**

# WHY ARE DOGS' NOSES WET?

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Discomfort food

## Why some hate chewing noises

Tiffany O'Callaghan

IMAGINE feeling angry or upset whenever you hear a certain everyday sound. It's the hallmark of a little-studied condition called misophonia. Now it seems the condition may be caused by altered patterns of brain activity.

Olana Tansley-Hancock knows the symptoms only too well. From the age of about 7, she had feelings of rage and discomfort whenever she heard the sound of other people eating. As time wore on, many more sounds would trigger her misophonia, including paper rustling, toes tapping on train journeys, and clacking keyboards in the office. Finally, she went to a doctor for help. "I got laughed at," she says.

"Misophonia seems so odd that it's difficult to appreciate how disabling it can be," says V. S. Ramachandran at the University of California, San Diego.

Until 2013, there had only been two case studies of the condition published. More recent research has found that misophonia isn't a symptom

of other conditions, such as obsessive compulsive disorder, nor is it a matter of being oversensitive to other people's bad manners. Some studies, including work by Ramachandran and his colleague Miren Edelstein, have found that people with misophonia experience a full fight-or-flight response when they hear their trigger sounds.

Now Sukhbinder Kumar and his team at Newcastle University, UK, have carried out a series of tests on 20 volunteers with severe misophonia, as well as 22 people

### Misophonia seems so odd that it's difficult to appreciate how disabling it can be

who don't have it. Tansley-Hancock, who is a neuroscientist, helped develop the tests.

Both groups listened to neutral noises, like the sound of rain; unpleasant sounds, such as a baby crying; and sounds that were triggers for the misophonics, such as chewing or breathing noises.

While both groups reacted to

the neutral and unpleasant sounds in a similar way, the misophonics group experienced increased heart rates and skin conductance – both signs of the body's fight-or-flight response – when they heard trigger sounds.

Brain scans revealed that, when the trigger sounds were played, the misophonics had heightened activity in the anterior insular cortex (AIC), an area that helps determine which things we should pay attention to. This change was also linked to surprising increases of activity in some other regions. "The AIC is hyperconnected to structures that are involved in emotion regulating and memory," says Kumar.

There was also increased connectivity to regions involved in the default mode network, which helps process internally generated thoughts (*Current Biology*, doi.org/bx8x). Together, these findings suggest that the systems that normally influence what we pay attention to, and respond to emotionally, are disrupted in people with misophonia.

The hope is that such work will lead to new coping strategies and treatments. For now, Tansley-Hancock opts for earplugs at times, and at meals she tries to mask the sound of other people eating by chewing in sync with them. ■

## New clue to where all the antimatter is

A HINT of matter and antimatter behaving differently to each other has been spotted in particles called baryons for the first time. If the find bears out, it could help explain the existence of all matter in the universe.

Physicists believe the big bang made equal amounts of matter and antimatter. But these contrasting particles annihilate each other whenever they meet, so they should all have been wiped out long ago.

The fact there's enough matter today for us to exist and wonder why means that some mechanism must have favoured matter over antimatter. "Today we have this complete imbalance between matter and antimatter," says Nicola Neri of the National Institute for Nuclear Physics in Milan, Italy.

One way the two could differ is by violating a rule known as CP symmetry about how the laws of physics affect particles and antiparticles. Previous tests showed CP symmetry is violated in particles called mesons, made of a quark and an antiquark, but it wasn't enough. "The sources we've found so far are not sufficient to explain this huge imbalance," Neri says.

Neri and his colleagues have now checked baryons, made of three quarks, and their antimatter equivalents made of three antiquarks.

And they were lucky. One of the particles tested at the Large Hadron Collider at CERN near Geneva, Switzerland, decayed in a way that seems to violate CP symmetry (*Nature Physics*, doi.org/bzb3). Theory suggested that there should be a lot of CP violation in these events, but they had never been seen before. "This is the first hint, a sign that something is going on there," Neri says.

"It's an important observation," says David MacFarlane at the SLAC National Accelerator Laboratory in Menlo Park, California. He says that seeing CP violation in more places will help nail down where all the antimatter disappeared to. Lisa Grossman ■

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# Friendly monkeys lose in rough times

Colin Barras

BEING too friendly can be costly. When a new alpha male takes over, female capuchin monkeys are more likely to lose their offspring to infanticide if they have an extensive network of social contacts than if they don't.

This new finding suggests sociable primates don't necessarily fare better than non-sociable ones when it comes to raising offspring.

Group-living mammals have plenty to gain from being sociable, says Urs Kalbitzer at the University of Calgary in Canada. They can have better access to food and more protection from predators, as they often take up a position near the centre of the group. These advantages should help the most sociable females raise more infants to adulthood.

But some researchers have suspected that being sociable carries a cost when the group's alpha male loses his position to a rival. The usurper can kill offspring he hasn't fathered so that adult females will become receptive to his sexual advances.

One idea is that the alpha

male is more likely to kill the offspring of females at the group's social core, as less sociable females on the periphery may escape his attention. To test the theory, a team led by Kalbitzer and his colleague Linda Fedigan looked at data from wild communities of white-faced capuchins (*Cebus capucinus*) in Santa Rosa, Costa Rica, between 2005 and 2011.

They found that an infant was, on average, more likely to survive during times of group stability if its mother was sociable. But when the alpha male's position was threatened or if he was replaced – which happened roughly once every four years – infants born to sociable females were more at risk of infanticide.

Overall, the team found that a female's level of sociability had no significant effect on the number of offspring she successfully raised over the course of her lifetime. In other words, the advantages of sociability seem to be counterbalanced by the price she pays during alpha male changeovers.

Surprisingly, there was no evidence that females changed



SUZIESZTERHAAS/NATUREPL

A friend in need...

how sociable they were at different times, even though becoming less sociable when the alpha male was threatened might reduce the risk of infanticide (PNAS, DOI: 10.1073/pnas.1608625114).

"Females with strong bonds may not opt out of their spatially central position in times of increased infanticide risk because peripheral positions are associated with increased predation risk," says Oliver

Schülke at the University of Göttingen, Germany. "It will be interesting to see whether, with more data accumulating, highly social females turn out to enjoy longer lives."

There might be lessons from such studies for understanding human social networks too, says Kalbitzer. "They can reveal which features of social relationships are relatively ancient, and which selection pressures may have acted on our ancestors." ■

## Drug wipes out chemotherapy side effects

PAIN, nausea and exhaustion are just a few side effects of undergoing chemotherapy to treat cancer. Now researchers have used a drug to stop chemo's side effects in mice.

The drug targets a certain type of cell, called a senescent cell. Older cells become "senescent" when they naturally stop dividing. These cells pump out chemicals that cause

inflammation and have been linked to age-related diseases including Alzheimer's and heart failure.

Marco Demaria at the University of Groningen in the Netherlands wondered if senescence might be responsible for chemo's side effects, which can occur for months after treatment has finished. His team genetically engineered mice so that senescent cells would fluoresce. They then gave the mice cancer and one of four common chemotherapy drugs.

Chemo increased the number of senescent cells. "We saw senescence everywhere: in the liver, lung, heart,

skin and fat," says Demaria. The mice also started showing side effects, becoming less active and developing heart and bone marrow problems.

In another experiment, the team gave some mice a drug known to kill senescent cells, a week after chemo. These animals were more active and didn't develop the health problems of the other mice (Cancer Discovery, doi.org/bwsq). "We are able to

**"We are able to interfere with multiple side effects of chemotherapy at the same time"**

interfere with multiple side effects at the same time," says Demaria.

Looking at women with breast cancer, the team also found that those with more senescent cells in their blood before chemo had more severe side effects when treatment began. "It's really interesting," says Darren Baker at the Mayo Clinic in Rochester, Minnesota. "Chemotherapeutics are obviously good, but they really do have caustic side effects."

The drug given to the mice can cause fatal complications in humans, so the hunt is on for one that people could take. Jessica Hamzelou ■



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## Sun's rotation is slowed down by its own photons

THE sun is hoist with its own petard. Its outermost layer frustrates photons of light trying to escape. Now it seems that when light does eventually stream away, it may in turn slow down the sun's rotation.

While the interior of the sun rotates like a solid sphere, the outer layers do not: the polar regions turn slower than the equator, and the layers closer to the core rotate faster than the outermost 5 per cent. But it's not clear why.

Even within the photosphere – the thin layer we see as the surface of the sun – there is a hint of a difference between the top layers and the bottom.

There is a possible explanation. Photons created in the sun's interior bounce around on their way out, gaining a small amount of momentum from each atom they ricochet off. When a photon leaves the photosphere thousands to millions of years later, it carries that momentum with it. The photosphere, meanwhile, experiences a backward push.

To test this theory, Jeff Kuhn at the University of Hawaii in Pukulani and colleagues used data from NASA's Solar Dynamics Observatory to measure the edge of the photosphere and its rotation. They calculated that over the sun's lifetime, those ricocheting photons would cause a slowdown of about 3 per cent in the rotation of the outermost 100 kilometres of the sun, and exert a drag on the outermost 5 per cent ([arxiv.org/abs/1612.00873](https://arxiv.org/abs/1612.00873)).

## Spacecraft may use starlight to park

WE'RE dreaming up technologies to travel quickly to other star systems, but how do we apply the brakes on arrival?

Rene Heller of the Max Planck Institute for Solar System Research and independent researcher Michael Hippke have an answer: we can slow a spacecraft using the stars themselves.

The nearest star system, Alpha Centauri, is more than 4 light

years away. Chemical propulsion would take 100,000 years to get us there, but ultra-light solar sails could help an interstellar probe reach the system – including the Earth-mass planet orbiting its companion star, Proxima Centauri – in just 20 years.

Unfortunately, at that speed, the craft would whizz through the whole system in just a few hours. "It's hardly enough time to take in

the view, let alone do serious science," says Heller.

Now, Hippke and Heller show that a combination of the stars' gravity and radiation pressure from their photons can bring the craft into a stable orbit around one of the stars, then around the tantalising planet (*Astrophysical Journal Letters*, doi.org/bx8t).

The idea is "scientifically viable and very interesting", says Avi Loeb at Harvard University, though he has practical concerns.

## Trees trap moth inside fruit for year

SOME relationships are a little stifling. One East Asian tree is so intimate with the moth that pollinates it that it holds the moth's offspring captive until they reach adulthood.

In April and May, one species of leafflower moth, *Epicephala lanceolaria*, lays its eggs in the flowers of the *Glochidion lanceolarium* leafflower tree – pollinating it along the way.

But unlike other leafflower trees, *G. lanceolarium* does not bear fruit until January the following year. Only at this point do the larvae emerge from their eggs and begin to feed on the fruit.

With their development squeezed into a few months, the larvae metamorphose into adults while still inside the fruit. In March, the fruits mature – and the moths fly out, just in time to mate and lay their eggs in the tree's new blooms (*The American Naturalist*, doi.org/bx8w).

## Stress genes help carnivore plants kill

DIFFERENT pitcher plants took similar evolutionary paths in order to trap and digest insects.

Genetic sequencing of three families of pitcher plants from the Americas, Asia and Australia shows that they all repurposed genes normally involved in the stress response to make the insect-killing fluids in their pitcher-shaped leaves (*Nature*, doi.org/bzb5).

"It's a big, complicated series of events at the evolutionary level to become carnivorous," says Victor Albert at the State University of New York at Buffalo. The fact that all these plants use the same genes suggests the paths plants can take to become predators are limited, or that this is the quickest path to their unusual lifestyle.

## DNA gives away baby dragon caves

RARE blind salamanders have been discovered in five new caves thanks to DNA they have shed into water. This extends the known range of the vulnerable salamanders and raises hopes for their long-term monitoring and conservation.

The olms, or baby dragons as locals call them, spend their entire lives in the underground waters of the Dinaric Alps running through the Balkans. Many of their caves are inaccessible to humans, but telltale DNA from bits of shed skin or their faeces – known as environmental DNA or eDNA – gets dissolved in their watery habitat. If washed out, it can give away their presence.

"Before you would only see these elusive animals if they were washed out of their home after heavy rain, or if you went cave-diving," says Judit Vörös of the Hungarian Natural History Museum, who led the work. "But now we can tell just from some cave water if they are there or not."

Her team tested cave water in Croatia for eDNA to confirm the presence of the salamander in 10 caves. They also found the species in five others for the first time (*PLoS One*, doi.org/bx8v).

Croatian conservationists have now adopted this technique to map the olms' habitat more precisely and learn more about their population genetics, both of which may help conserve the creature.



WILD WONDERS OF EUROPE / HODALIC / NATUREPL.COM

## Blood test could detect pancreatic cancer in time

A BLOOD test to detect pancreatic cancer in its early stages may let us spot the condition sooner.

The only way to treat pancreatic cancer is to remove it before it spreads. But because the pancreas is deep inside the body and is difficult to image or biopsy, spotting the cancer is hard.

As a result, pancreatic cancer is known as the "silent killer", because it is usually already too advanced to treat by the time symptoms arise and a diagnosis is made. Only 5 per cent of people diagnosed with

pancreatic cancer are still alive five years later, compared with 90 per cent of those diagnosed with breast cancer.

Now Tony Hu at Arizona State University in Tempe and his colleagues have developed a blood test that could spot pancreatic cancer before it spreads. The test uses gold nanoparticles to detect signs of cancer in the blood.

In a pilot study in 59 patients, it picked up early-stage pancreatic cancer in more than 90 per cent of cases (*Nature Biomedical Engineering*, doi.org/bzch).

The test could also tell the difference between pancreatic cancer and pancreatitis, which have similar symptoms and are difficult to distinguish using existing screening methods like ultrasound.

"There's no doubt that early screening tests, particularly a non-invasive blood test like this one, would be very valuable," says Anthony Gill at the University of Sydney, Australia. But the test still needs to be validated through wider testing, he says. "It's early days yet."

## Vaccine protects monkeys from Zika

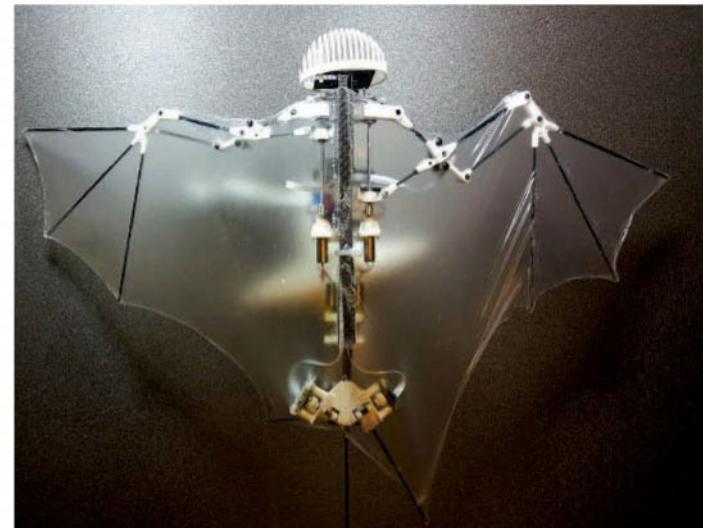
A VACCINE against Zika virus has given mice and monkeys immunity in tests. It is made from an inactivated version of the virus, and just one dose is needed.

"The critical difference between ours and everybody else's is that it's not a live virus. That makes it much safer and much easier to produce," says Drew Weissman at the University of Pennsylvania, a member of the team that developed it.

Zika has been reported in 70 countries and territories, and can cause babies to be born with abnormally small heads and brain damage.

Weissman's team found that mice given the vaccine were still immune five months later. The group also gave five rhesus macaques a single injection, and found that it conferred protection on four of them for at least five weeks afterwards (*Nature*, doi.org/bx8n). The fifth monkey had a small amount of the virus present after being exposed to it, possibly because it received too high a vaccine dose.

Dozens of vaccines are in the pipeline, but the other candidates all require two immunisation shots, says Weissman.



RAMEZANI, CHUNG, HUTCHINSON, SCI. ROBOT. 2, EAAL2595 (2017)

## Bat robot flies like the real thing

**WATCH** it swoop and soar. Engineers have built a bat-like autonomous flying robot that could one day be used to monitor building sites.

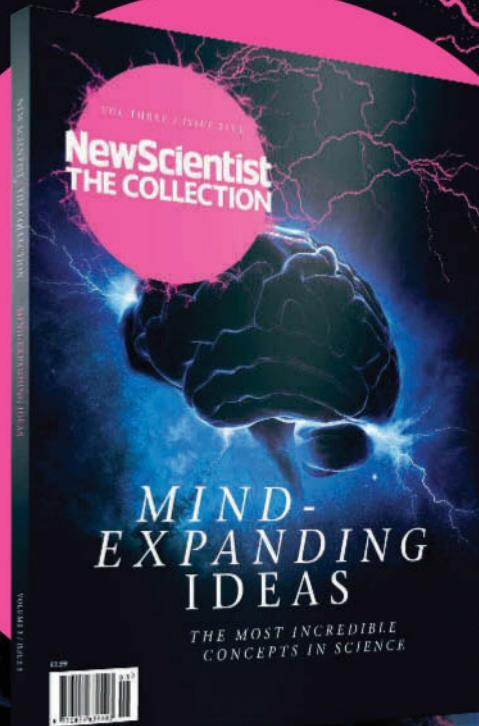
Robot designers have often taken inspiration from insects and birds, but aping bats is tougher because they have complicated skeletons and irregular flight patterns.

