

New Scientist

WEEKLY October 4 - 10, 2014

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How to tie anything

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More twists in the
gravitational wave story

MEN BEHAVING BADLY?
The real danger of
having too many boys

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HOW YOU CAN
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GETTY IMAGES

A life extended

The promise of a few more years is too tempting to turn down

BENJAMIN FRANKLIN once wrote that “in this world nothing can be said to be certain, except death and taxes”. That has not deterred a good many people – usually wealthy, ageing men – from trying to dodge one, or the other, or both.

Tax avoidance is one thing, but as yet nobody has achieved immortality, or even modest life extension beyond the apparent upper limit of about 120 years. The well of human optimism runs deep, though, and on a fairly regular basis somebody with deep pockets unveils ambitious plans to tackle or end ageing. The latest is Google, which a year ago announced plans to get into the longevity business with a biotech start-up called Calico.

It is easy to be cynical about such ventures. Around a decade ago there was a similar flurry of interest from Silicon Valley as the backers of the Ansari X Prize – fresh from awarding \$10 million to aviation pioneer Burt Rutan for putting a private vehicle into space – announced plans for an institute to solve the “problem” of death. The science of ageing was sufficiently advanced, it claimed, for us to be able to intervene to slow or even stop it.

Like so many quests for immortality, this one proved quixotic. But one of its main

goals – to extend human lifespan by reducing the rate of ageing – appears to have unexpectedly been achieved (see page 6). A number of drugs that were developed for other purposes seem to have the happy side effect of increasing lifespan in animals. Some researchers who work on them are now so convinced of their potential to add about

“Nobody has yet achieved even modest life extension beyond the apparent upper limit of about 120 years”

10 years to a human life that they have started self-medicating.

The appropriate warnings need to be wheeled out: the history of life-extension research is virtually defined by cycles of hype and disappointment. The evidence is little more than suggestive and the side effects unknown. But if the drugs work as the researchers believe – by slowing the ageing process itself – humanity is about to enter new territory.

There will be many scientific and regulatory hoops to jump through – the inevitable rise of a black market notwithstanding. There are also important political and ethical issues to chew over.

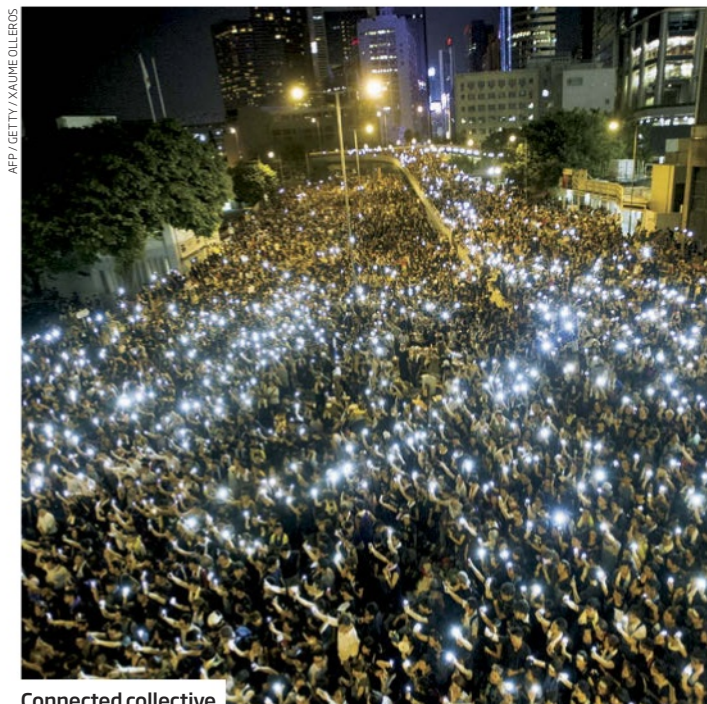
A critical one concerns overpopulation: if everybody

alive today added a decade to their life expectancy, the world’s already bloated population would inevitably rise even further. Quality of life is another concern: life extension could lead to a nightmarish “nursing home world” full of decrepit people who need to be supported by an ever-dwindling supply of youngsters. Yet another is inequality: drugs cost money, so could exacerbate the divide between haves and have-nots.

These are important questions. But it is hard to see them standing in the way. The temptation of extending our lives is too great.

It need not lead to a dystopian future. There has long been a strand of thought within gerontology that rejects radical life extension or immortality in favour of more modest goals. If we could slow ageing by about seven years, the argument goes, people would live longer, healthier lives, and then decline and die quickly with minimal decrepitude. The effects on population would be negligible, and the drugs are as cheap as aspirin and statins.

Some bioethicists will retort, do we really want this? Should we not just accept the lifespans that nature (or god) gave us? To which most people will surely respond, yes, and no. ■



Connected collective

Protesters networked

HONG KONG's mass protest is networked. Activists are relying on a free app that can send messages without any cellphone connection.

Since the pro-democracy protests turned ugly over the weekend, many worry that the Chinese government could block local phone networks.

In response, activists have turned to the FireChat app to send supportive messages and share the latest news. On Sunday alone, the app was downloaded more than 100,000 times in Hong Kong, its developers said.

FireChat relies on "mesh networking", a technique that allows data to zip directly from one phone to another via Wi-Fi or Bluetooth. Ordinarily, if two people want to communicate this way, they need to be fairly close together. But as more

people join in, the network grows and messages can travel further.

Mesh networks can be useful for people who are caught in natural disasters or, like those in Hong Kong, protesting under tricky conditions. FireChat came in handy for protesters in Taiwan and Iraq this year.

However, they also come with risks. Hans-Christoph Steiner at The Guardian Project, which helps activists circumvent censorship, warns that Firechat has no built-in encryption, so messages can be read by anyone within range. "This is not nearly as bad as one central authority being able to read all the messages. Nevertheless, it is something that at-risk users need to be aware of," he says. FireChat has said it aims to add encryption in the future.

Mending hearts

STEM cells are getting serious. Two decades after they were discovered, human embryonic stem cells (hESCs) are being trialled as a treatment for two

"Human embryonic stem cells have great potential - they can grow into any of the body's 200 tissues"

major diseases: heart failure and type 1 diabetes.

Treatments based on hESCs have been slow coming because of controversy over their source and fears that they could turn into tumours once implanted. They have enormous clinical potential; unlike stem cells isolated from adult tissue that have been the basis of stem cell treatments so far, hESCs can be grown into any of the body's 200 tissue types.

In the strongest test of their potential yet, six people with heart failure will be treated in France with a patch of immature heart cells made from hESCs, and 40 people with diabetes in the US will receive pouches containing

immature pancreas cells made from hESCs.

The hope is that the heart patch will help to regenerate heart muscle lost due to heart attacks. Trials in monkeys showed that the patch could regenerate up to 20 per cent of the lost muscle within two months.

The pancreatic cells are supposed to mature into beta-islet cells, which produce the hormone insulin. These would act as a substitute for the insulin-producing cells that are destroyed by the immune systems of people with type 1 diabetes.

Shuttle map

PEER into every crack and crevice. Fourteen years ago, the space shuttle flew a mission to map our planet. Now the data is finally being released in full.

Previous versions of the Shuttle Radar Topography data set only covered the US in high resolution, the rest of the world was in lower resolution. The latest release covers nearly the whole planet in nine times more detail than before.

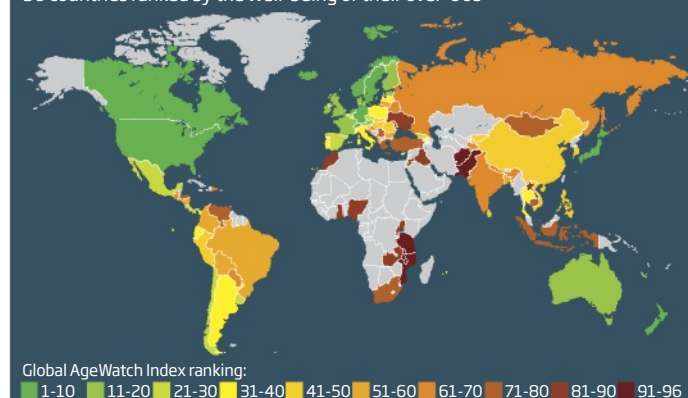
Robert Brakenridge, director of the Dartmouth Flood Observatory at the University of Colorado, says

that even though the mission to collect the data ran in 2000, the elevation data it collected remains the gold standard in mapping. The map of the world's peaks and troughs is used by Google Earth, among many others.

"It's the most widely used data set, it's the one we trust," says Brakenridge. "It's been exceptionally valuable for many years, and now it's nine times more valuable."

Each pixel in the new data release covers 900 square metres of the planet. The old data had 8100 square metre pixels.

96 countries ranked by the well-being of their over-60s



Where to grow old

THE future is grey. The world's population is ageing, but we aren't prepared for it.

That is the upshot of the Global AgeWatch Index, an assessment of quality of life for people of 60 and over, based on income security, health and living environment from the HelpAge International network (see map, left).

Ageing is widely seen as a rich-world phenomenon, but it is a global issue. It is a concern because

old people tend to have a worse quality of life in poor countries. The index predicts that as the poor world ages, millions face a bleak old age. Afghanistan is the worst place among those surveyed to be old, followed by Mozambique and the Palestinian territories. Norway is the most age-friendly, then Sweden and Switzerland.

Some countries with increasing wealth ignore their older citizens. Being old in booming Turkey is as bad as it is in Cambodia. Whereas Mexico, a poorer nation than Turkey but with superior pension provision, is now a better place to be old than Italy or Portugal.

Wildlife halved

ENJOY them while you can. Only half of the world's animals are left compared with 40 years ago, mainly due to habitat destruction either by locals for farming or by the multinational mineral and timber trades.

The biennial Living Planet Report, released this week by conservation charity WWF, tracked the fate of 10,000 vertebrate species around the world between 1970 and 2010. It found that the total population of fish, birds, mammals, amphibians and reptiles has declined by 52 per cent in only two generations of humans.

Latin America saw the steepest decline, with animal populations falling by 83 per cent. Animals living in fresh water also fared badly, plummeting by 76 per cent.

"The majority of species extinctions and declines are being driven by human pressures on the environment, both international and local," says Sam Turvey of the Institute of Biology at the Zoological Society of London, who helps run a scheme to protect unusual species.

"It's a very challenging issue that requires a lot of effort and attention with complex solutions, given that it's happening at a global level," he says.

Heatwave culprit

THE verdict is in: climate change is guilty. Without human greenhouse gas emissions, the heatwaves that occurred across the world in 2013 would have been very unlikely.

That's the conclusion of the third annual assessment of the role that global warming played in extreme weather events of the previous year. For 2013, the research included five separate heatwaves in Australia, China, Japan, Korea and western Europe. The report found that climate change played a part in all of them.

Australia's results were particularly damning. "The chances of observing such extreme temperatures in a world without climate change – it is almost impossible to imagine how that would have happened," says Peter Stott of the UK Met Office, an editor of the report, a special supplement in the *Bulletin of the American Meteorological Society* (bit.ly/Y13kZj).

The report has coincided with early data from the Met Office showing that this September was the driest on record for the UK – although we don't yet know if this was a result of global warming.

Eruption was unpredictable

THERE was no warning. The particular type of volcanic eruption that claimed the lives of 36 people in Japan last week is virtually undetectable in advance and could occur at many apparently sleeping volcanoes.

The 27 September eruption occurred on Mount Ontake, 270 kilometres west of Tokyo. It was what's called a phreatic explosion, when magma rapidly heats water into steam, causing it to burst out of the volcano.

Monitoring normally involves detecting unusual seismic activity, noticing obvious bulges in the volcano, or detecting the upwards movement of magma inside. None of these would have spotted a build-up

of steam, says Dougal Jerram, founder of volcano blog DougalEarth.

"If the rocks are viscous and rich in silica, the degassing causes violent tearing apart of the material," he says. "Whenever you walk around any volcano that's dormant or poorly active, there's always the risk of these explosive eruptions."

"Because there's no new magma injection or tilt movement of the volcano, these eruptions are highly unpredictable," says geophysicist Ian Stimpson of the University of Keele, UK. As *New Scientist* went to press, the Japan Meteorological Agency was reporting increased seismic activity on Ontake. Rescue and recovery operations had been suspended as a result of continued eruptions.



No warning possible

60 SECONDS

Remarkable extension

A drug to treat metastatic breast cancer extends life by 16 months, an unprecedented timespan for a cancer drug. Women who received pertuzumab plus two other drugs lived for 56.5 months after treatment compared with 40.8 months for those who received a placebo, last week's European Society for Medical Oncology conference heard.

Mangrove massacre

They store carbon and protect us from tsunamis, but mangroves are being destroyed up to five times faster than landlocked forests, warns a report from the UN Environment Programme. Around 20 per cent of mangroves were lost between 1980 and 2005, and action is needed to stop further losses to coastal development and logging.

Space nightmare

The dream is over. Sierra Nevada Corporation (SNC), the firm behind the Dream Chaser mini-shuttle, has filed a legal challenge after being rejected by NASA as a commercial taxi provider to the International Space Station. SNC missed out on the \$6.8 billion given to rivals SpaceX and Boeing and has had to lay off staff.

Harmful inroads

Where there are more roads in the Amazon, there are fewer birds – and it seems the explanation goes beyond the loss of habitat as trees are felled to make way for them. The roads lead to increased traffic, hunting and fire risks (*Proceedings of the Royal Society B*, DOI: 10.1098/rspb.2014.1742).

Studies are a-changin'

Five Swedish scientists have revealed a 17-year-long bet to sneak Bob Dylan quotes into the titles of their scientific papers. Their efforts include "Nitric Oxide and Inflammation: The Answer Is Blowing In the Wind" and "Blood on the Tracks: A Simple Twist of Fate?"

REUTERS/KVOD

Elixir of youth? It's already here

Life extension seems to be a side effect of several widely used drugs

Clare Wilson, Basel

MILLIONS of people are taking anti-ageing drugs every day – they just don't know it. Drugs to slow ageing sound futuristic but they already exist in the form of relatively cheap medicines that have been used for other purposes for decades.

Now that their promise is emerging, some scientists have started using them off-label in the hope of extending lifespan – and healthspan. “We are already treating ageing,” said gerontologist Brian Kennedy at

extension right now using available drugs,” says Mikhail Blagosklonny of the Roswell Park Cancer Institute in New York.

One of the most promising groups of drugs is based on a compound called rapamycin. It was first used to suppress the immune system in organ transplant recipients, then later found to extend lifespan in yeast

and worms. In 2009, mice were added to the list when the drug was found to lengthen the animals' lives by up to 14 per cent, even though they were started on the drug at 600 days old, the human equivalent of being about 60.

This led to an explosion of research into whether other structurally similar compounds – called rapalogs – might be more

potent. Now the first evidence has emerged of one such drug having an apparent anti-ageing effect in humans. A drug called everolimus, used to treat certain cancers, partially reversed the immune deterioration that normally occurs with age in a pilot trial in people over 65 years old.

Immune system ageing is a major cause of disease and death.

“We are already treating ageing. We have been doing research all along, we just didn't know it”

the International Symposium on Geroprotectors in Basel, Switzerland, last week, where the latest results were presented. “We have been doing ageing research all along but we didn't know it.”

Last year Google took its first steps into longevity research with the launch of Calico, an R&D firm that aims to use technology to understand lifespan. Geneticist Craig Venter announced he is pursuing a similar goal via genome sequencing. Now pharmaceutical companies look set to join in. At the conference, the head of Swiss drug firm Novartis said research into “geroprotectors” or longevity drugs was a priority.

Google and Venter's plans may have injected an over-hyped field with a measure of credibility but they are unlikely to bear fruit for some time. Yet evidence is emerging that some existing drugs have modest effects on lifespan, giving an extra 10 years or so of life. “We can develop effective combinations for life



CARL SMITH/PLAINPICTURE

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It is why older people are more susceptible to infections, and why they normally have a weaker response to vaccines.

That weak response, however, has proved useful for studying ageing, as it provides an easy read-out of immune system health. "In humans you can't do decades-long clinical trials," says Novartis researcher Joan Mannick. Instead, the company looked at a proxy that would quickly show results.

They gave 218 people a six-week course of everolimus, followed by a regular flu vaccine after a two-week gap. Compared with those given a placebo, everolimus

improved participants' immune response – as measured by the levels of antibodies in their blood – by more than 20 per cent, to two out of the three vaccine strains tested.

Of the three everolimus doses tested, the highest caused fatigue and mouth ulcers, while two lower doses had no apparent ill effects. Previous experiments in mice with rapamycin suggest this class of drug acts by inhibiting a protein called mTOR. mTOR also seems to be affected by calorie restriction – the strategy of trying to live longer by eating less.

mTOR is involved in sensing the level of nutrients available within cells, so one idea is that when times are scarce, cells shift into energy-conserving mode, which has knock-on anti-ageing effects, including on the immune system.

Mannick stresses that the study needs repeating, and the big question, of whether the drug keeps the participants healthier, can only be settled by long-term follow-up. There's also the issue of side effects beyond those seen in the trial. High doses of rapamycin used in organ transplants seem to nudge the recipient's metabolism into a prediabetic state – a harm that might outweigh its anti-ageing effect.

For now, it is an encouraging sign that rapalogs have similar effects in people as in mice, at least on the immune system, says Alex Zhavoronkov, CEO of biotech firm InSilico Medicine in Baltimore, Maryland.

Everyday remedies

And rapalogs are not the only game in town. The most commonly used medicine for type 2 diabetes, metformin, also seems to extend the lifespan of many small animals, including mice, by around 5 per cent.

There have been no trials of metformin as a longevity drug in people, but a recent study hinted that it might have a similar effect. The study was designed to

THE DISEASE OF AGEING

While some existing medicines have the potential to extend our lifespan by a few years, drug companies want to develop more potent longevity agents that can be patented.

But getting the drugs approved could be a challenge, as regulatory bodies in the US and Europe do not currently recognise "ageing" as a medical condition that needs treating.

The answer is for firms to initially seek approval of their drug as a treatment for a specific age-related condition, such as heart disease or

diabetes, and only then seek to demonstrate their broader powers, says Dan Perry of the US-based non-profit organisation the Alliance for Aging Research. "They're going to fly under the radar."

Novartis is currently exploring if its cancer drug, everolimus, can reinvigorate the immune system in older people (see main story). If it is canny, it will seek regulatory approval of the drug as an immune booster, rather than a longevity agent, predicts Alex Zhavoronkov of biotech firm InSilico Medicine.

compare metformin with another diabetes medicine, using records of 180,000 UK patients. To tease out the differences between the drugs, people who started taking them were compared with people without diabetes who had been closely matched for age and other health factors, and tracked over five years.

Surprisingly, diabetics taking metformin were not only less likely to die in that time than those on the other medicine but they were also about 15 per cent less likely to die than people without diabetes who took neither drug. "This shows we already have a drug that we can potentially use in humans," says Nir Barzilai, who heads the Institute for Aging Research at the Albert Einstein College of Medicine in New York.

Other familiar drugs might also fit the bill. Low-dose aspirin and statins are widely taken by healthy people to reduce their risk of heart disease. Both extend lifespan in animals and seem to have anti-inflammatory effects.

Inflammation is one of the proposed mechanisms behind ageing, so aspirin and statins could be effective heart drugs in part because they slow ageing, says Kennedy, who heads the Buck Institute for Research on Aging in Novato, California.

The fact that common mechanisms seem to be behind

the major diseases of ageing, like heart disease, stroke and dementia, is good news, as it suggests we should be able to extend our lifespan while also extending healthspan, according to many conference speakers. Indeed, it would be difficult to imagine an effective longevity agent that worked without alleviating or delaying such

"Part of why aspirin and statins are such effective heart drugs is because they are slowing ageing"

conditions. Rapamycin, for instance, has been found to reduce the cognitive decline that accompanies ageing in animals.

Some researchers are already convinced and have started taking various combinations of drugs – including low-dose rapamycin. Blagosklonny is one such convert, and he's not alone: "I know many people at this meeting who are taking it," he said. No doctor would advise such a move, though, as rapamycin's potential for causing diabetes could well outweigh its anti-ageing effects.

Nevertheless, the fact that anti-ageing prescription drugs are being developed at all is a measure of how far the longevity field has come, says Zhavoronkov. "It's the first time pharma has embraced ageing." ■



Eighty years young



Don't mention the dust

The rise and fall of cosmic inflation

Michael Slezak

INFLATION is dead, long live inflation! The very results hailed this year as demonstrating a consequence of inflationary models of the universe – and therefore pointing to the existence of a multiverse – may now do the exact opposite. If the results can be trusted at all, they seemingly suggest inflation is wrong, and raise the possibility of universes that predate the big bang.

