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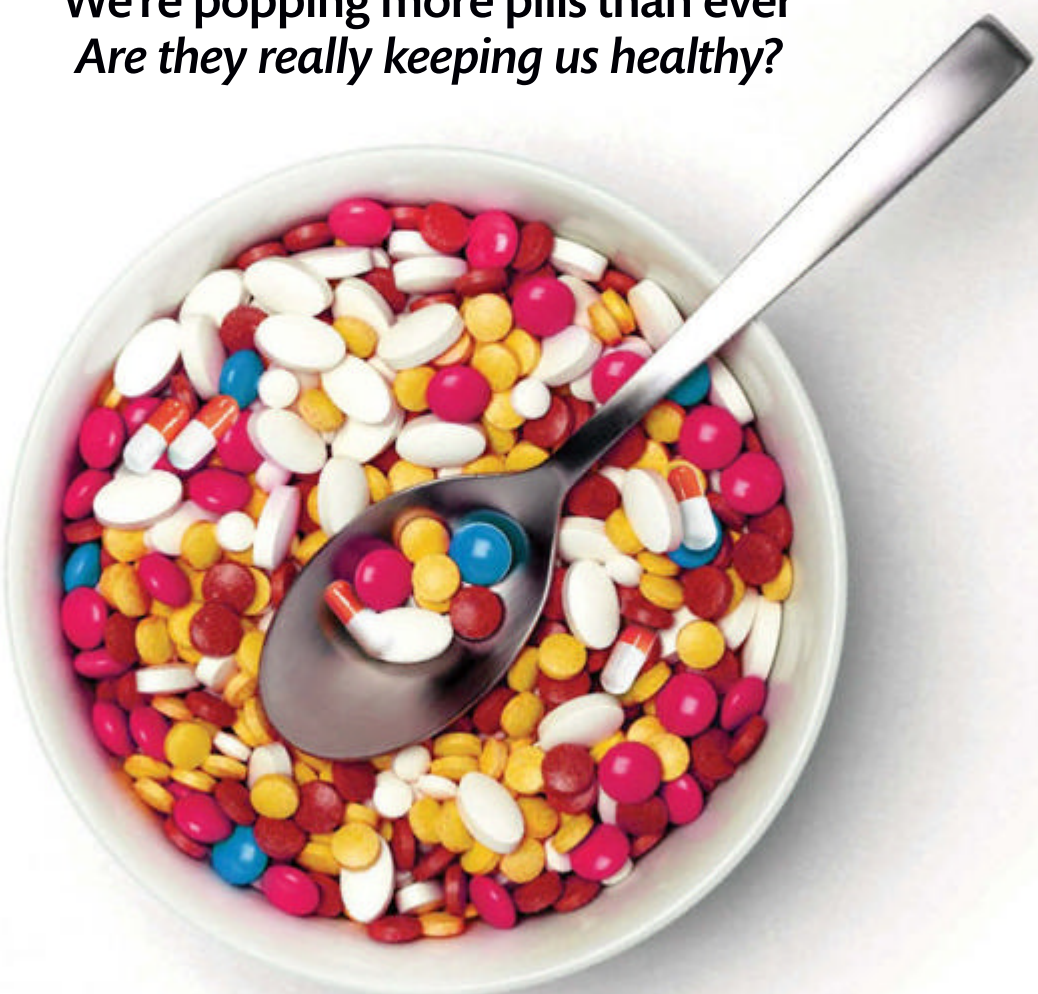

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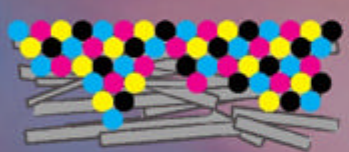

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London, WC1V 6EU
Tel +44 (0) 20 7611 1200
Fax +44 (0) 20 7611 1250

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CONTACTS
Contact us
newscientist.com/contact

Who's who
newscientist.com/people

General & media enquiries
enquiries@newscientist.com

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

Picture desk
Tel +44 (0) 20 7611 1268

Display advertising
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Syndication
Tribune Content Agency
Tel 800 637 4082

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

New Scientist at Reed Business Information, c/o Schnell Publishing Co. Inc., 225 Wyman Street, Waltham, MA 02451.

Periodicals postage paid at Boston, MA and other mailing offices.

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

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

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Too much of a good thing?

The quest for wellness will elude us until we define it

IF YOU have been to see a doctor recently, there's a good chance that whatever your specific complaint, you also got a general check-up: BMI, blood pressure, cholesterol and a raft of other tests. For many people that ends with a prescription for a condition they didn't know they had – perhaps a statin to lower cholesterol, or an ACE inhibitor for high blood pressure. Often, they will be taking those pills for the rest of their lives.

The lines between wellness and illness keep moving. Last year, for example, the UK's National Institute for Health and Care Excellence changed the guidelines that suggest who should take statins to reduce the risk of a heart attack, widening the net to take in an extra 5 million people in England and Wales. For increasing numbers of people, breakfast is no longer just about food. It is also time to pop a pill or two, or three or even more (see page 30).

Such measures seem like a good thing. Where's the harm in catching potential problems early and using modern medicine to deal with them? We should tread carefully. A decade ago, another form of preventive medicine – routine screening for diseases, including some cancers – seemed a sure-fire route to saving lives. But overall, most mass screening programmes proved to be ineffectual or even harmful and were duly dropped; only a few remain. Over-screening is a real problem: false positives lead to unnecessary medical intervention and psychological trauma, while false negatives can lead people to ignore genuine symptoms.

The risks of prophylactic medication are different. We don't know enough about the long-term effects of taking preventive drugs. And the ways in which multiple medicines interact is not well understood. As prophylactic prescriptions expand, public health bodies will have to decide if and when the benefits of adding more drugs to the mix are outweighed by the detriments.

"Wellness risks becoming a treadmill you can't get off, a never-ending guilt trip that you could do more"

Such decisions require long-term monitoring: the problems of screening should be a warning that large-scale preventive measures, no matter how well intended, can have unforeseen consequences.

We can be optimistic that these will be picked up. But we should also be aware that medicalising people who might otherwise consider themselves healthy has the potential to take on a life of its own as part of a broader "wellness" movement. Again, this may seem a good thing. For many, wellness means positive lifestyle changes: a few well-chosen supplements, a healthier diet, regular exercise and cutting down on "sins" such as alcohol. Indeed, instilling such a mentality in the public at large may be the only way to tackle today's healthcare challenges.

But there are many difficulties with the practice of wellness. We don't yet have a robust system for distinguishing useful measures from useless ones. More and more activities are being sold as good for your well-being, from yoga to meditation to volunteering. Wellness risks becoming a treadmill you can't get off: a never-ending guilt trip that you should be doing more. And a closer look reveals that some seemingly uplifting activities have a darker side (see page 28).

The root of the problem is that we do not have a good scientific definition of wellness: it is no more than the absence of illness. But if wellness is now the goal of public health policy, as well as a personal quest for millions of people, it is high time to decide what we mean by it. ■

STACEY LEE ROBSON

An IVF pioneer?

First stem cell baby born

HE'S known as the world's first stem cell baby. Zain Rajani was born three weeks ago in Canada after his parents opted for a new type of IVF that is claimed to pep up a woman's eggs by injecting them with mitochondria from her ovarian stem cells.

The idea is the mitochondria – the cellular energy generators – in these primitive cells function better than those in the eggs of women struggling to conceive. OvaScience, the firm that carried out the procedure, known as Augment, says it improves "egg health by increasing the eggs' energy levels for embryo development".

Although it appears to have worked for the Rajanis where traditional IVF failed, we don't know for certain that Zain owes his existence to Augment. "You can't prove that the technology they used is the one reason for this success," says Adam Balen, chair of the British Fertility Society. "Old eggs are less fertile because they don't have the integrity to go through cell division in an ordered way," says Balen. "There's no peer-reviewed evidence that mitochondria from immature eggs would correct this."

OvaScience points to work carried out in the early 2000s in which mitochondria from a donor egg were inserted into eggs of infertile women. "There are clinical reports which showed that using mitochondria from a younger woman's donor egg significantly improved IVF success," says the company.

It has been reported that 36 women in four countries have tried Augment, and eight are pregnant.

Arabian Mars

CALL it a new Hope. The United Arab Emirates has announced details of its uncrewed Mars probe, which it plans to launch in 2020 to monitor the planet's atmosphere from orbit.

"The UAE spacecraft will attempt to learn how Mars transitioned from wet and warm to dry and dusty"

The spacecraft, named Hope, will be a big step up from the country's previous space activities as it attempts to compete with other emerging space powers like India and China.

"The UAE Mars probe represents the Islamic world's entry into the era of space exploration," said UAE president Khalifa bin Zayed bin Sultan Al Nahyan last year when the probe was first announced. Now the UAE has announced its scientific goals for the mission, which include mapping the planet's weather and studying its atmosphere.

The probe will carry instruments to measure water, dust and other molecules in the planet's atmosphere, in an attempt to learn how Mars transitioned from wet and warm to dry and dusty.

These goals are similar to those of MAVEN and MOM, two Mars probes launched last year by NASA and the Indian space agency ISRO, but the UAE isn't just replicating those missions. "The science is complementary to MAVEN science," says David Brain of the University of Colorado, who is part of the MAVEN team and will also be working with the UAE on Hope.

Nuclear non-start

IT'S no party. The 190 countries that have joined the 1968 Nuclear Non-proliferation Treaty are meeting in New York for a five-yearly review of its progress. Apart from the deal struck with Iran in April, there is little to celebrate.

At the 2010 meeting, the US and Russia had just agreed renewed cuts in nuclear missiles, and delegates set out goals to help expedite that and other disarmament. Few have been achieved. Short-range nuclear weapons remain deployed in Europe and many of the US and Russia's 3680 warheads are ready to launch at a moment's notice. Hans Kristensen of the Federation of American Scientists says all nuclear states are investing in modernising their arsenals.

India and Pakistan, still outside the treaty, are seen as being in an arms race, acquiring new missiles and aircraft for delivering nukes. North Korea, which withdrew from the treaty in 2003, is churning out weapons-grade fuel and last week made waves with an underwater test launch of a submarine-based missile.

BEN STANSALL/GETTY

A climate-friendly face

Good for climate

AS THE UK's new Conservative government bedded down following its triumph in last week's elections, it has reaffirmed its commitment to fighting climate change – to the relief of environmental pressure groups.

The new secretary of state for energy and climate change, Amber Rudd, has made clear her unequivocal backing for action to combat climate change and for the science behind it. This is vital

in a year when an international deal to combat global warming is expected in Paris in December.

"It's reassuring to have a politician paying attention to reality rather than living in a fantasy world where the laws of physics don't apply," says Bob Ward of the Grantham Research Institute on Climate Change at the London School of Economics.

But others, such as RenewableUK, which represents wind and solar producers, have questioned the party's manifesto pledge to stop support for onshore wind farms – the cheapest renewable energy source.

Nepal still at risk

ANOTHER huge earthquake rocked Nepal this week, but it has released only some of the energy stored up along the boundary between the Indian and Eurasian tectonic plates.

The epicentre of the magnitude 7.3 quake was to the east of the more powerful 7.8 magnitude earthquake on 25 April that killed more than 8000 people.

"The latest quake will have released some of the stress, but was relatively small, given the overall size of the fault," says Alex Densmore of Durham University in the UK. He likens the fault to a three-dimensional zipper: "This quake extends the zipper a bit to the east, but everywhere else the fault remains locked."

The remaining stress could be released gradually in minor quakes, in a single large event, or a mixture of the two. "We simply don't know what will happen next, but we know it remains a risk," Densmore says.

"This latest quake releases pressure to the east, but everywhere else the fault remains locked"

Heat down under

AS CLIMATE-LINKED rows go, it's created its fair share of heat. The Australian government and a major university have come under fire for backing a proposed research centre to be run by the controversial Bjørn Lomborg. He argues that the global warming threat is overblown and money spent in fighting it largely wasted.