Bat wings have more than 40 joints for adjusting their shape during flight. Recreating this would make a robot too bulky, so instead, this "Bat Bot" has a nine-joint wing structure made of lightweight carbon fibre covered with a stretchy silicone

membrane that mimics bat skin.

The robot, made by Alireza Ramezani at the University of Illinois at Urbana-Champaign and his colleagues, weighs 93 grams and has tiny motors in its backbone. In tests, the Bat Bot performed a banking turn and a steep diving manoeuvre similar to the way bats move when pursuing prey (*Science Robotics*, doi.org/bx8s).

Bat wings could inspire a new generation of nimble drones that are less likely to be thrown off course by strong wind, says Bharathram Ganapathisubramani at the University of Southampton, UK.



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**NewScientist**

# A farewell to condoms

It can be safe to have sex without condoms if you are HIV-positive. But under what circumstances, asks **Clare Wilson**

JOHN is HIV-positive and in a relationship with someone who is not. Two years ago, they stopped using condoms. They had become aware of a groundswell of evidence that people like John, who take their HIV medicines every day, have a negligible risk of passing on the virus.

"I used to struggle with this feeling that even the blood running in my veins was toxic," says John. "Having this intimacy with my partner is such a big relief."

The message that people taking their meds are effectively uninfectious is now being promoted by activists, campaigners and researchers at the highest level. "Once you begin therapy and you stay on therapy, you are not capable of transmitting HIV to a sexual partner," said Carl Dieffenbach, who heads the Division of AIDS at the US National Institutes of Health at a conference last year.

Although some researchers remain sceptical, in the UK, the message is being translated into official guidance for doctors that is due to be published within a few months.

For the average person, this new reality might come as a bit of a shock: has HIV really become a disease you can't pass on?

It's a dramatic turnaround. In the 1980s, an HIV diagnosis was tantamount to a death sentence. Many countries launched stark advertising campaigns warning people that they risked their lives having sex without condoms.

Then came the development of antiviral drugs that stop HIV from reproducing – arguably one of the greatest medical success stories of the 20th century (see diagram). The treatment cannot eliminate

HIV from the body – the virus lurks inside dormant immune cells in lymph nodes and other tissues – but the life expectancy of people on therapy is near normal.

These medicines have another, more surprising effect: they reduce an infected person's risk of passing on the virus to sexual partners (see "HIV in retreat", right).

Just how much the risk falls has only recently become clear, after several studies of couples in monogamous relationships, in which one partner is HIV-

## **After 58,000 acts of sex without condoms, there were zero cases of HIV transmission"**

negative and the other positive and on treatment.

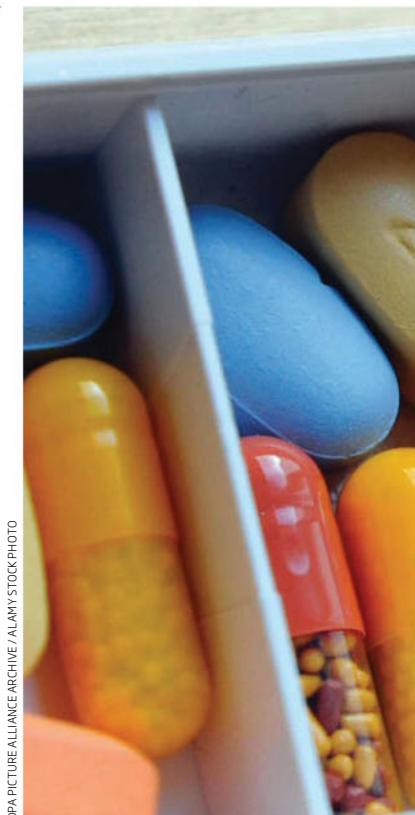
Doctors check that the drugs are working by measuring the amount of virus in the positive partner's blood. In those who are on treatment, levels are typically less than 50 per millilitre, the limit of detection for one of the main tests used – so the virus is said to be undetectable

in the blood. In time it's also undetectable in semen and genital fluids.

Does this keep the negative partner safe? Last year, results from the Partner study were unambiguous. It tracked nearly 900 gay and straight couples, where one partner was positive, through 58,000 acts of sex without condoms. As long as the person stayed on their meds for six months, and the virus was undetectable, there were no cases of HIV transmission.

These findings were supported by another large US trial called HPTN052. As well as the new UK guidelines for doctors, the trial results have triggered grass-roots campaigns to spread the word about "treatment as prevention", including a US campaign called Prevention Access. Similar advice went up last month on a UK website about HIV prevention called Prepster.

But there are concerns. For one thing, not everyone who has HIV is on medication or has undetectable virus, a detail that could get lost in the enthusiasm. "A lot of people feel that this is a



DPA/PICTURE ALLIANCE ARCHIVE / ALAMY STOCK PHOTO

licence not to use condoms," says Thomas Quinn of Johns Hopkins School of Medicine in Baltimore, "and that puts individuals at risk of [other] sexually transmitted diseases."

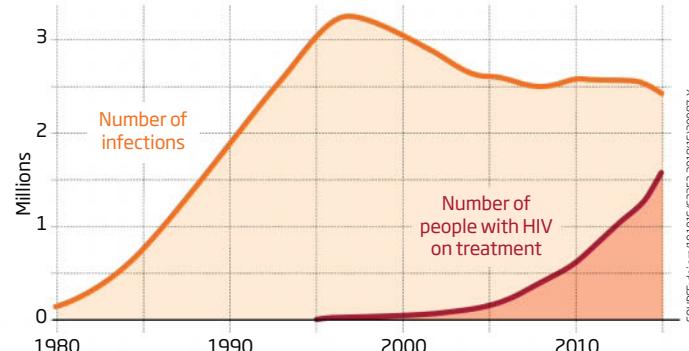
Although these are generally less serious than HIV, Quinn points out that gay men are at higher risk of hepatitis B, which can require lifelong treatment, and hepatitis C, which can be cured but the medicines can have side effects. There's also no cure for genital herpes.

## **Monogamy focus**

For these reasons, relying on treatment as prevention is usually considered a good option only in monogamous relationships, where the HIV-positive partner may have extra motivation to take their pills every day. John, for instance, takes his three tablets at 9 am every day, and his partner usually sees him do it, or hears his reminder alarm. If he were to

## **Under control**

The introduction of HIV medicines coincided with a global plateau in new HIV infections. There is growing evidence they may make people uninfectious





Drugs to tame HIV

start missing doses, John's viral load would rise, making him infectious again.

Even for people who are rigorous about taking their medication, however, there is another source of uncertainty: the possibility of a small and transient increase in their viral loads, typically going up to 200 per millilitre, sometimes up to 1000. We don't know what causes them. One theory is such "blips" are just random fluctuations in a person's virus levels, so sometimes it's lower and sometimes higher than the test's detection limit. Others think they are due to some infection such as flu, or a sexually transmitted infection, stimulating the immune system. This might awaken dormant immune cells and prompt virus levels to increase.

Does a blip raise the risk of infection? "The risk is extremely low," says Anthony Fauci, who heads the National Institute of

Allergy and Infectious Diseases in Bethesda, Maryland. However, he says, "It's very difficult to say zero."

But others say the risk is so low it can be effectively ignored. A viral load of 1000 sounds a lot compared with under 50, but it's

## HIV IN RETREAT

WE STILL have no cure and no vaccine, but HIV's days as a public health problem could be drawing to a close in some Western countries. For the World Health Organization that would mean the rate of new infections has dropped to less than one per thousand people a year.

How will this be achieved? Simply by upping the number of HIV-positive people who are diagnosed and taking their medicines. This slashes levels of the virus in their blood, and so they are unlikely to pass the infection on to others (see main story).

If that sounds unrealistic, Denmark is nearly there already. Annual rates of new infections in gay men - the

much less than in people who are undiagnosed and not on treatment, typically around 35,000. In fact, it's thought that most HIV is passed on by people in the first few months after they are infected – before they know – and when their viral load is higher still, often several million. According to some models, it's not even possible to pass on HIV with a viral load of under 400, while other studies place the cut-off higher still, at 1500.

While some blips nudge above these thresholds, the risk from such low levels is less than using condoms with someone who is not being treated for their HIV – because condoms can break or slip off, or not be used properly, says Dieffenbach. Yet the message that condoms are an effective defence against HIV is shouted from the rooftops, unlike the hesitation over treatment as prevention.

"That's a contradiction, says Will Nutland of the London School of Hygiene and Tropical Medicine, who runs the Prepster website. "People are being cautious but we should apply that caution equally across all forms of prevention – instead of seeing condoms as the holy grail."

The bottom line should be the

group at highest risk in this country – have fallen to 1.4 per thousand.

Replicating Denmark's vigilance elsewhere could be a lot harder, though, and not just in poorer countries.

Denmark's achievement stems from its universal healthcare system, which offers free treatment and easy access to testing.

The conscientious Danes are also very good at taking their HIV drugs every day – 98 per cent of those diagnosed report steadfast adherence to their daily regime. Statistical models suggest there are now only 617 undiagnosed HIV-positive gay men in the country.

data, says Dieffenbach. People in the Partner study and HPTN052 must have had blips between blood tests – and yet still there was no transmission between couples.

While some researchers continue to debate the data, forthcoming guidelines drawn up by three sexual health organisations say that for straight people in monogamous

## "The new reality will have implications for adoption and for conceiving children"

relationships whose HIV is undetectable, there is no risk in not using condoms, and that for gay people in the same circumstance the risk is "incredibly low". The message could not be more welcome for HIV activists. And it's not just about their sex lives.

"This has the potential to transform the way we think about HIV," says Matthew Hodson of UK charity NAM. HIV remains one of the most stigmatised of all viral infections, a hangover from the days before effective treatment, when the disease was defined by doom-laden advertising full of tombstones, says Hodson. As a result, he says, "many who live with the virus face not just sexual but also social rejection".

The new thinking, they hope, will reduce fear and stigma. If a person's virus levels are undetectable, it means they will not be able to pass it to healthcare professionals or anyone else.

This could affect the decisions of social workers who may have previously been reluctant to grant approval to HIV-positive adoptive parents. It also means that people trying to conceive their own children no longer need to take special precautions, such as the uninfected partner taking HIV blockers.

"When we are undetectable we are uninfected," says Hodson. "It means all the fear of living with HIV is just wasted energy." ■

# Just an illusion?

Claims are swirling of significant evidence that shows we live in a holographic universe. Do we really, wonders **Geraint Lewis**

THE holographic universe, an idea born out of the quest to reconcile our understanding of gravity with the other fundamental forces, has raised its head again, with the claim that “significant evidence” has been found that we live in a hologram. What’s going on?

The notion of such a universe comes from a mathematical quirk in string theory, our leading attempt at a theory of everything.

This quirk says that within a particular kind of cosmos, we can effectively do away with gravity by reducing the number of dimensions in our mathematical description by one. You can think about the resulting universe as information “painted” over a “cosmological surface”, which then permeates into other dimensions, creating the physical cosmos. This is akin to a hologram, a 3D image created from information in a 2D pattern.



The result would be that gravity and our third spatial dimension could be regarded as “illusions”.

While recent calculations show that this principle might hold in universes like ours, the question on everyone’s lips is, “How would we know?” Our day-to-day experience, with three spatial dimensions, would be the same whether the universe was holographic or not. We have to look into the quantum realm to try to see its impact. But all is not lost. Various attempts are being made to do this, although so far without a positive result.

And so to the latest reports of significant evidence for this strange reality. These sprang from a paper that worries about the fuzziness of space and time in the initial instants of the universe (*Physical Review Letters*, vol 118, 2017). In our standard cosmological model, which

## Location matters

In an isolationist world, Europe's Galileo satnav system looks like a wise bet, says **Paul Marks**

EVER wondered why the likes of Europe want their own versions of the US's space-based Global Positioning System?

Given that the full might of GPS is available to one and all, such variants have often been criticised as costly vanity projects. And although the US still has the ability to degrade the accuracy of

the GPS signal offered to civilians, it has not done so for 17 years.

But with the capricious Donald Trump in the White House and doubts about international cooperation, Europe must feel justified in having pursued its own space capabilities, including its positioning system, Galileo.

The signals that rain down from

such systems do more than tell our satnavs where we are. They provide location information to emergency services and logistics and transport industries, and to emerging sectors like driverless cars and precision farming. They also sync phone networks, bank transactions and power grids.

Norbert Barthle, Germany's state secretary for transport and digital infrastructure, recently said that isolationist messages from the Trump administration

underscore Europe's need for comprehensive space capabilities.

But such self-determination is not easy. In recent weeks, Galileo (which went live in December) and India's equivalent, IRNSS, both saw mysterious, in-orbit failures of their critical atomic clocks.

It is the differences in travel time of atomic clock signals that are used to compute a position on Earth. For backup purposes, each Galileo satellite has four clocks, while IRNSS spacecraft have three. So far, nine clocks have failed across five of the 18 Galileo craft so far in orbit, while all three failed on one IRNSS spacecraft.

Both systems are still running,

**“Isolationist messages from the Trump administration underscore Europe's need for space capabilities”**

has yet to explain gravity, the embryonic universe has a particular pattern of fluctuating energy, like ripples on a pond. In the rival holographic model, the pattern is different. In both kinds of universe, these fluctuations are accentuated by the expansion of the universe and are observed in the cosmic microwave background (CMB) radiation.

Just how "significant" is the evidence in this research for the holographic universe? Beyond the headlines, the best that can be said is that the theory does as well as our standard model in accounting for some observations of the CMB, but does a poorer job when considering all CMB data.

What all this means is that the idea of a holographic universe is not dead, as observations do not currently rule it out, but it is still on shaky ground compared with the standard model.

However, as the study authors note, calculating the ripples in the early universe is not simple, and future mathematics may yet lead to a better fit for observations and point to us living in a holographic universe. The true nature of our universe is still up for grabs. ■

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

but continued clock failures could ultimately mean a greater dependence on GPS, or perhaps the only other global system, Russia's GLONASS network.

The European Space Agency isn't commenting on its probe into the clock failures as Galileo is "critical infrastructure".

Perhaps it's even more critical now. Satnavs might tell us where we are – but the rise of isolationist politics means we no longer know exactly where we stand when it comes to cooperation. Europe's plan B looks wise. ■

**Paul Marks** is a science and technology writer based in London

## INSIGHT Online porn



# Age verification for porn sites won't work

**Sally Adey**

IT ISN'T easy to choose the worst part of the UK's Digital Economy bill. Put forward as a long-overdue upgrade to UK policy last July, the bill was meant to make the country a competitive player on the digital scene. This week, it is being scrutinised in committee in the House of Lords. "This is a crucial stage of the debate when the bill can be amended," says Jim Killock of campaign organisation Open Rights Group.

And the bill really does need amending, because key concerns have been left unaddressed. Alongside gestures like everyone having the right to broadband, it also contains some head-scratchers. One is the Sisyphean requirement that all adult sites in the world be vetted by the British Board of Film Classification.

That's just impractical, but one provision is actually dangerous: a requirement for age verification for all sites and applications containing pornographic material, in an attempt to protect children.

"It's almost impossible to do age verification without confirming your identity," says Adrian Kennard of

internet service provider Andrews & Arnold.

The first problem with this is that there is absolutely nothing in the bill detailing how age verification might work, but there are some clues. The draft of the bill sets out that simply checking a box or filling out your date of birth won't be enough – they want proof. Possible methods floated include providing details from driving licences or passports, or maybe matching electoral record information or bank details. More outlandish options include retinal scans or selfies.

So who will be responsible for

**"Ashley Madison showed that collating personal information with sexual preferences is a bad idea"**

collecting and storing this extremely sensitive information? Here, too, the draft is vague, but the bill seems open to a number of options. One is to force porn site operators – in the UK and elsewhere – to set up infrastructure that collects people's personal information to verify they are over 18. A second possibility is that your ISP

would be forced to verify your age, effectively creating a giant database of personal data.

However it's done, collating such information with your sexual preferences isn't a great idea, as the hack of infidelity dating site Ashley Madison – and attendant blackmails and suicides – showed in 2015.