In March, the team behind the BICEP2 telescope in Antarctica (pictured) announced that they had seen evidence of primordial gravitational waves. These waves were revealed as telltale twists and turns in the polarisation of the cosmic microwave background radiation (CMB), the remnants of the universe's earliest light.

Physicists hailed the discovery as preliminary confirmation of inflation, the idea that for a sliver of a moment after the big bang, the universe expanded at blistering

speed. The theory, the most widely held cosmological idea about the growth of our universe after the big bang, accounts for a number of mysteries, including why the universe is surprisingly flat and smoothly distributed.

Very quickly, though, the BICEP2 finding became shrouded in doubt, as it was revealed that the polarisation pattern could have been caused by cosmic dust. Preliminary results released last week from the space-based Planck telescope suggest that dust could indeed account for the pattern BICEP2 detected.

But this week, a team of theorists decided to ask: assuming the signal isn't caused by dust, what exactly does it say about inflation? David Parkinson at the University of Queensland in Australia and his team examined the nature of the apparent gravitational waves, rather than their mere existence, to see if they were the type of waves inflation predicts. And they weren't.

Most inflationary models require that, as you look at larger and larger scales of the universe, you should see stronger and stronger gravitational waves. In BICEP2's data, they get weaker. Contrary to what the BICEP2 collaboration said initially, Parkinson's analysis suggests that the BICEP2 results, if legitimate, actually rule out any reasonable form of inflationary theory.

"What inflation predicted was actually the reverse of what we found," says Parkinson (arxiv.org/abs/1409.6530).

Not everyone is giving up so easily. Alan Guth, a physicist at the Massachusetts Institute of

"The BICEP2 results may actually rule out any reasonable form of inflationary theory"

Technology who pioneered the concept of inflation, says the analysis is convincing, but not so convincing that he's ready to abandon the possibility that BICEP2's data holds a signal in support of more obscure models of inflation. Even if the signal ends up being mainly due to dust, that is not strong evidence against inflation, Guth claims, since many

inflationary models predict a much smaller signal that would require more work to find. "If BICEP2 has not seen [evidence of] gravitational waves, then only certain inflationary models are ruled out, while the concept of inflation remains completely healthy."

But some are cheerfully pulling down the curtain on inflation. Paul Steinhardt of Princeton University, who helped develop inflationary theory but is now a scathing critic of it, says that while the new study may be a blow for the theory, it pales in significance compared with inflation's other problems. He says the idea that inflationary theory produces any observable predictions at all – even those potentially tested by BICEP2 – is based on a faulty simplification of the theory.

Because of quantum fluctuations, inflation is thought to produce an infinite multitude of universes that exhibit every conceivable property. "That means it doesn't make any sense to say *what* inflation predicts, except to say it predicts *everything*," he says. "If it's physically possible, then it happens in the multiverse someplace."

As an alternative, Steinhardt suggests the universe might have existed before the big bang, and slowly collapsed in a big crunch, before bouncing back and expanding anew – over and over. That could explain the universe's smoothness without invoking multiverses. Not finding gravitational waves in the years to come will be the start of evidence for this theory, he says. Other observable predictions are being developed, but it's a relatively new theory and more work is needed.

The next step is to see what can be gleaned from the Planck data – due in the next month – about the exact nature of cosmic dust. Whatever the result, with BICEP2 in place and several new instruments on the way, all the cosmologists *New Scientist* spoke to say it is an exciting time. ■

INSIGHT Mars shot

Red Planet sorted - next the moon and the stars

"THERE is nothing symbolic about this," says Sundaram Ramakrishnan of the Indian Space Research Organisation. The nation's success in putting its Mars Orbiter Mission into orbit around the Red Planet was about testing the technology and skills needed to manage a complex mission, he says. ISRO scientists passed that test with flying colours.

In the early hours of 24 September word came through that the craft had executed its burn for 23 minutes and 8.67 seconds precisely and slowed to enter orbit. Staff were ecstatic.

"There was euphoria among people, hugging each other, shaking hands and jumping," Anil Bhardwaj, director of the space physics lab at the Vikram Sarabhai Space Centre in Thiruvananthapuram, Kerala, told *New Scientist*. "I can't tell you in words the way we were feeling."

The headlines summed it up: "The first Asian country to reach Mars", "India's Mars mission cost less than the making of the movie *Gravity*". Beyond the celebrations is a space programme that is quietly gaining in confidence and acquiring the ability to tackle lunar and interplanetary missions.

Getting to Mars on the first try was no mean feat, showing that the agency can tackle a range of highly

technical challenges in a coordinated way. These included modelling the craft's precise trajectory to Mars, designing an intelligent vehicle that can deal with problems autonomously once it is too far from Earth for real-time control, and building engines

robust enough to function flawlessly after a year in the cold of space. "It definitely gives us confidence to plan such complex missions," says Ramakrishnan.

And the trip to Mars cost relatively little: \$74 million, \$26 million less than filming *Gravity*. Bhardwaj credits that to tight cost control. Everything was done in-house, including building rockets, satellites, propulsion systems and sensors. ISRO does subcontract some

manufacturing to industry, but manages the entire process itself. This, says Bhardwaj, also helps the agency keep to deadlines despite being new to the interplanetary space game: from conception to rendezvous with Mars, the mission took three years.

With that triumph under its belt, ISRO is not resting on its laurels. Having put the Chandrayaan-1 probe in orbit around the moon in 2008, India's next lunar mission is in the works. This time it involves an orbiter, lander and a rover. "This is a new technology that we'll need for landing on any planetary surface," says Bhardwaj.

The rocket for this second moon mission will be the Geosynchronous Satellite Launch Vehicle. The heavy lifter successfully flew earlier this year with a cryogenic engine designed and built in India that uses liquid oxygen and hydrogen for fuel - a vital technology for large payload missions.

Another key mission in the pipeline is Aditya-1 (Aditya being the Hindu sun god). It will attempt to study the sun from Lagrange point L1, which lies between Earth and the sun, about four times as far away as the moon.

In the meantime, the agency is also building its own GPS system. It has already launched two satellites, with a third awaiting lift-off. Also on the agenda is the next generation of weather, remote-sensing and communication satellites.

Anil Ananthaswamy ■



Mission accomplished

Chimps spotted playing copycat in the wild

THREE years ago, an adult chimpanzee called Nick dipped a piece of moss into a watering hole in Uganda's Budongo Forest. Watched by a female, Nambi, he lifted the moss to his mouth and squeezed the water out. Nambi copied him and, over the next six days, moss sponging began to spread through the community. A chimp trend was born.

Until that day in November 2011, chimps had only been seen to copy actions in controlled experiments, and social learning had never been directly observed in the wild.

To prove that Nambi and the seven other chimps who started using moss sponges didn't just come up with the idea independently, Catherine Hobaiter of the University of St Andrews, UK, and her colleagues used their own innovation: a statistical analysis of the community's social network. They were able to track how moss-sponging spread and calculated that once a chimp had seen

another use a moss sponge, it was 15 times more likely to do so itself (*PLoS Biology*, DOI: 10.1371/journal.pbio.1001960).

A decade ago it was believed that only humans have the capacity to imitate, says Frans de Waal of Emory University in Atlanta, Georgia. "The present study is the first on apes to show by means of networking analysis that habits travel along paths

"The study is the first on apes to show that habits travel along paths of close relationships"

of close relationships," he says, adding that a similar idea was shown not long ago for humpback whale hunting techniques.

Given how rarely chimps pick up trends, it's exciting that someone was on hand to watch it happen, says Andrew Whiten of the University of St Andrews. Ultimately, he says, our ability to both invent and copy meant our ancestors could exploit a cognitive niche. "They began hunting large game by doing it the brainy way." Imitation, it turns out, is not just the sincerest form of flattery, it's also a smart thing to do. **Catherine Brahic ■**



COURTESY OF BEN HARRIS

Rat or rabbit, I don't like it

Psychology's 'lost boy' lost no more

Helen Thomson

YOU'LL have heard of Pavlov's dogs, conditioned to expect food at the sound of a bell. You might not have heard that a scarier experiment – arguably one of psychology's most unethical – was once performed on a baby.

In it, a 9-month-old, at first unfazed by the presence of animals, was conditioned to feel fear at the sight of a rat. The infant was repeatedly presented with the rat as someone struck a metal pole with a hammer until he cried at merely the sight of any furry object.

The "Little Albert" experiment, performed in 1919 by John Watson of Johns Hopkins University Hospital in Baltimore, Maryland, was the first to show that a human could be classically conditioned. The fate of Albert B has intrigued researchers ever since.

Hall Beck at the Appalachian State University in Boone, North Carolina, has been one of the most

tenacious researchers on the case. Watson's papers stated that Albert was the son of a wet nurse who worked at the hospital. Beck spent seven years exploring potential candidates and used facial analysis to conclude in 2009 that Little Albert was Douglas Merritte, son of hospital employee Arvilla. Douglas was born on the same day as Albert and several other points tallied with Watson's notes. Tragically, medical records showed that Douglas had severe neurological problems and died at an early age of hydrocephalus, or water on the brain (*American Psychologist*, doi.org/b9bsvx).

Beck and his colleagues reanalysed grainy video footage of Watson's experiments, in which they claim Little Albert acts oddly during his initial encounters with the animals. Clinicians suggested that Albert showed signs of neurological damage that fitted with Merritte's medical records. Could Watson have known about this impairment and lied when he

said that he had chosen Albert because he was a healthy baby?

If correct, "the significance of Beck's revelation was that it indicated the scale and nature of the researcher's dubious practices was far greater than previously supposed," says Alex Haslam, a psychologist at the University of Exeter, UK.

But not everyone was won over. "When Beck claimed he had discovered Little Albert I was so excited," says Russ Powell at MacEwan University in Alberta, Canada, "but then I started finding inconsistencies."

Powell and his colleagues decided to reinvestigate the case. They focused on another woman

"Albert lived a long, happy life. He disliked animals but there is no way to link that to the conditioning"

who had worked at the hospital – 16-year-old Pearl Martin, who, they claim, Beck had discounted after finding no evidence that she'd had a baby while there.

Having uncovered new documentation, Powell's team found that Pearl Martin, whose maiden name was Barger, had given birth to a child in 1919

before marrying. A census later revealed that the child was William Albert Barger, but hospital records showed he went by his middle name. "Albert B," says Powell, "it all added up."

As well as the name, the team argue that there are more significant consistencies between Albert Barger and Little Albert than for Douglas Merritte and Little Albert. Although both boys were born on the same day as Albert B, Barger was much closer in weight and left hospital at exactly the same age.

But what of the neurological impairment seen in the videos? Powell argues that the infant's behaviour is not unusual for a child who has never seen an animal before. If correct, it means Watson actually did test a healthy child as claimed (*American Psychologist*, doi.org/v2k).

Alan Fridlund at the University of Santa Barbara, who worked with Beck on his paper, stands by the original finding. "We sought two clinical experts to view Albert on film," says Fridlund. He also argues that body weight is meaningless when stature isn't considered, and that Albert's stature is consistent with hydrocephalus.

"The important point is not that Beck was probably wrong," counters Haslam, "but that we were rushing in to confer pariah status on the already unfashionable Watson."

What of Albert Barger? He died in 2007 after a happy life, says his niece. She describes him as an intellectually curious person who would have been thrilled to know he had participated in this kind of experiment. Intriguingly, he had an aversion to animals – the family dogs had to be kept in a separate room when he visited.

While it is impossible to link this to the experiments, says Powell, if Barger was indeed Little Albert, it does suggest Watson's claim that conditioning would do relatively little harm in the long run was, thankfully, correct. ■



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Super-neutrino key to cosmic ray puzzle

Hal Hodson

A COSMIC coincidence could be the first clue to the origin of a high-energy neutrino spotted in Antarctica – and may help pinpoint the source of high-energy cosmic rays that bombard Earth's atmosphere.

Cosmic rays are massive charged particles that barrel through deep space with energies that dwarf those achieved at particle accelerators on Earth. Some may be accelerated to such high speeds by supernovas, but others have mysterious roots.

"The origin of cosmic rays is one of the most intriguing questions in astrophysics," says Toshihiro Fujii at the University of Chicago. But because they can be deflected by magnetic fields, their sources are difficult to trace.

On the other hand, chargeless and nearly massless particles called neutrinos – a by-product of the processes that create cosmic rays – go direct, travelling in a straight line to Earth from their source. This directness could make neutrinos the key to solving the cosmic ray puzzle.

Now astronomers may have

observations to prove it. A new study reports a connection between a gigantic burst of energy at the core of the Milky Way and neutrino strikes on Earth.

Amy Barger at the University of Wisconsin-Madison and her

colleagues note that on 9 February 2012, the Chandra space telescope saw a spike in X-ray emissions from the centre of our galaxy, where a supermassive black hole is thought to be surrounded by a maelstrom of particles.

Three hours later – just long enough for some of those particles to have decayed into neutrinos – an array of sensors buried in Antarctic ice, called IceCube, saw one of the highest-energy neutrinos ever detected

coming from the direction of the galactic centre (*Physical Review D*, doi.org/v3p). This coincidence suggests that this neutrino, and probably lots more, was produced near the centre of the galaxy.

"This will be the first source of high-energy neutrinos ever detected," says Luis Anchordoqui at City University of New York, who wasn't involved in the study. "They have only one precise correlation, but there are not many objects in the galaxy that can accelerate particles like this."

If future observations confirm that neutrinos are accelerated to high energies by activity at the galactic centre, the same source could explain high-energy cosmic rays – although it's still unclear exactly how the accelerator works. Measuring the full range of energies of similar neutrinos will help calculate the power of the accelerator that kicked them across the galaxy. "We are not immediately going to be able to say what's going on there, but it's the first step to doing that," says Anchordoqui.

Meanwhile, other observations suggest cosmic rays may come from even further afield. In August, Fujii and his colleagues observed correlations between cosmic rays detected at The Telescope Array in Utah and other neutrinos spotted at IceCube. The source, based on their paths, seemed to be outside the galaxy. ■



NASA/CXC/UMASSD, WANG ET AL.

Source of the fast and furious?

Changing winds blew humans to Easter Island

EXPERT navigation and advanced boat-building technology were not enough for humans to finally colonise the world's remotest islands – shifting wind patterns also played a part.

There were no humans on Easter Island in the south-eastern Pacific until around AD 1100, when Polynesian sailors arrived there from the central Pacific islands. Within a

few hundred years, they colonised uninhabited islands all across the South Pacific. How they did so has been much debated.

To sail against today's winds, which blow from east to west in the tropics and in the opposite direction further south, would have been tough. Scientists have clashed over whether Polynesian seafaring could have coped with this.

"All previous research that's been done trying to understand this very rapid colonisation of the Pacific tried to grapple with the migration in terms of modern climate," says Ian Goodwin

of Macquarie University in Sydney, Australia. But his research suggests that these pioneering sailors might have had the winds in their favour.

Using evidence from tree rings, lake sediments and ice cores, his team tried to reconstruct ancient climates (PNAS, DOI: 10.1073/pnas.1408918111). They found that, for a couple of centuries, a unique set of wind changes would

"Ideal sailing routes would have been created exactly when archaeologists think the island was colonised"

have made these journeys easier.

From 1080 to 1100, changes in the climate caused the westerly winds to shift further north. During this brief window, ideal sailing routes would have been created from the already populated south Austral Islands to Easter Island – exactly when many archaeologists think the island was colonised. From 1140 to 1160, the easterly winds moved further south, allowing migration to New Zealand.

The sudden end to these wind changes could explain the lack of major voyages after 1300.

Michael Slezak ■

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Immune response predicts recovery time after surgery

THE operating room is booked, the surgeon is ready – but is your body? One day a blood test will help predict whether you'll need days or weeks to recover from surgery.

An operation is a stressful experience for your body. The trauma of the knife floods the blood with immune molecules that can trigger inflammation. As a result, some people are confined to bed for weeks, while others can be on their feet within days. The difference probably lies in individual variations in the immune response.

To find out more, a team at Stanford School of Medicine in California, led by Brice Gaudillière, used a cell-mapping

technique called mass cytometry to search for an “immune signature” that predicts recovery times. Mass cytometry allows researchers to work out which immune cells are present in a blood sample, and what molecules they are producing – a measure of their activity.

They analysed samples from 32 people who'd had hip-replacement surgery, taking samples at various times in the following six weeks. If a particular type of white blood cell was active in the first 24 hours after surgery, the person was more likely to take at least three weeks to recover. If the activity of these cells was low or decreased in the first 24 hours, they recovered faster (*Science Translational Medicine*, doi.org/v2p).

Gaudillière is now looking to develop a blood test that predicts recovery times before surgery is carried out.

Ancient quake fracked mystery rock

FRACKING wasn't invented by humans. The method of using pressurised fluids to break apart rocks was around at least 700 million years ago, and explains one of the world's strangest rock formations.

The Tava sandstone has baffled scientists for over a century. Found in the Front Range of the Rocky mountains in Colorado, it appears to have defied the rules

of geology. The rock formed by sandstone being injected as a liquid into surrounding layers of granite. While igneous rocks start life as a liquid, sandstone forms by sedimentation and will usually bend or break under stress rather than liquefy.

Christine Siddoway at Colorado College in Colorado Springs and her colleagues suggest that between 660 and 800 million

years ago, a nearby fault blasted the region with a series of enormous earthquakes. When quakes strike loose, wet sediment, the material begins to behave like a liquid, Siddoway says (*Lithosphere*, doi.org/v3h).

Huge slabs of rock shearing off from the fault could have hit the sediments below with enough force to drive them into solid granite, in a natural fracking event. “These are really extraordinary rocks,” says Siddoway.

Earth gets a new companion

ADD one to the entourage. Newly discovered asteroid 2014 OL339 is the latest quasi-satellite of Earth.

The asteroid, which is between 90 and 200 metres in diameter, has been hanging out near Earth for about 775 years. It will move on in about 165 years, say Carlos and Raul de la Fuente Marcos at the Complutense University of Madrid in Spain, who have just described it (arxiv.org/abs/1409.5588v1).

Quasi-satellites orbit the sun but are close enough to Earth to look like companions. Earth's gravity has guided 2014 OL339 into an eccentric wobble, which causes the rock to appear to circle backwards around the planet.

With four quasi-satellites catalogued so far, Earth comes in second to Jupiter's six, though the gas giant probably has many more that we can't see. The same is likely true of Earth, as small space rocks are notoriously hard to find.

Tap, tap, tap... is this molecule on?

THE world's smallest microphone, made from a single molecule, is listening.

Smaller microphones can detect smaller vibrations. Yuxi Tian of Lund University in Sweden and his colleagues have taken this idea to extremes by embedding a molecule of dibenzoterrylene inside a crystal. When sound waves disturb the molecule, it vibrates, shifting the frequencies of light it absorbs. So by shining a laser into the crystal and watching for changes in absorption frequencies, the team can listen in on the sound it picks up (*Physical Review Letters*, doi.org/v3d).

The team hope the device could be used as an acoustic microscope to spot tiny motions in chemical and biological systems.

India's tiger trade hotspots revealed

TIGERS take the train too. Poaching gangs are using India's railway network to traffic tiger parts across the country, according to an analysis of 40 years' worth of data on the nation's thriving illegal tiger trade.

The data, collected by the Wildlife Protection Society of India (WPSI) shows that today's trafficking hotspots form a corridor from southern and central India up to the country's Nepalese border, believed to be the main international hub for moving tiger parts into China, where demand for bones is high.

There are 73 districts that may be active hubs for poaching and trafficking. Of these, 17 are not near tiger habitats, including the Delhi region (*Biological Conservation*, [doi.org/v2m](https://doi.org/10.1016/j.biocon.2014.08.012)).

Trafficking is higher in districts closer to railways than highways. "Poaching gangs and middlemen prefer to use trains to transport tiger parts, since trains are well-connected to remote forested areas and usually crowded," says Belinda Wright of the WPSI. Buses carry fewer people and can be easily stopped and checked, she says.

In 2013, the society recorded 43 cases of poaching and trafficking of wild-tiger parts. The annual number is based on how many cases are identified each year, and fluctuates with the ability of poachers to evade detection.