The government has earmarked A$4 million to set up the Australia Consensus Centre, to be modelled on Lomborg's Copenhagen centre, which lost its Danish government funding in 2012. But there was an outcry. Critics contrasted the government's support for the centre with its cuts to the science budget and abolition of the Climate Commission, which communicated the dangers of global warming to the public.

The University of Western Australia had agreed to host the centre, but last week announced with "great regret and disappointment" that it would not. The government is still seeking a venue even though the Royal Society of New South Wales, the country's oldest science academy, has called on all universities not to accept.

Lomborg says the centre will produce peer-reviewed work to inform Australian public policy.

Sri Lanka to protect mangroves

MANGROVES matter in Sri Lanka. The nation is the first to promise to protect all of its mangroves, as it launches a major replanting programme. Hundreds of coastal communities have been recruited to the effort by the Small Fishers Federation – a local non-governmental organisation – with money from an NGO in California called Seacology.

Mangroves grow in brackish swamps and lagoons across the tropics. Sri Lanka has 21 species, making it a hotspot for mangrove biodiversity. "Sri Lankan fishers say the mangroves are the roots of the sea," says the founder of the Small Fishers Federation, Anuradha Wickramasinghe. Around 80 per cent of fish caught and eaten in the country are from lagoons sustained by these plants. But mangroves have been extensively and often illegally cleared, partly to make way for shrimp ponds.

As a result, the Sri Lankan government has now promised to give all mangroves legal protection and provide rangers for coastal patrols, says Seacology's director Duane Silverstein.

The $3.4 million deal will give loans and training to 15,000 women to set up businesses. In return, they will act as the eyes and ears for protecting the 9000 hectares of surviving mangroves. They will also plant 4000 hectares of mangroves in nurseries in 48 coastal lagoons.

MAJORITY WORLD/REX

The roots of the sea

60 SECONDS

Ceres yields secrets

Mysterious bright spots on the dwarf planet Ceres are actually composed of many smaller spots. NASA's Dawn spacecraft, which has been orbiting since 6 March, took the sharpest images yet of the cratered surface, from a distance of 13,600 kilometres. They may be the result of sunlight glinting off ice.

Double melting

The Larsen C Ice Shelf on Antarctica is melting from above and below. Between 1998 and 2012 it lost 4 metres of ice from its base and 1 metre from its surface. If it collapses it will allow the glaciers on land behind to slip into the sea, elevating sea levels (*The Cryosphere*, DOI: 10.5194/tc-9-1005-2015).

Shell's Arctic victory

Shell has been given the green light to resume exploration for oil in the Arctic. Previous exploration was stopped after an oil rig fire and safety failures. Despite approval from the US Department of the Interior, Shell will still need permits from other agencies before it begins drilling in the Chukchi Sea, Alaska.

Liberia free of Ebola

It's over – in Liberia at least. Last week the WHO declared the nation free of Ebola, after 42 days had passed since the last person died. Almost 5000 people were killed by the disease in Liberia, with 300 to 400 cases a week at the outbreak's peak. The disease continues to infect people in Sierra Leone and Guinea.

Size really does matter

A tiny seedbug, common in Europe and Africa, has a penis that makes up 70 per cent of its body length. Now it seems that size matters: when researchers snipped off the top 30 per cent, males bred less successfully even though the cut penises still released sperm (*Proceedings of the Royal Society B*, DOI: 10.1098/rspb.2015.0724).

‘Heavy’ fat – the secret to eternal youth?

A pill that strengthens our cells’ defences could be a cure for degenerative diseases – and might even slow down ageing

Jessica Hamzelou

COULD a shiny orange capsule of modified fat help to keep you young? For the first time next month, fats designed to reinforce our cells against age-related damage will be given to people in a clinical trial. The participants have a rare genetic disorder, but if the treatment works for them, it could eventually help us all live longer, more youthful lives, says the scientist behind the work.

Mikhail Shchepinov, director of Retrotope, a biotech company based in Los Altos, California, wants eventually to slow down the ageing process. But he is starting with a related problem – treating the inherited movement disorder Friedreich’s ataxia, with which ageing shares a mechanism. They are both caused, in part, by a molecular attack on our cells. Shchepinov’s idea is to counteract this assault by reinforcing our cells’ defences, slowing the progression of this incurable disease. If it works, it should demonstrate that the approach is also suitable for tackling ageing.

The damage he wants to address is caused by molecules called oxygen free radicals, made when our cells metabolise. Free radicals have unpaired electrons that desperately try to find a partner by tearing electrons off other molecules. This triggers a chain reaction as the denuded atom then does the same to its neighbour.

This chain reaction is particularly dangerous for the fatty acids that form our cell membranes. “They burn like gunpowder until hundreds of thousands are damaged,” says Shchepinov. Proteins and DNA also come off badly. Blocking the reaction should prevent the damage, but Shchepinov has a different idea.

“Swapping some of the fat we eat with stronger fats should allow us to build more robust cells”

He reckons we can protect our cells from free radicals simply by strengthening the bonds between molecules that make up our cell membranes. This can be done by swapping the hydrogen in the fatty acids for a different form known as deuterium. Because deuterium has an extra neutron, it is heavier than hydrogen and forms stronger bonds (see “The skinny on heavy fat”, right).

Enter the modified fat pill. The idea is that substituting some of the fats we normally eat with modified, stronger fats in pill-form should allow us to build stronger cells. To test the idea, Shchepinov and his colleagues developed heavy versions of an omega-6, polyunsaturated fatty acid. “It’s not a nutrient – it’s a new chemical that is different from the fats you get in your diet,” says Retrotope co-founder Robert Molinari, the biochemist who is leading the clinical trial.

The approach works in yeast – samples that metabolised heavy fats appear to be up to 150 times as resistant to the oxidative stress caused by free radicals as those given regular fatty acids.

The next step is to see whether heavy fat can slow the progression of Friedreich’s ataxia. This is caused by free radical damage to the nerves responsible for movement and usually means people are wheelchair-bound within 10 to 20 years of symptoms appearing. The idea makes sense,

AGEING EXPLAINED

You’re born, you age, you die. But no one is exactly sure what’s going on under the hood. Here are some ideas about why we age:

BLAME THE FREE RADICALS

When cells metabolise they produce reactive molecules called free radicals that attack other molecules, harming cells in the process. The damage is known as oxidative stress and as it accumulates over time, it is thought to cause the general wear and tear of the body as we age.

CHROMOSOMES WORN AWAY

The ends of our chromosomes are capped with bundles of protective DNA called telomeres. These shrink every time a cell divides, until eventually, the telomeres are too short for this to happen. When cell division stops, the cells are unable to replenish themselves and maintain the body’s tissues, leading to age-related disease.

CELLS GET GRUMPY IN OLD AGE

In the 1960s, scientists discovered that cells can only divide a finite number of times – a number referred to as the Hayflick limit. Once you get to this point, however, a cell doesn’t die. Instead, it senesces – it enters a state in which it stops dividing and starts pumping out chemicals that cause damaging inflammation. Researchers are beginning to link senescence to a range of age-related diseases, including Alzheimer’s.

PLAINPICTURE/IMAGE SOURCE

Holding back the years

says Corinne Spickett at Aston University in Birmingham, UK. "The underlying chemistry is quite correct – the fats are theoretically less susceptible to attack by free radicals," she says.

The trial launching in June is a safety study. The team will be checking that the doses of heavy fat are well tolerated by 18 people with Friedreich's ataxia. They don't expect problems – even if every cell membrane were made from their modified fatty acids, the total amount of deuterium in the body would still be around four times lower than a dangerous dose.

"Free radicals contribute to ageing, but there is so much going on, it might not just be down to this"

At first, each volunteer will be given two 1 gram tablets of heavy fat per day. "It looks like a fish oil pill," says Molinari. After a break, the dose will be ramped up, with people taking five tablets, twice a day. Because the heavy fats need to overwhelm the fats we usually get in our food, the volunteers will be placed on a special diet. "They can have olive oil and saturated fats but not polyunsaturated fatty acids," says Shchepinov.

Reverse the damage

Molinari hopes that the treatment will not only halt the progression of the disease, but also improve people's symptoms. By replacing cellular fatty acids with stronger ones, there is a chance of rescuing nerves that are sick, but not dead. "A degree of reversal of damage is possible," he says. "We see improvements in cell experiments – we won't know about the effects in people until we do the trial." Although a larger trial will be needed to determine any effect on symptoms, the team is hoping to see some hints during the safety study.

"The principle is sound, and some beneficial effects of heavy fats have been seen in cells and rodents," says Spickett. "But will this translate to humans? We'll have to see."

Theoretically, heavy fats could also prove useful in other diseases in which free radicals are implicated, such as Parkinson's. A few years ago, Shchepinov and colleagues at the University of Arkansas and the Scripps Research Institute in California, found that a diet rich in heavy fats protected mice against the worst ravages of the mouse equivalent of Parkinson's disease.

And then there's the question of whether a heavy fat pill can slow ageing. "If you can fix oxidative damage then lifespan will be extended," says Shchepinov. "It's the same mechanism."

To get a better idea of its potential, the team plans to run a trial in rodents, lasting around three years. A human trial would be more complicated as it would be incredibly difficult to tease apart the many factors known to play a role in ageing (see "Ageing explained", left). "The jury is still out on the free radical theory of ageing," says Mark Cooper at University College London. "Free radicals do contribute to ageing, but there is a massive amount going on – it might not just be down to one thing."

But Shchepinov is sanguine. To him, ageing is just a collection of diseases. If the fatty acids benefit people with these diseases, they will automatically extend lifespan, he says. "Maybe people will live until they are 180 and start dying of something else," he says. "It's a complex approach, but I hope our fatty acids will play a role." ■

THE SKINNY ON HEAVY FAT

WHAT IS HEAVY FAT?

Fatty acids are made up of carbon, oxygen and hydrogen. To make a fatty acid, or any other hydrogen-containing molecule ,"heavy", hydrogen is swapped for its heavier isotope, deuterium. The result is a molecule that forms stronger bonds, and is more resistant to damage.

DOES HEAVY FAT WEIGH MORE THAN NORMAL FAT?

A little bit. An ice cube made of heavy water will sink in a glass of normal water. A mole – a standard unit used in chemistry – of the fatty linoleic acid weighs 280 grams, while a mole of heavy linoleic acid weighs 282 grams.

WILL EATING HEAVY FAT MAKE ME FATTER?

Not according to the researchers launching the heavy fat trial (see main story). The fatty acids they want to use as a substitute only make up 1 or 2 per cent of the total energy intake in a normal diet.

How brain-eating amoebas really kill

Jessica Hamzelou

DON'T be too hard on them. Amoebas that work their way into our brains and chow down on our grey matter aren't welcome, but it's how our immune system reacts that's really lethal. Setting the story straight could help us deal with them better.

Brain-eating amoebas (*Naegleria fowleri)* are found in warm freshwater pools around the world, feeding on bacteria. If someone swims in one of these pools and gets water up their nose, the amoeba heads for the brain in search of a meal. Once there, it starts to destroy tissue by ingesting cells and releasing proteins that make other cells disintegrate.

The immune system launches a counter-attack by flooding the brain with immune cells, causing inflammation and swelling. It seldom works: of the 132 people known to have been infected in the US since 1962, only three survived.

Brain-eating amoeba infections are more common elsewhere. "In Pakistan, we have something like 20 deaths per year," says Abdul Mannan Baig at the Aga Khan University in Karachi.

There is no standard treatment. Doctors in the US have recently started trying to kill the amoebas with miltefosine, a drug known to work on the leishmaniasis parasite. Mannan thinks they should take a different approach, because the immune response may be more damaging than the amoeba itself.

The problem is that enzymes released by the immune cells can also end up destroying brain tissue. And the swelling triggered by the immune system eventually squashes the brainstem, fatally shutting off communication between the body and the brain.

To check their theory, Mannan and his colleagues compared how brain cells in a dish fared against the amoeba with or without help from immune cells. They found that when the immune response was absent, the brain cells survived about 8 hours longer (*Acta Tropica*, doi.org/4g4).