As the bill is currently worded, whoever is appointed to become the age verification regulator isn't bound by duty to protect against any security risks that could result. "This will be a gourmet feast for hackers," warns Kennard. Ensuring that a database of extremely desirable data – proof of identity, proof of age and porn preferences – is unhackable is a near impossible task.

But even if it can be achieved, it will still make us less secure. That's because fraudsters will use the opportunity to create fake sites that resemble genuine porn sites and ask for the same data as the UK-verified ones, says Kennard.

There's some cause for optimism that the age verification provision won't become law. On 17 January the House of Lords Constitution Committee published a scathing report that said it wants more info about how such a system will work.

Ultimately, the bill won't work anyway: "You can legally bypass all of this by using a virtual private network (VPN). And it's easy – so what's the point?" says Kennard. ■

# APERTURE





## In the heat of the night

Irish photographer Richard Mosse has come up with a novel way to inspire compassion for refugees. He presents them as drones might see them - as detailed heat maps, often shorn of expression, skin tone, and even clues to age and sex. Mosse's subjects, captured in the Middle East, North Africa and Europe, don't look back at us: the infrared camera renders their eyes as uniform black spaces.

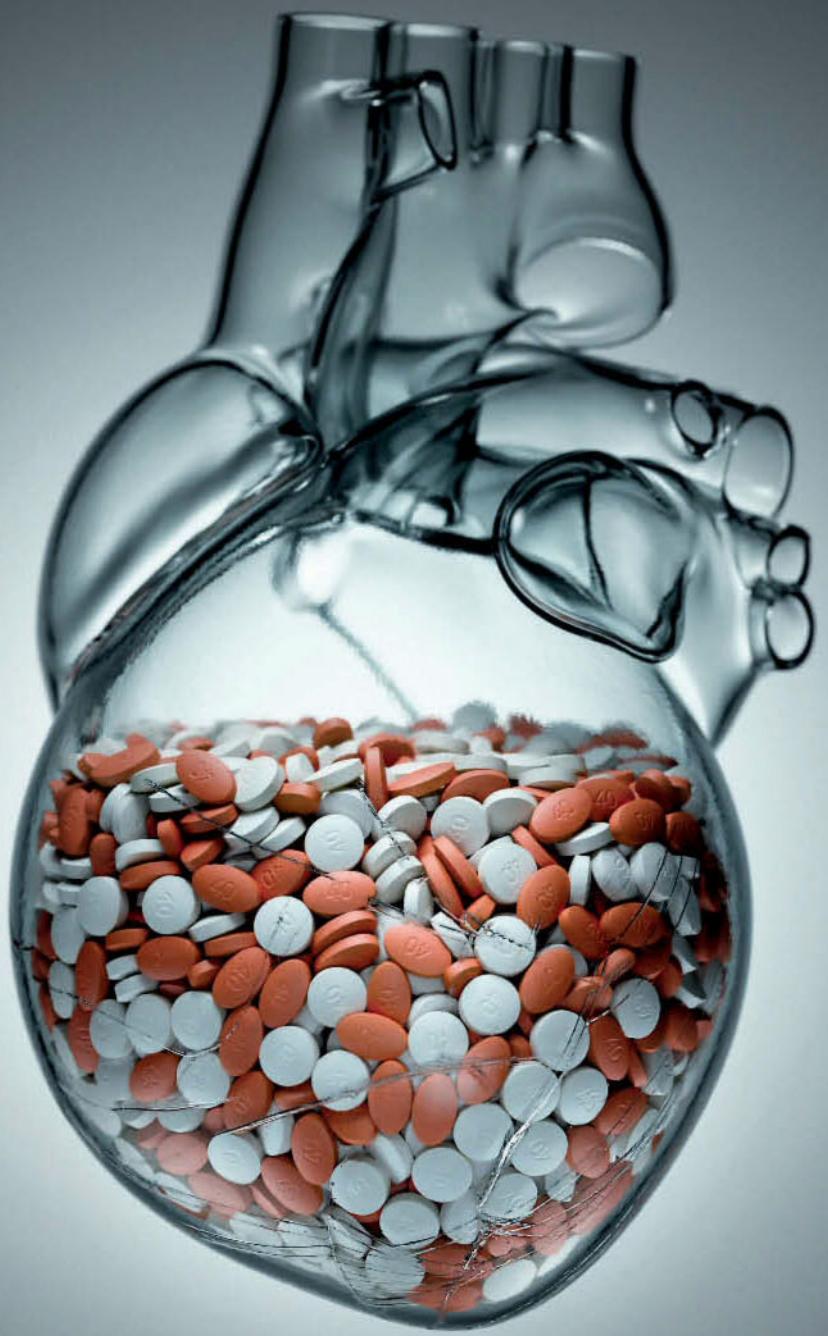
Mosse has made a career out of repurposing photographic kit meant for military use. The images here show his subjects as seen, mostly at night, by a super-telephoto device designed for border and battlefield surveillance. Able to zoom in from 6 kilometres away, the camera anonymises them, making them strangely faceless even while their sweat, breath and sometimes blood circulation patterns are visible.

The results are almost closer to the nightmarish paintings of Hieronymus Bosch than the work of a documentary photographer. Making sense of them requires imagination and empathy: after all, this is how a smart weapon might see us.

Mosse came across his heat-mapping camera via a friend who worked on the BBC series *Planet Earth*. Legally classified as an advanced weapons system, the device is unwieldy and - with no user interface or handbook - difficult to use. But, working with cinematographer Trevor Tweeten, Mosse has managed to use it to make a 52-minute video. *Incoming* will wrap itself around visitors to the Curve Gallery at the Barbican arts centre in London from 15 February until 23 April. Images from the project are on show at the Jack Shainman Gallery in New York City until 11 March, and signed copies of the accompanying book are available from mackbooks.co.uk. Simon Ings

### Photographer

Courtesy of Richard Mosse and Jack Shainman Gallery, New York



Is popping a daily pill really any way to keep your heart healthy? Michael Brooks needs to know

# CHOLESTEROL WARS

**I**T STARTED in 2014, with a routine health check. I was 44, and fit enough to have completed a string of Olympic-distance triathlons. I exercised most days, at the gym, on a football pitch, running or cycling. Admittedly, my body mass index always came up as “obese”, but that never worried me. I am the very definition of big-boned.

The problems began when a nurse did a finger-prick test of my blood cholesterol. She said I’d have to come back. “The machine seems to be broken,” she said. “I’ve never had a reading this high.”

It wasn’t broken. Further tests confirmed that my blood cholesterol was almost double the healthy level. It was probably genetic, my doctor said. Changing diet and lifestyle wouldn’t help. The only solution was medication: statins.

So, I was being invited to join the club. In the past 30 years, cholesterol-reducing statins have become some of the most widely prescribed drugs globally – small wonder, when heart disease and strokes are among the world’s biggest killers. In the UK, official guidance is that people with normal levels of cholesterol should take statins if their risk of a stroke or heart attack within 10 years is deemed to be higher than 10 per cent. The American Heart Association’s recommended trigger level is 7.5 per cent.

Even so, I’d been vaguely aware of a backlash against statins – and even against the idea that cholesterol really is a bogeyman for your heart. With my own health on the line, I set out to find some clear answers.

In wealthier parts of the world, heart disease and strokes account for over a quarter of deaths. Many factors are at play (see “What makes a healthy ticker?”, page 30), with

conventional wisdom identifying cholesterol as one of the biggest culprits. A fatty biomolecule synthesised primarily in the liver, cholesterol forms cell walls and the myelin sheaths that protect neurons in the brain. It plays a part in biological processes from cell signalling to making vitamin D, and may even help fight infections.

But a dark side has long been suspected. In 1913, Russian pathologist Nikolai Anichkov showed that rabbits fed pure cholesterol extracted from egg yolks developed higher cholesterol levels in their blood. Since then we’ve learned how excess cholesterol, carried in the bloodstream by lipoproteins, can stick to artery walls, restricting blood flow and making clots more likely – the condition known as atherosclerosis.

## Enter statins

The connection between cholesterol and heart disease became widely accepted in 1984, with the publication of the results of the Lipid Research Clinics Coronary Primary Prevention Trial. This followed about 3800 middle-aged men over seven years, showing that lower levels of “bad” low-density lipoprotein cholesterol correlated with a reduced risk of a heart attack, fatal or otherwise, or having to undergo heart bypass surgery.

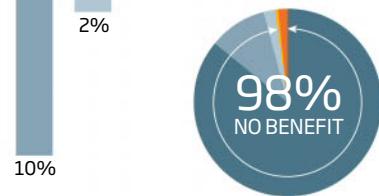
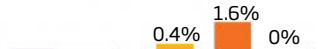
Enter statins. These drugs work by inhibiting the production of an enzyme crucial for making cholesterol in the liver. The first commercial statin received approval in the US in 1987, with plenty more marketed in the next decade. Many trials showed that they reduced heart attacks and strokes in people with high cholesterol or who were otherwise at high risk of heart disease – who smoke, ➤

# Good for the heart?

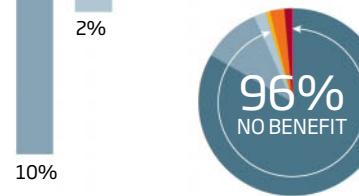
One measure of a treatment's effectiveness is how many people can expect a certain outcome, positive or negative, in a certain time

Benefits    Stroke prevented    Repeat heart attack prevented    Life saved

Risks    Diabetes    Muscle damage



**Patients with no known heart disease**  
treated with statins for five years



**Patients with known heart disease**  
treated with statins for five years

SOURCE: THE NNT.COM

The UK's National Health Service deals with  
**1.6 million**  
cases of cardiovascular disease  
1.2% of 1.6 million, means  
**19,200**  
lives are saved

SOURCE: BRITISH HEART FOUNDATION

*That's potentially still a lot of lives saved*

don't exercise, are overweight and so on.

More recently, studies have extended the benefits to people at lower risk. One key trial known as JUPITER, published in 2008, looked at the effects of taking rosuvastatin on 17,800 people with no known history of heart disease. These people had cholesterol levels below then-recommended thresholds for treatment with statins, but increased levels of a biomarker known to correlate with an increased risk of future heart problems. Over five years, incidence of heart attack among those who took statins more than halved.

Such results led the American Heart Association to update its advice on who should receive statins in 2013. The UK's National Institute for Health and Care

Excellence (NICE) followed suit in 2014.

When my hospital consultant recommended I take a daily "baby dose" of 20 milligrams of atorvastatin to lower my cholesterol levels and prevent future heart problems, he was only following prevailing wisdom.

But right from the start, JUPITER and other similar studies have caused controversy. For a start, heart attacks may have halved in the JUPITER trial, but the absolute incidence of heart attacks in the study population was low anyway. Only 99 people had a fatal heart attack during the trial period, 31 of whom were taking the statin. Viewed that way, less than 0.5 per cent of the people treated with rosuvastatin benefited, casting a different light on the drug's effectiveness.

Similar caveats arise in other analyses. As highlighted in a 2014 editorial in the *Annals of Internal Medicine*, for example, two meta-analyses of studies from 2012 and 2013 managed to come to opposite conclusions about statins' effectiveness, despite the mortality levels they found differing by less than half a per cent.

An alternative measure of a drug's efficacy is "number needed to treat" (NNT), the number of people that have to be given a therapy for a specified time for one to benefit. Analysis undertaken by TheNNT.com, a website run by a consortium of physicians and medical researchers aiming to put a patient's perspective on research data, suggests that people with existing heart disease clearly benefit by taking statins: 1 in 83 people, or 1.2 per cent, have their life saved over five years (see "Good for the heart?", above). In the absence of diagnosed heart disease, however, no such clear-cut statement is possible. A separate meta-analysis in 2013 led by John Abramson at Harvard University, found that "140 low-risk people must be treated with statins for five years to prevent one major coronary event or stroke". Not only that, but there was no reduction in the overall mortality rate from all causes in that period.

Such figures mean there should be no blanket prescription of statins, Abramson reckons. "Physicians should discuss these findings with their patients," he says. "Why would you impose the decision on people when it is at best a judgement call?"

Others beg to differ. Rory Collins leads the Cholesterol Treatment Trialists' (CTT) Collaboration based in Oxford, UK, which has access to by far the largest database of statin trials. He points out that even these low NNT

## WHAT MAKES A HEALTHY TICKER?

Many factors beyond blood cholesterol determine how healthy your heart is

**BEING YOUNG.** Muscle tissue tends to degrade with age, making your heart work that little bit harder with every passing year.

**BEING FEMALE.** Before age 60, men are at greater risk of heart disease than women. Overconsumption, smoking and work stress have all been blamed – but no one truly knows why.

**GOOD GENETICS.** Some predisposition to heart disease is hereditary, although we haven't singled out what genes are responsible. Lifestyle factors such as smoking or poor diet passed between generations may also contribute to a "hereditary" element.

**LOW BLOOD PRESSURE.** This reduces the risk of ruptured arteries, dislodged clots or plaque causing a stroke – stress, overeating, smoking and alcohol consumption all play a part in pushing it too high.

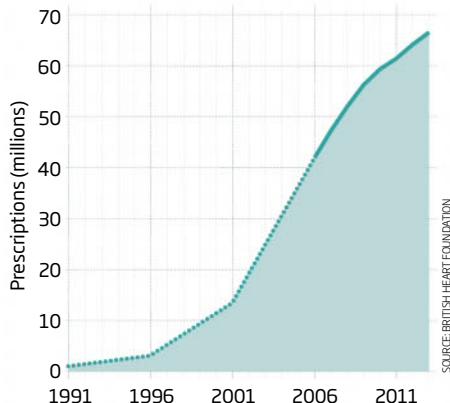
**HEALTHY BODYWEIGHT.** The heart has to work harder in people who are obese. Keeping trim also reduces incidence of type 2 diabetes, another risk factor for heart disease.

**REGULAR EXERCISE.** Like any other muscle, the heart grows stronger when forced to do a reasonable amount of work. Exercise also helps keep weight and blood pressure down.



## Statins on the up

The number of cholesterol-lowering drugs prescribed in England has ballooned with the advent of statins – a pattern repeated across the developing world



figures, extrapolated to whole populations, equate to hundreds of thousands of people avoiding heart attacks. That is worth it, even without life extension. “If you’ve seen someone who’s had a non-fatal heart attack or stroke, you’ll know it completely changes their physical and psychological life,” he says. “To say that coronary death is all that matters is absurd.”

I felt fit as a fiddle at the time of my diagnosis, but better safe than sorry – or dead.

## “After exercise I ended up curled up in a ball on the sofa, in flu-like muscle pain”

So I started popping a daily statin as my consultant recommended. At first it was fine. I even did another triathlon. But a year later, exercise was getting harder. I was slower on the football pitch. I couldn’t lift the weights I used to. If I did a lot of exercise in a day – two hours, say – I would end the evening curled up in a ball on the sofa, in flu-like muscle pain.

Muscle pain, or myalgia, is the most commonly cited side-effect of statins. I didn’t have to look far for another sufferer: my mother had also been put on statins for high cholesterol. “I stop taking them from time to time,” she told me. “I can’t stand the way they make me so weak and achy. They make me feel 10 years older.”

According to a review paper of clinical trials by Collins, Liam Smeeth at the London School of Hygiene and Tropical Medicine and others that was published last September, statin therapy causes muscle pain in “about 50 to 100 patients...per 10,000 treated for 5 years” – less than one per cent. But other studies have

found far higher figures – a quarter or a third, and in one study based in Paris, 87 per cent of participants complained of pain. Last year, David Spence and George Dresser at the University of Western Ontario in Canada wrote in the *Journal of the American Heart Association* that, despite claims from clinical trial data that adverse reactions are vanishingly rare, “in real-world practice, myalgia and cramps are more common than estimated from clinical trials”.

Humans are highly suggestible, meaning

## HEART ENEMY NO 1?

Not everyone is convinced cholesterol really is all that bad for your heart. “The cholesterol campaign is the greatest medical scandal in modern time,” says Uffe Ravnskov, a Danish independent researcher. He has published dozens of peer-reviewed papers about cholesterol’s biological role, and claims there is no link between blood-cholesterol levels and levels of atherosclerosis, the furring of the arteries that precipitates heart attacks.

It’s certainly true that half of all heart attacks and strokes occur among apparently healthy people with normal or low levels of “bad” low-density lipoprotein cholesterol, so it’s clearly not the sole factor. Drugs beside statins that lower LDL-C levels such as fibrates, ezetimibe and bile acid sequestrants also have little if any effect on heart-related deaths. Statins happen to both lower LDL-C levels and reduce deaths from heart attacks among those with diagnosed heart conditions, but that might just be coincidence, says Richard Lehman of Cochrane, a non-profit organisation that reviews available medical data. “The association may or may not be causal,” he says.