Crazy weather caused by Arctic ice melt

SICK of all the weird weather spells? Blame the melting Arctic.

Climate change has caused the rapid retreat of Arctic sea ice, and this may be to blame for more frequent prolonged spells of extreme weather in Europe, Asia and North America.

Weeks of freezing temperatures, storms or heatwaves can be caused by "stuck" weather patterns. Jennifer Francis of Rutgers University in New Brunswick, New Jersey, told a conference on Arctic sea ice reduction last week that a growing

number of studies suggest the melting Arctic is affecting the source of these patterns: the jet stream. This west-to-east flow of air in the Northern hemisphere is maintained by the gradient of heat between the cool Arctic and warmer areas near the equator.

The strength of the jet stream depends on the magnitude of the temperature gradient. Because the Arctic is warming faster than the rest of the planet, the gradient is lessening and with it the jet stream. The loss of sea ice is exacerbating the problem,

since the ice cools the Arctic air.

As the jet stream slows down, it becomes wavier. Where it forms extreme undulations, weather systems become trapped in one place for prolonged periods, according to Francis.

Between 1995 and 2013 – when the Arctic began warming disproportionately fast – extreme undulations over North America during the autumn and winter, the seasons when the Arctic melts, were 49 and 41 per cent more common than they were between 1979 and 1994.

Fickle female fish fancy fresh faces

A CHANGE can be nice. This is a feeling female guppies know all too well. After being courted by one male, a female will shift her attention to males with different appearances. Female guppies have no set type, it seems.

To see if female guppies really are attracted to something a bit unusual, Kimberly Hughes of Florida State University in Tallahassee and her colleagues introduced a female to a group of four males, like the fish equivalent of a cocktail party with too many male guests. As females in this situation circulated, they showed a clear preference for males that looked most unlike the last male they had spent time with.

On day two of the experiment, their behaviour changed: females no longer showed any preference for similar or dissimilar males, maybe because the four males had all become too familiar and their novelty had worn off (*Ethology*, [doi.org/v3g](https://doi.org/10.1016/j.ethology.2014.08.012)).

Hughes suggests seeking out different-looking males may help avoid inbreeding. "In the wild, if guppies do not move around much, females can end up living in the same pools with their brothers and sons," she says.



Earth's water is older than the sun

OUR water goes way back. Half of the water on Earth is older than the sun, a finding that hints at what planets around other stars might be like.

Water in our solar system is unusually rich in deuterium, a heavy isotope of hydrogen. Researchers have long thought that this was because the early solar system violently ripped apart interstellar ice – a richer deuterium source that dates to before the formation of our sun – and then reformed it as water.

But when Ilse Cleeves at the University of Michigan and her team created a model of the early sun they

found this couldn't have happened: once the ice was split, the oxygen became locked in frozen carbon monoxide and not enough ionised, deuterium-rich hydrogen was made. In short, this process didn't give the nascent solar system the ingredients for water with the levels of deuterium we see (*Science*, [doi.org/v28](https://doi.org/10.1126/science.1254444)).

Instead, interstellar ice must have made its way to planets, moons and comets intact. Cleeves calculates that half the water in Earth's oceans came from this source. This could mean that water is common in interstellar space, and therefore present on exoplanets.

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Sun-powered sunflower

An all-in-one solar energy harvester can deliver power, clean water and heat, says **Paul Marks**

SEND for the Sunflower. A solar energy harvester could soon become the first “drop-in” machine to provide renewable energy, water and heat to off-grid communities in remote regions.

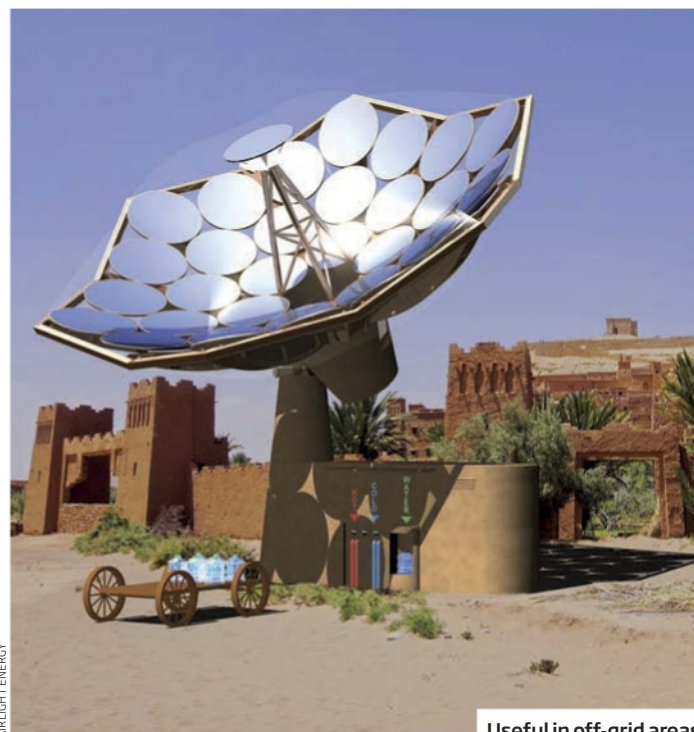
The 10-metre-high, sun-tracking dish has been designed to be transported in a single shipping container, so it can be delivered to any location. It is being developed by Airlight Energy of Biasca, Switzerland. As well as clean water and electricity,

panels, where the sunlight is concentrated 2000 times.

Each panel holds 25 photovoltaic chips cooled by water flowing in microchannels underneath. These carry the heat away at a rate that leaves the microchips at their optimal operating temperature. That makes the Sunflower more efficient than existing photovoltaic concentrating generators, so it needs a quarter of the panels to produce the same power. This makes it far cheaper, says Michel.

In coastal areas, the heated water can drive a low-temperature desalinator, also developed by IBM. It heats seawater to create vapour that passes through a polymer membrane and condenses in a separate chamber. The process is then repeated three times to extract maximum water. IBM claims this can produce 2500 litres of fresh water per day. In non-coastal areas, a water purifier could be fitted instead.

The structure is designed to keep costs down. Solar mirrors



Useful in off-grid areas

“The sun-tracking dish can be transported in a shipping container and delivered to any location”

it can generate heat or, with the addition of a heat pump, provide refrigeration.

The core technology is a water-cooled solar panel developed by Bruno Michel and his colleagues at IBM, for which Airlight has licensed the patents. Mirrors on the flower-shaped structure direct the sun’s rays onto six of the

would normally be made of heavy, expensive polished glass, but here each 1-metre mirror is made of metallised foil. “The same material potato chip and chocolate wrapping is made of,” says Ilaria Besozzi of Airlight.

If the flow of cooling water failed for any reason, the solar chips would quickly reach 1500 °C and melt. However, a low vacuum keeps the foil mirrors in their concave shape, and releasing this defocuses the sunlight, preventing a solar-chip meltdown.

Tests of an 18-mirror prototype

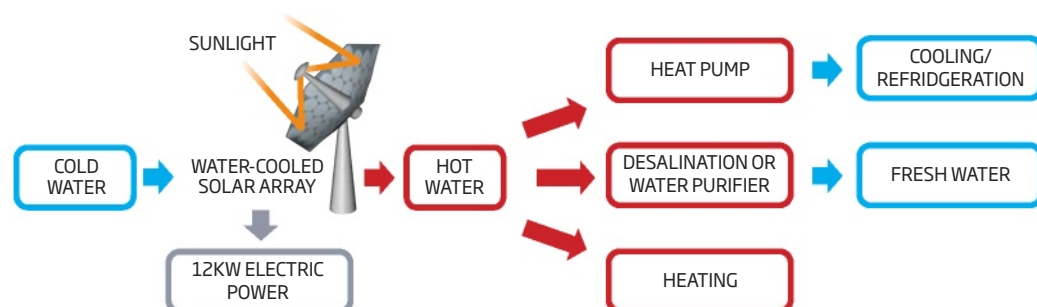
have shown that on solar energy conversion, the Sunflower is 30 per cent efficient, and on heat, 50 per cent, Airlight says. The final 36-mirror Sunflower (illustrated above) should be able to provide 12 kilowatts of electricity and 20 kilowatts of heat from 10 hours of sun. The firm is also looking at how to store the energy created, including using rocks to store it as heat so that it can be tapped when needed.

Airlight is planning to field test the dish in seven remote sites, likely to be in Morocco and India, in early 2016, before the product proper goes on the market in 2017.

Sunflower will need support, warns Erik Harvey, who coordinates global programmes such as borehole well provision at the London-based charity Water Aid. “Inventions like these create dependencies on supplies of spare parts, skills and consumables. Without a supply chain to provide those things the technology might not be sustainable once it is in place.” Airlight says the Sunflower’s design means it should need minimal maintenance. ■

The all-in-one machine

Sunflower turns solar energy into electricity and heat, and produces clean drinking water in the process



Watson explores heart mysteries

The *Jeopardy*-winning supercomputer is being used to assess the risk of having a fatal disease

Paul Marks

SUDDEN cardiac arrests kill someone every 5 seconds. Now the fact-finding power of Watson, IBM's *Jeopardy*-winning supercomputer, is being harnessed to help assess the genetic risk behind the condition.

Unlike a heart attack, which happens because of a blockage in blood flow to the heart muscle, sudden cardiac arrest can be caused by combinations of hard-to-predict factors, including irregular electrical disturbances that upset heart rhythm, genetic factors and the side effects of drugs. So it can appear to strike out of nowhere.

"Very often," says Matthias Reumann at IBM's research lab in Zurich, Switzerland, "the first symptom of sudden cardiac arrest is death."

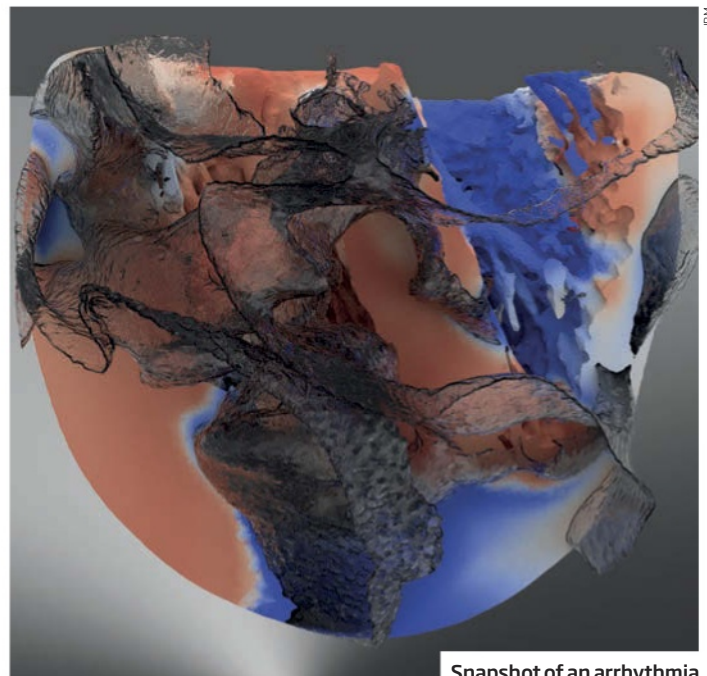
So he and his colleagues at the Lawrence Livermore National Laboratory in California and the University of Rochester in New

York have turned to supercomputers to help them identify the risk factors leading to fatal arrhythmia. Their algorithms use CT and MRI scans to create detailed 3D computer models of the heart. The simulations mimic

"Sudden cardiac arrest can appear to strike out of nowhere. Very often, the first symptom is death"

the electrical and mechanical behaviour of a beating heart down to the level of cells – allowing the team to recreate the conditions that cause problems. It lets them simulate what happens when you add drugs to the heart cells.

But a crucial component has been missing: genetics. No matter how good the graphics produced by the lab's IBM Sequoia supercomputer, if a patient's background genetic susceptibility to sudden cardiac arrest is not factored in, the risk prediction could be way off.



Snapshot of an arrhythmia

US oncologists are already using Watson to help them personalise cancer treatment, so Reumann knew where to turn for help. Watson is now mining the medical literature to look for interactions between specific genes that humans could never spot, but which could help us understand how they contribute to sudden cardiac arrest. These findings will then be plugged back into the 3D model to see what effect they have.

Ultimately, the plan is to be able to use scans of a heart,

recordings of its electrical activity, and gene sequence data, to predict someone's risk of sudden cardiac arrest. If they are at risk, they could be prescribed antiarrhythmic drugs, for example.

Andrew Grace at Papworth Hospital in Cambridge, UK, who studies how genes affect heart arrhythmias, says the strong genetic component in sudden cardiac arrest makes Watson's contribution valuable. "Whether you are going to drop dead or not is in your genes," he says. ■

Digital flip book exposes our changing world

PHOTOGRAPHS may freeze a moment in time, but our world never stops changing. Now a system called Scene Chronology can use photos from across the internet to create a video that shows this change in action.

Kevin Matzen and Noah Snavely from Cornell University in Ithaca, New York, created a 3D model of Times Square in New York City and the



Face of change

Akihabara district of Tokyo. Their system then overlaid the models with millions of photos taken between 2011 and 2013 that were automatically pulled in from sites across the web, including photo-sharing website Flickr. The resulting time-lapse videos show billboards and signs winking in and out of existence.

They applied the same technique to 5 Pointz, an old factory building in New York City (pictured), famous for being a graffiti Mecca. Using photos taken over the same period, their model of the building captures artwork in context that would otherwise be lost.

Snavely says Scene Chronology can preserve our cultural heritage. "Our method can help automatically document what art existed, when, and where, as a way of virtually preserving and exploring that site." The pair exhibited the technique at the European Conference on Computer Vision in Zurich, Switzerland, last month.

Eventually they want to apply the idea across more cities and investigate how artistic styles change over time. It could also capture the deterioration of infrastructure, says Matzen. Hal Hodson ■

The strangers who do your choosing for you

WHAT do you fancy doing tonight? Just ask a bunch of strangers.

Online firms like Netflix and Amazon use algorithms to try to second-guess our desires. Now a team of researchers is bringing people back into the equation, using crowds of online workers to find your fancy.

Netflix-like algorithms work well when they have large amounts of data to learn from, but they fall down when asked to divine human preferences about sets of objects that are either very niche, personal or in flux.

That's not a problem for humans, so Peter Organisciak at the University of Illinois at Urbana-Champaign and his team wondered if crowdsourcing could work out what we like with very little data to work with. To do so, they hired crowdsourcing workers on Mechanical Turk to make personal recommendations.

To test it, they took 100 different salt and pepper shakers from Amazon's online store – some sleek and silver, some modelled after gnomes – and 100 photos of different types of meals from popular restaurants in Boston and San Francisco. The workers were presented with some of the shakers and meals and asked to give each one a suitability rating out of five for a target person. The only information these human recommendation engines, which Organisciak calls

“taste grokkers”, had to go on was a small sample of the individual's actual taste in shakers and food. They did well. The average rating from the top three recommenders matched the target person's own ratings to within half a star. The results will be presented at the Conference on

“Crowdsourcing opinions on your 2000 holiday snaps could help you cull them to 50 for Facebook”

Human Computation & Crowdsourcing in Pittsburgh in November.

Organisciak says that using crowds rather than algorithms to determine preference is useful in personal data sets for which training an algorithm is impossible – identifying the best photographs from a large personal collection, for instance.

“When you come back from vacation with 2000 photos it's fun looking through them, but the whole task of culling it down to 50 for Facebook or 200 to show your family can be tiresome,” he says. Paying a few dollars to crowdsource human opinion could remove that pain.

Anand Kulkarni, CEO of crowdsourcing firm LeadGenius, says the technique is a great way to give people their own “personal shopper” on the internet. Hal Hodson ■



Which is best?

ONE PER CENT



You're going to wear *that* to the toilet?

“OK Glass, I'm going to the loo.” To prevent a wearable device like Google Glass from catching people on camera during a private moment, a team at the University of North Carolina in Charlotte taught smartphones to automatically detect when the user had entered a restroom. The phone's microphone searches for sounds that are similar to other bathrooms, like echoes from tiled floors, and shuts down a device's picture or video apps. It was presented earlier this month at the International Symposium on Wearable Computers in Seattle.

31,000

The number of invite requests per hour that new social network Ello claims it received on last week's launch. It says it won't sell user data to advertisers

From the mouths of robo-babes

A robot with artificial vocal cords resembling those of a 6-month-old child has been created. Lingua, developed by Nobutsuna Endo and his team at Osaka University, Japan, can only produce baby-like bumbles with its robot voice box and moulded silicon tongue. The team is working on giving it the ability to shape its lips and produce vowels and consonants, in a bid to produce increasingly human-like speech.

Computers that “melt” after use

A vanishing computer? Just add water. New biodegradable circuit boards made from cellulose gum make it possible to build a computing system that is less damaging to the environment when discarded. John Rogers and his team at the University of Illinois at Urbana-Champaign made a printed circuit board that measures temperature for 24 hours, reporting its readings wirelessly. The circuit disintegrates after 10 minutes in water, leaving only traces of relatively safe metals behind (*Advanced Materials*, doi.org/v29).

INSIGHT 3D printing



Time to talk shop

Streets ahead

3D printing's future will be in shops, not homes, says **Aviva Rutkin**

IF YOU print it, they will come. Last summer, two surfers wanted to film themselves in the waves, so they headed over to The UPS Store. The guys asked the store to 3D-print a prototype of their idea – a gizmo that lets you hold a camera in your mouth. Now their MyGo Mouth Mount is sold at surf shops around the country.

At the time, that store in San Diego, California, was part of a pilot project, one of only six UPS stores in the US that offered 3D printing. Last week, the company announced that it had been a success and plans to put printers in 100 more US stores. It's an intriguing move for a company that is generally known for shipping packages. Daniel Remba, small business technology leader at UPS, says the firm hadn't considered 3D printing until a survey suggested that customers were clamouring for it.

"They told us that 3D printing was something they thought would be helpful for their businesses, but they didn't want to invest in printers or didn't have the capital to do it," Remba says. "We wanted to make all that stuff convenient."

UPS isn't the only big name adding 3D printing to its bag of tricks. Staples

is testing printers out at stores in New York and Los Angeles, and Amazon now offers customised trinkets like toys and jewellery. 3D printing shops are popping up in London too. Even some public libraries have started putting machines in. Is printing about to make the leap from niche tool to popular hobby?

"It's reached a point where we're really starting to see its wide applicability of use," says Michael Chui at consulting firm McKinsey Global

"3D-printing experts will embed electronics, make unusual shapes or mix materials on demand"

Institute, which last year identified 3D printing as a technology likely to transform society in the next 10 years.

But the industry has yet to come up with a compelling reason for people to buy their own 3D printers. It is usually cheaper and easier to purchase what you are looking for than it is to print it yourself. The machines can be difficult to use and if there isn't a template out there for the object you want, you might have to design it yourself, which is tricky for an untrained user.

"3D printing is only good to produce objects that are really one-offs," says Matt Ratto of the University of Toronto in Canada. "You don't want it to reproduce industrial goods. What you want it for is to produce things that are really custom."

Services like the one UPS offers may represent a happy medium. Those who know how printing works can quickly make the item they need, without having to invest time and effort in their own machine. Those who don't can talk to a professional, who will walk them through the design and printing process. It makes sense when you consider what the printers are most useful for: ideas like the MyGo Mouth Mount, what-ifs in search of a fast track to reality.

As 3D printers become more powerful and widely available, there will be greater demand for people who know how to use them, says Ryan Schmidt of design company Autodesk Research in Toronto. He envisages experts who can embed electronics, make unusual shapes or mix materials on demand. "Maybe there will be thousands of people whose job is just to talk to people and do custom design," he says. ■

Lip-reading computers unlock with a word

READ my lips. We might log on to future computers simply by having them watch our mouths as we speak, because the way our lips move can identify us, akin to a fingerprint.

Ahmad Hassanat at the University of Mu'tah in Jordan trained software to look for patterns of lip and mouth movements associated with different words as people spoke to a camera – how much of the teeth were showing in any given video frame, for example. From mouth movements alone, the system correctly identified the words being said nearly 80 per cent of the time.

Hassanat also found that every person moved their lips a little differently when they spoke. While this meant the lip-reading accuracy level is too low to be useful yet, it could mean that one day a "visual password" could work as a form of biometric security (*International Journal of Sciences: Basic and Applied Research*, vol 13, no 1).

Even the best actor would find it impossible to exactly duplicate someone else's lip movements, Hassanat claims.