In light of this, Mannan suggests that people infected by the amoeba should first be treated with drugs that dampen down the immune system, before getting medicines that target the parasite.

Jennifer Cope at the US Centers for Disease Control and Prevention in Atlanta, Georgia, thinks the idea is sound. "It is worth testing, but it is very hard to test because the infection is so rare," she says.

A warming climate could change that, however. Although infection rates haven't risen significantly since the amoeba was first described 60 years ago, cases are starting to crop up in unexpected places, such as the northern state of Minnesota. "In the US we've had our first case linked to drinking water," says Cope. "We need to track these cases and keep an eye on them."

In the meantime, Mannan says the brain-eating amoeba deserves a rebranding. He suggests "nose-brain-attacking amoeba" or "olfacto-encephalic amoeba". "It doesn't roll off the tongue quite as easily," says Cope. ■

MARK NEWMAN/FLPA

Nose clips at the ready

Roman townies outlived rural folk in England

RURAL living today may conjure up images of health and wholesomeness. But it wasn't always that way. The skeletons of people living in England during the Roman occupation suggest that, at that time, town-dwellers were better off.

"The assumption is always that if you're living in the countryside it's healthier," says Rebecca Redfern of the Museum of London. "But we found that urban dwellers were more likely to reach old age than their rural counterparts."

Redfern's team examined bones from 344 individuals buried in rural and urban cemeteries between 1 and 500 AD at 19 sites in what is now Dorset in southern England. The townies had a small but significant edge over country dwellers. Some 34 per cent of them lived beyond the age of 35 compared with 29.5 per cent of country dwellers (*American Journal of Physical Anthropology*, doi.org/4jp).

Redfern says many of the rural dwellers were likely to have been serfs and labourers for rich landowners, and so lived much harsher lives than the urban folk. "They died early because of enforced labour and survival on basic diets," says Redfern.

But urban living did have its drawbacks. Town children were more likely to die before the age of 10, possibly because Iron Age child-rearing traditions, which prioritised resources for children, persisted more in the country compared with towns.

"Townies lived longer but had worse teeth, perhaps due to access to foods like wine and preserves"

Disease was more prevalent in the towns, too. Rickets and tuberculosis were found in a few town dwellers, but not in rural people.

Townies also had worse teeth, perhaps because of easier access to processed foods such as wine and preserves, says Redfern.

"This research adds to a growing body of evidence that is forcing Roman archaeologists to reject the notion that cities always produce poorer health outcomes and lower life expectancies when compared with rural living," says Martin Pitts from the University of Exeter, UK.

Andy Coghlan ■

Missing galaxies found hiding in plain sight

YOU look everywhere for something and it was in your pocket all along. Millions of ancient galaxies thought to have been destroyed in collisions seem to be hiding in discs of stars in other galaxies. Even our own Milky Way may be hiding another galaxy at its centre.

In 2005, astronomers found that there were a lot of compact spherical galaxies in the early, distant universe. These galaxies, which appeared to be about a third of the size of ones in our own backyard with a comparable mass and shape, were abundant about 11 billion years ago but seemed scarce nowadays. The local universe is dominated by large "elliptical" galaxies – giant clouds of stars with little structure – and disc galaxies like the Milky Way.

"There are 1000 times as many compact galaxies in the local universe than previously thought"

"Pretty much all of the compact massive galaxies were thought to be missing from the nearby universe," says Alister Graham of Swinburne University of Technology in Melbourne, Australia. "Very few compact massive galaxies had been found locally, just a handful."

Computer simulations showed that these galaxies of the early universe could have been destroyed through mergers and collisions with each other. Many astronomers thought this explained the discrepancy, but there was one problem: if there were that many mergers, we should see a lot of those galaxies orbiting one another and heading towards collisions. But we don't.

"It was known that there are not enough mergers; this was an unexplained problem," says Graham.

Graham and his colleagues think they now have an explanation. They have found that many galaxies in surveys of the local universe had been mischaracterised. Their analysis of images reveals that 21 galaxies that originally looked like giant elliptical 3D clouds of stars were actually flat 2D discs with bulges in the middle. This is because unless the thin edge of a disc galaxy is facing us, it can look like a 3D clouds of stars (*Astrophysical Journal*, doi.org/4jv).

Those bulges have "exactly the same physical mass and compact size as the galaxies in the early universe", Graham says. "The original, compact spheroid of stars remains basically unchanged in their centres." This suggests that the vast majority of compact spheroids aren't actually missing, they have just grown a disc, possibly by gathering hydrogen gas and stars from smaller galaxies but without major mergers. "They were hiding in plain sight," says Graham.

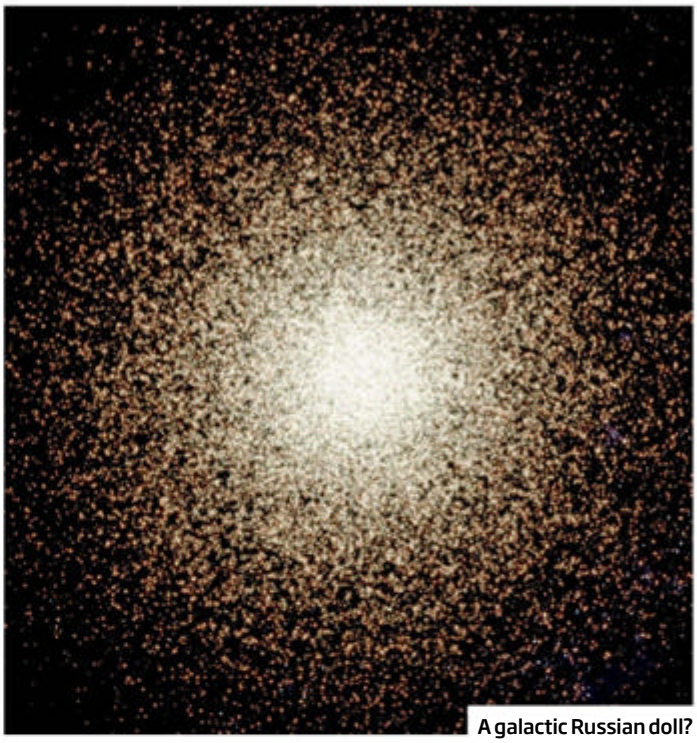
The results suggest that there are 1000 times as many of these compact galaxies in the local universe than previously thought – roughly as many as there were in the early universe.

Graham says part of our own galaxy's central bulge may once have been one of these compact galaxies. The disc that formed around it would have contributed some stars to the bulge, as could other processes such as mergers.

Emanuele Daddi at the French Alternative Energies and Atomic Energy Commission was one of the first to notice the apparent excess of compact spherical galaxies in the early universe. "The idea did not occur to us that they could actually be bulges of local [disc galaxies] that had not yet grown their discs," says Daddi. "Neither did the few hundred papers that subsequently studied the problem consider this idea."

Daddi thinks a mystery remains. The bulges in the nearby galaxies seem larger than those in the early universe, which leaves him with some doubt that this explanation will definitively solve the problem.

Michael Slezak ■



GABRIEL PÉREZ DÍAZ

A galactic Russian doll?

INSIGHT California's drought

Refill aquifers to quench drought

Hal Hodson

THE worst recorded drought in California's history has forced state regulators to restrict people's water use by a quarter. In the long-run, though, climate change and limited supply mean the state must radically change the way it manages water, particularly below ground.

The state normally depends on winter storms to replenish its water. Most climate models suggest these storms will become less frequent but more intense, says Alexander Gershunov, a climatologist at the Scripps Institution of Oceanography in San Diego. So water will come in huge, sudden gushes, possibly bringing more than existing infrastructure can capture. "You're either in a drought or in a flood," says Bridget Scanlon of the University of Texas at Austin. "What you really need is storage to even that out."

The traditional method of storage is to create a reservoir by damming a river. But dam-building is expensive, can be environmentally damaging, and most of the good spots are already in use. An alternative is to push water underground using recharge ponds or injection wells. Recharge ponds are constructed surface basins that allow water to collect and seep through the soil; injection wells use high-pressure pumps to actively push water down into aquifers.

Kern County, in the south of California's vast, central Joaquin valley, has already reaped the rewards of managing its groundwater. With its surface water supply becoming increasingly unreliable, the county began to look for alternatives. It gave up huge chunks of agricultural land and started using it as recharge pools.

Water accumulates in wet years and drains into the depleted aquifer below. In the dry season, when the pools are empty, winter wheat is sown. Its roots break up the soil and improve drainage in readiness for the next batch of water.

Around 1.2 trillion litres of water collected this way helped alleviate the effects of the current drought, says Jim Beck, general manager of the Kern County Water Agency. "Without that we'd have had much more farming land go out of production."

Further north, a pilot project by the University of California has bulldozed levees along the Cosumnes river, allowing water to flow over the surrounding flood plains. As a result, a small storm in February pushed hundreds of millions of litres of water into the aquifer below – far more than normal.

Groundwater management has several advantages over other methods. It is generally cheaper than building dams or desalinating water. What's more, aquifers lose no water through evaporation, do not flood ecosystems, and in California they have capacity for between 17 and 26 times as much water as all of the state's reservoirs combined.

"California needs to get a grip on its groundwater," says Bill Alley, the director of science and technology for the National Ground Water Association. "There's no doubt of that." That might now be starting. Last year, California's governor Jerry Brown announced $1.5 billion to increase the state's storage capacity. Almost all of the districts in line for such funding sit atop overdrawn aquifers and could make use of them with new funding. ■

REUTERS/LUCY NICHOLSON

Hard times for almond trees

Corkscrew planets spiral between suns

HELTER skelter! It turns out that in some rare cases, a planet in a binary system could spiral around the axis that connects its two stars.

We normally think of planets orbiting sedately around their star, like Earth does. Binary systems are more complicated, but astronomers usually assume that a planet will stay confined to a single plane of motion, tracing a disc either around both its parent stars or just one.

Eugene Oks, a theoretical physicist at Auburn University in Alabama, wondered what would happen without that assumption. His model shows that, if you imagine a line connecting the two stars, a planet could trace a corkscrew around that line, travelling back and forth between the stars.

As it moves closer to one star, the spirals get closer and closer together as the planet moves more slowly, until it turns and moves back toward the other star. In the middle, it traces wild, fast curves around the axis (*Astrophysical Journal*, doi.org/4j6).

Life – if it could survive – would be very different to that on Earth. Sandwiched between two stars, only a small slice of the planet would ever experience night. If the planet was tilted on its own axis, then mini seasons would come and go quickly, with every turn of the spiral.

Oks was inspired by a rare class of molecules called one-electron Rydberg quasimolecules that display the same corkscrew orbit of their electrons under electromagnetism that Oks's hypothetical planets do.

"Sandwiched between two stars, only a small slice of the planet would ever experience night"

While the corkscrew planet is mathematically plausible, it is less clear how such an orbit could come to be through the evolution of a real stellar system. "It's hard to imagine planets forming or being captured in such an orbit," says Sara Seager, an astrophysicist at the Massachusetts Institute of Technology. "But for exoplanets, never say never." Hal Hodson ■

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SCOTT EELLS/REDUX/EYEVINE

Protection from more than measles

Measles hits kids' disease defences

Debora MacKenzie

MEASLES is often painted as a trivial disease by anti-vaxxers. Apart from the fact that it can cause brain damage and kill you, here's another reason it isn't: having measles destroys your immunity to other diseases – and some of those are far more deadly.

Prior to mass vaccination in the 1960s, some 650 children a year died from measles in the US. When mass vaccination came in, deaths plummeted. But so did childhood deaths from infectious disease generally, in every country where the vaccine was introduced. The vaccine was only supposed to protect you from measles, so what was going on?

The measles virus kills white blood cells that have a "memory" of past infections and so give you immunity to them. Those cells were assumed to bounce back because new ones appear a week or two after someone recovers.