Those who deny a link are talking complete nonsense, counters Rory Collins, head of the Cholesterol Treatment Trialists’ (CTT) Collaboration in Oxford, UK. “The few people who have raised the question are a bit like those individuals who think homoeopathy works or think Earth is flat,” he says. Liam Smeeth at the London School of Hygiene and Tropical Medicine agrees. “I’m all for proper debate, providing the people I’m debating with are not denying science,” he says. “But cholesterol

demonstrably causes heart attacks.”

Lehman thinks that’s probably the case too – it’s just that we don’t yet have hard causal evidence. “This point is important because it allows drugs to be marketed on the basis of surrogate markers, like cholesterol-lowering, without long-term hard evidence of their benefits and harms,” he says.

## FALSE ASSURANCE

Rita Redberg at the University of California, San Francisco, doesn’t deny a link either, but warns against over-emphasising cholesterol. “Measuring blood cholesterol diverts focus from things that are much more powerful in terms of reducing cardiovascular risk,” she says – things like not smoking, eating a healthy diet and exercising regularly. She points to evidence that people on cholesterol-lowering statins frequently become more sedentary, and eat a less-healthy diet. “It’s human nature,” she says. “They have a false assurance that they have now reduced their risk and they don’t need to be paying attention to their diet and exercise.”

Not a problem, says Collins: lifestyle factors don’t matter, as long as you bring your cholesterol levels down. “This is the beauty of the statin data,” he says. He argues that statins reduce the risk of coronary heart disease in direct proportion to the reduction in LDL-cholesterol. “That is true across a very wide range of individuals, from higher risk to lower risk,” he says. “What’s more, it is irrespective of why they are at risk.” It seems that where you stand on cholesterol is inextricably bound up with where you stand on the statin debate (see main story).

reports of muscle pain caused by statins may cause other people to feel it too. But some researchers contend that a flaw in the design of trials so far means those who experience side effects tend to withdraw before a trial’s formal start. Smeeth is conducting a further study on muscle pain and says it simply hasn’t been a prime concern so far. “We’ve done trials in over 100,000 people, but we were worried about people dying, having strokes and heart attacks. Muscle pain and fatigue were just not measured properly,” he says.

Concerns about statins causing diabetes seem less solid. The US Food and Drug Administration advises that “a small increased risk of raised blood sugar levels and the development of Type 2 diabetes have been reported with the use of statins”. But Richard Lehman of Cochrane, a non-profit organisation that reviews available medical data, thinks this is just an artefact of the way we define diabetes. While statins cause a small rise in blood sugar, this is unlikely to cause the kind of damage we associate with severe, long-standing diabetes. In this respect, he says, the harmful effects of statins are “generally mild and reversible”.

## False allegations

I hope he's right. After two years on statins I had stopped going to the gym. I gave up running. I cut down on swimming. I simply couldn't bear the pain – or the humiliation of being so weak and sluggish. In the end, I told my doctor I wanted to stop taking statins because they were turning me into a couch potato. Surely that was as bad for me as having high cholesterol?

That echoes concerns of some who think the focus on cholesterol and statins hinders rather than helps heart health (see “Heart enemy no. 1?”, page 31). Certainly, the questionable benefits of statins for those with no existing heart condition, and their under-studied adverse effects, have led to calls for wider scrutiny of the raw patient data. “When you get an independent look at all the data, including the clinical study reports, you find things that weren't found before,” says Fiona Godlee, editor-in-chief of *The BMJ*.

Her call last year for an independent



GRUZZA/GETTY

government review of the evidence led to a war of words with Collins. His CTT team has access to most of the data, but does not own it – and he says the number of pharmaceutical companies, charities and public bodies involved makes it impossible to get requisite permissions to release it more widely. “The *BMJ* is making false allegations that we are holding all the adverse event data and not making that available,” Collins says.

New results seem to increase the confusion. Last year, modelling of available data by Judith Finegold at Imperial College London showed

**Regular exercise may be more beneficial for your heart than cholesterol-lowering medication**

that a 50-year-old, non-smoking man without diabetes and with average cholesterol and blood pressure will increase his life expectancy by seven months on average after starting preventative statin therapy. But that average is highly misleading, Finegold says: it disguises the fact that 7 of that 100 will gain an average of 99 months (8.25 years) of life – while the remaining 93 get nothing at all.

In June 2016, NICE reflected that result by making it clear that patients taking statins are entering a health lottery. These drugs probably do save some lives – we just can't ever know which ones, says Smeeth. “And we'll never know, because the ones who benefit don't have a heart attack,” he says.

You just have to hope you're one of the lucky ones, then. I have only played the UK's national lottery three times, and on none of those occasions did it make sense to do so. But one time I won £5000. Clearly, I'm lucky. But while people with diagnosed heart conditions should keep on popping the pills, it's far from obvious the rest of us should. I probably shall: when I'm fit again, I'm going to try a different statin. But I certainly won't see them as the cure-all I once did. ■

## CHOLESTEROL: THE GOOD AND BAD NEWS

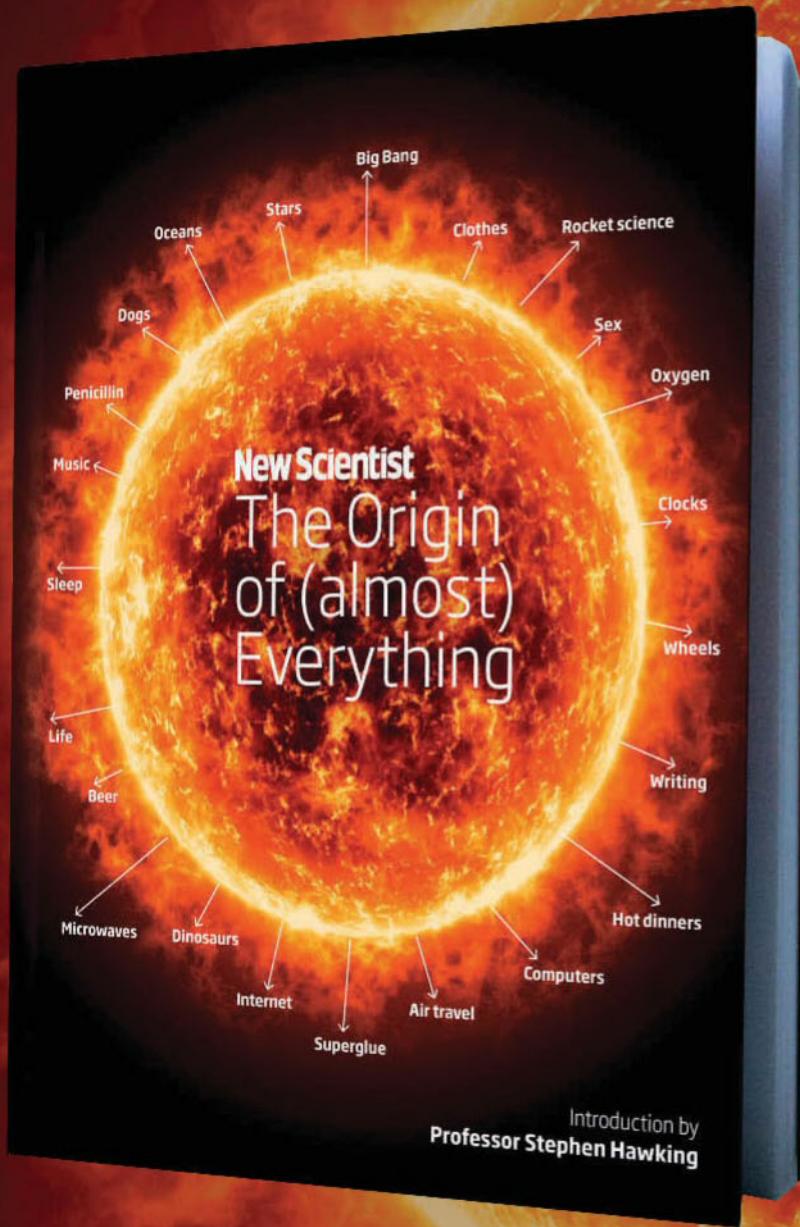
**Most of the cholesterol in your body** is made in the liver. However, most people can bring their blood cholesterol down to levels considered safe through diet alone – just not necessarily by reducing cholesterol intake directly.

A review published in 2015 said that although dietary cholesterol does increase blood cholesterol, it is impossible to draw rigorous conclusions on its effect on heart disease risk. Consumption of saturated fat seems to have a greater effect on blood cholesterol levels – although it's far from clear that this leads directly to increased risk of heart disease either (*New Scientist*, 2 Aug 2014, p 32).

Another complication is the existence of “good” and “bad” cholesterol. Actually, it's not the cholesterol that's good or bad: it's the lipoprotein molecules that carry cholesterol to and from cells. Low-density lipoprotein cholesterol (LDL-C) is bad because of its reputation for sticking to artery walls, making them less flexible and impeding blood flow. Meanwhile, high-density lipoprotein cholesterol (HDL-C) is “good” because it helps slough LDL-C from artery walls. But while some say the lower the LDL-C the better, others are not so sure: a number of studies show LDL-C helps to build lean muscle – so perhaps it's not so bad after all.

Michael Brooks is a consultant for *New Scientist*. For links to studies relevant to this article, see the online version at [newscientist.com/issue/3112](http://newscientist.com/issue/3112)

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



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Introduction by **Professor Stephen Hawking**

**New  
Scientist**

# A MOUNTAIN OF WORDS

The graphic features a large, bold title "A MOUNTAIN OF WORDS" at the top. Below the title, a mountain shape is constructed from a dense, overlapping stack of various words. The words are rendered in a variety of black typefaces and sizes, creating a textured, jagged surface that mimics the appearance of a real mountain peak. Some words are partially obscured by others, while others stand out more prominently. The overall effect is a creative and artistic representation of language and communication.

## Emails, social media and online news mean we have more reading to do than ever before. How best to cope, wonders Emma Young

THE onslaught of words begins the moment you wake up. Even before dressing, you may check your emails, peruse the morning news online, respond to texts and skim your Twitter feed. Then, at work, there are reports, memos or articles to be read and more emails to deal with. You might even dip into some prose for the sheer pleasure of it.

With the rise of the internet and social media, many of us encounter far more written information than earlier generations. This daily deluge of text can be overwhelming. Whether you're struggling to cope or would just like to read even more, it's tempting to wonder whether there are better methods.

We know that the human brain is capable of amazing feats. "People are now memorising decks of cards in less than 20 seconds, and an individual recently solved eight Rubik's cubes under water in a single breath," says David Balota of Washington University in St Louis, Missouri. "It's interesting to speculate whether such training may be achievable within the reading domain."

Realistically, most of us can never hope to challenge six-times world speed-reading champion Anne Jones, who has clocked up rates of 4251 words a minute. But there are ways anyone can get more from what they

read. To read more efficiently and more accurately, you just need to know which advice to follow and which to ignore.

The average university-educated person reads between 200 and 400 words per minute. Historically, reading better has been synonymous with reading faster. Since US teacher Evelyn Wood pioneered the concept of speed-reading in the 1950s, there has been a proliferation of courses and books promising to teach people to read up to five times faster without any loss of comprehension. Now modern technology has made the idea even more attractive. One popular app called Spritz, for example, has been used by millions of people worldwide, according to the company behind it. It even comes pre-loaded on some cellphones.

"Until recently, speed-reading systems were only available on training courses, so you'd have to go out and enrol and it would take several weeks," says cognitive psychologist Elizabeth Schotter from the University of South Florida. "With the tech-based approaches, one claim is that you don't need to do any training and you can start right away. That's really appealing, because people are always looking for quick and easy ways to solve their life problems – like having too much to read."

However, until recently, we had little idea of whether speed-reading actually works. To find out, Schotter and her colleagues have evaluated many of the most popular strategies and systems. Their findings make disappointing reading.

Take the common "solution" suggesting that your reading will accelerate if you learn to get rid of sub-vocalisations. The trick here is not to "hear" the words in your mind, and to rely solely on a "visual" reading process. Internal vocalisation is a time-wasting carry-over from how we learned to read, aloud, as children, the argument goes. However, Schotter and her colleagues point to good evidence that getting rid of this inner speech reduces comprehension. It makes sense that translating visual information into an aural form helps readers to understand it, she says, given that the primary form of language is vocal and auditory. We started talking to each other at least 100,000 years ago but it wasn't until about 3400 BC that Mesopotamians invented a written language.

Another popular concept used in apps is to present single words rapidly, one after the other. With Spritz, for example, users can set the rate at anything between 250 and 1000 words per minute. It is claimed that this does away with the need to make eye movements. ➤

## ATTENTION! ATTENTION!

Reading is good for you. Literary fiction has recently been shown to improve our ability to understand other people's emotions. And a study has also found that reading an engrossing book of any kind is an effective stress-reliever. Yet, just when we have evidence for the millennia-old concept of "bibliotherapy", reading for pleasure seems to be on the wane. Last year, 73 per cent of US adults read at least one book, in any format - down from 79 per cent in 2011.

It may simply be that we are devoting more of our reading time to shorter texts online. But Maryanne Wolf, director of the Centre for Reading and Language Research at Tufts University in Massachusetts sees a more disturbing possibility. Many forms of digital and online materials require the reader to regularly switch attention from audio to visual presentations, or from one website to the next. This, she argues could be shortening our attention spans, making it harder to sustain the focus needed to concentrate on - and benefit from - a literary novel or even a non-fiction book.

Evidence for this idea is still lacking. However, a report by Microsoft published in 2015 puts the attention span of the average Canadian at 12 seconds in 2000 and just 8 seconds in 2013. Meanwhile, studies in which people are interrupted at random intervals while reading and asked what they are thinking indicate that mind-wandering is both common and highly variable. We spend anywhere between 15 and 50 per cent of the time off-task.

The good news is that our ability to focus can be improved if something alerts us when our attention starts to wander. If Wolf is correct, reading more books should also help. The Slow Books movement, which encourages people to luxuriate in the pleasures of reading, agrees. It advocates spending between 30 and 45 minutes a day reading a printed book or an e-book with internet connectivity switched off.

"The argument that we waste time with unnecessary eye movements is subjectively compelling," says Balota. Unfortunately, it's wrong.

Research on how we read demonstrates why. The first step is for the eyes to focus on the letters. Visual acuity is highest in the fovea, the centre of the visual field, which is roughly equivalent to the width of the thumb when held at arm's length from the eye. Quick eye movements – saccades – allow a reader to shift the fovea from one word to another. Each forward saccade generally spans about seven letters. On average, the eyes then hover for about 250 milliseconds on a word, and the brain is still working to understand what has just been registered as they flick onward. But reading is not a constant forward-moving process. About 30 per cent of the time, we skip a word. This usually happens when the word is very short (such as "of" or "at"), frequent (such as "been" or "very") or predictable, given what has just been read. And about 10 to 15 per cent of the time, we go back to a previous word, perhaps because we realise we haven't understood it properly or, given new information, we want to revisit it to aid our comprehension. When an app is relentlessly moving you on through a text, previewing and reviewing are not possible, and comprehension is reduced, says Schotter.

**A good reader, averaging 400 words a minute, can double their speed"**

Our understanding of normal reading also undermines the speed-reading strategy known as "chunking". Advocates often claim that, with practice, readers can learn to visually take in entire groups of words and phrases, even those well outside the fovea, in single fixations. Schotter says this doesn't work because chunking isn't physiologically possible and, besides, reading speed is limited by our ability to attend to, identify and understand words, rather than our inability to see them.

For wannabe speed-reading champions, Schotter's assessment of these strategies is disheartening. "They're all kind of crazy," she says. "They're not absurd. But they only seem reasonable if you haven't really studied the reading process." Claims of spectacular reading rates have not been verified scientifically, she adds. In speed-reading competitions, for example, readers are



asked questions about the text to test their comprehension. But it's possible to get a correct answer by skimming and making intelligent guesses to fill in the gaps.

It's not all bad news. Schotter believes that a "good" reader, averaging 400 words per minute, can probably double their speed – but not triple it, which is often claimed by speed-reading systems. However, she cautions, this isn't really "reading", but "effective skimming" – and there will inevitably be some deterioration in comprehension. Still, if all you want from a document is the gist, skimming is a smarter approach than reading. And you don't need to buy an app or attend a special course. Schotter recommends that you concentrate on subheads and on the first and last sentences of paragraphs, because this is often where the key information is to be found – in "good writing" at least. And if the first sentence of a paragraph suggests it will be useful to read it carefully, then you can.