Stephen Cox at the University of East Anglia, UK, warns that such a system may run into similar problems as face recognition: bad lighting or new facial hair could trip it up. Jesse Emspak ■



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APERTURE

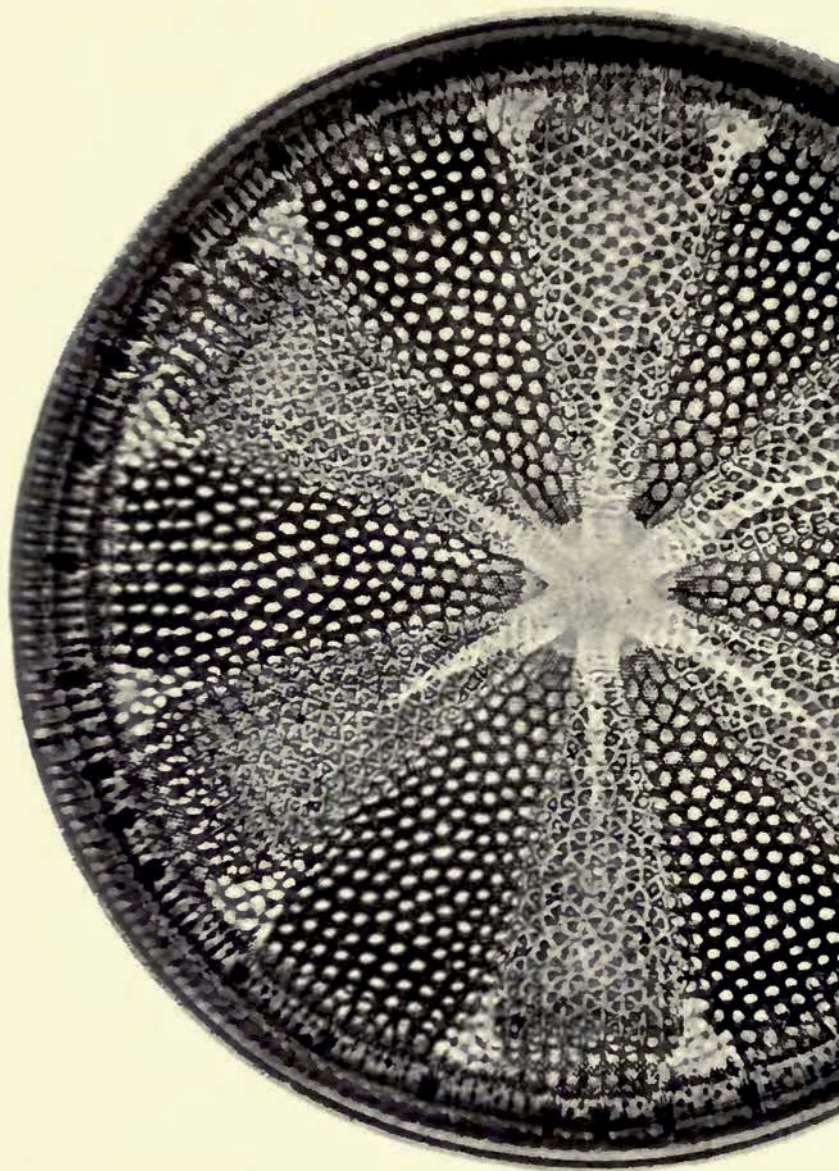
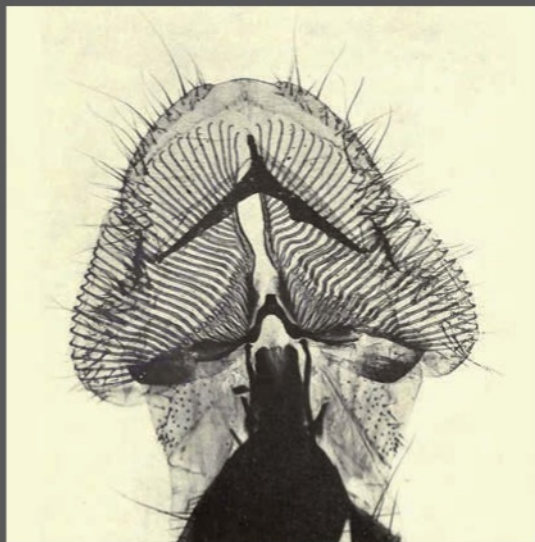
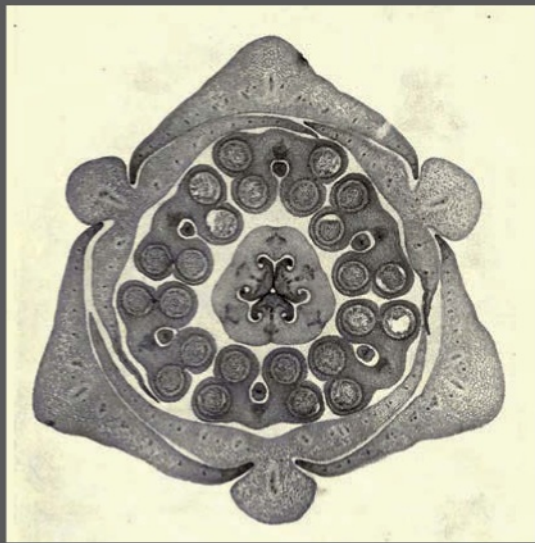
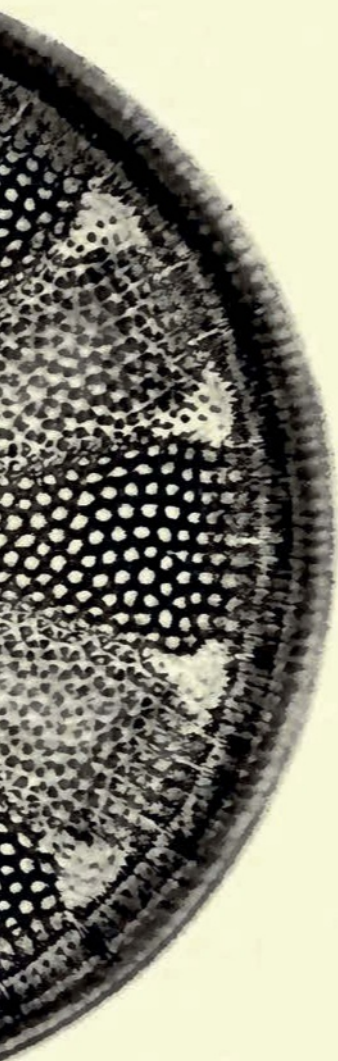


FIG. 3.
DIATOM, HELIOPELTA METII.
× 350.



[to face p. 7.

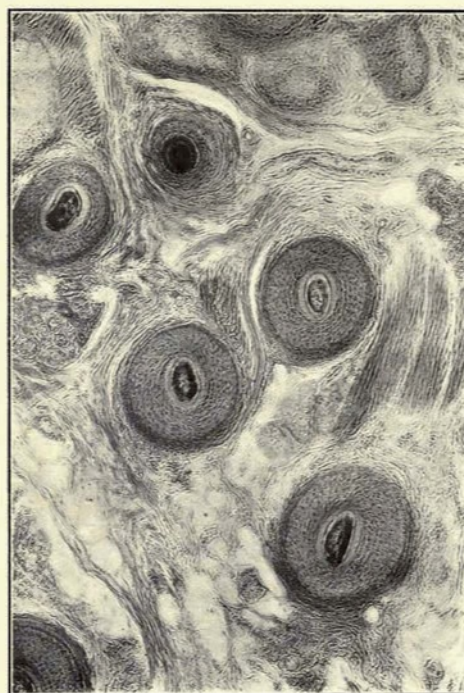


FIG. 46.
TRANSVERSE SECTION OF HUMAN SCALP.
X 100.

[to face page 149.



FIG. 52.
HUMAN TOOTH, VERTICAL SECTION.
X 8.

[to face page 157.

Micro slices of life

In 1904, the Royal Society in London exhibited an extraordinary collection of photographs - or more correctly, photomicrographs. The public had never seen anything like it: photographs taken through a microscope, revealing a startling, previously unknown world. The photographer was Arthur E. Smith, of whom little is now known except for the elaborate equipment he used (see image, below), and that in 1909 he contributed images to a book, *Nature Through Microscope & Camera*.

From top to bottom, left to right, the images show: the cross section of a lily bud; the proboscis of a blowfly; a sheep tick; a diatom; a section through the human scalp; and a vertical section through a human tooth.

Incidentally, the author of the introduction to that 1909 book was an anti-Darwinian. He notes the exquisite form and wondrous beauty captured in Smith's photographs, then asks: "Can we believe that behind all this design there is no great designer - that, in fact, this is not the very 'garment of God'?"

"Garment of God" is a wonderful phrase - it makes me think of a supernatural fashion designer. But, of course, there is no need to invoke any such magical being to explain evolution. Rowan Hooper

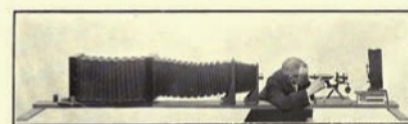


FIG. 7.
MR. SMITH FOCUSING THE OBJECT IN THE MICROSCOPE.

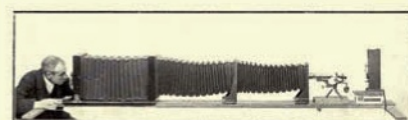


FIG. 8.
MR. SMITH FOCUSING ON THE CAMERA SCREEN.

[to face page 157.

Photographer

Arthur E. Smith

Nature Through Microscope & Camera

Turbocharge our plants

A long-awaited breakthrough by crop scientists raises some thorny issues for conservation. **Michael Le Page** proposes a radical solution

PLANTS are badly out of date. They gained their photosynthetic machinery in one fell swoop a billion years ago, by enslaving bacteria that had the ability to convert sunlight into chemical energy. Plants went on to conquer the land and green the earth, but they also became victims of their own early success. Their enslaved cyanobacteria have had little scope to evolve, meaning plants can struggle to cope as the atmosphere changes.

The free-living relatives of those bacteria, however, have been able to evolve unfettered. Their photosynthetic machinery is faster and more efficient, allowing them to capture more of the sun's energy.

Scientists have long dreamed of upgrading crop plants with the better photosynthetic machinery of free-living cyanobacteria. Until recently all attempts had failed, but now they've taken a huge step forward.

A joint team from Cornell University in New York and Rothamsted Research in the UK has successfully replaced a key enzyme in tobacco plants with a faster version from a cyanobacterium (*Nature*, vol 513, p 547). Their success promises huge gains in agricultural productivity – but is likely to become controversial as people wake up to the implications.

The enzyme in question is called RuBisCo, which catalyses the reaction that “fixes” carbon dioxide from the air to make into sugars. It is the most important enzyme in the world – almost all living things rely on it for food. But



it is incredibly slow, catalysing only about three reactions per second. A typical enzyme gets through tens of thousands. It is also wasteful. RuBisCo evolved at a time when the atmosphere was rich in CO₂ but devoid of oxygen. Now there's lots of oxygen and relatively little CO₂, and RuBisCo has a habit of mistaking oxygen for CO₂, which wastes large amounts of energy.

Its inefficiency is the main factor limiting how much of the sun's energy plants can capture. The version found in most plants has become better at identifying CO₂, but at the cost of making it even slower. Meanwhile, free cyanobacteria found a way to concentrate CO₂ around

RuBisCo, so that they could keep the faster version.

Hence the desire to upgrade crop plants by adding cyanobacterial machinery, which could boost yields by about 25 per cent (*New Scientist*, 22 February 2011, p 42). What's more, such plants will need less water, because they don't need to keep their pores open as much, meaning they can better retain moisture.

That is what the Cornell and Rothamsted collaboration is working towards. They are not

“Crops with turbocharged photosynthesis will be growing in our fields in a few decades”

there quite yet: a few more parts of the cyanobacterial system need to be transferred for their plants to take full advantage. But the work is a massive step forward.

It now seems certain that supercrops with “turbocharged photosynthesis” will be growing in our fields in a few decades, if not sooner. This seems like great news in a world where demand for food, biofuels and plant materials like cotton continues to increase, and where global warming will have an ever greater impact on crop production. More productive plants means greater yields.

But there is a danger too. Critics of genetic modification have long argued that GM crops will spread in the wild, or that their modified genes will “pollute” wild relatives, with disastrous effects. So far these fears seem exaggerated. There are monster plants running rampant through many countries, but they are not GM creations – they are invasive species.

This is not surprising: most GM traits are not useful to wild plants. A trait such as herbicide resistance is only useful to plants growing in areas where herbicides are used, such as in fields and road verges.

Upgrading photosynthesis is a different story. If biologists succeed in boosting it by 25 per cent or more, the upgraded plants are going to have a big advantage over their unmodified cousins. And that could spell trouble.

There is a precedent. About 30 million years ago some plants evolved a way to concentrate CO₂ like cyanobacteria do. These are called C₄ plants, and although they make up only 4 per cent of

plant species, they account for 25 per cent of plant biomass. Look out over a grassy savannah and just about every living thing you see will be a C4 plant.

If we fill our fields with supercrops and plant forests of supertrees it seems inevitable that they will turn feral and, like C4 plants before them, come to dominate some ecosystems – though it might take millennia. That prospect will horrify many. When anti-GM campaigners start protesting against the introduction of turbocharged crops, they will have a point: the wisdom of growing superplants in open fields is definitely debatable.

But the arguments in favour – boosting agricultural yield to feed more people with less land while also sucking more CO₂ out of the atmosphere – are also powerful. And there's another side to it. Wild animals need to eat too, and we're not leaving much for them. An ecosystem based on superplants would support more life overall.

If society decided to go ahead, another choice would almost certainly come up. We could just stand by and let boosted grains, vegetables and trees run wild, possibly driving some other plant species to extinction. Or we could level the playing field by upgrading many wild plants too.

This may seem like a shocking idea. But the reality is that we are way, way past the point where we can preserve Earth the way it was before we came to the fore.

We are already well into the Anthropocene. The areas we think of as wild and untouched are nothing like they were before our ancestors arrived. The apples and bananas we feast on are much-mutated monsters compared with their wild relatives.

If we are going to reshape plants so that they can make more food, why not do it in a way that benefits most life on Earth, not just us humans? ■

Michael Le Page is a features editor at *New Scientist*

ONE MINUTE INTERVIEW

A novel take on forensics

Her bestselling fiction is steeped in forensic science, but it's true stories that really inspire crime novelist **Val McDermid**



PROFILE

Val McDermid is a Scottish crime writer who has penned more than 30 novels. To coincide with a new Wellcome Trust exhibition, she has written a non-fiction book on the history of forensic science, *Forensics: The Anatomy of a Crime* (Profile Books)

How has forensic science influenced your writing up until now?

It helps me to anchor my books in the real world. Everybody knows crimes don't get solved the way we write about them in crime fiction; it's not one grumpy inspector and a sergeant buying the pints. But anything I can do to bolster your suspension of disbelief is valuable. If I tell you the truth about the science, it helps make you think I must be telling the truth about all the stuff I'm making up.

Where do your story ideas come from?

It's things that make me go "wow". For instance, I once rang up the forensic anthropologist Sue Black at the University of Dundee because I wanted to know what your tattoos would look like if you'd been submerged in a bog for 200 years. She said that when you get a tattoo, the nearest lymph nodes take up the ink. It occurred to me that if the tattoo was made after death, there wouldn't be any staining on the lymph nodes: I had a starting point for a novella. I snap up trifles like that. It's the same thing that makes me good at pub quizzes.

How much scientific research do you do for your novels?

It depends on the book. I might just ring up a forensics specialist and say: "I want this piece of evidence to lead to this; how do I do it?" Very often the stuff that really works comes in at tangents – the conversation leads to something much more interesting. In general, the scientists are just delighted that anyone is interested in their work.

Were you surprised by anything you learned while researching your new non-fiction book?

Over the years I've spent a lot of time with people who do this for real, so I have a pretty good idea of how completely unlike *CSI* or *Silent Witness* it is. But the truth is often stranger than fiction. For instance, I interviewed a researcher who investigates the synthesis of illegal drugs. She told me that at any given time, she's got a cupboard full of crystal meth. At one point she had her PhD students going out to buy decongestants for the raw ingredients to make it.

Crime novelists and screenwriters have been blamed for giving jurors unrealistic ideas of forensic evidence. Is that a fair criticism?

I think it happens, though it surprises me that people are that naive. I suppose that when evidence is presented week after week with an aura of scientific certainty, it does have an effect. You could argue that we should take more responsibility, but it is entertainment.

By and large, I try to be pretty accurate in how I write about the science. But sometimes you do need to make changes for dramatic necessity – for instance, squeezing a test that would take three weeks into two days. That's the area where we mostly fall down – compressing time frames.

Will your new book change people's views?

I hope readers take away a greater understanding of the science, as well as an appreciation of the integrity and commitment of the kind of people who do this work. What they do is just as important to the living as it is to the dead.

Interview by Linda Geddes

Testosterone overload

A surplus of men leads to violence, right? It depends on how you look at it, say anthropologists **Ryan Schacht**, **Kristin Rauch** and **Monique Borgerhoff Mulder**

IN ASIA there are 100 million more men than women and this excess of men, particularly in China, has led to fears of “macho militarism and imperialism”. These concerns portray a violent, socially unstable world, caused by a glut of testosterone-driven, unmarried men. But although it is generally true that men are more violence-prone than women, does it follow that an abundance of men will cause an abundance of violence?

Claims of “more men, more violence” come primarily from two scholarly traditions. From a biological perspective, male violence results from antagonistic competition over mates, which intensifies when partners are rare. Sociologists typically argue that violence increases when the sex ratio is male-biased because of the large pool of unmarried men (the group most prone to violence). But what does the evidence say?

In a 2014 review of the research on violence in different societies, we found that violence was equally likely to be associated with extra women as with extra men (*Trends in Ecology & Evolution*, vol 29, p 214). Out of 20 studies, nine showed violence increasing with more

men, but nine showed the opposite. Two were inconclusive.

Why the conflicting evidence? Clearly, the expectation of a straightforward relationship between violence and the sex ratio is overly simplistic. It stems from beliefs about innate sex differences in predilections for violence and responses to sexual frustration. Breaking free of such restrictive thinking allows us to see the possible reasons for the inconsistent relationship between sex ratios and violence in the scientific literature.

What alternatives do men have when there aren't enough women? Some insight can be gleaned from “mating market models”. In these models, based on the principle of supply and demand, the rarer sex has more bargaining power in the marketplace. If not pleased with the terms of the relationship, they have little trouble going elsewhere. But the more abundant gender has few options, and therefore must cater to the preferences of the rarer gender. Mating market logic predicts that when there are extra women, men have the upper hand – behaving promiscuously, offering little parental investment, and yet

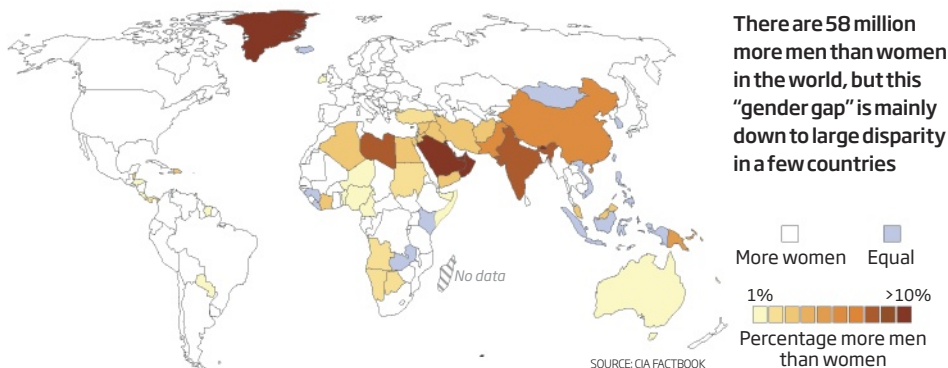
PROFILE

Ryan Schacht is an anthropologist at the University of Utah in Salt Lake City. Kristin Rauch and Monique Borgerhoff Mulder are anthropologists at the University of California, Davis. They specialise in human behavioural ecology



still being able to obtain partners. On the other hand, when women are in short supply, men will find that marriage and a commitment to family are necessary to attain mating opportunities. In this situation, the best strategy for the average man is to secure and maintain a single partner.