However, recent work in monkeys shows that these new memory cells only remember measles itself; the monkeys lost cells that recognise other infections. If humans get similar "immune amnesia", childhood deaths from infectious diseases should rise and fall depending on how many children had measles recently, and how long the effect lasts, says Michael Mina of Emory University in Atlanta, Georgia.

Mina and his colleagues used a statistical model to analyse child mortality records from the US, UK and Denmark in the decades before and after measles vaccination began. In any given year, the number of children who died of infectious disease was linked to how many measles cases there had been two to three years previously. In all three countries, the data was what would be expected if immune amnesia after measles lasted 27 months.

"Measles may not be scary enough to convince people to get their kids vaccinated but meningitis might be"

The biggest killers were pneumonia, diarrhoeal diseases and meningitis. The effect was so large that when measles was common, the team calculated that it was implicated in half of all childhood deaths from infectious disease (*Science*, doi.org/4jq).

The duration of the immune amnesia tallies with the time it takes infants to build up natural immune defences. This suggests that measles resets children's immunity to that of a newborn. What's more, if measles can wipe out a child's naturally acquired immunity, then any gained from vaccinations is likely to go too.

Much anti-vaccine sentiment focuses on MMR (the measles, mumps and rubella vaccine), so some parents reject the measles shot but accept vaccines for other diseases, says Ab Osterhaus of Erasmus University Medical Centre in Rotterdam. If their kids then get measles, this immunity could be destroyed, leaving them open to the diseases as adults, when symptoms are more severe.

There could be a silver lining. Parents who reject vaccines often do so because they think having measles is healthier than the vaccine. If there is evidence that measles leaves a child at risk of pneumonia or meningitis, it might be the nudge they need to see the measles vaccine as essential. ■

Extreme El Niño is all set to wreak havoc

THE bad boy of global weather is on its way. El Niño can cause floods, droughts, fires and epidemics around the world, and the next one could be a humdinger.

El Niño crashes on to the scene once every four years or so as hot water emerges in the Pacific and moves towards the Americas. This can bring drought to Australia and parts of Asia, while parts of the Americas experience heavy rain, flooding and outbreaks of waterborne diseases.

Many experts are warning of a "super El Niño" this time round. "We have this enormous heat in the subsurface that is propagating eastward and it's just about to come to the surface," says Axel Timmermann of the University of Hawaii in Honolulu. "I looked at the current situation and I thought, 'oh my dear'."

Similar forecasts were made last year, too, and proved wide of the mark. This time it's different. For one thing, we are already in an El Niño year, which makes it easier for an extreme one to form.

Also, this year ocean temperatures seem to be coupled with atmospheric winds in a feedback loop that makes the El Niño stronger, says Wenju Cai at the CSIRO, Australia's government research agency. US climate models, on average, are pointing to an El Niño comparable to the devastating 1997/98 event, says Timmermann.

Another thing likely to give this year's El Niño an extra kick is the presence of the Southern Hemisphere Booster. A low-pressure system near Australia that boosts westerly winds across the Pacific, it helps unlock the heat fuelling El Niño, says Fei-Fei Jin of the University of Hawaii at Manoa.

Timmermann says we should be preparing, clearing rivers of debris in flood-prone areas and storing water in drought-prone areas. He has already installed hurricane clips on his roof, as El Niño also increases the chances of hurricanes making landfall on Hawaii. Michael Slezak ■

FIELD NOTES Uganda's forest reserves

ESTHER NAKKAZI

Heavily logged Ruzaire forest

Dwindling forests are hollowed out

Esther Nakkazi

IT'S early morning in the forest. All is quiet except for cricket song in the distance. The insects and birds overhead seem uninterested in the few bare tree trunks still standing – the only evidence that giant trees once stood here. The destruction goes as far as the eye can see. In some areas freshly sown beans are sprouting.

As we walk through Ruzaire forest reserve, some 12 square kilometres of protected land in Uganda, it is as though the perpetrators have just left. An axe and a coat hang on a tree trunk, near freshly cut firewood tied in bundles. It's indicative of a larger struggle: the dwindling forests here are being hollowed out despite efforts to preserve them.

Roughly a third of the 16 forest reserves in Kibaale district have been seriously damaged and occupied by squatters. About half of those are 50 per cent occupied, says Charles Arian, a manager for Kibaale district at the National Forestry Authority (NFA).

Uganda's forest cover fell from 24 per cent in 1990 to 10 per cent in 2009, and it is still falling. Every year the country loses around 88,000 hectares of forest, according to the NFA. If forest loss continues at this rate, there will be none left in a few decades. Commercial logging is largely licensed, but illegal logging by people settling in the forests often takes the authorities by surprise.

Arian says migrants from other parts of the country as well as neighbouring countries started encroaching on Kibaale central forest reserves over 20 years ago. They create extensive farms and build permanent settlements; some take possession of land using fake documents.

From the outside, the forest reserve looks intact. This is because the "encroachers", as they are called locally, start clearing from the centre. "Inside, the forests have all been cleared and permanent structures – churches, schools, brick houses – are all in sight," says Arian.

Protecting the forest reserves isn't easy – or safe. "Most illegal loggers work at night and rest during the day. Even then they are usually armed with traditional tools [like] spears, machetes, hoes, ready to fight back," says Frederick Kugonza, a district forest supervisor at NFA.

"Illegal loggers are armed with traditional tools like spears or machetes and ready to fight back"

Most of the native hardwood species like African teak have been cut down. Reforestation efforts focus on softwoods like eucalyptus or pine, which mature within 20 years, a third of the time needed for a hardwood tree to mature. This is changing the forestry landscape, too, as well as affecting the wildlife.

The forest animals have moved on as the illegal loggers have moved in. There used to be elephants, wild pigs, apes, baboons, antelopes and duikers here. But little trace of them remains.

In the evening we head for Kangombe central forest reserve, which is about 10 times the size of Ruzaire. The name Kangombe comes from the local word for the trumpeting elephants that once lived here but are now gone.

Whatever wildlife is left has an unhappy relationship with the new human residents in these two reserves. Baboons, for example, raid cars and gardens for food. "The animals have nowhere to go and little to eat," says John Makombo, director of conservation at the government's Uganda Wildlife Authority. "We are getting so many cases of conflict between man and animals."

One of the squatters, Phoebe Kyokusaba, tells me she was terrified to find chimpanzees surrounding her 10-month-old baby when she left her in shade while digging in the forest. "When chimpanzees see these children they think they have been abandoned," says Edward Asalu, the conservation area manager for the Kibale National Park. This can lead to chimps biting the struggling children, he says.

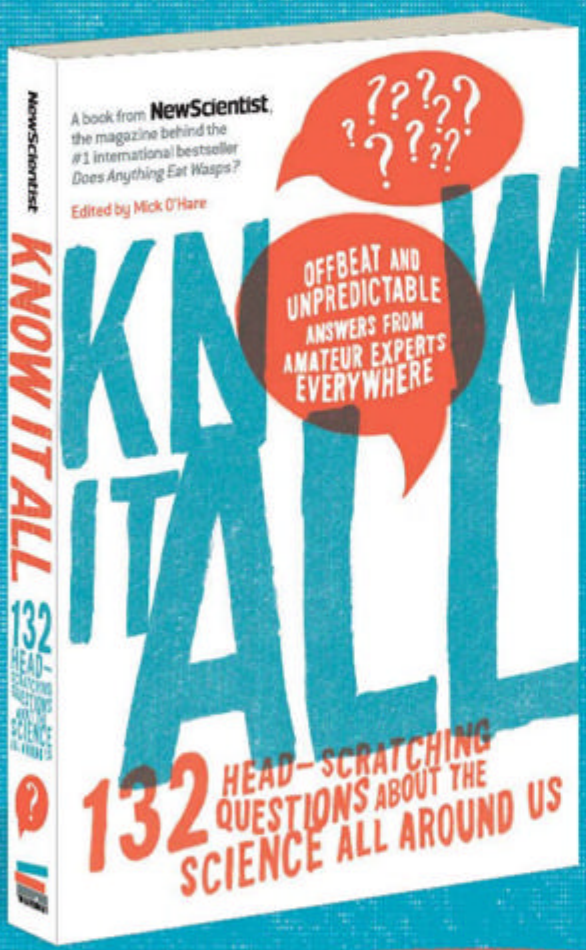
People I speak to say politicians are partly to blame, accusing them of turning a blind eye to illegal settlers in the forests, hoping for their vote in future elections.

But Margaret Adata, the commissioner for forestry at the Ministry of Water and Environment in Kampala, says the country is committed to reversing the trend. The goal is to reattain the forest cover of the 1990s by 2040. This will involve moving the illegal settlers out of the forests and then reforesting.

Asalu is hopeful this will help the wildlife, too. "Once we get the forests protected, then we get the animals protected," he says. ■

THE BAFFLING, TRIVIAL, CURIOUS, OR STRANGE . . .

KNOW IT ALL



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GRAEME ROBERTSON/EYEVINE/EYEVINE

Count apples at night to help robots pick them

AN APPLE by night makes the count come out right. An algorithm for identifying apples on trees gets the most accurate count yet by shining a light on them at night, paving the way for future automated harvests.

Determining how much fruit is on a tree or the ground is a challenge for computers as leaves and branches get in the way. Algorithms also have to contend with apples of different colours, depending on their ripeness, variety, the weather and the time of day.

To solve these problems, Raphael Linker and Eliyahu Kelman of the Technion - Israel Institute of Technology in Haifa wrote a program to search photographs of lit-up apple trees for glints in the foliage: light reflecting off the shiny fruit. Leaves give off reflections, too, but those off the apples are circular.

The system isn't perfect – it missed as many as 20 per cent of the apples, and reported false positives. But as long as such errors are consistent, says Linker, you can correct for them and arrive at very accurate estimates. In one experiment, when humans counted 6713 apples in the pictures, the computer counted 6687 – not too far off (*Computers and Electronics in Agriculture*, doi.org/4hb).

"With farms getting larger, farmers only have the time to look at a few trees," Linker says. "If you could have an automated system driving over the orchard, you'd get a much more reliable picture."

Genes weaken your health in winter

THE chilly, rainy months can easily become our winter of discontent. Not only do we get more coughs and colds, but there are also more heart attacks and diagnoses of autoimmune diseases. Now we have an idea why.

Our immune system becomes more reactive in the colder months and this has unwanted effects on the body. The discovery came from analysing how gene activity changes through the year using blood samples from more than 16,000 people.

The most striking pattern was that 147 genes involved in the immune system made it more reactive or "pro-inflammatory" during winter or rainy seasons (*Nature Communications*, DOI: 10.1038/ncomms8000).

Inflammation is increasingly being implicated in heart disease, autoimmune diseases and other conditions.

The discovery that some of our genes are seasonal suggests we should watch our health more closely in winter, says co-author John Todd, from the University of Cambridge. "If you swapped hemispheres every winter, you could probably lower your pro-inflammatory status," he says. "Some people do move to sunnier climates in winter and they probably feel better for it."

Necrophiliac mite prefers dead mate

DROP-DEAD gorgeous. That is how the two-spotted spider mite must see its potential mate. The only trouble is, she might actually have dropped dead.

Male spider mites of the species *Tetranychus urticae* wait next to immobile female larvae that should soon emerge to mate. But Nina Trandem of the Norwegian Institute for Agricultural and Environmental Research and her team found that some mites are dead wrong about who they court.

They presented the mites with a choice of live female larvae and those killed by a pathogenic fungus. The males prodded and guarded some cadavers more than they did healthy females, and some even touched infectious cadavers (*Journal of Invertebrate Pathology*, doi.org/4g7).

The team thinks the fungus may be producing chemicals that the mites find attractive – or the males may simply be confused.

Slower rise in sea level is an error

AN APPARENT slowdown in rising sea levels over the past decade is a measurement error. In fact, sea levels are rising faster than ever.

Satellite data since the 1990s suggested that sea levels had risen slightly more slowly in the past decade than in the decade before – even as we saw more glacier and ice-cap melt. "It was a bit of puzzle," says Christopher Watson of the University of Tasmania in Hobart.