A strategy like this will require the reader to fill in the gaps using suppositions based on what has been read. If you want to read faster without compromising comprehension, there are no shortcuts, says Schotter. The maximum speed at which we can move between words, while still understanding what we're reading, is largely determined by our familiarity with



FERDINANDO SCIANNA / MAGNUM PHOTOS

It's very hard to put a figure on how much reading people are now doing on screen. "No one has meaningful data comparing minutes per reading platform," says Naomi Baron at American University in Washington DC, author of *Words Onscreen: The fate of reading in a digital world*. However, according to the Pew Research Center, in Washington DC, about half of the newspaper-reading population of the US relies exclusively on the print version. And, in 2016, 65 per cent of US adults read at least one print book – down from 71 per cent in 2011. Over the same period, those that read an eBook rose to 28 per cent from 17 per cent. However, in the past year eBook sales have dropped off in the US and UK – the second biggest consumer globally – perhaps because they are becoming more expensive, Baron says.

Reading on screen is often seen as a "good thing", especially when it comes to education, says Anne Mangen at the University of Stavanger in Norway, who chairs a European Union initiative called E-READ. However, this view is largely untested. "There is a lack of knowledge and a very strong drive from the technology industry," she says. "A lot of the debates and discussions and decisions – in the educational field especially – are based on assumptions, and on almost a faith in the technology. People say 'Oh, but it's more motivating and this is the way most people read and will be reading'."

In fact, research Mangen has been involved with hints that people find it harder to comprehend information presented in a PDF format on a computer screen, compared with the same text on paper. This could be because it is more difficult to navigate an online text, to return to a part you want to revisit. A reader might remember that a segment of information was about a

those words. While one person may hesitate over "insignificant", it could take "floccinaucinihilipilification" to slow another down. Schotter's advice? "This is never a popular thing to say, but read more. Expand your vocabulary and your general knowledge about the world."

So, a smarter approach to reading involves appreciating your limitations, and recognising the drawbacks and benefits of effective skimming. But it should also involve a consideration of the medium you use, because reading from a screen is not the same as reading in print.



SEOKYONG LEE/BLOOMBERG VIA GETTY IMAGES

Our brains are evolved for talking but humans only began reading 3600 years ago

quarter of the way into a printed document, two-thirds of the way down a physical page, but that contextual information is missing from an electronic book. "It's interesting to read studies finding that there is a preference for print for study purposes," she says. This might help explain, and provides some support, for the idea that it is smarter to read complex material that you want to fully comprehend in print rather than on a screen.

The same may apply when reading for pleasure. Mangen has found that people who used a Kindle to read a short mystery story were worse than paperback readers at recalling

## "It is smarter to read complex material in print rather than on a screen"

the sequence of plot events, probably because the tactile sense of progressing through a story that a paperback provides is not offered by an electronic reading device, she says. There is also some evidence that readers feel more empathy with characters when they read from paper.

Still, depending on the reason for reading, there are potential advantages to reading on screen and online. The facility for increasing the size of the typeface is one. The keyword search function and the ease of cross-referencing are others. However, there may be trade-offs here too. "Using 'Find' typically leads us only to read the specific item we are looking for rather than benefiting from reading the surrounding text," says Baron. And flitting between websites could be reducing our ability to focus (see "Attention! Attention!", left).

As with speed, the best advice is to tailor your reading platform to suit your goals. But whatever you want out of a text, there's one thing we can all do to become better readers. "The critical element is not time spent reading or even the reading platform but concentrating on the work in front of you," says Baron. "Some slow readers don't process much of what they read while some fast readers are actually excellent at both memory and analysis."

"The real issue for me," she says, "is that when one undertakes to read a work whose content one cares about – whether that's fiction or non-fiction – the reading gets one's undivided attention." ■

Emma Young is a writer based in Sheffield, UK

# Vertically challenged

Can the nations of the world finally agree on how to measure heights, asks Laura Spinney

**S**EA levels are rising; it is one of the great worries of our age. But what are they rising relative to? Why, sea level of course. But how high is that?

It's a momentarily confusing question that masks a real problem. In a flurry of cooperation we can only marvel at today, the world's nations came together in the late 19th century to adopt international standards of time, longitude and metric measurement. But they never agreed a standard for the vertical.

Even today, some 100 "points zero" are in use around the world, in some cases differing by metres. Technical difficulties and a lack of political will have hampered attempts to do away with this confusing mishmash. But now technology and the increasingly pressing need to measure rising seas look set to force a quiet revolution. "I expect we will see a global standard within five years," says Reiner Rummel, a geodesist recently retired from the Technical University of Munich, Germany.

Thanks mainly to variations in water temperature and salinity, sea level differs around the world. That came as a surprise when European efforts to standardise latitude and longitude in the 1860s extended into the vertical. Several countries had already set up coastal tide gauges – essentially, a float attached to a pen that traced a line on a chart –

and were calculating mean sea level, defined as the average of sea level measured at regular intervals between high and low tide. It turned out their levels weren't the same.

In hindsight, says environmental historian Wilko von Hardenberg of the Max Planck Institute for the History of Science in Berlin, the surprise is that they were surprised. The sea is only at mean sea level transiently several times a day. Over longer time frames, effects including climate change and the shifting of tectonic plates mean neither the sea nor the land stands still. Coastlines migrate,

## "Rising seas alerted us to climate change, but what are they rising relative to?"

mountains appear and disappear. "The point is that there is no fixed point," says von Hardenberg.

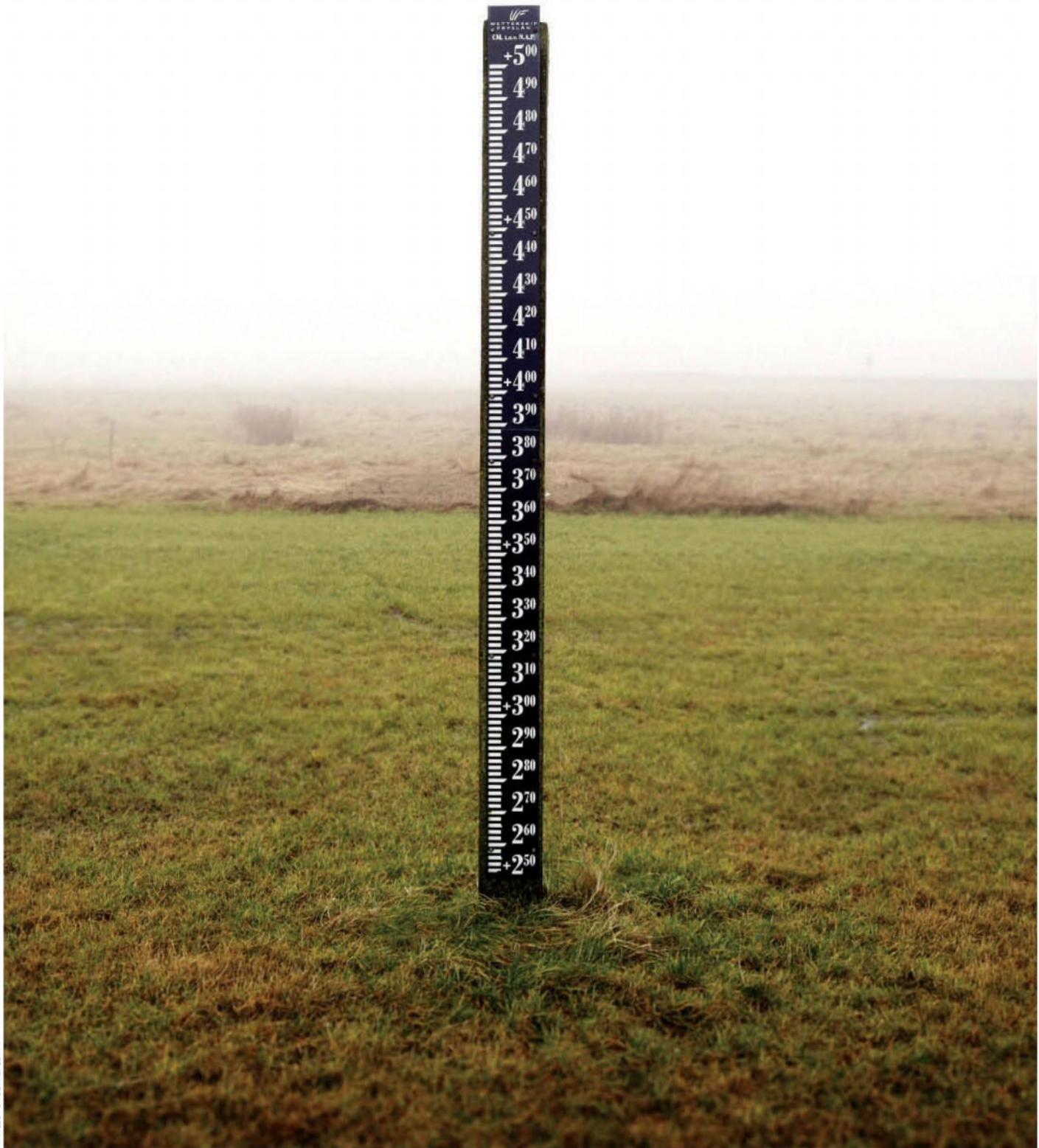
It was measurements of rising mean sea levels that first alerted us to the idea that we might be affecting the climate. And yet there was never one mean sea level to measure. "National pride always won, so instead countries compared levels and posted the differences at borders," says von Hardenberg.

This imperfect system remains in place today.

Worse, most national benchmarks are now woefully out of date. The UK's mapping agency, the Ordnance Survey, measures altitude with respect to mean sea level as calculated during the first world war at Newlyn in Cornwall – since when it has risen there by about 20 centimetres. "I got into trouble with the director of the Ordnance Survey once, for saying that the height of Mount Snowdon was really 20 centimetres lower than it was marked on the map," says Philip Woodworth of the National Oceanography Centre in Liverpool, who studies sea level change.

Measuring mountain height is just one area in which the system's drawbacks are apparent (see "Take your peak", page 41). In the past, the national benchmark had to be carried through the country every half-century or so, for local benchmarks to be re-calibrated and all points expressed as new "heights above sea level". These levelling operations were costly, error-prone and time-consuming. Of the three that have been carried out in the UK, the second got under way in 1912, reached Scotland in the 1930s and wasn't completed until 1952.

And national benchmarks have caused the occasional expensive error – perhaps most notoriously at a bridge built over the Rhine between Switzerland and Germany at ➤

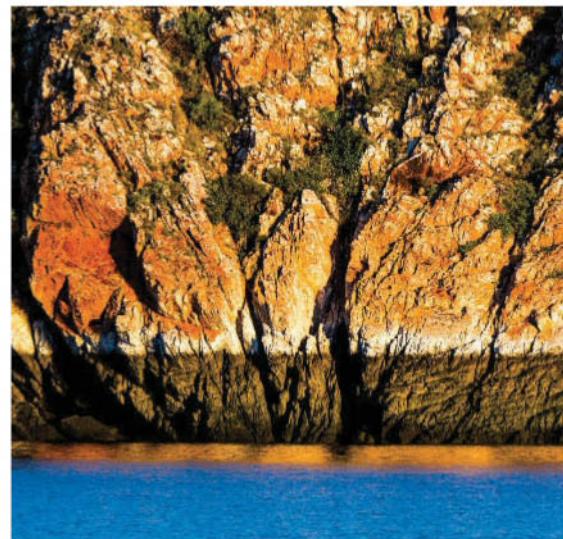


Laufenberg in the early 2000s. Germany uses a zero calibrated to a benchmark at Amsterdam in the Netherlands, while Switzerland refers to one at Marseille in France. The two differ by 27 centimetres, and somehow they got added rather than subtracted. For a while, a 54-centimetre vertical gap yawned between the two halves of the bridge.

Yet abandoning the status quo has long been seen as the more costly option – within nations, mean sea level is often used to determine property boundaries and insurance requirements, among other things. The global challenge of sea level rise has been a game changer. It turns out that sea level is rising at different rates in different parts of the world, but it's proving hard to get an overview. "Without a global standard, you are measuring apples and pears," says Johannes Ihde of the German Federal Agency for Cartography and Geodesy in Frankfurt-am-Main, who has worked on setting on a common standard for Europe (see "On the level", below).

If Earth were a perfect sphere, we might use

Is Everest (centre) taller than Ecuador's Chimborazo (far right)? Only if you take unreliable sea level as your zero



JASON EDWARDS/GETTY

GPS measurements: these calculate the user's distance from the centre of the GPS satellites' orbits. But Earth looks more like a rugby ball, with a radius 21 kilometres longer at the equator than at the poles. It's a lumpy rugby ball too, with a depression of about 100 metres to the south of India, for example, and a peak of about 100 metres over Indonesia.

These lumps are in Earth's geoid, or

gravitational surface – a plane that you would move across if you did no work in the vertical dimension, like a marble rolling over a table. They occur because gravity is stronger where mass accumulates, as in a mountain or denser rocks. The geoid largely determines where the surface of the sea lies. If you were to swim from India to Indonesia, you would move 200 metres away from Earth's centre.

## ON THE LEVEL

Mean sea level means different things in different places (see map of Europe, right). In the UK, all heights are measured relative to the time-averaged height of the sea at Newlyn in Cornwall – except in Northern Ireland, where the reference point is Belfast. In the Republic of Ireland it's Malin Head, while the French look to Marseille – unless they're Corsican – with landlocked Switzerland following their lead. Since the 1990s, the Germans and Swedes have followed the Dutch in setting their point zero at Amsterdam.

Meanwhile, Italy refers to Genoa, except Trieste which refers to itself – as does Austria and most of the former Yugoslavia, which all belonged to the Austro-Hungarian Empire at the time the Trieste benchmark was fixed. Other parts of eastern Europe refer, along with Russia, to Kronstadt on an island in the Gulf of Finland, a legacy of Soviet influence. Cosmonaut Yuri Gagarin orbited at a height given relative to Kronstadt, reportedly inspiring him to call the town the hub of the universe.

Elsewhere in the world, both the US and Canada use benchmarks based on mean sea level as measured at Rimouski in Quebec, Canada. China worked with a tapestry of benchmarks until 1956, when under the new leader of the People's Republic, Mao Zedong, these were swept aside in favour of a single reference at Qingdao on the Yellow Sea.

Recent efforts to establish a common vertical benchmark across Europe have made clear how national standards just don't match up

Numbers are the approximate difference in centimetres between existing national reference points and the proposed European Vertical Reference System

Amsterdam  
1

Newlyn  
7

Ostend  
-232

Marseille  
-49

Cascais  
-32

Alicante  
-49

Genoa  
-26

Trieste  
-41

Kronstadt  
14

Helsinki  
21

Tregde  
0

Sea level in Denmark is gauged to 10 different locations

Constanta  
6

CLIFFORD HANNIS/HUNDE ET AL



Agreeing on a vertical standard, therefore, boils down to agreeing on a model of the geoid – and with the latest satellite measurements, we're getting close to doing that. In 2002, NASA and the German Aerospace Center launched the Gravity Recovery and Climate Experiment (GRACE) satellite, and seven years later, the European Space Agency launched its Gravity Field and Steady-State Ocean Circulation Explorer (GOCE) mission. GOCE orbited until 2013, while GRACE is still in orbit, and the two now have enough data to make a geoid model accurate to within a few centimetres. "The gravity field is smoothed because the satellite is far from the Earth's masses," says Rummel, who led the GOCE mission. "But it can be complemented by terrestrial gravity measurements." Together, the two provide the millimetre accuracy required for, say, building bridges.

These advances allow us to measure heights using GPS devices with a built-in geoid model. That represents a conceptual shift, because these devices measure land height relative not to sea level, but to Earth's centre – a single point in space that, in theory at least, everyone should agree on. The geoid itself shifts over the long term with shifts in the structure of Earth's crust, but these can be tracked by GRACE and successor satellites.

A map of the geoid can tell us new things about the oceans, too. The sea's surface in general follows the geoid, but the correspondence is not perfect: temperature and salinity differences drive it into peaks and troughs that account for another metre's worth of variability, on top of the hundred-fold greater variability in the geoid. If you were to swim across the English Channel from Dover to Calais, you would move uphill by about 9 centimetres with respect to the geoid. "You would do work in the physics sense," says Woodworth.

## TAKE YOUR PEAK

Devising an international standard for height (see main story) might conceivably rob Everest of its status as the world's tallest mountain. The Himalayan peak was first awarded that title by the British during their 19th-century survey of the Indian subcontinent, the mammoth Great Trigonometrical Survey, in which surveyors measured its height relative to mean sea level as established at Karachi in modern-day Pakistan.

A widely accepted figure for Everest's height is 8848 metres above sea level, although China

and Nepal, whose frontier the mountain straddles, disagree over whether it should be measured by its rock height or its snow height, and the US National Geographic Society disagrees with them both. It favours a figure of 8850 metres, as arrived at by its own team in 1999. Long-term tectonic movements are said to be pushing Everest up, while the Nepalese earthquake of 2015 is thought to have shaken it down slightly.