There is substantial support for these expectations. In general, in many different societies around the world, male-biased sex ratios are associated with a greater proportion of men being married, less promiscuity in both sexes, greater marital stability, higher rates of paternal involvement, and lower rates of female-headed households and out-of-wedlock births. These findings directly contradict many alarmist predictions about the hazards of too many men. Rather than becoming ever more violent when faced with a deficit of women, men can engage in much more positive social behaviour to attract and keep a partner. This alternative strategy could





as commonly happens in the US, might actually be contributing to higher rates of violence in society. The resulting shortages of men in the communities they come from reduces rates of monogamy, marriage, family stability and paternal involvement in parenting. Rash reactions to the recent shocking rape cases in India blame “too many men”, but evidence for this relationship is lacking – and jumping to such conclusions could obscure other, more influential, causes.

Finally, we turn to China, the country of key concern when it comes to rising sex ratios and social unrest. A common narrative is that the growing number of bachelors might form gangs of violent, unattached men who will threaten China’s stability. This does indeed sound frightening. Fortunately these claims

“These concerns portray a violent world, driven by a glut of unmarried men”

are based largely on historical accounts about marauding groups of males and intuitive arguments, rather than on data. There is evidence that rates of some types of crime are higher in the more male-biased provinces. However, in an evaluation of the current state of “maleness” and violence in China, Susan Greenhalgh, a Harvard University anthropologist specialising in Chinese society, argues that the very government programmes seeking to limit violence there may only be intensifying it. Bachelors from poor, rural communities are socially marginalised and the state limits their marriage options.

In this way, government policies may be producing the very group of unmarried, violent men that they are trying to eliminate.

The belief that violence and crime increase in human populations with an excess of men is overly simplistic. Cross-national evidence consistently shows that rates of rape, sexual assault and male-on-male homicide are greatest when men are rare, not abundant. Of course, that doesn’t necessarily mean “more women, more violence” either.

Many factors complicate the relationship between sex ratios and violence, including unique cultural and historical influences. To better understand the causes of violence, it is important to be specific about different forms of it, and to be sensitive to the different ways in which people can respond to partner availability, otherwise we will miss the patterns that can allow us to create appropriate intervention programmes. ■

be one reason why the results of research on sex ratios and violence are inconsistent.

Another reason for inconsistent findings could be vague concepts of “violence”. If we are interested in the role that imbalanced sex ratios play in this, then we need to look at specific forms of violence. When we move away from vague notions, we find evidence that specific acts are associated with an overabundance of one gender or the other.

Courting and catering

In general, there are higher rates of men killing men and sexual assault in female-biased sex ratios. Perhaps this is because when women are abundant, men compete directly with one another in an aggressive pursuit of multiple sexual partners. Rates of intimate-partner violence by men (both assault and homicide) are higher in male-biased sex ratios. This might reflect attempts to control

and guard a mate from potential competitors.

These findings show how men might adopt different behavioural strategies in response to a shortage of women, from antagonistic competition with other men to courting and catering to the desires of scarce women.

This is important, because a better understanding of these dynamics can help shape policies and interventions. For example, researchers have suggested that female-biased sex ratios in classrooms could reduce bullying. The cartoon version of the argument is that boys bully other boys, and so fewer boys means less bullying. But this policy recommendation is based on intuitive arguments, not data. Although well-intentioned, this suggestion could exacerbate the problem if, for example, it means there is a larger audience of girls for boys to perform in front of.

Another example is “tough on crime” policies. Incarcerating large numbers of men for non-violent offences such as drug crimes,

BRUCE GILDEN/MAGNUM PHOTOS

"Finding an alternative to bank finance was our recipe for success"

Timo Schmidt, CEO of Gousto



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Ebola and bushmeat

From Simon Pooley, John E. Fa and Robert Nasi

Tennyson Williams suggests it would be opportune to use the current Ebola crisis to convince governments in the affected region to ban the consumption and smuggling of wildlife (6 September, p 26).

We fear that in a time when “paranoia and uncertainty... drive behaviours reminiscent of those during the Black Death”, as Williams states, identifying bats, chimpanzees and other species as primary sources of this terrible scourge could trigger attempts to eradicate these animals.

It also smacks of hypocrisy to ask these African governments to forbid the use of local natural resources in this way. By analogy, following the spread in the UK of BSE – aka mad cow disease – should British citizens have given up eating and trading beef once and for all?

This is not to downplay the serious impact of the eating of bushmeat on wildlife in tropical regions. To maintain clarity over which behaviours threaten wild animals and which do not, however, it is preferable to avoid lumping all domestic consumption of indigenous fauna under the term “bushmeat”. This will also help us avoid foisting culturally specific moral imperatives on others from different cultural backgrounds and economic circumstances.

We agree with Williams that an answer to reducing the threat to vulnerable wildlife in the region, and possibly also the wider spread of Ebola, is stopping the illegal trade in wildlife – dead or alive. This seems a more equitable approach to addressing a culturally divisive issue: the consumption of indigenous wild animals in developing countries.

Using the Ebola epidemic as a Trojan horse for conservation leads to unfortunate associations with that long outdated discourse

of conservation which favours wildlife over people. Ascot, Berkshire, UK

Research wrongs

From Willem Windig

Richard Smith argues that research misconduct degrades trust in scientists and causes real-world harm (13 September, p 27).

The term “peer review” is generally interpreted as the review of manuscripts for journals. However, an important



goal of scientific papers is to give other scientists the opportunity to reproduce the results – or not.

When there are serious problems, blogs, letters to scientific magazines and the press will make this known. This is also peer review. As far as I know, most, if not all, scientific misconduct is reported and corrected from within its own community, something that rarely happens in other areas. Peer review is a great achievement of the scientific community and should be recognised as such.

The problem is that when a faulty paper is published, such as Andrew Wakefield’s linking of the MMR vaccine to autism, it is promoted by people without any scientific background, who most likely did not even read the paper, never mind the many papers that debunked it.

So who causes most of the “real-world harm”? The self-correcting scientific community, or the

scientifically illiterate celebrities and politicians who promote bad research?

Rochester, New York, US

From Joseph Doran

Smith asserts that universities and other employers of researchers are not very good at gathering and weighing evidence. Since this seems to be a good part of the scientific method, perhaps that is why these institutions so often produce the dodgy papers that he is concerned about.

Spring, Texas, US

National records

From Stephen Durnford

Reading Debora MacKenzie’s valuable article examining nation states, two questions struck me immediately concerning my own field, the literate bureaucracies of the Bronze Age (6 September, p 30).

It has long been believed that writing had its origin in the need for bookkeeping in ancient, palace-centred cultures, and the Linear B tablets – inscribed by Mycenaeans some 3500 years ago – do show central bureaucracy active right down to recording the names of individual cows in a pasture. Did the government spawn the bureaucracy, and the bureaucracy the script, or was it some other way round?

The second question is whether we now tend to project the modern concept of the nation state back upon those ancient polities, depicting them as such on maps and in analysing their history. We seem to do so, and this mirage view of the past appears to add weight to modern conflicts based on supposed entitlement to land, be it in the Levant or across the Aegean.

Saltdean, UK

From Dieter Gold

The mention of Sudetenland in MacKenzie’s article struck me personally since my family comes from this area, and I was born in a

part that now falls inside Poland.

The history of relationships between linguistic groups in this region is a striking example of how a political preference for one group over others creates tensions and conflicts. When Hitler invaded, the Czechs and Poles suffered much under the Nazi regime, the German-speaking minority less so. As soon as the Reich fell, German speakers faced recriminations.

In Czechoslovakia, the “Beneš decrees” laid the groundwork for the expulsion and punishment of German speakers. Your article states that “the numbers who claimed to be German in the Czech Sudetenland... changed dramatically before and after the war.” That was the result of ethnic cleansing, not a voluntary change of national identity.

Voiron, France

Liquid assets

From Scott Kirwin

Naomi Lubick highlights the issue of crumbling water infrastructure and the ideas being developed to handle it (16 August, p 38). As one of the 16 million households in



the US that relies on a well and septic system, I take issue with the idea that “nothing gets done” regarding well-water quality.

This assumes that people have to be forced by government to drink clean water. Nonsense. Having moved to a rural area five years ago, water supply

became one of our top concerns. When you rely on your own well for water you come to know all aspects of its delivery. Pumping water out of the ground costs money, so we don't waste it. We get sick if it gets colonised by bacteria. We are more aware of above-ground contamination because we know our aquifers are connected to these sources.

Ask a well owner, and he or she will often be able to tell you their water's pH, hardness and flow rate, along with well depth and where the septic tank is, what goes into it and what does not. Well and septic owners have more "skin in the game" regarding water quality than their spoiled urban peers.

We don't need the government taking care of us; we're doing just fine on our own, thank you.
Dobson, North Carolina, US

Nutrients on a plate

From Peter Hogg

Your article on Jupiter's moon Europa makes the point that tectonic plate subduction may deliver nutrients from comets and other sources to possible life forms in the ocean beneath the ice (13 September, p 17). Subduction of the ice could, further, deliver oxygen to the European ocean.

Ultraviolet light and high-energy radiation striking the ice would create free oxygen, some of which may get drawn beneath the surface. Just as life around ocean hydrothermal vents on Earth is dependent on oxygen dissolved in seawater, so life on Europa would need a source of oxygen.

Melbourne, Victoria, Australia

First impressions

From Richard Epworth

Anil Ananthaswamy describes some key differences between the responses of babies' minds and those of adults (23 August, p 40). Yet he seems to take little account of the most profound difference:

a newborn baby knows essentially nothing of what is out there, so must interpret almost everything it senses in real time. We adults,



on the other hand, have spent a lifetime building an idea of what is out there, and so we are already familiar with everything we experience, and need only attend to the differences between what we expect and what we sense.

The difference between these processes is huge, and might easily explain why babies' conscious responses are slower.

Even with drugs or love, as Ananthaswamy says, those who already know the world can never again experience what an open-eyed baby does, nor recall it with the same innocence.

Sawbridgeworth, Hertfordshire, UK

Stranger than fiction

From Gwydion Williams

How appropriate to have an article about the importance of imagination (20 September, p 32) in the same issue as a report that "droplets" the size of Ireland form in the sun's atmosphere and fall the equivalent of one-sixth the distance from Earth to the moon (p 38).

People living at the end of the Stone Age were probably amazed to discover that certain rocks could be heated to produce a fiery liquid that flowed like water but which cooled to produce workable materials. Or that melting copper

and tin together would produce bronze, harder than either.

As the first article said, we need good imaginations to cope with the strangeness of the world.
Coventry, West Midlands, UK

Quirky crystals

From Crispian Strachan

In her article on quasicrystals, Lisa Grossman states that simple tiles with three, four or six sides can tessellate a two-dimensional surface (13 September, p 38).

I wonder if she is familiar with the work of draughtsman and artist M. C. Escher, who made much livelier shapes tessellate, including riders on horseback.
Morpeth, Northumberland, UK

At the pointy end

From Dave Green

Airlines have many more managerial and technical staff than aircraft. To require at least one of the above staff to be physically present on each flight might be sound safety legislation, especially in the context of pilotless planes (9 August, p 30).

They would thus gain a very sharp incentive to ensure that everything possible is done to deliver a safe flight and landing. And their other work needn't suffer: with the expected "continuous" internet access, including telepresence meetings, they will just be in a flying office.
Shrewsbury, UK

Hallelujah spaghetti!

From Craig Gosling

I was amused by the letters from Brian Josephson and Eric Kvaalen concerning anti-afterlife dogma (20 September, p 30). Since when does anyone have to disprove every unfounded claim submitted by science fiction fans?

To do so is like proving false the claim that a Flying Spaghetti

Monster circles Earth and accepts our prayers every time we pay homage by eating spaghetti and meatballs.

Science examines evidence, as published in established peer-reviewed scientific journals. In the absence of evidence, David Silverman and the rest of us have every right to chuckle.
Indianapolis, Indiana, US

Naming neutrons

From John Fuhr

Ron Barnes asks what name might be given to a neutron separated from its spin (30 August, p 31). In the US, where odd baseball terms abound, a neutron without spin might be named a "knuckletron", after the infamous non-spinning pitched ball that curves, dips, wobbles and floats unpredictably.
Downingtown, Pennsylvania, US

From Alan Webb

With regard to naming, how about an "unspun neutron" and a "neutered spin"?
Boulder, Colorado, US

For the record

■ Our article on stopped-light lasers pointed readers in the wrong direction (20 September, p 16): the address for Ortwin Hess's paper is doi.org/v23.

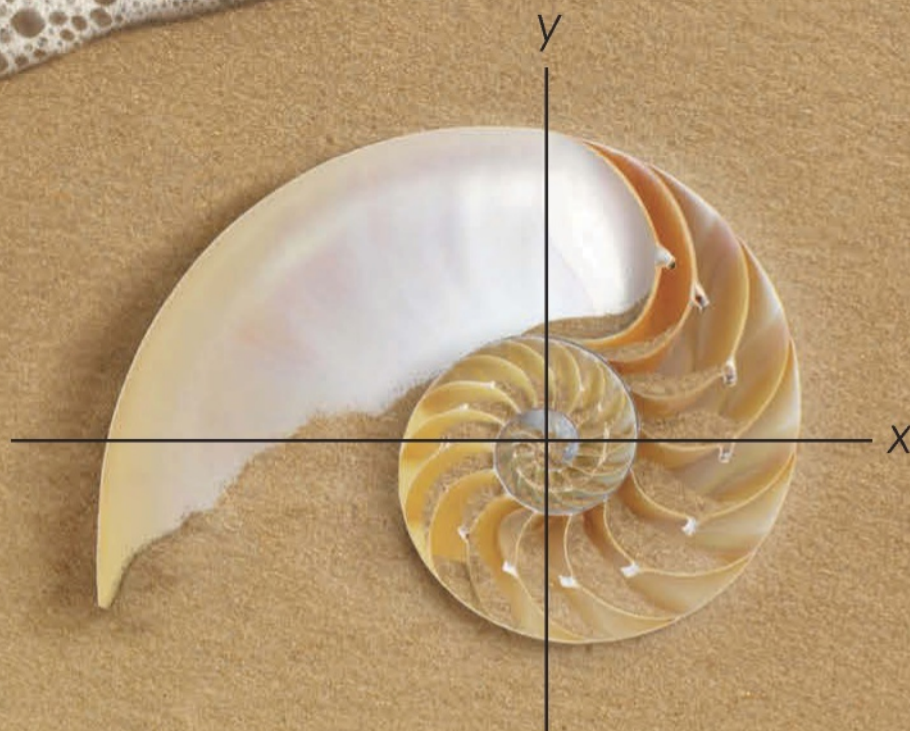
■ Contrary to our report, the eye-testing smartphone kit developed by Smart Vision Labs does not yet have a fixed price (20 September, p 21).

■ We flipped up in our story of the sun's strange behaviour (20 September, p 38). The star's magnetic poles switch places every 11 years or so.

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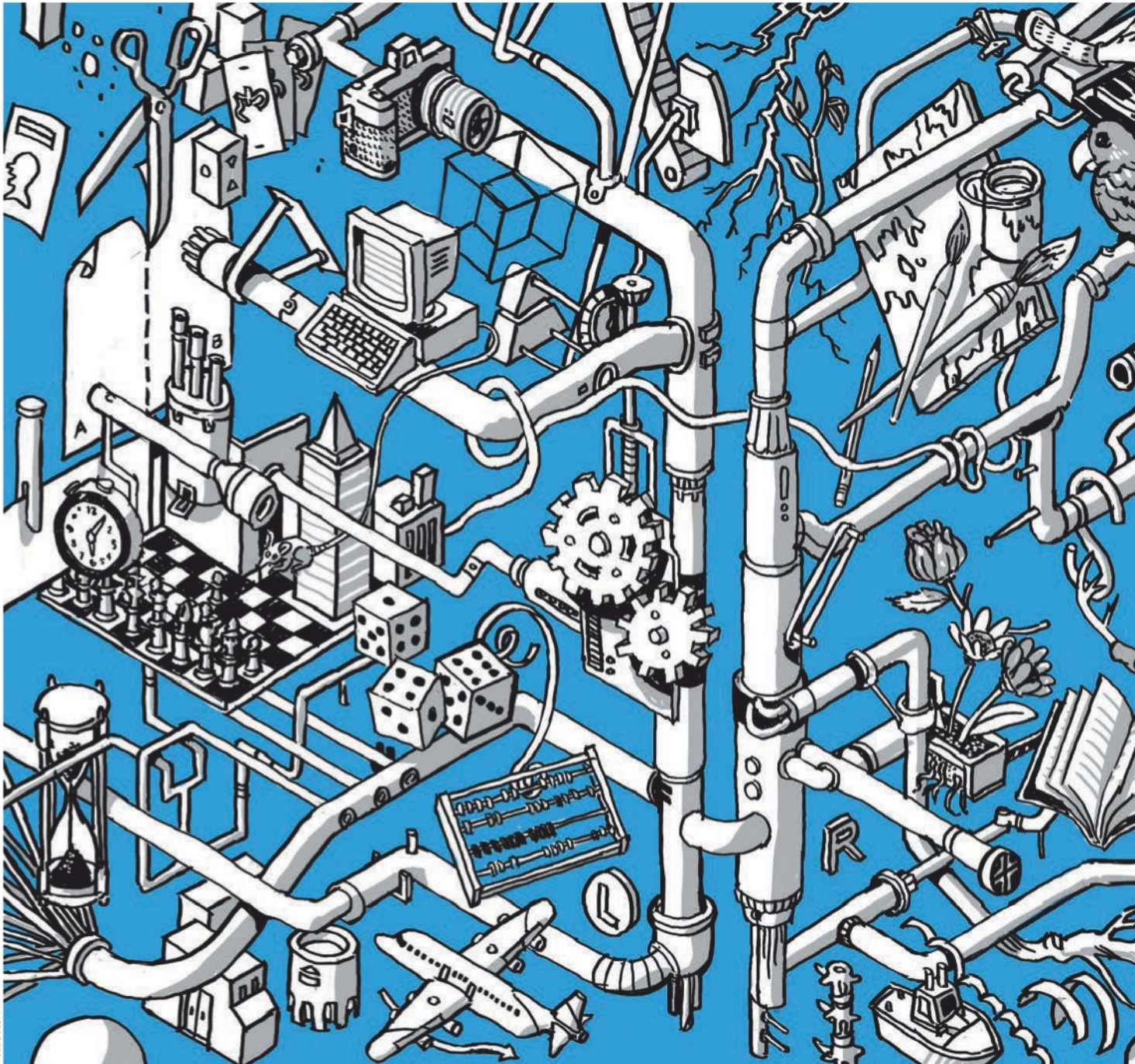
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THE MIND

The human mind is the most complex information processing system we know. It has all sorts of useful design features but also many glitches and weaknesses. The problem is, it doesn't come with a user's manual. You just have to plug and play.

But if anyone knows how to get the best out of our brains, it's neuroscientists. So we asked some of the best to explain how the human brain performs many of its most useful functions and how to use them to the max. **By Caroline Williams**





1 ATTENTION

2 WORKING MEMORY

3 LOGICAL AND RATIONAL THOUGHT

4 LEARNING

5 KNOWLEDGE

6 CREATIVITY

7 INTELLIGENCE

While we wait, the next best option is learning to chill out in exactly the right way. Long-term meditators have been shown to have thicker parts of the brain associated with attention, while other studies have found that attention test scores improved after a short course of meditation. So learning to focus better may be as simple as making time to sit still and focus on not very much. ➤

“Top-down attention is prone to losing focus, or being rudely interrupted”

2 WORKING MEMORY

Like attention, working memory is one of the brain's most crucial front-line functions. Everything you know and remember, whether it's an event, a skill or a fascinating fact, started its journey into storage by going through your working memory.

But working memory is much more than just a clearing house for long-term memories. It has been described as the brain's scratch pad: the place where information is held and manipulated. If you are doing anything that requires effortful, focused thought, you are using your working memory.

In the 1970s, Alan Baddeley and Graham Hitch of the University of York, UK, came up with an influential model to explain how the system works. The main component is the executive controller, which runs the show by focusing your attention on the relevant information.

It also kicks "slave" systems into action. One of these holds up to four pieces of visual information at a time; another can memorise about 2 seconds of sound, especially spoken words, which it loops over and over again (think of mentally repeating a phone number while you search for a pen). The third is the episodic buffer, which adds relevant information from long-term memory.