His team's analysis showed the apparent decline was due to calibration errors that meant the first satellite – which operated from 1993 to 1999 – slightly overestimated sea levels. This masked the ongoing acceleration (*Nature Climate Change*, DOI: 10.1038/nclimate2635).

Breathe in, hold it, that feels better

PAINFUL needle heading your way? A sharp intake of breath might make the pain a little more bearable.

When you are stressed, your blood pressure rises. But pressure sensors on blood vessels in your lungs can tell your brain to bring the pressure back down. Signals from the sensors also make the brain dampen the nervous system, leaving you less sensitive to pain.

Gustavo Reyes del Paso at the University of Jaén in Spain wondered whether holding your breath – a stress-free way of raising blood pressure and triggering the pressure sensors – might also raise a person's pain threshold. To find out, he squashed the fingernails of 38 people for 5 seconds while they held their breath. Then he repeated the test while the volunteers breathed slowly. Both techniques were distracting, but the volunteers reported less pain when breath-holding than when slow breathing (*Pain Medicine*, doi.org/4gk).

Reyes del Paso doesn't think the trick will work for unexpected injuries. You have to start before the pain kicks in, he says, for example, in anticipation of an injection.

"It may be possible to coach people in acute pain – such as during childbirth – to control their pain by breath-holding," says Richard Chapman at the University of Utah in Salt Lake City.

WENDY ASHTON/GETTY

Mars volcanoes launch dust storms like a skate ramp

OLYMPUS MONS is the solar system's sickest halfpipe. It and other Martian volcanoes act like skate ramps to launch dust up to 75 kilometres above the planet's surface, observations from NASA's Mars Reconnaissance Orbiter (MRO) have revealed.

Massive dust storms can whip particles up into the Martian atmosphere and turn the entire planet hazy.

But there are other dust layers that don't seem to be related to large storms, say Nicholas Heavens of Hampton University, Virginia, and his colleagues. The team analysed data from dust sensors on MRO and discovered unusually thick layers of dust above an altitude of 50 kilometres, extending horizontally for over 1000 kilometres. They seemed to cluster around Olympus Mons and the Tharsis Montes, a group of three large volcanoes nearby.

There were no signs of these layers elsewhere on Mars, suggesting that the volcanoes play a role in their formation.

The layers were also most common during Mars's northern summer, when the volcanoes' summits are heated more intensely than their slopes, creating thermal currents.

Modelling suggests that localised storms with winds of over 150 kilometres per hour could be blowing dust up the slopes (*Geophysical Research Letters*, doi.org/4gm).

"Our interpretation is that the dust layers do come from volcanically based dust storms, which occur far more frequently than previously inferred from observations," says Heavens.

Magnetic Mercury sticks around

MERCURY has always had a warm gooey heart. Now NASA's Messenger spacecraft has revealed that the planet's liquid iron core has been generating a magnetic field for the past 3.8 billion years.

Mercury has a magnetic field about 1 per cent the strength of Earth's. It is generated by the rotation of liquid iron in the core, just as happens inside Earth.

Messenger orbited over 200 kilometres above Mercury for most of its four-year mission, but towards the end it circled lower before crashing last month. Below 100 kilometres, it saw an even weaker magnetic signal coming from the rocks on the surface, says Catherine Johnson at the University of British Columbia in Vancouver, Canada.

The magnetism was strongest in terrain estimated to be between 3.7 billion and 3.9 billion years old, suggesting that Mercury has had a magnetic field for almost the entirety of its 4.5-billion-year history. If that ancient field has persisted all this time, it makes Mercury the planet with the longest-lasting magnetic field known. Earth's earliest trace of magnetism dates back just 3.5 billion years (*Science*, doi.org/4g5).

CHRISTIAN LUKHAUP

Solved: case of the unknown crayfish

IT HAS been one of the aquarium trade's mystery stars. But although this colourful crayfish has been on sale since the early 2000s, no one was sure of its species or where it came from.

Suppliers are secretive to stop others muscling in on their business, says Christian Lukhaup, an independent researcher from Germany. So he did his own detective work on the crayfish's origins. "It is like an investigation in a crime case," Lukhaup says. "This is the only way to find out more."

Lukhaup suspected the crayfish was from Indonesia's West Papua province, and he asked local people if they had ever seen it. Eventually, he found specimens at a creek. Detailed study revealed it was a new species. In honour of its appearance, he named it *Cherax pulcher* – pulcher meaning "beautiful" in Latin (*ZooKeys*, doi.org/4g6).

"It is gorgeous," says Zen Faulkes from the University of Texas-Pan American. The crayfish is captured extensively in its native habitat. "It may be from this tiny location, and it could be wiped out before we know anything about them," Faulkes says.

Happiness, the AI way

Gadgets with emotional intelligence will soon be bonding with us to try to bring joy into our lives, finds **Sally Adee**

BETSIE VAN DER MEER/GETTY; LEFT EMO SPARK

"BRIAN? How are you, Brian?" The voice is coming from a screen dominated by a vast blue cartoon eyeball, its pupil dilating in a way that makes it look both friendly and quizzical. Think HAL reimagined by Pixar.

This is EmoSPARK, and it is looking for its owner. Its camera searches its field of view for a face and, settling on mine, asks again if I am Brian. It sounds almost plaintive.

EmoSPARK's brain is a 90-millimetre Bluetooth and Wi-Fi-enabled cube. It senses its world through an internet connection, a microphone, a webcam and your smartphone. Using these, the cube can respond to commands to play any song in your digital library, make posts on Facebook and check for your friends' latest updates, stream a Netflix film, answer questions by pulling information from Wikipedia, and simply make conversation.

But its mission is more complex: EmoSPARK, say its creators, is dedicated to your happiness. To fulfil that, it tries to take your emotional pulse, adapting its personality to suit yours, seeking always to understand what makes you happy and unhappy.

Feeling... boxed in

The "Brian" in question is Brian Fitzpatrick, a founding investor in Emoshape, the company that makes EmoSPARK. He and the device's inventor, Patrick Levy Rosenthal, compare EmoSPARK's guiding principles to Isaac Asimov's laws of robotics. They are billing the cube as the world's first "emotional AI".

But EmoSPARK isn't the first robotic agent designed to learn from our emotions. There's Jibo the family robot and Pepper the robot companion. Even Amazon's Echo voice-activated controller might soon be able to recognise emotions.

The drive to give artificial intelligence an emotional dimension is down to necessity, says Rana el Kaliouby, founder of Affectiva, a Boston-based company that creates emotion-sensing algorithms. As everything around us, from phones to fridges, gets connected to the internet, we need a way to temper machine logic with something more human.

And when the user is immersed in a world that is as much computer as real life, a machine must learn some etiquette. For example, you shouldn't come home from a funeral to find your AI itching to tell you about the latest Facebook cat videos.

How can a machine be trained to understand emotions and act on them? When EmoSPARK's webcam finds my face, a red box flashes briefly on screen to indicate it has identified a face that isn't Brian's. Behind the scenes, it is also looking for deeper details.

EmoSPARK senses the user's emotional state with the help of an algorithm that maps 80 facial points to determine, among other things, whether he or she is smiling, frowning in anger or sneering in disgust. EmoSPARK also analyses the user's tone of voice, a long-established method of mood analysis.

Having sensed these details, EmoSPARK uses them to mirror your emotions. First, it creates an emotional profile of its owner based on the combination of facial and voice input. At the end of each day, it sends this information to EmoShape, which sends back a newly tailored emotional profile for that particular device. Through this feedback loop, Fitzpatrick says, the cube's personality changes ever so slightly every day.

Hard problems

Rosalind Picard at the Massachusetts Institute of Technology is sceptical that this can produce an accurate emotional profile. Picard, who designs facial and vocal analysis software to help computers interpret emotion, and co-founded Affectiva with el Kaliouby, says there's more to understanding moods than mapping points on the face. "What does it know about the context? How much data is it trained on? How is it being taught the true feelings of the person? These are still hard

FEELINGS CAN SWAY ROBOT CHOICES, TOO

Artificial intelligence works when the programmer has a specific goal in mind, such as collision avoidance. But what about something more open-ended, such as foreseeing risk?

This requires the human capacity to make judgements. One approach is to equip the machines with emotions such as fear, curiosity or frustration, says Massimiliano Versace at Boston University. Such emotions are an important aspect of our intelligence and decision-making, but are different from the social emotions now in vogue in AIs (see main story).

These motivational emotions might be invisible to users of the AI, but more often than not, Versace says, the winning strategy "is the one that feels better". He and his team have started working with NASA to design robot brains with emotional intelligence, to be used for exploring planetary surfaces.

Do I detect a smile?

problems to solve."

The algorithm used by EmoSPARK isn't necessarily all that sophisticated. Coaxing it to register a user's smile requires a toothy grin in good lighting; real-world conditions, for most people, don't live up to that.

But maybe you don't need a million-dollar algorithm. One aspect of creating "emotional" AI requires neither hardware nor software: it's just a matter of exploiting what our brains do naturally. "We anthropomorphise everything," says Eleanor Sandry at Curtin University in Perth, Australia. Humans project intent and emotions on to anything from dolphins to Microsoft's paper clip. We can't help ourselves.

And EmoSPARK pulls out all the stops to put this tendency to work. To calibrate your cube, you undertake a ritual which ensures that only one person can be emotionally bound to it. "Are you the person I am to bond with?" is its first question. Although it will recognise other individuals in the same house or building, it only creates the emotional profile for its owner.

That doesn't mean it can't interact with anyone else. When someone who is not Brian taunts it, saying "I don't like you", EmoSPARK manifests its displeasure with a pulse of green light that shudders through the cube. "It's funny, I don't like you that much either," it responds. If EmoSPARK had been complimented, it would have glowed purple.

Fitzpatrick says EmoSPARK can react to the user in more subtle ways, too, such as by withholding information or trivia that it regards as having displeased its owner previously. "If you don't like a joke it tells you, it won't tell you that joke again," he says.

Until EmoSPARK has spent some time in people's homes, we won't know whether it can live up to its promise, or even whether having an AI trained on your emotional profile will make anyone feel happy. By now, however, 133 of EmoSPARK's early crowdfunders have received their cubes and will act as beta testers. About 800 more should be available this month.

Whether EmoSPARK succeeds or fails, AI with EQ is something we can expect to see much more

"We just can't help projecting emotions on to anything from dolphins to Microsoft's paper clip"

of, says el Kaliouby. She believes all devices will one day have emotion processors, much as they now contain a GPS chip. This means every device will have its own proprietary algorithm for interpreting users' emotions, and will reflect them back at the user in slightly different ways. If your TV and your phone treat you a bit differently, that only adds to the illusion that you are surrounded by a sentient cast of characters, she says.

Two weeks ago, Affectiva released a mobile software development kit which will allow smartphone and tablet programmers to use its Affdex algorithm to assess emotions. Some prototype applications are already up and running.

Chocolate firm Hershey's is using Affdex to determine whether people smile at a candy dispenser. If it detects a smile, the user gets a free chocolate sample.

Another is an art installation that reads the facial expressions of passers-by and composes messages in real time on a wall to cheer up the depressed and cheer on the happy. "The idea that you can measure emotion and act on it?" says el Kaliouby. "That's happened." ■

ONE PER CENT

BRENDON THORNE/GETTY

Tag it, smell it

Graffiti artists, beware. Trains in Sydney, Australia, can now smell when you are up to no good. An undisclosed number have been fitted with electronic chemical sensors that can detect the vapours emitted by spray paint and permanent markers. When the sensors pick up a suspicious smell, live CCTV in the train sends images directly to security staff. So far, more than 30 people have been apprehended, say police.