None of this matters much, though, when you start to look at Everest using other vertical

benchmarks. The Hawaiian volcano Mauna Kea rises only 4207 metres above sea level, for example, but 10,203m above its base on the sea floor. Topping both when you start measuring heights from Earth's centre, as a new standard might, is the Ecuadorean peak Chimborazo. It stands 6310 metres above locally defined sea level, but is almost on the equator, which thanks to Earth's squished rugby ball shape is further from the centre than the Himalayas. On this basis, Chimborazo beats Everest by a whopping 2 kilometres.

GPS devices along coastlines and floating out at sea capture that extra layer of variability, allowing oceanographers to chart what they call the "physical surface" of the sea. Water circulates around those peaks and troughs like air around areas of high and low pressure. "If you know where that  $\pm 1$  metre is, you know where the ocean currents are," says Woodworth. He and his colleague Chris

## "The technology for a global height standard is there – but is the political will?"

Hughes have been using this new data to build predictive models of phenomena such as El Niño.

The technical capability that underpins a geoid-based global standard of height is there – but is there the political will to agree on it? Perhaps. The US, Canada and Mexico

have announced that they will switch to a unified geoid-based height system in 2022, and a meeting in Prague of the International Union of Geodesy and Geophysics in 2015 passed a resolution to support the adoption of a single global reference frame. "We agreed," says Ihde. "Now we have to put it into practice."

That may turn out to be the harder step, because the surveyors who lay out supermarkets and car parks still make measurements based on local mean sea level. That flurry of 19th-century cooperation hid a painful truth: it only came about long after the British clock-maker John Harrison invented the chronometer back in the mid-18th century, solving the problem of calculating longitude at sea and simultaneously laying the foundations of a unified system for measuring time. On that precedent, it could be a century or more before we're all on the level. ■

Laura Spinney is a writer based in Paris

# That's a termite colony between your ears

After wrestling with the nature of the mind for over half a century, **Daniel Dennett** uploads his latest thinking on consciousness, word-based "mind viruses" and why we must doubt the power of artificial intelligence

## You believe the philosopher René Descartes led us astray. In what way?

He's the one who argued that the mind couldn't be just the brain, couldn't be just the body, that it had to be a different kind of substance altogether. It's one of the greatest mistakes in the history of thinking. And we have been trying to undo that mistake ever since. Certainly, I have.

## Why has it been so hard to overturn this picture of the mind?

There's a very powerful and ultimately emotional resistance to the idea that our brains are organs for thinking, and that our experience of mind is simply the workings out of some neural machinery. Darwin showed us how all the wonderful "intelligent design" of the universe, and that includes our brains and minds, comes out of a non-intelligent process: evolution. Some people have a lot of trouble with that. Then Alan Turing came along.

## What did Alan Turing add to this idea?

Turing showed that you could launder all the mentality out of computation and make an entirely mechanical computational device, then build that up into artificial intelligence (AI). Both Darwin and Turing were visionary theorists of bottom-up design. One of the great things about a modern computer is that you know to a moral certainty that there is no extrasensory perception in there – it's just as mechanical as an adding machine.

I call it "competence without comprehension" – that's my bumper sticker. Your basic computer doesn't understand what arithmetic is or why it's useful, but it does it perfectly. And evolution by natural selection is a process that's breathtakingly competent, but has no

understanding at all. Yet it has given humans the ability to reason, to understand. And now that we have such thinking tools, we are using them to achieve kinds of comprehension that no other species has. But I don't think we ended up with the likes of Shakespeare simply through evolution acting on our genes. It took another evolutionary process to join forces with it – cultural evolution. Memes.

## How do you define memes?

It's a way of doing something – including ways of doing something in your mind – that you weren't born knowing. It's not in your genes; it's something you've acquired from society, your social environment, and it's contagious.

## What is the basic unit of a meme?

Words. I don't claim to know how and when human language evolved, but it's very clear that when it first started, the hominins that were infected with these "mind viruses" didn't know what they were doing. They didn't know they were talking. They were making sounds to do things that benefited them, in the same way a butterfly uses eye spots on its wings to benefit it but doesn't need to know why.

## How did these mind viruses get us to here?

Gradually, the protolanguage of these hominins turned into a wonderful medium for manipulating others, and manipulating yourself. And as the products of the cultural evolutionary process have accumulated, they have enabled us to become truly intelligent designers, with forethought, planning and so on. Contrast a termite castle with Antoni Gaudí's wonderful church in Barcelona, La Sagrada Família. They look similar, but

## PROFILE

Daniel Dennett is a cognitive scientist and philosopher at Tufts University in Medford, Massachusetts. His new book is *From Bacteria to Bach and Back: The evolution of minds* (Allen Lane)

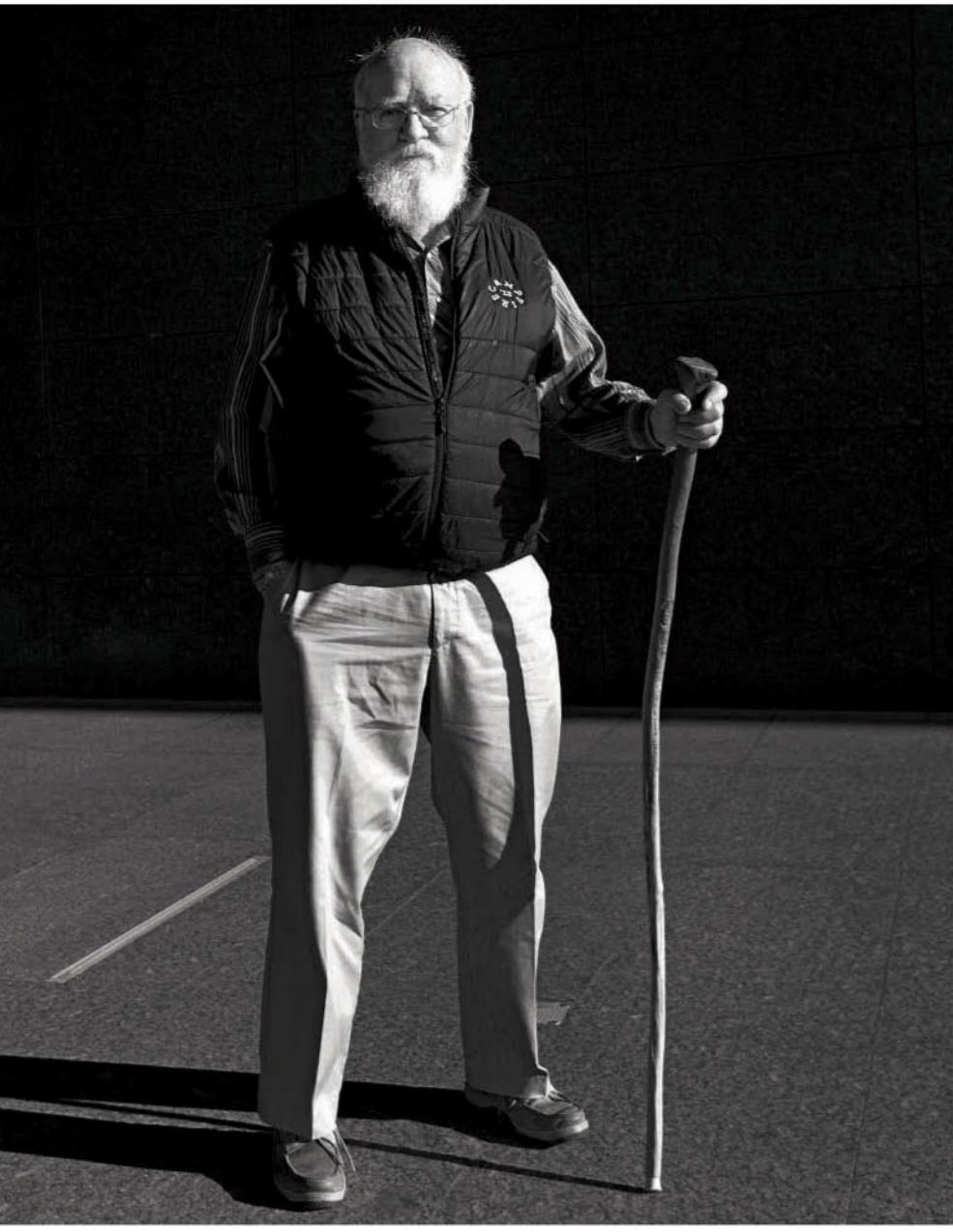


Gaudí's church is a product of intelligent design; it's top-down, with a charismatic boss who thought it out in advance. There is no Gaudí in the termite castle.

What has to be explained is how, in one species, we've gone from termite-style building to Gaudí-style building, or to Turing-style building or Shakespeare-style building.

## And that's the transformation we need to unpick?

Yes, and it's particularly thorny when you recognise that what we have between our ears is more like a termite colony than you might be happy thinking. The latest count is 86 billion neurons, each more clueless than a termite, with no boss. How on earth do you organise 86 billion neurons into Gaudí's mind or Shakespeare's mind? That's the puzzle.



### Why might it be a bad idea to make AI with the ability to comprehend?

I think it's better to use AI as a tool than a colleague. As soon as it is a colleague, we will have the problem we have with colleagues: we won't know for sure what they know, and they may not want to tell us. Trust becomes an issue.

### Are you worried about machine superintelligence?

Well, I'm not worried about super-AI that is going to design computers more intelligent than we are and then enslave us. I'm worried that we'll overestimate the comprehension of our devices and cede authority to them. It's happening already. In certain areas of medical diagnosis and treatment, there are computer systems that can do a better job than any doctor, and doctors who overrule the software could later be deemed irresponsible or liable for malpractice. This means that, with the best of intentions, doctors will start following the

## "How on earth do you organise 86 billion clueless neurons into Gaudí's mind?"

advice of AI advisers. This will substantially diminish the role of doctors: if they are going to be turned into glorified doorkeepers with good bedside manners and an ability to push buttons, what about the rest of us?

### In your new book, you also worry about our reliance on technology and that we are becoming "overcivilised"...

I don't think people realise how incredibly brittle the technology that we depend on is. If the internet goes down today, we'd be in a world of chaos. I'm worried about the first 48 hours, about people just going berserk if they don't have the internet. They are not going to have TV, they are not going to have radio stations probably, their cellphones will fail. They are going to be plunged into electronic darkness and scared out of their wits. After all, they have just been plunged back into the 19th century, and frankly they don't have the skills to cope.

### Would you survive a digital dark age?

I could be a pretty good survivalist. I'm getting a little old, sore and cranky, and I don't know what I'd do for my protein exactly, because I've never hunted. But I'm pretty good with making fire by flint, at least. ■

### As intelligent designers, we build computers. We don't claim they are able to comprehend, but will they get there?

It's possible, but we're not there yet. Take Google Translate. Until just a few years ago, the idea that you could translate from one foreign language to another without comprehending what the words meant was laughable. But today Google Translate does just that, through machine learning and big data. It's completely parasitic, though. It works because it has a huge database of successful translation and can sift through many millions of little bits of translation that have been endorsed by human translators. It uses them to guide its own translation. Otherwise it's clueless.

It shows that it is possible to do decent-quality translation without any real

comprehension at all. Some people view that as sort of the end of the line. But I don't think it is.

### What do you think is coming next with artificial intelligence?

The new wave is projects to add comprehension to existing machine learning or deep learning systems. There's a project at the Massachusetts Institute of Technology that is supposed to permit a self-driving car to tell you why it's doing what it's doing. And there's a new initiative at the US military agency DARPA calling for AI that can interact with humans in a reason-giving way.

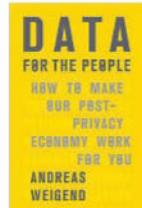
I think these projects are much, much harder than the people who are doing them think. In any case, I'm not sure it's a good idea.

Interview by Anil Ananthaswamy

# A digital reckoning

How free can a post-privacy world be, asks **Lydia Nicholas**

*Data for the People: How to make our post-privacy economy work for you* by Andreas Weigend, Basic Books



AT THE 2010 TechCrunch conference, Eric Schmidt, then CEO of Google, described his ambition for the company. It would, he said, collect and analyse data about its users until "we know more or less what you are thinking about". This would offer a "new future [in which] you're never lost... never lonely... never bored... never out of ideas".

Recent years have seen not just more data of more kinds being produced, but a fundamental shift in our experience of the world: our news, entertainment, routes home, products and potential romantic partners are data-driven: evolving in real time, and wrapping us in personalised market segments of one.

These services are enormously convenient. The idle thoughts and urgent worries we express in searches are autocompleted and autocorrected; information, products and opportunities tailored to our interests surround us. But questions about the effects of letting commercial services in on our most critical and intimate choices are growing ever louder and more urgent.

In *Data for the People*, Andreas Weigend, former chief scientist at Amazon and consultant to a host of data-driven businesses, sets out to explain how many of these technologies work, how companies profit from them, and the ways in which he believes the balance of power needs to be

shifted back in favour of users.

It is a hugely interesting read, packed to bursting with intriguing examples. We learn how our attention can be tracked as we consume content, how depression impacts our use of devices, about the different ways dating sites try to unpick what we really want and connect us most effectively, and how the unique quirks in the ways we swipe and tap our phones can be used to track us across devices.

The depth and breadth of Weigend's experience is clear in the sheer range of technologies and business models he describes. He explains critical concepts clearly and concisely, at a pace that should keep both experts and those new to the field hooked.

But his examples are no mere abstractions. With such services reshaping our lives and society, Weigend chooses to describe not only the current world but also his hopes for a better one. He sets out a series of rights, demanding that

## "Weigend expresses shock at discovering a file kept on him as a teenager in East Germany"

data-driven businesses be more transparent and grant users more agency over what data is collected and how it is used.

Many chapters end with stirring words – calls for a social data revolution, for consumers to take a stand and demand more power – but there is little real force behind the rhetoric. For the most part, Weigend appears to believe that companies will voluntarily comply with his demands because doing so would drive both efficiency and innovation in the long term.

The data utopianism begins to grate as this argument develops. Sections on optimising shift work make no mention of the potential impact on workers of unpredictable hours, or of them being constantly monitored. In one instance, Weigend cites analysis of sociometric data in the workplace – covering staff movements, whom they speak to and in what tone, plus when groups nod in agreement – and tests show that teams who took breaks together were 25 per cent more efficient. One wonders what the impact of treating them with care and respect might be.

Weigend makes clear that he is aware of the power of data, how those in power hunger for it, and the potential for abusing it. His prologue is unnerving, opening with a description of his father being seized by the Stasi in East Germany and languishing for six long years in solitary confinement, never learning why he was arrested or released. And Weigend's shock at discovering a file kept on him as a teenager may be matched by our own when he explains that at the time East Germany collapsed, fully 1 per cent of the workforce was employed by the secret police.

But the solutions are lightly sketched. We are offered a future of hacker-auditors giving companies regular security checks, and of regulatory bodies subjecting mega corporations to privacy audits that detail how much benefit users gain in exchange for sharing their data.

It may be unfair to judge a book by events that unfolded after

reviewers received their copies. A year ago, Weigend's ideas might have felt sufficient to justify the bold title and rhetoric. But recent events have made the situation more urgent, bringing concerns long expressed by academics and technologists to the public eye.

We have seen a frantic surge in interest across the political spectrum in how data-driven businesses are reshaping, even undermining democracy by filtering our access to information in personalised newsfeeds and



**Is the data we unwittingly share set to explode in our face?**

cutting us off from opposing views, thus undermining attempts to collaborate and compromise. And concerns are surfacing about how data collected for convenient apps might be repurposed: many of the companies mentioned in the book have stated publicly that they would not collaborate in attempts to create a so-called Muslim registry.

Weigend's crisp description of the mechanisms Google uses to rank its search results was written before the search giant rushed through a fix to its algorithm so that the top result for the query "did the Holocaust happen?" was

**"Google rushed through a fix so the top answer to a Holocaust query was no longer a Nazi denier group"**



no longer a link to a Nazi group that denies it. The move was interpreted by many as frank recognition on the data broker's part of its responsibility for the accuracy and impact of its services. Ranking pages according to how much attention they receive, no matter how sophisticated the analysis, is no longer good enough.

In such a context, *Data for the People*'s neutral, optimistic stance feels unsatisfying, rendered immediately dated by developments beyond the author's control.

Other omissions are less forgivable. In a book that delights in rich explanations, it is jarring to see "redlining" described as "treating applicants differently based on where they live" rather than what it was: a state-sanctioned effort to destroy investment opportunities in black communities by declaring areas where black people lived ineligible for mortgage underwriting by the Federal Housing Administration.

Elsewhere we find straightforward cop-outs. A section on how market segments are named, for example, hints that many of those labels were "even worse" stereotypes than "suburban soccer moms". Surely a book setting out to motivate readers to fight for transparency would give us examples of these labels?