A weakness of this model is that working memory doesn't occupy a discrete brain area that can be watched in action in a brain scanner. Because of this, some cognitive neuroscientists have suggested that it might not be a separate system at all, but just the part of long term memory that we are currently paying attention to.

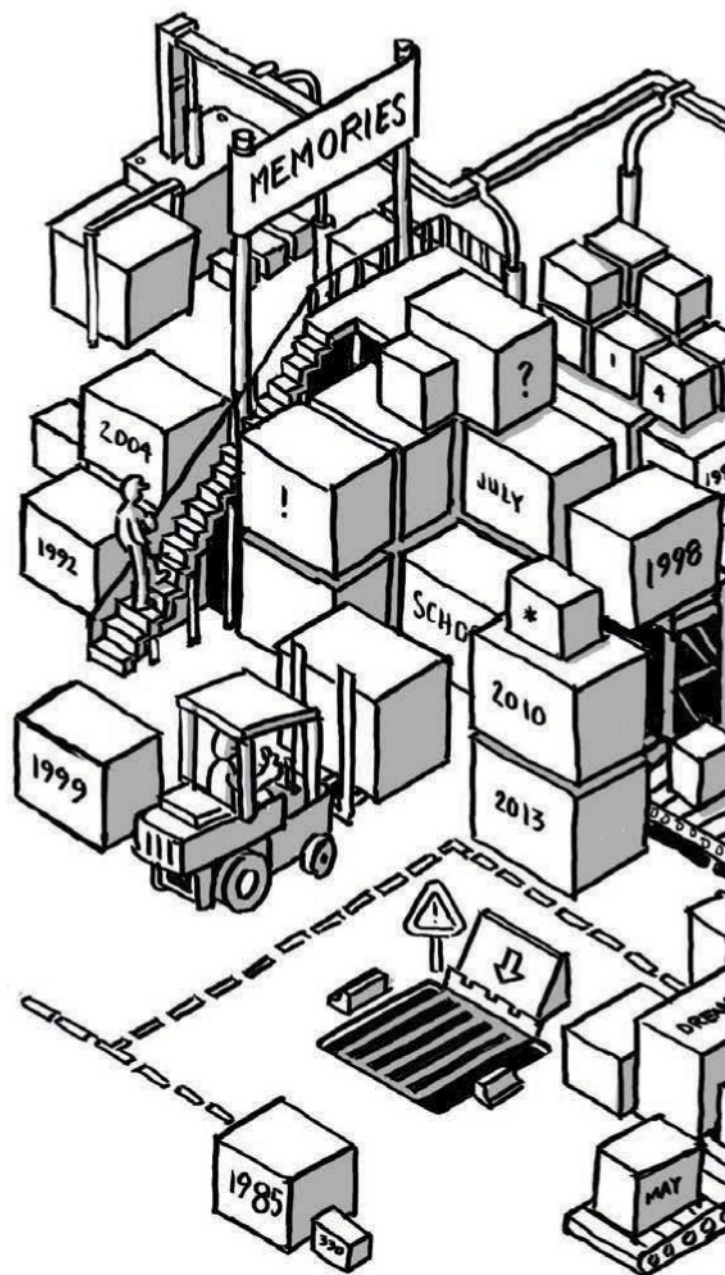
Whatever it is, working memory comes as standard in the human

brain, but some people have better working memories than others. Working memory capacity is a better predictor of academic success than IQ, so getting the most out of it is useful.

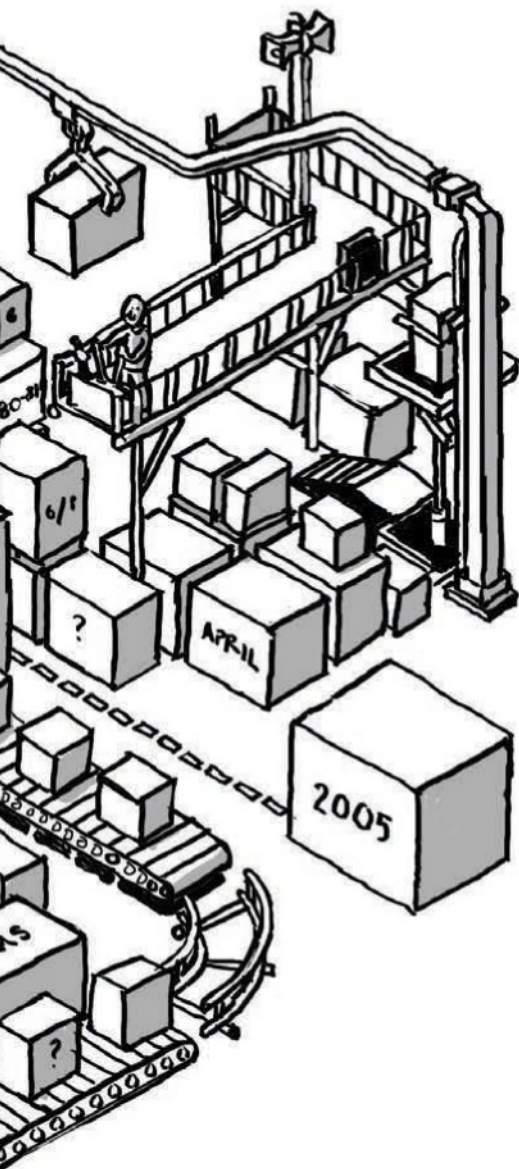
The good news is that the system can probably be upgraded. Some studies have shown that brain training programmes aimed specifically at working memory can produce improvements, and there are even a handful of training packages on the market. But it's not clear whether they make you better at anything other than working memory tests.

Cognitive neuroscientist Jason Chein of Temple University in Philadelphia, Pennsylvania, who studies working memory, says there seems to be evidence of improvements in other cognitive skills, although any changes are quite small. "A small effect may still be important in the sense that even modest gains can have a meaningful impact on everyday cognition," he says.

"Even modest gains in working memory can improve general cognition"



3 LOGICAL AND RATIONAL THOUGHT



We like to think of ourselves as rational and logical creatures. And so we can be - but not without some effort.

Logical thought requires us to behave like a microprocessor, executing stepwise operations on information using the rules of logic. This doesn't come naturally to most people, requiring outside instruction to learn and lengthy training to master. Even then, we struggle to maintain a purely rational perspective.

It turns out that there is a kernel of truth in the popular wisdom that "left brain equals logic". Imaging studies have shown that the left prefrontal cortex is needed to make logical trains of thought happen and, a lot of the time, no input is needed from the right.

But when there is conflict between what seems logical and beliefs we already hold, the right side of the prefrontal cortex kicks in to help sort out the confusion (*Brain Research*, vol 1428, p 24). Unfortunately, the right hemisphere usually wins. Study after study has shown that where new information conflicts with existing beliefs, our brains bend over backwards to keep beliefs intact rather than revise them.

Another surprise is that, contrary to popular wisdom, emotions aren't necessarily the enemy of rationality. People who have damage to the part of the prefrontal cortex that processes emotions struggle to make decisions at all, especially when there is no logical advantage to either option (*Cerebral Cortex*, vol 10, p 295).

So embracing our not-particularly logical gut feelings about decisions might actually help us make more rational choices. But not always: other studies

have shown that strong emotions can interfere with making rational decisions, particularly when they concern people we love.

Other than hard graft - and an appreciation of the role of belief and emotion - is there anything we can do to become more logical?

Vinod Goel, a cognitive psychologist at York University in Toronto, Canada, says that a zap to the head might one day help. "Brain stimulation techniques may eventually offer a route to improving reasoning," he says. His team recently

"There is a kernel of truth in the popular wisdom that left brain equals logic"

used a similar approach to enhance creative thought and, he says, "one can imagine the same techniques being used to enhance our ability for logical reasoning." As yet, though, there is no shortcut. For now, he says, practice is your best option. Recent studies have shown that a few months' training in rational thought, as part of law degree training, increased the number of connections between frontal and parietal lobes and between the two hemispheres (*Frontiers in Neuroanatomy*, vol 6, p 32). The catch is, without regular practice this effect would almost certainly fade a few months after the course ended. ➤

4 LEARNING

Learning is what your brain does naturally. In fact, it has been doing it every waking minute since about a month before you were born. It is the process by which you acquire and store useful (and useless) information and skills. Can you make it more efficient?

The answer lies in what happens physically as we learn. As it processes information, the brain makes and breaks connections, growing and strengthening the synapses that connect neurons to their neighbours, or shrinking them back. When we are actively learning, the making of new connections outweighs the breaking of old ones. Studies in rats have shown that this rewiring process can happen very quickly – within hours of learning a skill such as reaching through a hole to get a food reward. And in some parts of the brain, notably the hippocampus, the brain grows new brain cells as it learns.

But once a circuit is in place, it needs to be used if it is going to stick. This largely comes down to myelination – the process whereby a circuit that is stimulated enough times grows a coat of fatty membrane. This membrane increases conduction speed, making the circuit work more efficiently.

What, then, is the best way to learn things and retain them? The answer won't come as a huge surprise to anyone who has been to school: focus attention, engage working memory and then, a bit later, actively try to recall it.

Alan Baddeley of the University of York, UK, says it is a good idea to test yourself in this way as it causes your brain to strengthen the new connection. He also suggests consciously trying to link new bits of information to what you already know. That makes the connection more stable in the brain and

less likely to waste away through underuse.

The learning process carries on for life, so why is it so much harder to learn when we reach adulthood? The good news is that there seems to be no physiological reason for the slowdown. Instead, it seems to be a lot to do with the fact that we simply spend less time learning new stuff, and when we do, we don't do it with the same potent mix of enthusiasm and attention as the average child.

Part of the problem seems to be that adults know too much. Research by Gabriele Wulf at the University of Nevada, Las Vegas, has shown that adults tend to learn a physical skill, like hitting a golf ball, by focusing on the details of the movement. Children, however, don't sweat the details, but experiment in getting the ball to go where they want. When Wulf taught adults to learn more like kids, they picked up skills much faster.

This also seems to be true for learning information. As adults we have a vast store of mental short cuts that allow us to skip over details. But we still have the capacity to learn new things in the same way as children, which suggests that if we could resist the temptation to cut corners, we would probably learn a lot more.

A more tried-and-tested method is to keep active. Ageing leads to the loss of brain tissue, but this may have a lot to do with how little we have about compared to youngsters. With a little exercise, the brain can spring back to life. In one study, 40 minutes of exercise three times a week for a year increased the size of the hippocampus – which is crucial for learning and memory. It also improved connectivity across the brain, making it easier for new things to stick (*PNAS*, vol 108, p 3017).

KNOWLEDGE 5

One of the brain's most useful features is the ability to absorb pieces of information and make connections between them. Knowledge really is power: a little can be a dangerous thing and the more you know the better equipped you are to deal with life.

But what exactly is knowledge? How are facts stored, organised and recalled when needed?

Knowledge obviously relies

“There seems to be no limit to the knowledge that can fit into a brain”

on memory – in particular the type of memory that stores general information about objects, places, facts and people, known as semantic memory. This is the part of memory which knows that Paris is the capital of France, a constitutional republic in western Europe – but not the part which stores memories of a weekend break there.





Knowledge isn't so much about what information you store as how you organise it to create a rich and detailed understanding of the world that connects everything you know.

The sight of a dog, for example, automatically activates other bits of information about dogs: how they look, smell, sound and move, the fact that they are domesticated wolves, the names of similar dogs you know, and your feelings about dogs.

How the brain achieves this gargantuan feat is far from clear. A recent proposal is that it has a "hub" which tags categories to everything we know and encounter, allowing us to connect related things.

In 2003, Tim Rogers, a cognitive psychologist now at the University of Wisconsin-Madison, proposed the anterior temporal lobe (ATL) as the hub (*Nature Reviews Neuroscience*, vol 4, p 310). The ATL is badly affected in people with semantic dementia, who progressively lose their knowledge of the meanings of words and objects but retain their skills and autobiographical memories. Experiments since then have backed this up – when

the ATL is temporarily knocked out by a small electromagnetic pulse, people lose the ability to name objects and understand the meanings of words.

Rogers says that without this system we would spend a lot of time being confused about how things fit together. "How would you infer, for instance, that when making a collage with your kids, if you run out of sticky tape you can use the glue stick instead?" he says. "The tape is not similar to the glue stick in its shape, colour or how you use it. You need a representation that specifies similarity of kind."

The good news is that there seems to be no limit to the knowledge that can fit into a brain. As far as we know no one has ever run out of storage space.

But it seems you can know too much. Michael Ramscar at Tübingen University in Germany reckons that anyone who lives long enough eventually hits that point just by virtue of a lifetime's knowledge. He suggests that cognitive skills slow down with age not because the brain withers but because it is so full. And that – like an overused hard drive – takes longer to sift through.



6 CREATIVITY

J. K. Rowling has said that the idea for Harry Potter popped into her head while she was stuck on a very delayed train.

We have all had similar – although probably less lucrative – "aha" moments, where a flash of inspiration comes along out of the blue. Where do they come from? And is there any way to order them on demand?

Experiments led by John Kounios, a neuroscientist at Drexel University in Philadelphia, suggest that the reason we aren't all millionaire authors is that some brains come better set up for creativity than others. EEG measurements taken while people were thinking about nothing in particular revealed naturally higher levels of right hemisphere activity in the temporal lobes of people who solved problems using insight rather than logic (*Neuropsychologia*, vol 46, p 281). Kounios says recent work hints that this brain feature might be inherited, but even if you happen to have a more focused, less creative brain, there are plenty of general tips on how to get it into creative mode.

Boringly, the first is to put in the groundwork to build up a good store of information so that the unconscious has something to work with. Studies on subliminal learning have poured cold water on the idea that knowledge can drift into the brain without any conscious effort, so it pays to focus intently on the details of the problem until all the facts

are safely stored. At this stage, anything that helps with focus, such as caffeine, should help.

Once that's taken care of, it's time to cultivate a more relaxed, positive mood by taking a break to do something completely different – like watching a few entertaining cat videos. Studies where people have either watched a comedy film or a thriller before coming up with new ideas have shown that a relaxed and happy mood is far more conducive to ideas than a tense and anxious one (*Psychological Science*, vol 21, p 1770). Not only that, but it pays to turn down the focus knob a little, and the easiest way to do that is to look for ideas when your brain is too tired to focus properly. A 2011 study showed that morning people had their most creative ideas late at night, while night owls had theirs early in the morning (*Thinking & Reasoning*, vol 17, p 387).

Mental exhaustion might be a more realistic state of mind than relaxation when an important deadline is looming, but if the ideas are still refusing to come there may one day be an easier solution. Brain stimulation studies, in which activity was boosted in the right temporal lobe and suppressed in the left, increased the rate of problem-solving by 40 per cent (*Neuroscience Letters*, vol 515, p 121). So the stressed creative of the future might be able to pop on a "thinking cap" to help those juices flow. ➤

7

INTELLIGENCE

Intelligence has always been tricky to quantify, not least because it seems to involve most of the brain and so is almost certainly not one “thing”. Even so, scores across different kinds of IQ tests have long shown that people who do particularly well – or badly – on one seem to do similarly on all. This can be crunched into a single general intelligence factor, or “g”, which correlates pretty well with academic success, income, health and lifespan.

So more intelligence is clearly a good thing, but where does it come from? A large part of the answer seems to be genetics. In 1990, the first twin studies showed that the IQ scores of identical twins raised apart are more similar to each other than those of non-identical twins raised together (*Science*, vol 250, p 223). Since then a few genes have been linked to IQ, but all of them seem to have a tiny effect and there are probably thousands of genes involved.

That doesn’t mean the environment plays no part, at least in childhood. While the brain is developing, everything from diet to education and stimulation plays a huge part in developing the brain structures needed for intelligent thought. Children with a bad diet and poor education may

never fulfil their genetic potential.

But even for educated and well-fed children, the effects of environment wear off over time. By adulthood genes account for 60 to 80 per cent of the variance in intelligence scores, compared with less than 30 per cent in young children. Whether we like

“Like it or not, we get more like our close family members as we get older”

it or not, we get more like our close family members the older we get.

So if genes play such a big part, is there anything adults can do to improve IQ? The good news is that one type of intelligence keeps on improving throughout life. Most researchers distinguish between fluid intelligence, which measures the ability to reason, learn and spot patterns, and crystallised intelligence, the sum of all our knowledge so far. Fluid intelligence slows down with age, but crystallised intelligence doesn’t. So while we all get a little slower to the party as we get older, we can rest assured that we are still getting cleverer.



AND FINALLY: THE RIGHT TIME?



The brain is a fickle beast – at some times as sharp as a tack, at others like a fuzzy ball of wool. At least some of that variation can be explained by fluctuations in circadian rhythms, which means that, in theory, if you do the right kind of task at the right time of day, life should run a little more smoothly.

The exact timing of these fluctuations varies by about 2 hours between morning and evening types, so it is difficult to give any one-size-fits-all advice. Nevertheless there are a few rules that it's worth bearing in mind whatever your natural waking time.

It's an idea not to do too much that involves razor-sharp focus in the first couple of hours after waking up. Depending on how much sleep you have had it can take anything from 30 minutes to 4 hours to shake off sleep inertia – also known as morning grogginess. If you want to think creatively, though, groggy can be good (see “Creativity”, page 39).

If hard work can't wait, though, the good news is that researchers have backed up what most of us already know – a dose of caffeine helps you shake off sleep inertia and get on with some work (*Perceptual and Motor Skills*, vol 116, p 280).

Another tip is to time your mental gymnastics to coincide with fluctuations in body temperature. Studies measuring variation in everything from attention and verbal reasoning to reaction times have shown that when our core temperature dips below 37°C the brain isn't at its best.

By this measure, the worst time to do anything involving thinking is, unsurprisingly, between midnight and 6am. It is almost as bad in the afternoon slump between 2pm and 4pm, which has more to do with body temperature than lunch – studies of people who have no lunch or just a small one have the same problem. All in all, the best time to get stuck in is between mid-morning and noon and then again between 4pm and 10pm.

There may be a way to hack the system, though. Studies have shown that body temperature changes and alertness also work independently of the internal clock, so a well-timed bit of exercise or hot shower can work wonders.

Competitive sports, though, are worth leaving until the end of the day. Studies have shown that reaction times and hand-eye coordination get progressively better throughout the day, reaching a peak at around 8pm.

After that, there's time for a little more focused energy before the body cools down, the brain slows and there's nothing more to do with it but dream. ■

Caroline Williams is a writer based in Surrey, UK



“If you want to think creatively, morning grogginess can be good”

Get knotted

They've been practising for ages, but physicists are finally learning how to tie knots in things, finds **Leonie Mueck**

PERHAPS it was the foul stench that inspired William Thomson to one of his oddest ideas. In 1867, the physicist, now better known as Lord Kelvin, was observing his colleague Peter Guthrie Tait producing smoke rings from ammonia, sulphuric acid and salt in his Edinburgh laboratory. As the rings glided across the room with elegant stability, a thought struck Thomson: was this what matter was made of?

What if atoms weren't solid spheres, as most gentleman scientists then believed, but looped vortices tied in the field of the lumeniferous aether, the medium then thought to carry light waves? That might explain why atoms absorb light. And as for the different chemical elements – why, they would just be ever more complex sorts of knots.

Thinking they were constructing a table of the elements, Tait and others went on to busy themselves classifying all the different sorts of knots by their number of loops and crossings, thus founding the modern mathematical discipline of knot theory. Sadly, though, the underlying idea was soon undone: apart from anything else, experiments two decades later showed the lumeniferous aether didn't exist.

But the basis of Thomson's ruminations has been bugging some physicists ever since. Can you actually tie a knot in anything so ethereal as a field – be it light, gravity or anything else? It has taken a century and a half, but now it seems we have an answer.

The attraction of knots for physicists is apparent to anyone who has fought with entangled earphone cords. Knots are extraordinarily stable, needing considerable investment of time or energy to untie. "Once you have a knotted structure, it's persistent, it's stuck," says theoretical physicist Randall Kamien of the University of Pennsylvania in Philadelphia.

That's one reason why knotted fields have become the mainstay of many a physical theory since Thomson's day. In the late 1960s, theorists found that knots in the fields that map out fluid flows could help to explain turbulence, itself one of physics's knottiest problems – or at least, they might do in a hypothetical, perfectly flowing fluid.

The quantum field theories that underlie the standard model of particle physics, too, suggest that Thomson wasn't so far from the truth after all. The building blocks of matter might come not just in the form of the point-like elementary particles already known, but also as knotted "topological" particles with exotic names such as glueballs and magnetic monopoles. These particles could play a big part in the universe, most notably in its earliest moments.