"This may go down in history as the 'it's not our fault' study"

Internet researcher **Christian Sandvig** on Facebook's paper in *Science*, which claims that individual choices – rather than its algorithms – create the "filter bubble" effect, which governs what a user sees and doesn't see on social media

Virtual reality on sale

It's almost time for everyone to get immersive. Oculus Rift says its consumer virtual reality headset will go on sale in early 2016. Details, including the price, are scant. Oculus says the consumer version, based on recent prototypes, is lighter than the developers' kits. It will also have an improved tracking system that will allow wearers to sit or stand while immersed in another world.

INSIGHT Self-driving trucks

DAIMLER AG

Just sit back and enjoy your drive

Long road to autonomy

Can smart trucks go it alone? Nevada will tell us, says **Aviva Rutkin**

THE next big thing in autonomous vehicles really is big. Car-maker Daimler has just unveiled a self-driving truck – the first to be approved for use on US roads.

For the freight industry, the Inspiration Truck holds the promise of a future with fewer accidents, lower fuel costs and well-rested drivers.

In recent years, autonomous trucks have been the focus of attention for companies that need vehicles for routes where they are unlikely to encounter people or other vehicles, such as on farms or remote mines.

The Inspiration is different, designed to travel on the highway alongside ordinary cars and trucks. Its clearance to drive on Nevada's highways could be big news for the trucking industry, which struggles to find drivers to do the exhausting work. If it succeeds, other big self-driving vehicles could follow, such as garbage trucks or city buses.

Autonomous trucks have a few potential advantages over their hands-on counterparts. For one thing, they could help cut fuel use, as they accelerate and decelerate more gently than a human driver might. Programming multiple trucks to travel in convoys would be beneficial, too: one truck could travel in the slipstream created by the one in front, reducing air resistance and so using less fuel. The trucks would communicate wirelessly to tell each other when to slow down or speed up automatically.

The freight industry is one that has already embraced robotic help. In the port of Rotterdam in the Netherlands, for example, robotic cranes move containers around. Last year, the country announced a five-year plan to prepare for vehicles like the Inspiration.

"A self-driving car doesn't have emotions when it's driving home from a break-up with its girlfriend"

Proponents of self-driving vehicles also tout their safety benefits. The vast majority of road accidents are down to human error, and artificial intelligence would take those mistakes out of the equation, they say.

"A car never gets tired. It doesn't have any emotions when it's driving home from a break-up with its girlfriend. It doesn't get drunk or old and slow," says Patrick Vogel at the Free University of Berlin in Germany.

Although a human driver still sits in the cab, the Inspiration trucks know how to stay in lane, change speed and avoid collisions. A dashboard-mounted camera with a 100-metre range can recognise pavement markings and keep the truck in its lane. Radar monitors the road up to 250 metres ahead to spot other vehicles, and the truck also automatically complies with speed limits.

But like other self-driving vehicles, the Inspiration is still years away from being produced commercially. Daimler plans to collect real-world data on Nevada's roads to help improve the truck further.

There are non-technical issues that need to be addressed, too. It is not yet clear whether self-driving vehicles can be insured, for instance, or where blame would be attributed in the event of an accident. And the long-term implications for truckers' jobs or roadside businesses like motels and truck stops are also hazy.

"Before it became clear that the technical issues could be addressed, these were academic exercises," says Peter Stone, a computer scientist at the University of Texas at Austin. "Now, they've become very real questions." ■

Robot cleaner can empty bins and sweep floors

ROOMBAS were just the start. An office cleaning robot is being put through its paces by Dussmann, one of Germany's largest cleaning companies, at its Berlin HQ. The goal is getting it to work alongside human cleaners in large offices, emptying bins and vacuuming floors.

The robot was developed by roboticist Richard Borman and colleagues at the Fraunhofer Institute in Stuttgart. It is designed to do two tasks – clean the floors and empty wastepaper baskets – with complete autonomy. It can recognise dirt on the floor and identify wastepaper baskets before its robotic arm grabs and then empties each bin.

At the moment, it cleans too slowly for Dussmann. "Humans can do about 450 to 500 square metres an hour," says Borman. "The robot can do 100 to 120 square metres an hour."

Borman is applying for a grant to work with Dussmann and develop a commercial model that should be much quicker. It also needs a longer-lasting battery: the prototype has only four hours of power – a commercial version would need to run all night.

Only big offices are suitable for this kind of robot; humans would have to move it between small offices, which negates the benefits. Other cleaning robots do exist, but they can't navigate a building autonomously and have one function. Hal Hodson ■

FRAUNHOFER IPA

Clean living

TOMORROW'S MEDICINE TODAY

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NewScientist

The icemen cometh

FANCY a vodka on the rocks? This Arctic iceberg could be heading for a luxury drink near you.

Floating off the coast of Newfoundland in Canada, this massive chunk of ice is big business. Iceberg hunters like Ed Kean and Philip Kennedy (below) have found a way to cash in on this unlikely crop: catching the floating icebergs in large nets, hauling them aboard and selling them on to upmarket mineral-water and vodka manufacturers.

These companies want the ice for its Arctic purity: the water in these icebergs is around 12,000 years old and probably contains very few pollutants. For millennia, this water has lain trapped and preserved in the glaciers of Greenland, only recently breaking off in chunks and drifting southwards to Canada at speeds of up to 7 kilometres a year – pretty fast for an iceberg.

Catching the ice and dragging it aboard is a rewarding but tricky task. In addition to the sheer difficulty of physically capturing and handling a massive ice chip, the iceberg hunters face increasing competition from each other as they fight to meet demand in a highly lucrative market.

Not everyone is happy with this icy harvest, however. Tour operators in the region say that this business is destroying one of its main visitor attractions. Iceberg tourism is one of the few growth industries since the decline of cod fishing in this cold, eastern stretch of Canada.

Penny Sarchet

Photographer

Veronique de Viguerie

Getty Images Reportage

Fallible forensics

Crime labs must be open to greater scrutiny, says **Greg Hampikian**, a DNA expert on the Amanda Knox case

GALILEO famously declared that "science proceeds more by what it has learned to ignore than by what it takes into account". As DNA consultant for the defence in the Amanda Knox case, I was constantly reminded of the pertinence of this observation during her legal battle in Italy.

Knox, along with Raffaele Sollecito, was definitively cleared of killing Meredith Kercher earlier this year, but only after a long fight that had at its heart the ability of forensic science and the judiciary to know what to ignore.

On the day of the murder in 2007, police collected many samples from the room where Knox's housemate Kercher died. Knox and then boyfriend Sollecito were held on the basis of the prosecutor's gut instinct, but when fingerprints and DNA from the scene were analysed, only two profiles were identified: those of

the victim and Rudy Guede, a man known to police. He was convicted of murder, but the prosecutor still pursued Knox and Sollecito.

One piece of evidence emerged as crucial: a kitchen knife at Sollecito's house. It didn't match many wounds on the body and tested negative for blood. DNA from Knox was on the handle – she had cooked with it. But on one swab from the blade, a minuscule trace of DNA was detected, just once during many analyses. It had some that was consistent with the victim's. This finding was never repeated, despite many attempts. The debate was about whether or not that single result was reliable.

For any scientific procedure, it is crucial to know how often it gets things wrong as well as right. In Knox's case, the DNA on the blade came from so few molecules that analytical instruments were pushed to read below the level

OK computer?

Data science seeks to resolve debates in music history. Is it a hit or miss, asks **John Covach**

THE power of big data is regularly hailed. But can it really pin down key turning points in pop music and settle long-running debates among scholars of music history?

That is the premise of "The evolution of popular music: USA 1960–2010", which analysed 17,094 singles in the US Billboard Hot 100. It concluded that 1964, 1983 and 1991 saw "revolutions" in music. The first was the rise of rock, the second synthesiser sounds and the third hip hop.

Although the information is fascinating and the general goal is laudable and forward-looking, this study is far from being a definitive take because of design limitations and problems with interpretation. The authors are aware that several million singles were released in the US over the period studied. Yet claims are made about the history of pop beyond what the data can support.

They used 30-second segments from about 86 per cent of Hot 100 songs, each analysed for aspects of harmony and timbre to map out when new sounds took hold. It is unclear how the excerpts were extracted. But if we assume these were continuous, as appears to be the case, it means vital elements of many songs could be missed.

"The most pressing problem is the use of the Hot 100 chart to back broader claims about pop history"

But the most pressing problem is using the Hot 100 to back broader claims about pop history. Pop historians consider many factors apart from chart position, which they tend to be wary of because of possible music-industry manipulation. And if one does rely heavily on ranking, the album charts must be included. No single was released from the landmark *Sgt. Pepper's Lonely Hearts Club Band* (1967) by The Beatles, for instance. In 1975, Led Zeppelin's *Physical Graffiti* spent six weeks at the top of the Billboard album charts, whereas

that the FBI, my lab, or anyone I knew would go. We asked the Italian lab to supply validation of such a sensitive measurement, but they never complied. Despite this, Knox was convicted. DNA experts in the US spoke out and a new study on the knife was then ordered in Italy. This failed to repeat the DNA finding, and Knox and Sollecito were freed on appeal in 2011. Then in 2014, the conviction was inexplicably reinstated. The final hope rested with the supreme court this March. Justice would require it to see that there was no credible DNA evidence. Apparently it did.

Knox and Sollecito waited years to be properly cleared. Calls followed for global standards on use of low copy number DNA. But we also need better ways to weigh up new forensic techniques and issue warnings if required.

My research has shown that DNA tests are prone to subjectivity in labs. So forensic facilities must put out validation records and error reports, and open data up to scrutiny – anything less creates too high a risk of false convictions. ■

Greg Hampikian is a professor of biology and criminal justice at Boise State University and directs the Idaho Innocence Project

the single *Trampled Under Foot* only reached number 38. A broader sample outside the singles charts would reveal 1967 and 1977 (and maybe 1970) as other revolutionary years.

The authors say pop history scholarship appeals to "anecdote, connoisseurship, and theory unadorned by data", and their approach views pop data as a "fossil record" ripe for analysis. I reckon palaeontologists would want more than a fossil record if they could get it. Most music researchers certainly do. ■

John Covach heads the Institute for Popular Music in Rochester, New York

ONE MINUTE INTERVIEW

Airships over the Amazon

The rainforests of Brazil offer huge transport challenges, so **Marcelo Felippes** is developing a lighter, greener approach

PROFILE
Engineer **Marcelo Felippes** is the institutional director of Airship do Brasil, based in São Carlos, near São Paulo, Brazil, which develops lighter-than-air technology. He is an authority on jungle logistics

What gave you the idea for using airships to transport cargo in the Amazon?
I was a lieutenant in the Brazilian army in the 1980s and I saw the difficulties of moving equipment around in the Amazon, especially for platoons working in densely forested border regions. The army has a long tradition of using balloons and airships for border surveillance.

What advantages do airships offer?
The Amazon is a very harsh environment and transporting heavy cargo by land is a Herculean task. Waters rise and fall annually and roads get flooded and erode, or get buried in mud. In order to cross streams and rivers, many roads are connected by small ferries. Air freight and river transport are options, but the first is very expensive and the second is very slow. Airships are cheaper than planes and faster than boats.

And environmentally friendly, presumably...
Absolutely. To transport heavy equipment you need surfaced roads from departure to destination, and to build those roads you need to clear the path, tearing down vegetation and disturbing all the wildlife. Roads are terrible for the Amazon's ecology. They are also colonised by people who further disturb the forest with agriculture and hunting. Airships need very little in the way of infrastructure, and ours will be able to stay afloat for up to 20 days without refuelling. They are also much less polluting than planes.

Tell me about your airships.
Our first semi-rigid, crewed airship – a 3-tonne-payload version – will be completed in the coming months. We will then build a fleet of larger airships, each capable of carrying 30 tonnes. These craft will be 140 metres long and 60 metres tall, with a top speed of between 80 and 120 kilometres per hour.

What will you use your craft for?
Reduced dependency on ground infrastructure makes airships ideal for transporting heavy equipment in difficult and fragile regions. For example, our airships could carry hydroelectric turbines, towers for high-voltage power lines or blades for wind turbines with minimal disruption. Lower-impact logging is another possibility.