But *Data for the People* motivates and provokes thought even as it disturbs and frustrates. Technologies that uncover our emotional state might, Weigend is willing to acknowledge, be used unethically in first dates or job interviews, yet the reader is very capable of extrapolating more. "What sort of world do we want to create with this new resource?" Weigend asks.

What sort of world, indeed. ■

Lydia Nicholas is a senior researcher at the London-based innovation foundation Nesta

## The VR challenge

Film an explanation of your favourite science in 360-degree virtual reality, and win £1000



STANISLAW PYTEL/GETTY

CAN you explain exactly why the Higgs boson is so important, or the precise science behind the inheritance of genetic diseases? If so, you could be in with a shot of winning £1000.

Explaining science is vital, and can be enjoyable and satisfying. Witness the rise of "explainers" on YouTube, which help us grasp how all sorts of things work, from explosive school experiments to animations of ideas as huge as cosmic inflation.

We've teamed up with the SCI-FI-LONDON film festival to create the VR Science Challenge and bring coherent and catchy science to the world in immersive virtual reality. The best explanation shot using a 360-degree camera will win £1000.

The challenge is to create an untethered mobile experience for VR headsets, such as Samsung Gear or Google Cardboard. Trawl your favourite textbooks and find a scientific principle or theory that you really care about, then explain or demonstrate it.

Take us on a journey. Let us explore your world and get a clear understanding of the science. For example, you could

**Immersive VR could add another dimension to explaining science**

show us the difference between AC and DC, or why you can't fold paper more than eight times, or perhaps you are ambitious enough to want to visualise current thinking on black holes.

The winners and best examples will be showcased in the first week of May at the 2017 SCI-FI-LONDON Film Festival. The overall winner will receive £1000, and there will be many other prizes announced over the next few weeks.

The closing date for entries is 30 March 2017, so get your thinking caps on, dig out your 360-degree cameras, and download your favourite VR engine (Unity, Unreal, etc).

Submit your work by uploading to it YouTube and sending the link to [nsvr@sci-fi-london.com](mailto:nsvr@sci-fi-london.com). Details on how to upload your 360 file can be found at [bit.ly/1ALGPc6](http://bit.ly/1ALGPc6).

All other details, along with full terms and conditions, can be found at [sci-fi-london.com/vr-science-challenge](http://sci-fi-london.com/vr-science-challenge).

Good luck – and get cracking! ■

# The art of shape-shifting

D'Arcy Thompson's book *On Growth and Form* is being celebrated anew, finds Simon Ings

A Sketch of the Universe, Edinburgh City Art Centre, until 19 February. Other events at [ongrowthandform.org](http://ongrowthandform.org)

**IN** A small, windowless corner of the University of Dundee, UK, Caroline Erolin is ironing a fossilised pterodactyl. At least, that's what it looks like. In fact, Erolin's "iron" is a handheld 3D scanner, and her digitised animals are now being used as teaching aids worldwide. Her enthusiasm for the work (which she has to squeeze in when not researching medical visualisation and haptics) is palpable. She is not just bringing animals back from the dead, but helping to bring a great collection back to life.

In 1884, the biologist and classicist D'Arcy Wentworth Thompson (pictured, right) began assembling a teaching and research museum in Dundee. His network of friends and contacts included Dundee's own whaling community, who provided him with extraordinary, then-unique specimens of Arctic fauna.

In 1956, the building that housed the University of Dundee's natural history department was scheduled for demolition and Thompson's collection, created as part of his work there, was dispersed. Scholars have been scrambling to recover its treasures ever since. Asked whether it can in fact be reassembled, Erolin laughs and gestures at the confines in which the surviving items are (rather artfully) squeezed. "It's a question of space. We're already sitting on an entire elephant skeleton."

Together with Charles Darwin,

**Physics steers biological form, just as maths can morph a portrait**

Thompson, who died in 1948, is the most culturally influential English-speaking biologist in history. We have one book to thank for that: *On Growth and Form*, first published in 1917 – the event commemorated by an exhibition, *A Sketch of the Universe: Art, science and the influence of D'Arcy Thompson*, at the Edinburgh City Art Centre.

In neither the first edition nor the revised and expanded 1942 version does Thompson talk much about Darwin, and even in the 1940s he considered genetics hardly more than a distraction. Thompson pursued another line entirely: how physical constraints and initial conditions shape

the development of plants and animals.

Thompson was fascinated by tiny, single-celled shelled organisms such as foraminifera and radiolaria. He was convinced (rightly) that their wildly diverse shell shapes play no evolutionary

**"Genetics explains why dogs look like other dogs; Thompson glimpsed why dogs look the way they do"**

role: they arise at random, their beauty emerging from the self-organising properties of matter, and not from any biological code.

Crudely put, genetics explains why dogs, say, look like other

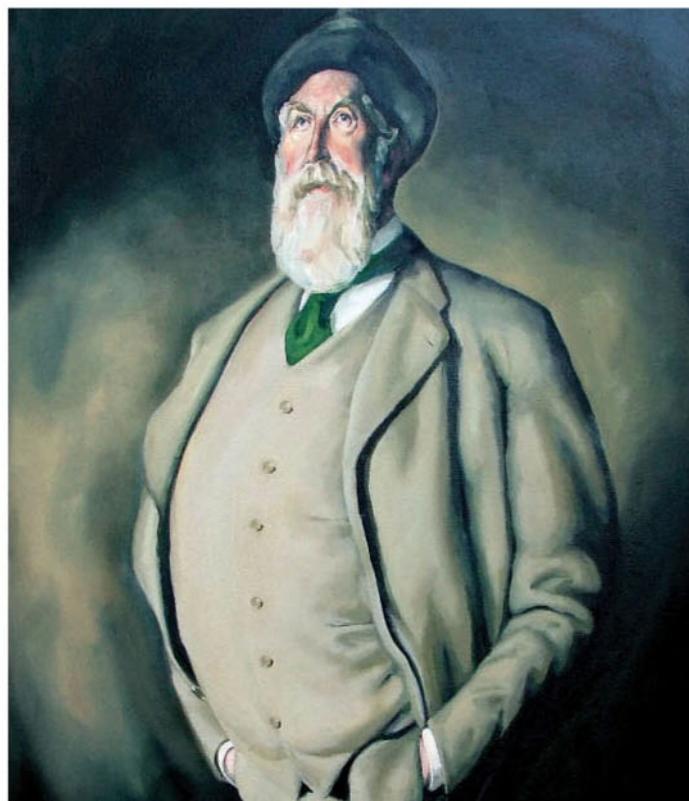
dogs. Thompson did something different: he glimpsed why dogs look the way they do.

Thompson's contemporaries were busy synthesising the seemingly incompatible demands of chromosomal genetics and Darwinian selection theory, and didn't know quite what to do with him. Thompson himself understood their problem: he described his landmark book as "all preface", the sketch of a territory he lacked the mathematical skill to penetrate. What the arguments in *On Growth and Form* really needed was a computer, and a big one at that.

Artists, though, from Henry Moore to Richard Hamilton to Eduardo Paolozzi, knew exactly what to do with his ideas. The Edinburgh exhibition combines past work and new commissions. Several stand-out pieces are by artists who once studied at Dundee's Duncan of Jordanstone College of Art and Design.

Thompson's alma mater has wisely capitalised on the way his work straddles art and science: it supports an art-science crossover gallery called LifeSpace, as well as offering degrees in animation, medical art and medical imaging, connecting digital processes with traditional illustration.

Researchers there are making the most of *On Growth and Form*'s centenary, and they are right to do so. For all our anxious predictions about genetic engineering, for all the hype surrounding synthetic biology, and all the many hundreds of graduate design shows stuffed with "imaginary animals", we have barely begun to explore, let alone exploit, the spaces Thompson's work revealed to us. ■



DARREN CEARL/SCARUS ROMANTHUS, 2012, OIL ON CANVAS, UNIVERSITY OF DUNDEE MUSEUM SERVICES © THE ARTIST

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## Let's Help Researchers Navigate their Vocational Journey

To help scientists transition into successful careers, institutions can improve vocational counseling programs to give researchers the professional guidance they deserve, writes Victoria McGovern of the Burroughs Wellcome Fund.

Career planning is hard for everyone. But for scientists, the combination of limitless interests and limited non-academic experience provides challenges that can be overwhelming. Growing into high-impact work requires getting experience picking the right problems, managing projects all the way to completion, and learning how to guide, influence, and inspire other people.

Timely advice — or a little hands-on experience — can mean a world of difference in making a successful move into a new role. For the last two decades, a few institutions have been developing resources to get grad students and postdocs that advice and experience. In most places, though, the primary and sometimes the only resource for career development remains the lab — and some faculty are flummoxed by the challenge of how to provide help for those looking to work outside traditional roles.

The idea of an Individual Development Plan (IDP) — writing out a roadmap for what one wants to achieve in training as a scientist — is one idea that makes a lot of sense. So does the idea behind Preparing Future Faculty (PFF), a program that brought research institutions together with their local teaching-intensive schools to provide better opportunities for students to see and understand faculty life.

Looking for ideas — where seeing something done well in one place will help others understand how to make a similar idea work elsewhere — is a key goal for our Career Guidance for Trainees (CGT) initiative at the Burroughs Wellcome Fund. Since 2012, our CGT program has awarded 20 one-year grants between \$30,000 to 50,000 to academic institutions and professional societies, so they can test curricula and tools that have the potential to help biomedical scientists effectively pursue career paths.

Awarded CGT proposals have been imaginatively diverse. Some are specific to a career path: the American Society for Microbiology created a fellowship to prepare doctoral-trained students for teaching careers at the community college and undergraduate level — with more than 130 fellows trained to-date. Others are specific to a skillset: Vanderbilt University successfully piloted a training module — “Business and Management Principles for Scientists” — now offered in its second year — while the Icahn School of Medicine at Mount Sinai is focusing on science communication trainings — even giving postdocs the chance to practice in K-12 classrooms.

CGT awardees also vary in their envisioned products. UCSF is creating the “Interactive Simulation Exercises for Career Transitions (INTERSECT) Workbook” — curating self-guided exercises for users try out tasks and skills from science fields beyond academia. Whereas the University of Alabama-Birmingham is taking a comprehensive approach via their “EXPERIENCES” program — first walking trainees through their individual development plan, followed by multiple weekend “boot camps” exploring different vocational paths, and concluding with a mini-residency shadowing mentors at a host office.

For me, one thing unites these projects: they all have a core idea that could be picked up and applied elsewhere. We love seeing one successful training program being emulated by another, benefiting countless more. The diversity of the funded program reminds us of something else, too: that when you look harder at a job or skill set — even the ones we’re all familiar with from the lab — you often find there is something richer in your experience and your career goals than you had realized.

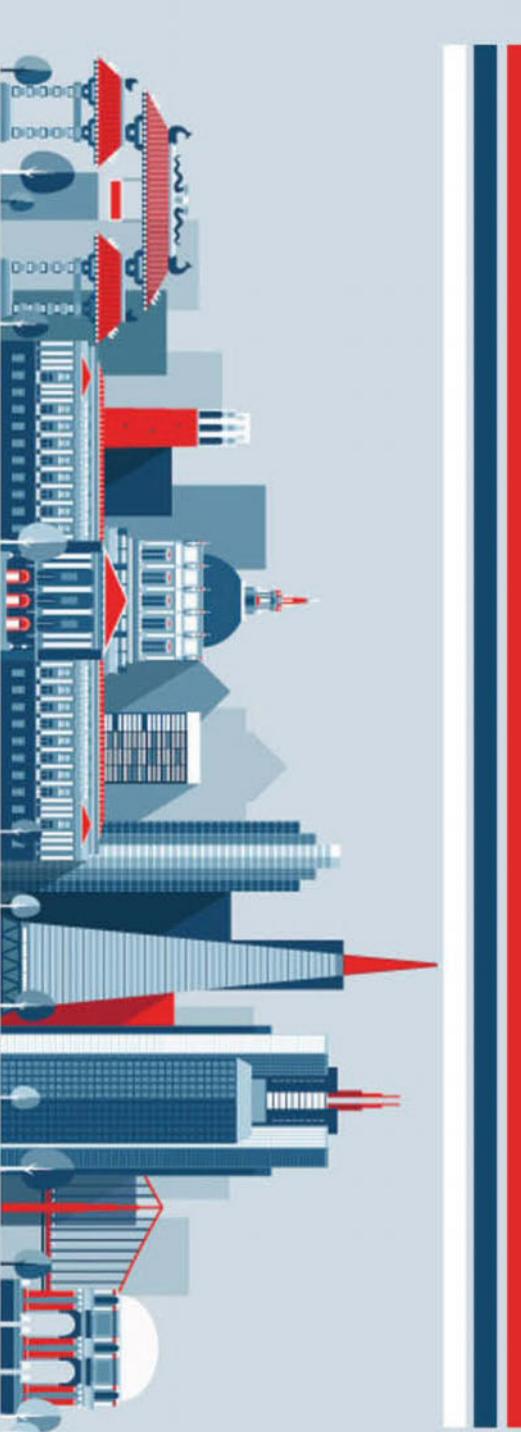
If you’re changing up how you cultivate biomedical professionals, let’s talk. Maybe together, we can encourage innovations in how new scientists are prepared.

—Victoria McGovern, PhD

Victoria McGovern, PhD, is a Senior Program Officer with the Burroughs Wellcome Fund. Follow McGovern on Twitter at @BWFPATH.

Academic institutions, professional societies, and other nonprofit organizations are invited to apply for the Career Guidance for Trainees (CGT) grant. The program provides one-year grants of \$30,000 to demonstrate affordable projects that help individual scientists assess their personal growth and effectively pursue career paths. Proposals are due March 6th, 2017.

Visit [www.bwfund.org/CGTNS](http://www.bwfund.org/CGTNS) to apply.



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**EDITOR'S PICK****More evidence of volcanic impact on England**

**From Maurice Brown,  
Goxhill, North Lincolnshire, UK**  
David Hoey discusses the impact a volcanic event at Laki in Iceland may have had on the English countryside (Letters, 17/24/31 December 2016). I have some parts of the memorandum book kept by a gentleman farmer in Goxhill called Thomas Hardy and later

by his son. It recorded the day-to-day transactions of their farm.

I have extracted from it information on yield and prices for arable crops during the years 1781 to 1786. The recorded total yields of wheat, barley, beans and in some years also oats were 14.96, 14.0, 6.74, 16.37, 15.48 and 12.91 tons. This reveals the effect that the 1783 Laki eruption had on this farm: at 6.74 tons, yield was half the six-year average.

In addition to its arable land the village had large areas of meadow and grazing, which probably mitigated the effect upon livestock. Hoey observed "drastic changes" in buildings on a farm in Cheshire. Buildings in Goxhill weren't substantial, as there was no good local stone or durable timber, and local manufacture of bricks and tiles was just beginning.

**Don't blame AI coders, prejudice is in the data**

*From Robert Fulton,  
Belfast, UK*

Aviva Rutkin suggests that lazy coding is teaching software to be sexist (17/24/31 December 2016, p 19). I contend that algorithms aren't biased, but the data is. The bias shown by artificial intelligences may point to institutionalised sexism and racism in society at large.

It isn't the coding that is lazy, but the curation and classification of data. I believe the unconscious (and conscious) biases of those assembling and using the data are being exposed.

Some chat in the darker corners of the internet shows there are people who would be happy to propagate such bias.

As AI becomes a bigger part of our lives, I think it will become

ever more important to assess the bias it shows – or uncovers.

*From Andy Green,  
Epsom, Surrey, UK*

As a software developer I am incensed by the suggestion that "lazy coders" are to blame for sexist software output. Removing biases such as gender bias from existing bodies of data would be a big challenge. Most businesses would reject such a project on the basis of cost. The headline "Profit-driven business is teaching software to be sexist" would be closer to the truth.

**Welcome to the internet  
of pro-privacy states**

*From Scott Marshall, Sydney,  
New South Wales, Australia*  
You report Elon Musk's ambition to launch 4425 satellites to provide internet access to the

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## **f "Politicians wanting to look over papers before being published is a nightmare"**

Natasha-Belle Hancock responds to suggestions that US scientists learn from Canada (4 February, p 25)

world (26 November 2016, p 7). Should he succeed, and should he base his business in a nation with little regard for monitoring the net (21 January, p 22), would traffic on his network evade all government monitoring?

### **Fair pay, the value of work and tax avoidance**

*From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK*  
John Hockaday seeks alternative ways to introduce fairness into income levels (Letters, 14 January). This is the centenary year of the report of John Henry Whitley MP that led to the UK government setting up Joint Industrial Councils, which developed into wage negotiating bodies.

The government at the time, under Prime Minister Lloyd George, arguably had a basic sense of fairness. It also realised that the

troops about to return from the trenches of the first world war would be in no mood to accept a return to the old order.