Closer to home, theories first developed in the 1980s suggest the tying and untying of braids in the magnetic fields of the sun's outer layers might release energy. That would explain why these layers are so much hotter

than our most basic models allow.

All this leaves a rather large loose end dangling: can you actually make a knotted field in practice?

It is certainly no easy task. Fields map quantities that fill all of space, so to tie a knot in one bit of one, you must distort it in all the surrounding space, too. William Irvine at the University of Chicago can fill books with his failed attempts to pull that off. One idea of his was to distort a flow field in water to create tiny doughnut-shaped vortices rather like Tait's smoke rings, and shoot two of them at each other in the hope they would link up into a simple trefoil knot. In vain. "We learned afterwards that this is what Kelvin himself had tried, and many people since," he says.

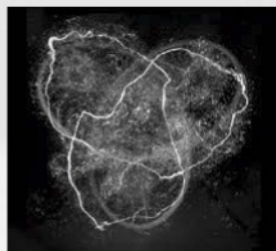
New twists

The French physicist Yves Bouligand got the closest four decades ago when investigating liquid crystals. These materials, commonly used in display screens, consist of rods that all have the same orientation, as in a solid crystal, but are otherwise free to move around, as in a liquid. The orientation of the rods maps out a "nematic" field, whose alignment can be changed from parallel to twisted by applying an electric field. In 1974, Bouligand saw a hint of knottedness in one twisted alignment – but the experimental tools at his disposal didn't allow him enough control over the liquid crystals to confirm it.

It was left to Mark Dennis at the University of Bristol, UK, to make a breakthrough in 2010. His team used the fields of a liquid crystal to imprint patterns in the field of a laser beam. The contrast between light and dark regions created was too faint to observe anything directly, but when digitally enhanced, the lines of complete darkness showed distinct signs of knottedness.

Just recently, though, evidence of knotty fields has been multiplying faster than the

ALL TIED UP



Knots are possible not just in shoelaces and headphone cords, but more slippery contexts such as water flows (left) and the alignment of particles in a liquid crystal (right)



"Knotted fields pop up in all sorts of theories – but can you make one in practice?"

twists in a telephone cord. Using a 3D printer, Irvine and his colleague Dustin Kleckner last year made tiny knot-shaped plastic wings that created eddies off their edges when accelerated under water. Injecting these eddies with air bubbles to make them visible exposed wet trefoil knots that lived for a few hundred milliseconds.

Slobodan Zumer at Ljubljana University in Slovenia and his team have recently achieved something similar in a nematic field. Differently shaped 3D-printed nanoscale knots coaxed the rods of the liquid crystal to align, producing a menagerie of different knots. These had different numbers of loops and crossings that could be made out using advanced microscopic techniques.

And there's also been tentative evidence that knots are indeed the explanation for some of nature's conundrums. Last year solar physicists using NASA's High-resolution Coronal Imager (Hi-C) instrument claimed to have observed just the signature of knotty energy release in the sun predicted by theory.

The aim now is to refine techniques to make knotty fields in the lab, and so explore natural knot dynamics in the sun as well as in other situations in which they are proposed to arise. "The next step is taking one of the knots and looking at what it does after it's produced," says Irvine.

There are more down-to-earth goals, too. The stability of knots makes them promising candidates for creating a long-term, durable way of storing information. In this vision, a high-intensity knotted light field would be used to encode knots in a liquid crystal, say, with lower intensity knotted light used to read it out. "The holy grail would be to be able to use knotted light fields to put knots into liquid crystals," says Kamien.

That's still a way off – but a century and a half on, it seems there might have been something in Kelvin's vision after all. ■

FAR LEFT: DUSTIN KLECKNER & WILLIAM T. IRVINE; LEFT: IVAN J. SMALYUKH ET AL./NATURE MATERIALS; RIGHT: PHIMAGES/GETTY IMAGES
Leonie Mueck is an editor at *Nature*

State of the art

From old classics to avant-garde sculptures, a lot of science goes into saving masterpieces from decay and damage, finds Norman Miller

IT TOOK just seconds for self-styled art anarchist Włodzimierz Umaniec to calmly step up to the giant Mark Rothko canvas hanging in London's Tate Modern gallery and graffiti his signature and a slogan across one corner in permanent ink.

The damage caused to Rothko's 1958 masterpiece *Black On Maroon* was considerable. Glazed areas made with egg and dammar resin had been destroyed, while in unglazed parts the ink had seeped to the back of the canvas through complex layers of oils, pigments, colourants and glues.

The 18-month scientific analysis and painstaking restoration that followed shone a rare spotlight on some of the complexities of art conservation. "We found out during that process how hard it is to paint like Rothko," says Bronwyn Ormsby, senior conservation scientist for the UK's Tate galleries.

The Rothko restoration was aided by a copious body of prior documentation on his materials and technique. But other artists are pushing conservation science into uncharted areas, with work fashioned from materials as diverse as soap and chocolate, blood and faeces (yes, some modern art really is crap). In the early 1960s, New York's Museum of Modern Art (MOMA) turned down a Robert Rauschenberg sculpture over concerns about maintaining a work whose centrepiece was a stuffed angora goat. Vermin were one major worry.

Old masters are objects of flux and change too, and while we know much about conserving them, techniques are still far from perfect – pigments discolour, varnishes crack, canvases warp under centuries of stress.

This capacity for change and degradation in the materials of an artwork is what conservators call "inherent vice". Applying science to the problem has helped restore many deteriorating works to their former glory. But with the challenge of new materials, some of the restoration techniques required are so extensive that it raises another question: is what we are left with the same as the original? And if not, should we be bothering to rescue them at all?

Conservators today are as likely to have backgrounds in chemistry or physics as art history. "The founding of museum laboratories was a turning point – at Harvard's Fogg Museum in Massachusetts and the

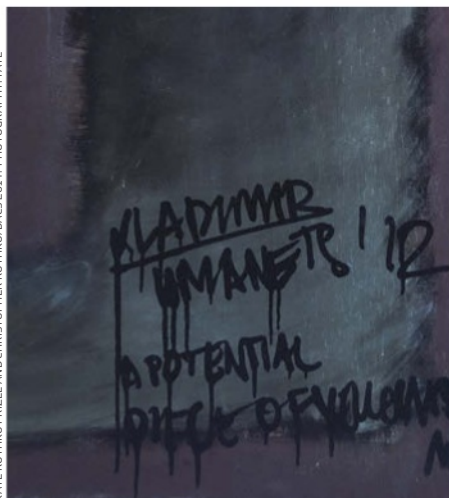
Louvre in the 1920s, then here in the 1930s," says Marika Spring, head of science at London's National Gallery.

These teams often collaborate with scientists at the cutting edge of seemingly unrelated fields. Famously in 2011, X-ray techniques proved crucial when Letizia Monico at the University of Perugia in Italy set out to solve a long-standing mystery around some of the most renowned works of Vincent van Gogh.

Her international team, which included researchers from the Louvre in Paris, wanted to know why the yellow paint in a number of the great artist's works, including some – but, intriguingly, not all – of his iconic *Sunflower* series had turned a dull brown.

They collected minute samples from brown sections and subjected them to the powerful X-ray generator at the European Synchrotron Radiation Facility in Grenoble, France. First, X-ray fluorescence (XRF) was used to determine which chemical elements were present in the offending pigment. When a fine X-ray beam is aimed at a substance, it causes changes in the energy levels of its atoms. This triggers the release of secondary X-rays whose energies depend on the structure of the atom hit by the original beam. Analysis of these X-rays shows which elements are present. A variant of XRF called XANES (X-ray absorption near edge spectroscopy) gives the precise chemical state of the atoms.

Van Gogh had painted with chrome yellow pigment, also known as lead chromate. The analysis revealed that around two-thirds of the chromium in the darkened samples had changed from bright yellow chromium(VI) ➤



KATE ROTHKO PRIZEL AND CHRISTOPHER ROTHKO/DACS 2014. PHOTOGRAPHY: TATE

Removing the graffiti from Rothko's *Black on Maroon* took painstaking work



“Conservation depends not just on available technology but also on law and ethics”

to the darker green chromium(III), also known as viridian green. Together with some of the paint oxidising over time, this was enough to produce brown. But why did the change occur in just some of Van Gogh's yellows?

The reason, ironically, turned out to be the artist's efforts to make some of his yellows even brighter. Van Gogh had mixed the basic lead chromate pigment with a white powder based on lead sulphate. The sulphate reacted with the chromium under the influence of light to change it from the (VI) to the (III) state.

Scientific investigations such as these are useful not only for finding out how an artwork has changed, but for understanding how to deal with damage, such as that done to the Rothko by Umaniec's pen. Nine months were spent analysing the ink, using gas

chromatography to work out its precise chemical make-up, then consulting with experts worldwide to whittle down thousands of possible combinations of solvents to a shortlist that might remove the ink without damaging Rothko's materials.

Even after hitting on a blend of benzyl alcohol and ethyl lactate, several months had to be spent testing removal methods on artificially aged canvas plus a 1950s primed canvas supplied by the Rothko family. “One scientific challenge was that Rothko used so many different kinds of media to get a beautiful luminous effect,” says Ormsby. Then there was the highly penetrating nature of the graffiti ink. This could not be completely removed – some of the damage can still be seen in bright light. But the team's hope was to be able to restore the painting so that it didn't stand out in a room of around eight other Rothkos. “And we achieved that,” Ormsby says.

At least Ormsby was dealing with paint. In 1991, when British artist Damien Hirst put a shark in a tank in the name of art, he didn't realise the pickle that would ensue. Hirst's shark began to decompose, the preserving liquid clouding and the skin starting to wrinkle.

Despite its increasingly sorry state, the work was bought in 2004 for several million dollars. So Hirst had no choice but to address the issue. His first attempt to salvage the piece was to skin the shark, tan its hide, then drape it around a shark-shaped fibreglass frame.

Unfortunately, this made an object intended to evoke metaphysical dread look more like a cheap prop at a *Jaws* convention. Eventually, Hirst decided to remake the sculpture with proper conservation in mind, calling in Oliver Crimmen, senior fish curator at London's Natural History Museum.

Alcohol bath

“Preservation is an ongoing experiment,” says Crimmen, as he hauls on a tangle of clanking chains in the bowels of the museum to uncover a huge tank full of big fish and snakes, immersed in a bath of brown alcohol. “There's a lot we don't know about the chemistry. To a great extent it depends on what you want to do with a specimen.”

Although Crimmen firmly backs alcohol as the best long-term preservation medium, an artist concerned with aesthetics might opt for formalin. It is paler and more transparent than the dark brown of a strong alcohol-based solution. So it proved. “Damien said formalin is part of the artwork itself – he likes the



STEVE FORREST

colour,” says Crimmen, adding that the flammability of alcohol was another issue when it came to sticking a huge tank of the stuff in a public gallery, or on a plane if it needs transporting.

If Hirst's choice of preserving liquid wasn't the problem, what had gone wrong? “When I went to look at the specimen I saw definite tissue shrinkage manifesting in the skin, due to improper fixation inside the body,” says Crimmen. “If you fix tissue in formalin it's got to get all the way in, and the only way to do that is to inject.” Sharks are especially difficult, he says. “You couldn't really choose a more problematic animal. Their body cavity is largely taken up by this enormous liver, and if it starts to break down – which happens if the fluid is not properly injected – the whole thing starts to shrink.” Crimmen finds no fault with Hirst, though. “It was a very easy mistake to make. Little information would have been available to him.”

In fact, Hirst's choices demonstrate the challenge posed by the interplay of inherent

THE REAL DEAL?

Tools similar to the ones conservators use to save artworks from damage and decay (see main story) can be used to discern fakes. Take the works of 20th-century forger Han van Meegeren, who notoriously painted in the style of 17th-century Dutch master Jan Vermeer. His efforts were so good they were proclaimed genuine by experts in the 1930s.

The truth came out when van Meegeren was accused of selling a Vermeer to the Nazis. Facing jail or even execution for treason, he admitted that this painting, and several others, were fakes. Van Meegeren died soon after.

Knowing his pictures would have to withstand certain tests available at the time, van Meegeren used genuine 17th-century canvas and pigments. But technology eventually caught up with him. As recently as 2011, gas chromatography and mass spectrometry (GC-MS) proved a painting at London's Courtauld Institute – thought to be by Dutch master Dirck van Baburen – was a van Meegeren.

Tiny paint samples from it were dissolved, then injected into a stream of gas and forced through a thin, heated tube. This broke them down into component chemicals, analysis of which revealed the modern-day material Bakelite. It had been added to the oil paint because the mixture, when heated, hardens to give the impression of great age. The advent of GC-MS turned a previously undetectable forger's technique into a finger of guilt.



Damien's Hirst's tiger shark needed a formalin injection to stabilise it (left); Anselm Kiefer's work is inherently fragile (right)

between artists' wishes, the object itself, and the wishes of owners, whether gallery or collector. Given how much some art is worth, perhaps it's no surprise the law has weighed in – although legislators on either side of the Atlantic have reached different verdicts.

Since the 1880s, Europe's Berne Convention has defended artists' right to protect their work from "distortion, mutilation or other modification". So to a litigious artist, well-meaning conservation could be "other modification". In contrast, the US Visual Artists Rights Act (VARA), passed in 1990, stated that "the modification of a work of visual art which is the result of conservation... is not a destruction, distortion, mutilation, or other modification". That means conservation depends not just on available technology but also on the law or ethics surrounding a repair.

To pre-empt these issues, institutions increasingly rely on negotiations with living artists before acquiring one of their works. "At Tate we have a lengthy discussion around longevity and change," says Ormsby. "Some artists want change to be evident. Others want preservation as much as possible."

Sculptor Tom Claassen, for instance, solves issues around his use of highly degradable rubber by telling conservators how he makes his pieces, so they can remake them every 10 years. Remaking also underpins the approach to a giant cube of lard sculpted with her teeth that is part of Janine Antoni's work *Gnaw*, which New York's MOMA recasts for every exhibition using moulds replicating Antoni's bite.

Other artists explicitly challenge the concept of conservation, such as painter Anselm Kiefer. His monumental canvases embody the chaos and destruction he saw growing up in Germany's post-war landscape, using techniques such as attaching electrodes to paintings with metallic content to bloom colourful oxides. Canvases are sent to galleries in full expectation that bits of them will fall off

"Works are sent to galleries in full expectation that bits will fall off in transit"

in transit. "It is not so easy having a painting of mine," Kiefer once noted mischievously.

The increasing use of technology-based media in art causes other issues around inherent vice, thanks to obsolescence and breakdown. Some artists acknowledge the issues and try to help. When the Tate group



BERTRAND RINDOFF PETROFF/GETTY

bought Michael Craig-Martin's 2003 work *Becoming* – an endlessly changing computer-generated animation on an LCD screen – the artist provided its source code as a cornerstone for exhibition on whatever displays might be around in the future.

It's not always so easy. *Video Flag Z*, created in 1986 by Nam June Paik, is a kaleidoscopic wall of 84 cathode-ray-tube TVs whose fuzzy pictures are integral to the work's appearance. The old sets kept breaking down, and couldn't simply be put in storage as they need periodic powering up to keep the diodes going. After initially scrambling to buy old CRT sets, conservator John Hix decided emulation was the only sustainable answer, making new sets that try to capture the look and feel of the old.

Challenges like his, and that faced by the Tate team after the Rothko vandalism, show that even the best-laid conservation plans cannot anticipate all problems, or which scientific advances will prove most useful in solving them.

In the meantime, perhaps it's best to just enjoy art as a manifestation of human creativity, however it is made or displayed. "I would never advise an artist not to use ephemeral media, or a curator not to acquire the work," says Glenn Wharton. "If art production was driven by durability alone, everything would be carved in granite. What a boring world that would be." ■

Norman Miller is a freelance writer based in Brighton, UK

vice with artistic knowledge. "When I lecture at art schools, I am surprised how little information about art materials is taught," says Glenn Wharton, a conservation specialist at New York University.

Take artist brothers Naum Gabo and Antoine Pevsner. In the 1920s and 30s, they made a series of abstract sculptures in cellulose nitrate and cellulose acetate, following a modernist credo of testing the artistic potential of new materials. They knew nothing of plastic's vulnerability to disintegration, discolouration, crazing and warping. Today, their sculptures lie in tatters in museum back rooms as prime examples of what conservators have dubbed "dead art". "It's sad," says Ormsby, "but all we can do is analyse it, and if it's gone, it's gone."

Is it acceptable to make replicas of dead art? Ormsby says her team has grappled with that idea for the Gabo sculptures, but hasn't done it yet. "We got as far as creating 3D digital models to have replicas made," she says.

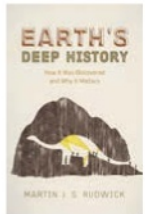
Such interventions highlight a tension

The birth of geology

Crazy-sounding, literal-minded attempts to date Earth's creation mark nothing less than geology's true origins, finds **Jonathon Keats**

Earth's Deep History: How it was discovered and why it matters
by Martin J. S. Rudwick, University of Chicago Press, \$30

Imagining Deep Time, National Academy of Sciences, Washington DC, until 15 January 2015



IN 1650, James Ussher, archbishop of Armagh, Ireland, published a book in which he stated that the Creation occurred on 23 October, 4004 BC.

Other scholars disagreed, some dating the world to as early as 4103. Isaac Newton eventually weighed in with a later date, 3988.

All were some way off. The modern estimate is that the Earth is 4.5 billion years old, provoking scientifically educated audiences to scoff at the literalism of those chronologists. Historian Martin J. S. Rudwick, however, believes Ussher and the rest deserve respect.

In *Earth's Deep History*, he argues compellingly that biblical chronologies mark the origin of geology and are important in understanding the subject today. Chronology was a sophisticated field in the 17th century, a multidisciplinary endeavour to produce a timeline of world history. As Rudwick writes, the Bible was one source among many, important because it was believed to be the only available textual record of "the beginning".

One task facing chronologists was to reconcile scripture with other evidence, such as coins and monuments. An important consequence was that material evidence came to be seen as

authoritative in its own right, a means of discovering aspects of history for which no textual records existed. Scholars realised that "nature might, metaphorically, have its own antiquities". Fossil shells could supplement scriptural sources; more radically, they could reveal Earth's own history.

That might not seem groundbreaking, but Rudwick is skilled at elucidating pre-modern ways of thinking. As he writes, "the natural world was... taken to have been a stable backdrop throughout human history. That nature might have had its own dramatic action began to seem plausible only when the ideas and methods of historians were transposed into the natural world, from culture into nature."

Much of *Earth's Deep History* is concerned with the ramifications of this. Once the idea of terrestrial history was established, the age of the world could be investigated in ways Ussher never imagined. For

"Earth's history is highly contingent throughout, and thus unpredictable even in retrospect"

example, strata were no longer seen as structural attributes of an immutable Earth. Instead, they were deposited over time, serving as a terrestrial "archive".

Of course, it was easier to conjure a metaphor than to act on it. As Rudwick explains, Earth's archive could be read in multiple ways. Most "men of science" agreed the planet was millions of years old, yet the actual age could be inferred only by estimating the rate of stratification – and that

raised more profound questions. Were strata steadily created, or was the process more capricious?

The former position was most powerfully argued by the 19th-century geologist Charles Lyell, who believed that the world was a steady-state system of deposition and erosion, and past geological processes were analogous to those observed in the present. The latter notion, that Earth's past was erratic, emerged from fossil research by Georges Cuvier, revealing the world had gone through several mass extinctions.

Rudwick credits Lyell with giving geologists "a better appreciation of the power of present processes, acting over vast spans of deep time", but is wary of Lyell's theorising. He prefers Cuvier's observations because the extinctions belong to Earth's history, whereas Lyell's steady-state model was posited as a universal law – and Rudwick insists that geology is a historical science. Like human history, Earth's history is "highly contingent throughout, and therefore utterly unpredictable even in retrospect".

Rudwick's book is authoritative and riveting, and its historical breadth is bound to make geology exciting for readers from both sciences and humanities. As it happens, one of his previous books, *Bursting the Limits of Time*, helped inspire an exhibition now on at the National Academy of Sciences in Washington DC.