What kinds of challenges have you faced?
The biggest challenge is overcoming people's fear. When people think of airships, they tend to think of disasters: the explosion of the hydrogen-filled Hindenburg in 1937 and the British R101 on its first overseas voyage in 1930, for example. Our airships are filled with helium, which is neither flammable nor explosive. And the materials we use are composite, plastic-like components that do not attract lightning. We are convinced they are safe.

Will the airships entice tourists?
Airships offer excellent views of the forest and rivers. We are not focusing on tourism, but we may develop something for the Olympics in Rio de Janeiro in 2016. We'll have airships ready by then.
Interview by Adrian Barnett

AIRSHIP DO BRASIL

Ommm… aargh!

Meditation and mindfulness have a dark side that should not be ignored, say psychologists **Miguel Farias** and **Catherine Wikholm**

TWITCHING, trembling, panic, disorientation, hallucinations, terror, depression, mania and psychotic breakdown – these are some of the reported effects of meditation. Surprised? We were too.

Techniques such as transcendental meditation and mindfulness are promoted as ways of quieting the mind, alleviating pain and anxiety, and even transforming you into a happier and more compassionate person: natural cure-alls without adverse effects. But happiness and de-stressing were not what meditation techniques, with their Buddhist and Hindu roots, were originally developed for. The purpose of meditation was much more radical: to challenge and rupture the idea of who you are, shaking one's sense of self to the core so you realise there is "nothing there" (Buddhism) or no real differentiation between you and the rest of the universe (Hinduism). So perhaps it is not so surprising that these practices have downsides.

Blissful or distressful

Take mindfulness, a technique in which you try to develop a state of "bare awareness" by focusing on what you are feeling and thinking in the present moment. Such meditation for 20 minutes a day is likely to provoke mild changes in self-perception. While practising this, you usually feel more aware of your breathing, body and thoughts. Now imagine going on a meditation retreat and trying to extend your focus on the flow of awareness for six or more hours a day.

This might feel blissful for some as everyday concerns dissipate, but for others the outcome will be emotional distress, hallucinations or perhaps even ending up in a psychiatric ward. David Shapiro of the University of California, Irvine, found that 7 per cent of people on meditation retreats experienced profoundly adverse effects, including panic and depression. Experience appears to make no difference – experts and naive meditators are equally likely to be affected.

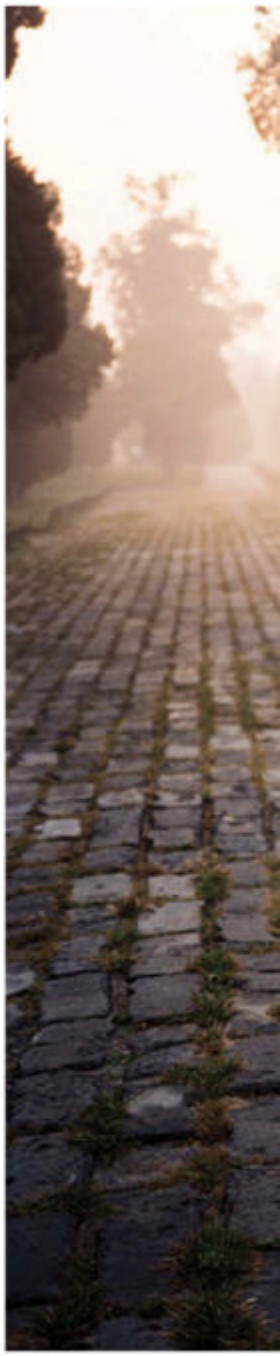
This may all sound counter-intuitive given the many studies published every year on the benefits of meditation, such as last month's report in *The Lancet* that mindfulness-based cognitive therapy could be an alternative to antidepressants for preventing a relapse of depression. Perhaps secular models of meditation such as MBCT are safer than more spiritual types. But even so, we are no closer to understanding the specific part of this therapy that provides the benefit. Is it meditation itself or the cognitive education that comes with the therapy?

And not everyone agrees about the therapeutic merits of meditation. Albert Ellis, one of the founders of cognitive behavioural therapy (CBT), spoke critically of the use of meditation in therapy and argued that it should be used only as a "thought-distracting" or "relaxing" technique. He explained that, like tranquillisers, "it may have both good and bad effects – especially, the harmful result of encouraging people to look away from some of their central problems, and to refrain from disputing their disturbance-creating beliefs".

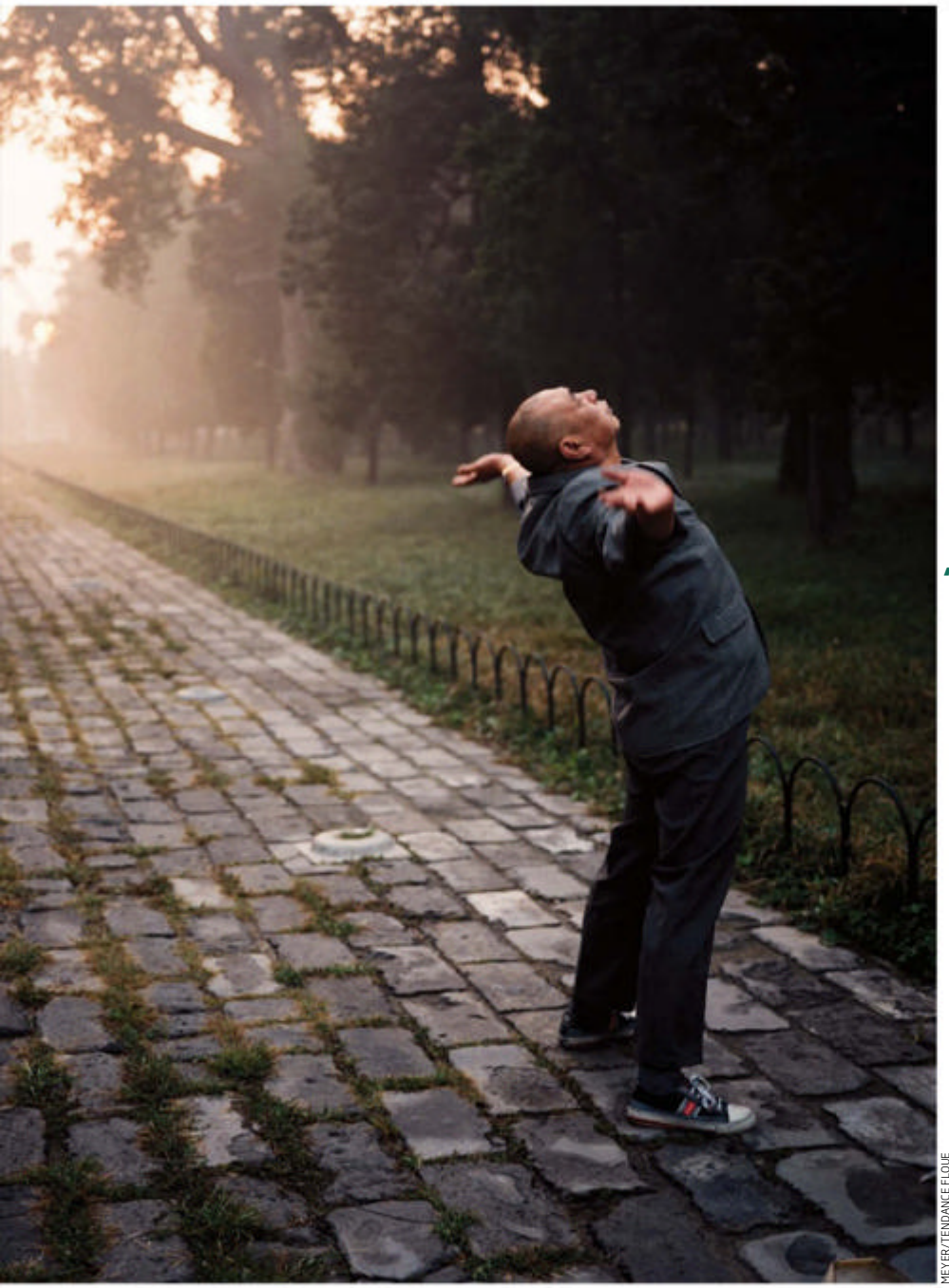
Another key figure in the development of CBT, Arnold Lazarus, argued that meditation was not for everyone and reported that some of his patients had serious disturbances after practising it.

As we scrutinised evidence on the effects of meditation and mindfulness for our book *The Buddha Pill: Can meditation change you?*, we realised that media reports were heavily biased: findings of moderate positive effects were inflated, whereas non-significant and negative findings went unreported. The most rigorous study so far on the results of mindfulness therapy for recurrent depression, conducted by Mark Williams of the University of Oxford, failed to find any main effects: overall, people were as likely to become depressed again whether they had MBCT or not (except if they had suffered trauma as a child). Another study found that practising mindfulness for 20 minutes a day resulted in higher levels of biological stress, as measured by the hormone cortisol (despite lower reported levels of subjective stress) than for those in the non-meditation group. Neither finding made the headlines.

PROFILE
Miguel Farias leads the brain, belief and behaviour research group at Coventry University, UK. **Catherine Wikholm** is finishing her doctorate in clinical psychology at the University of Surrey in Guildford, UK. Their new book is *The Buddha Pill: Can meditation change you?*



The path to enlightenment may be unexpectedly bumpy



MEYER/TENDANCE FLOUE

Why would meditation make you feel more stressed? There are various reasons. Trying to focus your awareness on what you are feeling and thinking can be a demanding cognitive exercise. Another reason that is less well known is that when you meditate "the scum rises to the surface". These are the words of Swami Ambikananda Saraswati, a charismatic meditation teacher and translator of Hindu sacred texts who we interviewed for our book. She confided that most meditation teachers know about this, but don't like to discuss the intrusive thoughts and feelings – such as sexual, sad, fearful or violent ones – that may arise rather abruptly when you meditate.

The reason why this aspect of meditation has been neglected is not a secret. Ideas about meditation as a panacea and a straightforward tool for positive transformation have been around for a long time. But in the early 1970s, when the first papers were published on the effects of transcendental meditation in prestigious journals such as *Science*, the hope that meditation might easily transform the individual and the world started to permeate mainstream culture. The "science of mindfulness" movement that emerged with the popularisation of MBCT and mindfulness-based stress reduction across health services, schools and universities has reinforced these hopes and helped propagate a one-sided, idyllic image of meditation.

Not everyone has bought into this mantra of positivity. Historians and religious-studies scholars have identified a relationship between meditation and violence. Torkel Brekke of the University of Oslo in Norway, who edited a book on Buddhism and violence, describes Buddhist texts that explain how individuals who have become enlightened through meditative practice may act amorally if their actions are undertaken in a detached state of mind. Rather than being exceptional, the association between meditation and detached killing became the norm in Japan during the second world war.

"Meditating can produce powerful effects, but not all of these are beneficial"

The historian and Zen priest Brian Victoria writes how the training of Japanese soldiers included the use of meditation techniques to ensure that the soldier lost his sense of self and "became" the very order he received. This is not a modern phenomenon. Takuan, a famous Zen master from the 1600s, wrote that "[t]he uplifted sword has no will of its own, it is all of emptiness… The man who is about to be struck down is also of emptiness, and so is the one who wields the sword".

Meditating can produce powerful effects on the mind, but not all of these are beneficial or peace-generating. The practice has become a multimillion-pound industry, marketed as if it were the new aspirin – a kind of Buddha pill without religious beliefs or unforeseen side effects.

Despite popular opinion, meditation is not a panacea. The truth is that most of us, including scientists, have beliefs about meditation that are often naive, and have turned a blind eye to its potential dark side. We need to change this. People who try meditation and mindfulness should be aware of the whole range of effects associated with these techniques and how they work differently for each of us. ■

SHOULD YOU SWALLOW IT?