The councils required every employed person in effect to answer two questions. The first is that of market forces: what can the enterprise afford to pay? The second is much more searching: the value of their contribution to the well-being of society at large.

This notion of "value" isn't wild outrageous idealism – the UK Equal Pay Act determines that workers have the right to equal pay for "work of equal value".

Today, disparity in incomes has virtually returned to the levels it reached then. Is it perhaps time to revive Whitley?

*From Chris deSilva, Dianella, Western Australia*  
Hockaday suggests that an 85 per cent marginal tax rate should be

imposed on individuals earning more than A\$200,000 and companies with profits of more than A\$2,000,000 to fund health, education, welfare and other good things.

If I earned more than A\$200,000 (which I do not), I would immediately find an accountant to ensure that my taxable income never exceeded the threshold. Or I could emigrate: when the taxation gets tough, the rich get going – to a country with lower taxes.

### **Spot, thief! The limits of artificial crime detection**

*From Keith Thomas, Richmond, North Yorkshire, UK*  
So computer vision systems can tell innocent from suspicious behaviour (14 January, p 14)? Some years ago I ran into a town centre car park to renew a ticket, only to

be forcibly apprehended by two police officers chasing a shoplifter who took cover amid the cars.

If our highly trained law enforcement officers working face-to-face can mistake an identity, how will automated systems working at a distance fare?

### **Beware parasitical artificial intelligence**

*From Geoff Badley, Hedge End, Hampshire, UK*  
Greg Nuttgens thinks AI won't take over soon because it can't make a body for itself (Letters, 7 January). Perhaps. But we should remember that many life forms – possibly even DNA – started off as parasites. No parasite sets out to kill its host, either as an individual or a species, but it may change its host's health and behaviour. And, as with any organism, a parasite's basic aim is simple: to replicate. ➤

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## Call Affordable Care Act by its proper name

From Marilyn Lott,  
Front Royal, Virginia, US  
You often refer to "Obamacare" (for example 21 January, p 6). That epithet was coined by Republicans who, having passed Public Law 111-148 in both the US Senate and the Republican-controlled House of Representatives, decided they despised their handiwork.

They have chosen to blame it on (then) President Barack Obama, despite passing it by large enough majorities to override any veto. The proper short name for this law is the Affordable Care Act.

## You are a different kind of physics genius

From Martin Lesser,  
Stockholm, Sweden  
Richard Webb, considering the proposition "You are a physics genius", writes: "our physics engine is programmed with the equations of classical mechanics" (10 December 2016, p 28). It is highly improbable that our brains use these equations to solve the

problems of our motions in the physical world, and far more likely that neural networks or other mechanisms in the brain adapt to our sense experience and build suitable response patterns. That is why we need time to learn when adapting to situations such as riding a bicycle or moving in free fall in orbit. Such a mechanism would also allow our brains to achieve shorter response times than would be possible when using classical mechanics.

## Blame where blame's due for painkillers

From Tony Durham,  
Brighton, East Sussex, UK  
What exactly are "codeine-related deaths" (7 January, p 6)? Obviously they are regrettable, but how many are caused by codeine itself, and how many by substances that are mixed with codeine in over-the-counter preparations, such as paracetamol?

And as for it being a "rubbish" painkiller: if we banned every drug that "doesn't help people as much as they think it does" we would have few medicines left.

*The editor writes:*

■ A study found that paracetamol or ibuprofen was involved in 55 per cent of the 1200 codeine-related deaths recorded in Australia between 2000 and 2013 (*Medical Journal of Australia*, doi.org/bxzt). But it's the codeine that's addictive and contributes to people consuming too much paracetamol or ibuprofen.

for children, but it carries the risk of infection with disease-causing bacteria too.

## Monogamy is for the birds, or maybe not

From Sam Edge,  
Ringwood, Hampshire, UK  
David Bird claims that gray jays form pair bonds and don't cheat (7 January, p 24). Almost every time this assertion has been made about a species, subsequent observation or DNA profiling has shown that the so-called monogamous creatures are happy to "play away" regularly.

Still, loyalty has many interpretations and I hope the gray jay gains acceptance as Canada's national bird.

## Have we found the very latest quantum food fad?

From Peter Verity,  
Edinburgh, UK  
Penny Sarchet reports that exposure to soil may be key to a healthily diverse microbiome (14 January, p 28). Alongside this you answer the question "Should I wash food?" with "raw fruit and vegetables – yes".

So do vegetables have to be simultaneously clean and dirty, to nurture an optimum microbiome? Should we, in fact, seek out Schrödinger's carrot?

*The editor writes:*

■ This is indeed a conundrum. Exposure to soil seems to be good

## Fearing the shortest of geological epochs

From Tim Humphries,  
Epsom, Surrey, UK  
The proposal to label the present as a new geological epoch – the Anthropocene – is gaining ground (3 September 2016, p 7). Recent news suggests that it might be the shortest geological age.

## Synthetic meat offers surprising possibilities

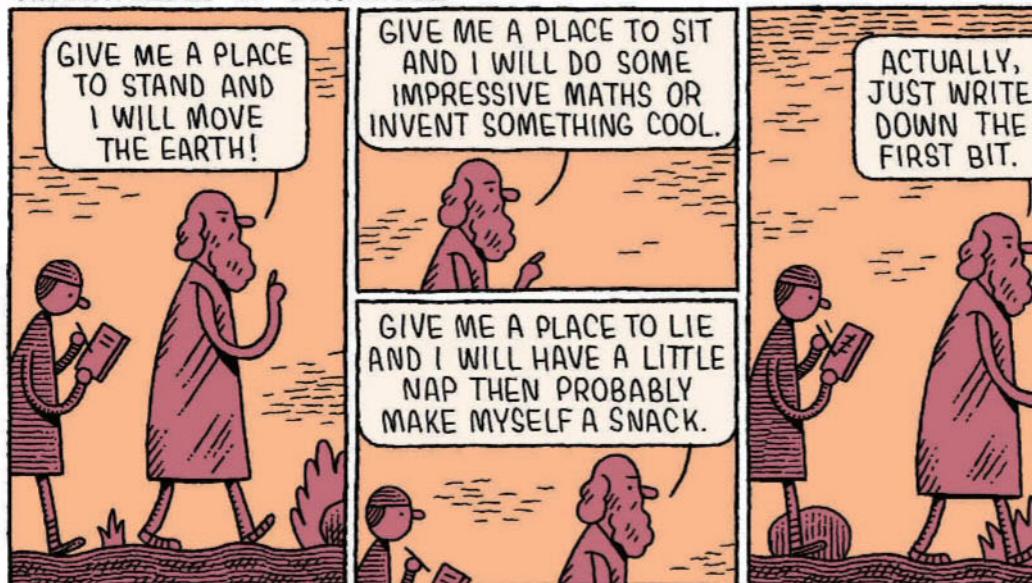
From Shane Jones,  
Ipswich, Queensland, Australia  
Sandrine Ceurstemont reports on home-brew synthetic meat (14 January, p 44). Assuming stem cells can be harvested without any harm, why stop at beef, pork and turkey? Couldn't we circumvent the bias against eating some species? People with allergies might brew their own stem cells.

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TOM GAULD

### ARCHIMEDES OF SYRACUSE



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## Loved up and clued in

Find romance on Valentine's Day with a digital treasure hunt



THE apple of your eye always has their eyes on their Apple - iPhone that is. So how to get their attention? Here's a simple way to impress your Valentine: a techy QR code treasure hunt.

These 2D barcodes can store masses of data, from texts to web links, email addresses, even geographic coordinates. All your sweetheart needs is an app that reads QR codes.

To get started, search for a QR code generator online to create your clues. QR codes can be read in any orientation and the built-in error correction means different colours and styles scan just fine. In fact, they can be rendered in almost any material, from collage to cake. There's even a firm that prints QR codes on chocolate - for a twist on a Valentine's day classic, order a box of edible clues. I've cross-stitched a QR code before - turning a clue into a keepsake.

For the hunt, slip the first code inside a card with a "scan me" note. Have it lead to some

text explaining the game and where to find the second clue. The next could be GPS coordinates of your special place. There, plant a code that opens a home-made picture clue or, even just a shot of the menu at their favourite restaurant.

Or perhaps the hunt was a ruse to keep your other half out of the house while you cook a fancy dinner and scatter some rose petals. The final code could even be a gift - encode a link to e-tickets, or an audio clip of the show you've booked.

The idea works well for long-distance love - mail the clues in numbered envelopes, and have them open video clips of the hints since you can't be there in person.

Of course, if you're leaving QR codes in public, anyone with a smartphone can decipher them. To avoid a stranger turning up to dinner, keep your treasure trail hidden by cutting the codes in two and keeping the second half of the current clue with the first half of the next. And if you do hang a cross-stitched QR code love letter to your paramour on the wall where guests might scan it, just don't make it too lewd.

Hannah Joshua ■

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THOSE helpful spooks at the CIA have put more than 12 million declassified documents online for the first time, allowing amateur sleuths and conspiracy theorists to sift through a treasure trove relating to everything from tunnels dug under the Berlin Wall to second-hand reports of Soviet UFO sightings.

One report in particular caught our eye, an account of "an experimental probe of the planet Jupiter". In 1973, psychics Harold Sherman and Ingo Swann took a mental jaunt to the gas giant, narrowly beating the Pioneer 10 spacecraft that was already en route.

The astral-nauts described the (non-existent) surface of Jupiter in detail, including fiery vents, sand dunes, mountains, volcanic peaks and crystal-strewn valleys.

Swann also predicted that there were several very dark planets between Mars and Jupiter, with life forms "lesser or equivalent to ours". Perhaps he meant fruitloops?

PAUL MCDEVITT

MEANWHILE, a cover page from 1984 reports that some psychics, when pricked with acupuncture needles, could "magnify the size of cells to the size of cherries", though thankfully only in the mind's eye. Doing so allowed the psychics to "watch the material exchange" in and out of the cell. Thrillingly, there was a belief that all humans could perform this magnification feat, which would have saved the world's health services a fair bit of money on microscopes and biopsies, and would have made removing splinters a lot easier.

PRESIDENT Trump is issuing memoranda and signing executive orders at such a pace that we suspect making comment on his activities in a weekly magazine will be about as successful as playing snooker on a waterbed. But it behoves us to discuss Trump's attempts to gag employees at federal agencies such as the

Environmental Protection Agency and the Department for Agriculture, none of whom are now permitted to discuss scientific matters openly with the public.

A few National Park Service employees and some others have rebuked the ban, angrily tweeting facts about climate change through alternative accounts. So to recap on the state of the States in 2017: you can have alternative facts from official sources, or official facts from alternative sources. Clear?

PREVIOUSLY John Ripley hypothesised that the missing socks of the universe could be accounted for by their metamorphosis into coat hangers, which seem to multiply unchecked in our wardrobes (4 February).

"I'm afraid you are wrong," writes Alan Dix, "as science fiction writer Avram Davidson declared in 1958 that it is paper clips that transmute into coat hangers, which then transmute into bicycles."

This seems like a profitable form of husbandry, thinks Feedback, especially as in our experience, bicycles left unsecured in the street are liable to vanish, and return in due time as large mattresses.

MEANWHILE, Dave Hulme has a clever way to avoid incurring the wrath of your roadside assistance company if you find yourself drifting to the wrong shoulder of the bell curve of breakdown frequency (21 January). "Simply join several motoring organisations and rotate through them for breakdown assistance."

Dave thinks that the cost of multiple memberships would certainly be offset by the low price of a reliably unreliable car.

FROM lemons to hot rods: Feedback's attention is drawn to a study from Stephen Brown at New York University and his colleagues, who find that "hedge fund managers who own powerful sports cars take on more

investment risk. Conversely, managers who own practical but unexciting cars take on less investment risk." But critically, those with a taste for white-knuckle rides – both on the trading floor and off – did not deliver better returns for the increased risk.

So if you're in the market for a trader, best stick with someone who likes life in the slow lane.

TEARFUND is a charity that allows patrons to twin their toilet with a distant latrine, providing sanitation to some of the world's poorest people. Andy Bebington reports that he was given a certificate to hang in his commode, which cites the location of the toilet's twin in degrees south and east to eight decimal places.

"I calculate that this locates the loo with a precision of 0.4 mm square," says Andy. "No one tells me how the



Burundians are supposed to use such a teeny toilet." Well, it is the smallest room in the house.

FINALLY, we cannot resist printing Howard Vernon's letter, in which he writes, "I wonder if you have ever heard of names that sound like the occupation of the person – what I call onomatopoeian nominative determinism?" He suggests an allergist that he chanced across, called Dr A. Chiu.

**"You can take our official twitter, but you'll never take our free time!"** US National Park Service employees launch an alternate account following Trump's gag order on the department

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

## Offal way to die

The Last Word has told us that lions prefer to eat the fat and organs of their prey rather than the muscle. Apparently, muscle tissue is relatively poor in energy and vitamins (for lions, at least), and lions are able to make glucose in the liver from protein, so do not need carbohydrates. What, then, are the equivalents in humans? And if, when civilisation crashes, I finally manage to catch a stray cat or dog, which parts should I eat first, and why?

■ Our livers, like those of lions, can use proteins and fats to manufacture all of the glucose we need, to supply red blood cells and some brain cells, for example. The rest of our cells do just fine on free fatty acids and compounds called ketones.

As the US Institute of Medicine declares in its snappily titled report "Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol,

acids and fats, but there are no such things as essential carbohydrates.

The Inuit people, who traditionally consume almost no dietary carbohydrate to no ill effect, are proof of this. So are the millions of people on a low-carb, high-fat diet, and those prescribed a carbohydrate-free ketogenic diet for epilepsy.

Therefore, if your questioner manages to catch a stray animal wandering around after the collapse of civilisation, he should do pretty much what the lion does and what our forebears once did: consume the marrow and brains for fuel, the organs for vitamins, and some of the muscle to replenish protein.

No need for pudding.

*Nick Mailer  
Edgware, Middlesex, UK*

■ If you are fortunate enough to catch a stray cat, start with the blood before it leaks away, but discard the urine.

Then eat the most microbe-rich parts before they rot. That means working your way through the gut from the tail forward.

You should make sure that you include all of the gut content, because it is nutritious as well as tasty, and your gut can digest some of the food components that a cat cannot.

Let's just hope that you are not sensitive to high concentrations of tyramine – an indicator of spoiled meat – which is common in cat intestines.

Next, you should eat the parts

that rot rapidly – because of bacterial exposure or the cat's own enzymes – such as the lungs, liver and other soft tissues.

Eating the rest is a little less urgent if you can dry all the remaining bits before they go off, especially if you can smoke them, salt them, or shred and sun-dry them. Start with muscles and the like and then move on to

## "Polar explorers forced to eat sled dogs to avoid starvation were poisoned by the livers"

the brain. Crush any remnants such as bones (to make them easier to digest), skin and fibrous connective tissue such as eyes, tendons and fur.

Remain alert for flies and other scavengers which are attracted to your supplies, although they might be welcome additions to your menu. Bon appétit.

*Jon Richfield  
Somerset West, South Africa*

■ Don't eat cat or dog livers. Excess vitamin A is stored in this organ and is especially concentrated in carnivore livers, which can therefore be toxic.

Polar explorers who were forced to eat their sled dogs to avoid starvation found their livers were the easiest thing to eat uncooked. They experienced severe poisoning as a result. In error, they then fed the rest of the carcasses to the surviving dogs.

*Hilary Johnson  
Malvern, Worcestershire, UK*

## This week's questions

### NEVER BETTERED

During a recent cycle ride I was passed at some speed by an ancient Rolls-Royce car, which was far and away the quietest vehicle I encountered all day. Given the huge advances in engineering, materials and design techniques in the 60 or 70 years since that car was built, why can't today's car manufacturers get close to crafting a car with such a quiet engine, so little tyre noise and a lack of discernible wind noise?

*Tony Green  
Ipswich, Suffolk, UK*

### POOR LITTLE URCHINS

Recently we came across endless dead sea urchins on the beach at Troon in Scotland. The next day they had all gone. How did so many suddenly appear like this when there had been no strong winds or exceptional tides? And why did they subsequently disappear? Is this normal?

*Barbie Short  
Troon, Ayrshire, UK*

### REMOTE SCENTING

How far away can flies smell potential food? We see very few flies in our garden, yet by the time a sparrowhawk had finished his breakfast on our lawn a few days ago, the remains were covered with flies. Do they hold a record for keenness of sense of smell versus their size?

*Karen Packham  
New Malden, Surrey, UK*

## "If you catch a stray animal after the collapse of civilisation, consume the marrow and brains for fuel"

Protein and Amino Acids (Micronutrients)" (The National Academies Press, 2005), and as our history as a species proves: "The lower limit of dietary carbohydrate compatible with life apparently is zero, provided that adequate amounts of protein and fat are consumed." This is why there are essential amino

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

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