Imagining Deep Time showcases contemporary artists seeking to embody the "deep time" of geology and cosmology through painting, sculpture and photography. It lacks coherence,



RALPH LEE HOPKINS/NATIONAL GEOGRAPHIC CREATIVE

Deep past: Lower Antelope Canyon, Navajo Tribal Lands, Arizona

but there are standout works such as Jonathon Wells's *Boston Basin*, a composite photo showing a thin sliver of Boston skyline above millions of years of strata. The proportions alone capture the grandeur of geology, the depth of history Rudwick evokes.

In one respect only is *Earth's Deep History* a little shallow. Ironically, Rudwick's strength as a historian undermines his arguments about the nature of geology. Drawing a contrast between geology and physics, Rudwick insists on a "distinction



between establishing historical realities and finding causal explanations". His version of geology is unconcerned with causality because he deems causality hopelessly out of reach for sciences mired in contingency.

However, his fine analysis of geology's roots shows how keenly historians work to find causal explanations, and how worthwhile such explanations can be. Whatever other similarities they have, history and geology at least share the virtue of being explanatory. ■

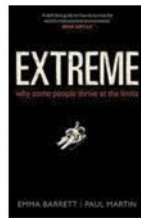
Jonathon Keats is an experimental philosopher and conceptual artist

Armchair explorers

Most of us could never climb Everest or survive a space mission, but it is fun finding out what it takes

Extreme: Why some people thrive at the limits by Emma Barrett and Paul Martin, Oxford University Press, £16.99

Caroline Morley



I LIKE to think of myself as adventurous, although if I'm honest (and from the comfort of home), I recognise that I probably

have little in common with astronauts, explorers or mountaineers. I also have no desire to find out for sure.

But *Extreme*, by psychologists Emma Barrett and Paul Martin, reminds us that in terms of physiology and psychology, we are all made of the same stuff, albeit in different proportions.

Unlike the similarly titled 2013 book *Extremes* by Kevin Fong, which looked at medicine in extreme places, Barrett and Martin concentrate on how people living in extreme environments respond to the stresses that surround them.

Within the first few pages, a couple of dozen adventurers have already died quite horrible deaths involving falls from great heights, freezing, starvation and asphyxiation, in various combinations. And then we're thrown straight into the human biological responses to the kind of situations that lead to such deaths.

Deeply researched, and told through personal anecdotes of explorers and studies of how people cope in extreme conditions, the book is amusing,

intriguing, exciting and a little horrifying. At one point we're treated to a particularly fruity account of astronaut Jim Lovell's two-week Gemini 7 mission, orbiting Earth alongside a fellow astronaut in "a capsule no bigger than the front seats of a small car".

Without a bathroom, the two astronauts simply had to do their business into their specialised suits. NASA's urine management system leaked and, because they couldn't take off their suits to

"Imagine how you'd cope if the daily challenges you face stretched into weeks or months without a break"

wash, the pair developed skin problems. Lovell described it as "like spending two weeks in a latrine". Clearly, though, the experience didn't put him off space travel as he completed several more missions at NASA.

Other familiar names, such as Ernest Shackleton and Charles Lindbergh, crop up throughout the book, recalling bedtime tales of heroism. However, the

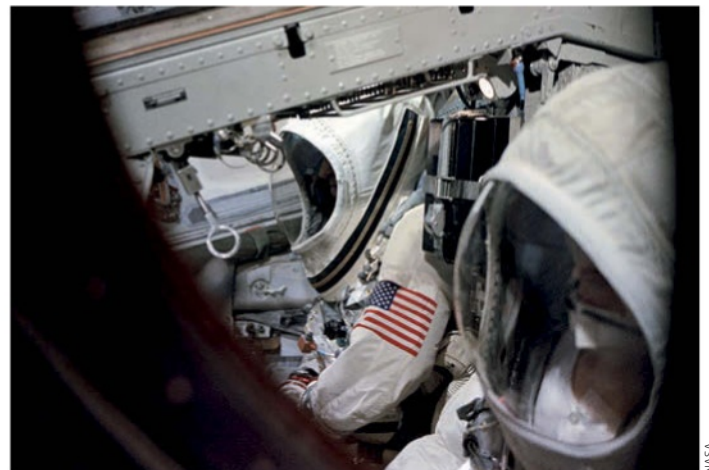
overriding message is that these people are all human, so are as flawed, irritable and irritating as the rest of us.

Still think you'll pass on climbing Everest or crossing the Arabian desert barefoot? No problem. Barrett and Martin point out that knowing how people cope with the toughest scenarios that nature and bad luck throw at them could help all of us handle more mundane situations in our lives.

And here the book strays a little into self-help, advocating meditation for everyone and inviting people to compare their picky bosses to the oversensitive and moody Robert Falcon Scott of Antarctic fame.

The authors are right, of course, that we all have daily challenges to face – ranging from loneliness and boredom to lack of sleep and annoying colleagues. But just imagine how you would cope if those hardships stretched into weeks or months without a break.

So get comfy, fellow armchair explorers, and enjoy discovering how this book can help you face your own personal Everests. ■



Journeys don't get much more extreme than those to space

The jaguar whisperer

This is a cracking tale of a big cat and a stuttering boy who became its best friend, says **Phil McKenna**

An Indomitable Beast: The remarkable journey of the jaguar
by Alan Rabinowitz, Island Press, \$30



WHEN Alan Rabinowitz was a child he had a problem: he had a stutter so severe it left him unable to utter a complete sentence to

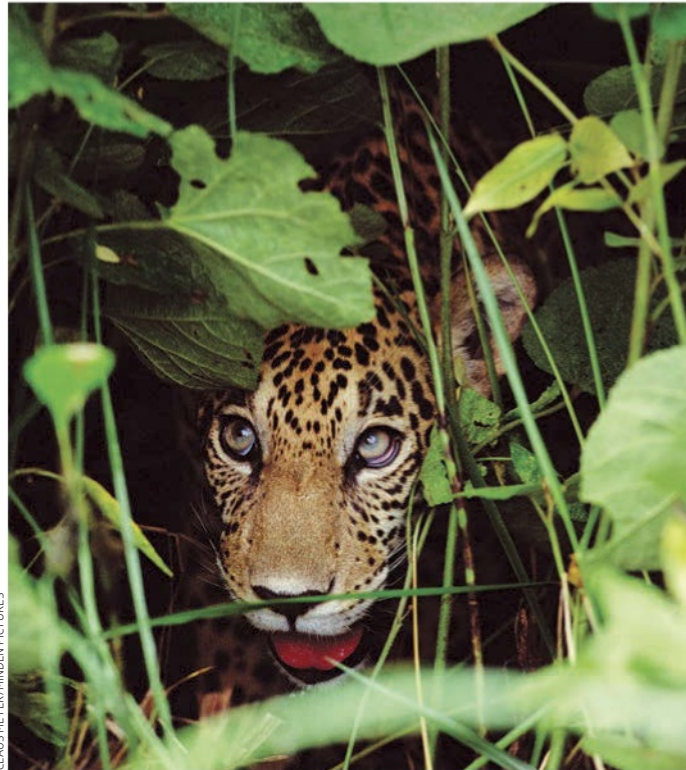
another person. Like many who stutter, however, Rabinowitz could talk freely to animals.

At night, he would step into his bedroom closet and whisper to his pet turtles, snakes and hamsters. His favourite animal, however, was an old jaguar, trapped behind bars at New York's Bronx Zoo. Some day, Rabinowitz promised the animals, he would find his voice, and then he would speak for the creatures that couldn't.

So begins a riveting tale of environmental success by a man who has been a force of, and for, nature ever since. While other big cats have plummeted to near extinction, jaguars thrive. What, I wondered, were Rabinowitz and others doing differently? Could their work be a model?

An Indomitable Beast begins with an exhaustively researched natural history of the jaguar from palaeo to present. And in telling the cat's story, Rabinowitz takes the reader on a personal quest, from ancient Mayan ruins to London Zoo, as he seeks to uncover the unique "jaguariness" of the animal he seeks to protect.

We learn of the animal's savagery (jaguars kill by crushing the skulls of their prey). And of its adaptability (these cats crossed a land bridge from northern Asia before settling in the tropics of



CLAUS MEYER/MINDEN PICTURES

Much of what kept jaguars off the endangered species list is blind luck

North, Central and South America). They are also not aggressive toward humans (there are no "man-eating" jaguars).

But what struck me most of all was that much of what has kept the western hemisphere's largest cat off the endangered species list has come down to blind luck.

When Europeans colonised the New World, the diseases they carried killed 90 per cent of the indigenous population. Ironically, this incredible loss of life gave jaguars breathing room from human encroachment that lasted for several centuries.

By the time Rabinowitz came to

Belize as a young biologist, local Mayans were poaching "el tigre" by the score. To protect jaguars, studies alone wouldn't suffice. In the summer of 1984, Rabinowitz landed a meeting with Belize's prime minister and his cabinet. Drawing on lessons learned in intensive speech therapy and a tremendous amount of sheer nerve, he overcame his stutter and convinced them to create the world's first jaguar reserve.

A single reserve, however, doesn't save big cats. What I found most interesting about Rabinowitz's efforts to save jaguars was a discovery he and his colleagues made decades later.

Until recently, everyone had assumed that jaguars, in common

with other large, wide-ranging carnivores, consisted of a number of non-interbreeding subspecies. In order to protect the species as a whole, conservationists assumed they would have to build habitat corridors between distinct populations so the cats could find each other and interbreed.

Then a genetic analysis made across the jaguar's range turned the notion upside down. From the deserts of northern Mexico to the wetlands of southern Brazil, cats were moving and mating as one population. The corridors already existed, they just had to be

"He promised the animals he would find his voice, and then speak for the creatures that couldn't"

uncovered and maintained. That's what Rabinowitz and Panthera, a non-profit organisation he co-founded, have done ever since in the Jaguar Corridor Initiative.

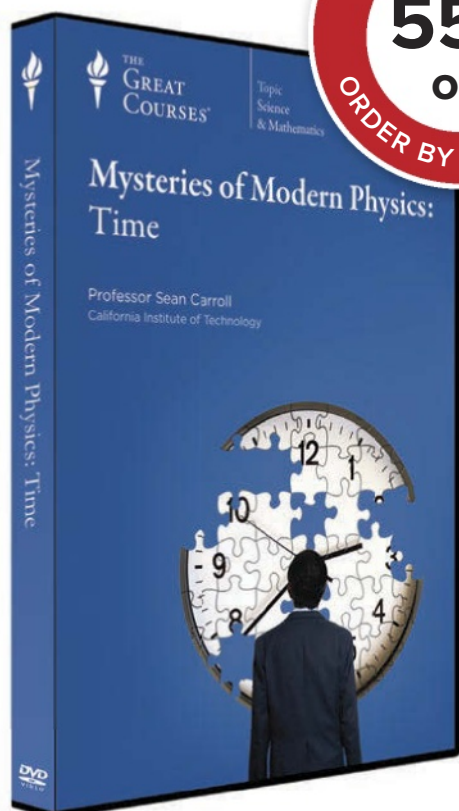
One month after Rabinowitz secured what would be the first of many protected areas for jaguars, he was walking through the Belize jungle when he came upon the largest tracks he had ever seen. He followed the tracks through the forest for hours with no luck.

When he turned around to head home, he realised the animal had circled back and was following him. Rabinowitz froze, then crouched down. The jaguar sat down too. He thought back to the old, caged animal that he used to visit at the Bronx Zoo. The two beasts stared at each other. Then Rabinowitz leaned forward. "It's all right now," he whispered to the cat. "It's all going to be all right." ■

Phil McKenna is a science writer



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You will have a PhD in plant science, agronomy, or related disciplines and an affinity for plant breeding and crop genetic improvement. Some understanding of soil-based measurements is desirable. For more information go to <http://www.niab.com/vacancies/index>.

Your application should include a covering letter and CV quoting ref. T/283 to jobs@niab.com or by post to Kate Harrison, NIAB, Huntingdon Road, Cambridge CB3 0LE. This opportunity will remain open until the right candidate is identified but the first sift will take place on **Monday, 3 November**.

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- development of improved or novel methods of stunning animals
- refinements in electrical stunning of turkeys, ducks and geese
- improvements in fasting, handling, transport & slaughter of fish
- refinement of existing, or development of novel, methods of assessing states of consciousness, enabling correlations of neurological activity with animal behaviour and physiology
- refinements to electrical stunning methods, to improve both animal welfare and meat quality

Application is a 2-stage process. Initially, supervisors are required to submit a Concept Note by **19 November 2014**. Further information and the Concept Note application form are available at: www.hsa.org.uk or from: info@hsa.org.uk



Immunocore Limited, just south of Oxford, UK, is an innovative and dynamic biotechnology company developing a unique platform of T Cell antigen receptor-based therapeutics, called ImmTACs, as a novel class of treatments for cancer. Having recently entered into four major partnerships with Genentech, GlaxoSmithKline, MedImmune and Eli Lilly, and with our first drug candidate in clinical trials, we are now aiming to broaden the application of the platform to the treatment of autoimmune and inflammatory diseases. To this end we are seeking candidates to join this exciting new autoimmune research group and to strengthen our oncology programmes.

Protein Engineering Scientist (Autoimmune Team)

We are looking for candidates with a high degree of technical proficiency in the areas of molecular biology (cloning, site directed mutagenesis) and protein biochemistry (expression, purification, characterisation, ligand-ligand interaction screening). Candidates with experience in antibody library construction/screening, phage display and SPR are particularly encouraged to apply. However, outstanding candidates with diverse technical proficiencies (e.g. practical cell biology and immunology skills) will also be considered and comprehensive training will be provided.

The role will be primarily bench-based and should appeal to enthusiastic candidates keen to contribute openly in a team environment and to develop their career as a key member of an exciting new research initiative.

Applicants should have a BSc or MSc in protein engineering/biochemistry or in a related discipline.

If you would like to work in a friendly, dynamic environment developing exciting therapeutic research programmes please send your application (copy of C.V. and short covering letter), to Mrs. C. Canuto, Immunocore Limited, 57 Jubilee Avenue, Milton Park, Abingdon, Oxfordshire, OX14 4RX, or by email to hr@immunocore.com

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LAST week we reported on the Ig Nobel prize awarded to David Hanauer and colleagues for their finding that patients suffering from cat bites were more than four times as likely to be depressed as other patients (27 September). Just as that page was going to the printers, a colleague said: "Maybe they are depressed because the cat they love bit them."

The Ig Nobel prize is given for scientific work that makes us laugh, then think... and this made us think even harder than usual. Were these people depressed before the bite? Or may mind-altering toxoplasmosis have been involved? It's hard to tell.

We described Hanauer's research as "data-mining", and some readers will have caught a note of scepticism from that phrase; but we should spell it out. If you trawl the records of 1.3 million patients to see what correlates with what, you will get results. Whether they mean anything is another matter. Equally, if you jointly trawl the records of US presidential elections and sporting results, you will find a strong

correlation between the outcome of the last Washington Redskins football game before an election and its outcome. So?

Sanity checks are always required. The traditional rule of statistics - that we must always formulate a question before crunching the numbers - may seem philosophically mysterious, but it guards against a data mine becoming a pit of despair.

SANITY seemed, as it happens, to have been the theme of this year's Ig Nobel awards. It arose as an issue when biologists dressed up as polar bears to fool reindeer. The serious purpose was to discover whether reindeer in the Svalbard islands recognised polar bears as predators.

Failing sufficient polar bear participation in the experiment, the researchers dressed in white and approached reindeer themselves. The reindeer backed off between 1.6 and 2.6 times as far as they did from humans

wearing usual, dark clothes. Thus Eigil Reimers and Sindre Eftestøl earned the Ig Nobel prize in Arctic science (dx.doi.org/vrvv).

As ever, alternative explanations should be considered. What if reindeer turn out to possess the concept "barking-mad human" and so avoid those in fancy dress?

HUMANS may fear for the sanity of anyone who approaches them with the intention of stuffing salt pork up their nose, and decide to avoid such people on those grounds. All the same, the Ig Nobel prize for medicine went to Ian Humphreys and colleagues of the Detroit Medical Center for recalling this folk remedy for a nosebleed - and finding that it works (bit.ly/nose0).

A child suffered from a rare bleeding disorder. Modern techniques had failed, leaving her in critical condition in intensive care. The senior doctor on the case, Walter Belenky, thought back decades, sent someone to the market, and stopped the bleeding almost immediately.

MODERN food, meanwhile, seems to be all about microbes called "probiotics", touted as improving your digestive fauna and thus your health. Now food producers want to put them in sausages.

So they seek microbes that can survive the salt and acidity of curing - and the human digestive tract. Raquel Rubio and colleagues in the IRTA food safety programme in Spain earned the Ig Nobel nutrition prize for isolating such microbes - from the faeces of human infants (doi.org/vsh).

Here Feedback agrees with the belief, popularly attributed to Otto von Bismarck, that wanting not to know how sausages are made is axiomatic. It thus illustrates the horror of seeing how laws are made.

YOU can find the rest of the Ig Nobel prizes at improbable.com/ig.

endeavour frequently makes quantum mechanics appear as intuitively plain as a very plain thing.

A friend forwards the news that in June, Scotland's first-tier tax tribunal ruled that "Snowballs" - gooey, coconut-covered globs of marshmallow - are, in law, "cakes". They thus attain parity with their quintessentially Scottish chocolate-covered cousin, the "teacake"; and their makers avoid a multimillion pound bill for value added tax, because they are officially food (not biscuits or cookies, which are classed as candy) and taxed at 0 per cent.

This follows a famous old case that went to the House of Lords when it was the UK's supreme court. Their lordships decided that Jaffa Cakes are indeed cake. We await with interest the trajectory of the Scottish case through higher tribunals.

FINALLY, a colleague forwards an email offering the chance to "Own a piece of Scotland" - sent just before the independence referendum there. For £14.99, Highland Titles will sell us "one square foot of Scotland... delivery



included!" or 10 square feet (1 square metre, near as) for £24.99.

The colleague is "thinking of going for the 10 square feet if delivery is included. I could have a small Scottish garden in my London flat."

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

Inspired by discussions of cats and cakes, Roland Curtis asks: "May I humbly propose Schrödinger's cake, which one can both have and eat?"

HAVING discussed food, or objects claimed to be food, and sanity, where else can we go but to consideration of tax law? This field of human

Sense of proportion

Why do we care so much about restoring lost sight and hearing, but give relatively little focus to restoring taste, smell and touch?

■ It is only natural that we care most about the senses that are critical for our immediate survival. Arguably, sight is the most useful sense. It allows us to move at high speed through our environment, while avoiding hazards like low-hanging tree branches and cliff edges. It also allows us to notice problems and opportunities to find food, as well as greatly helping us to fend off predators.

Although blind people can learn to compensate for lack of sight, they do so within a community of people who are sighted. If all humans were to become suddenly blind, then our modern transport system would literally come crashing to a halt and civilisation as we know it would collapse – as happened in John Wyndham's science fiction novel *The Day of the Triffids*.

"It is only natural that we care most about the senses that are critical for our immediate survival"

Hearing is also very useful. It facilitates teamwork and communication of knowledge that may be important for our survival. Those who become deaf can easily become socially isolated. Of course, sign language



and the written word can also be used to communicate, but these only work when the recipient is looking. In contrast, we can hear and respond to warnings shouted to us from any direction.

Unlike blindness, if the world's population were to become deaf overnight, it is quite conceivable that civilisation could survive, albeit without a radio or music industry.

The senses of touch, taste and smell are less immediately essential for day-to-day survival. Obviously taste and smell can warn us if food is not fit to eat, but these senses are poorly developed

in humans – I have on occasion unwittingly eaten spoiled food that later caused me illness. Similarly, the loss of the sense of touch makes fine motor tasks



such as doing up buttons and cracking an egg more difficult, but not impossible, provided we can see what we are doing.

It should be noted, however, that eating loses its rich pleasure without a sense of taste and smell. There is much research to suggest that in the long term this results in much higher rates of depression in people who have lost these two senses.

And without a sense of touch, the cumulative effect of not noticing all those bumps, burns and scratches results in serious skin infection, as seen in people with leprosy.

Simon Iveson

Callaghan, New South Wales, Australia

This week's questions

RING OF CONFUSION

This photograph (above, left) was taken on 22 June this year in north Pembrokeshire, UK. There were aircraft trails in the sky – but all of them were absolutely straight. So what is this?

Bob Holmes

By email, no address supplied

WAXWORK HORRORS

I left a tea light candle on my windowsill for six months in a transparent plastic box. It now looks very strange (see photo, below left). How did this happen to the wax?

From Rose Howie

By email, no address supplied

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