Many of us pop at least one pill a day. But all this medicine could be making you sick. ***Chloe Lambert*** *reports*

WHEN did you last pop a pill? The chances are it was recently, no matter how healthy you are. A growing number of us are taking medicines as part of our daily routine, not because of illness, but to prevent it. A recent survey found that 43 per cent of men in England and 50 per cent of women had taken a prescribed drug within the past week, and half of those had taken three.

"What we've seen is a massive rise in reliance on medicines as a panacea for all our woes," says Clare Gerada, former chair of the UK's Royal College of General Practitioners. "There's been a big rise in screening to look for diseases before they happen, and we have begun treating people 'just in case'."

With life expectancies stretching, many of us have come to see prevention as a sensible route to living a greater number of disease-free years. And the evidence shows this strategy can work, for us and for health services. "There's a very strong argument for saying that screening allows us to intervene to reduce the risks and consequences of developing the illness," says Nick Finer, who studies obesity medicine at University College Hospital in London.

But there is reason to be cautious, too, and take stock of how medicalised our society is becoming. "Preventive drugs can be of huge benefit to people at high risk of disease, but we've gone too far," says Gerada. As a doctor, she says it's not unusual to see patients on 15 different medications.

Doctors and decision-makers can become so focused on a drug's benefits that they overlook the wider effects on patients, says Klim McPherson, an epidemiologist at the University of Oxford. "It's a benign arm of paternalism. They don't think about what it's like to take a drug every day for the rest of your life."

For some people it may feel comforting to be taking pre-emptive action. But at times that can be an illusion, as the examples on the following pages show. What is more, it can distract us from the wider social causes of disease, like alcohol, obesity and loneliness, Gerada says, none of which can be treated with a pill.

> "Doctors don't think about what it's like to take a drug every day for the rest of your life"

Taking several medicines at once can be risky, too. "We might know what will happen if someone takes a statin, but we don't know what happens if they're on a statin, and a vitamin D pill, an aspirin and a proton pump inhibitor to stop the side effect of stomach bleeds," Gerada says. One British study found that 6.5 per cent of hospital admissions were due to drug side effects.

Central to the debate is how the evidence for preventive medication is established. Many are prescribed to prevent conditions they were not developed to treat, for example. "We invent a drug which has an effect on people's complaints, test it to see what it does and end up using it not for therapeutic reasons but for prophylactic reasons, where the benefits are much less and where the possible harms may be much greater," says McPherson.

Preventing illness should save money in the long term, but channelling limited resources into treating healthy people could come at a cost to those who are sick right now, leaving clinicians tied up with patients who aren't even ill. What is more, doctors and patients alike can be bamboozled by evidence, often apparently contradictory, which frequently makes headline news.

Understanding the risks and statistics surrounding health can be puzzling for even the most mathematically literate. But as our society becomes increasingly medicalised, we need to arm ourselves with the information to help us decide whether we should be swallowing those pills. "I am surprised at how few people now complain about the number of medications they are on," says Gerada. "Even a decade ago, people would come and question whether they needed them all."

So should we embrace a drug regimen to promote better health, or accept treatments only when we need them? Over the following pages, we assess the evidence for the five most common – and controversial – everyday medicines.

BALLYSCANLON/PLAINPICTURE

STATINS

One of the most widely prescribed medicines in the world, statins are thought to reduce the risk of heart attack and stroke by lowering blood cholesterol levels, and are now taken by one in four adult Americans over 45. However, once hailed as wonder drugs, they have hit the headlines in recent years over safety concerns and their use in healthy people.

The guidance used to be that statins should be prescribed to anyone who has had a heart attack or stroke. But, increasingly, people with no history of heart problems are offered them too.

In the UK, anyone deemed to have a 20 per cent risk of developing cardiovascular disease in the next decade would have qualified for a daily dose of statins – until last year. Then, following an analysis of 27 trials, the National Institute for Health and Care Excellence (NICE) lowered the threshold to a 10 per cent risk. The risk is calculated using factors like smoking, age, ethnicity and BMI (body mass index – an indicator of being under or overweight), as well as blood pressure and cholesterol levels.

That equates to an extra 5 million people on top of the estimated 7 million already taking statins in England and Wales alone. In the US, the threshold is even lower: the drugs are recommended to those with a 7.5 per cent risk of heart attack, after new guidelines came out in 2013.

NICE estimates that its strategy could prevent 28,000 heart attacks and 16,000 strokes every year. And statins are cheaper than treatment after the event.

But their increased use has met with strong resistance from doctors and patients suspicious of the notion of treating people who are not unwell.

For one thing, it means that for every heart attack prevented, more people will be taking the drug for no benefit. "For low-risk people, with a risk of, say, 10 per cent, taking statins will reduce it to about 8 per cent. A 2 or 3 per cent difference in risk of having a cardiac event is not very big," says Klim McPherson of the University of Oxford. "If you're expected to take a drug every day, you've got to wonder whether it's worth the gamble." ›

For many that gamble is the possibility of side effects. A study and subsequent article in the *BMJ* questioned the data behind the NICE recommendations, warning that some trials included in the analysis were funded by statin manufacturers and that data on side effects was lacking.

Patients taking statins often anecdotally report muscle pain, although this has not been seen in the major, placebo-controlled trials. The *BMJ* article said that one in five people on statins experiences a side effect of some kind, although it later withdrew this claim after Rory Collins at the University of Oxford, a leading statin researcher, spoke out against the accuracy of the statistics.

Yet the anecdotal reports continue to surface. "Some doctors say they keep seeing patients with the same complaint and they feel it's due to the statin," says David Preiss of the University of Glasgow. "It doesn't look that way from the trials, but we need a better answer."

There does seem to be a link to diabetes. Preiss has studied the connection between statins and type 2 diabetes. He says taking a medium-dose statin raises your risk by 10 per cent, and the risk continues to rise in line with dosage. "These are modest changes – people who are probably already on the trajectory to diabetes, and the statin pushes them over the threshold."

In light of all the concerns, Collins is undertaking a major review of the data on side effects, which he hopes will reassure people. That's important, he says, because fears over statins are discouraging people from taking them, to the detriment of their health.

The results should be out later this year. In the meantime, if you've ever had a heart attack or stroke, you should be on a statin if possible, says Preiss. "And if you haven't, but you've been shown to be moderately or markedly at risk of having a heart attack, the benefits of a statin considerably outweigh any risks."

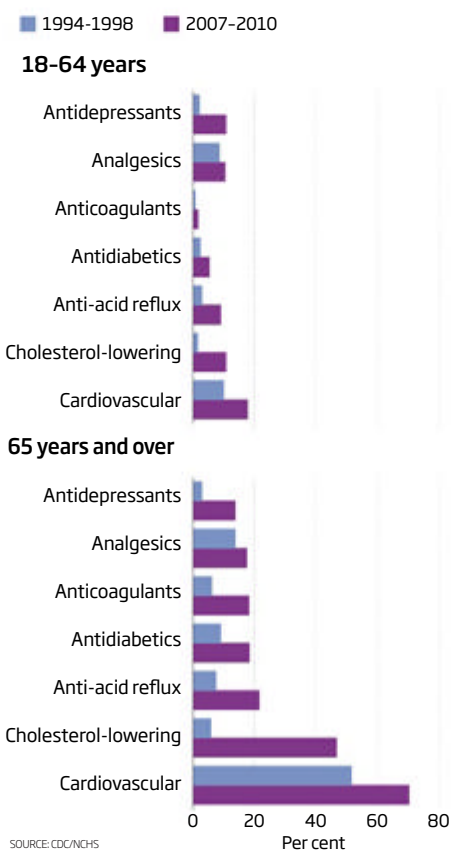
No one should pin all their hopes on a pill in any case. Taking statins should be accompanied by lifestyle changes such as taking exercise and giving up smoking.

BSIP/UIG/GETTY

"For every heart attack prevented, more people will be taking statins for no benefit"

What they popped

The percentage of adults taking the commonest types of prescription drugs is rising, according to a US survey



SOURCE: CDC/NCHS

TESTOSTERONE

If the adverts are to be believed, testosterone supplements are a cure-all for men facing the unfortunate effects of middle age. The hormone is claimed to improve muscle strength, energy and sex drive. However, not only is there little evidence for this, several studies have found a link with heart disease.

Traditionally, testosterone was prescribed to men with abnormally low levels due to a congenital condition or damage to the testes from chemotherapy. Now, though, middle-aged men are being prescribed "testosterone replacement therapy" (TRT) to make up for the natural decline that often comes with age.

In the US, the number of men being prescribed testosterone rose from 1.3 million to 2.3 million in the five years up to 2013, and the UK has seen a similar trend, although the numbers are far lower (see graph, below right).

But in March, the US Food and Drug Administration cautioned that testosterone should only be prescribed to men with low levels caused by medical conditions, rather than general ageing, and confirmed by a lab test. The European Medicines Agency has issued a similar statement.

The health bodies also asked manufacturers and prescribers of testosterone products to warn users about a possible risk of heart attacks and strokes after a number of studies showed an association. One trial was even terminated early due to an "excess of cardiovascular events" among participants. Worryingly, a 2013 analysis found that the level of cardiovascular risk reported varied, depending on whether the study was funded by the pharmaceutical industry.

One possible mechanism for testosterone's effect on the heart could be through raising the number of red blood cells, which thickens the blood and can lead to dangerous clotting.

Another worry is prostate cancer, which feeds on testosterone; drugs blocking testosterone are sometimes used to stop the cancer spreading. A meta-analysis published in 2014 found no link with TRT in the short term, but called for more long-term data.

"There's an absence of data on the use of testosterone outside its key clinical application and yet some clinician enthusiasts, particularly private practitioners in the US, have just exploded testosterone prescribing to the point where it's almost become mainstream," says Richard Quinton, an endocrinologist at Newcastle University, UK.

Part of the problem, at least in the US, is that men are not being properly tested before starting treatment, says Sander Greenland an epidemiologist at the University of California,

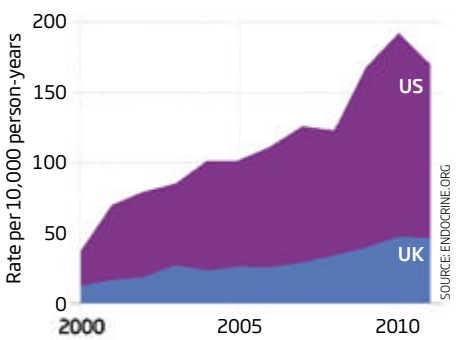
Los Angeles, who recently found that some clinics were even failing to use blood tests, and instead diagnosed men on the basis of a questionnaire about symptoms. Others relied on a single test, which is unreliable because levels vary dramatically throughout the day.

Low testosterone can be a result of health problems such as obesity and diabetes, and some researchers are examining whether TRT could help. But in these cases, says Quinton, it would often be more appropriate to treat the primary condition – for example, by losing weight. He questions whether age-related low testosterone – or "low T" – is even a genuine condition. "Slim, healthy older men have similar levels of testosterone to healthy young men," he says. "So probably 90 per cent of the fall in testosterone with age relates to just accumulating chronic diseases."

It's a personal choice, says Greenland, but "if I was somebody with any cardiovascular risk, I wouldn't go there. Most of all, get tested – and not just once – before you embark on this."

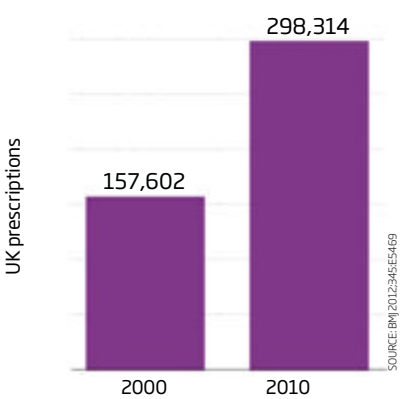
Building up

Between 2000 and 2011, the number of men in the US having their testosterone level tested rose greatly



More muscle

Testosterone prescriptions surged by 90% in the decade up to 2010



HRT

Few treatments have been the subject of such confusing and conflicting findings as hormone replacement therapy, which surged in popularity in the West in the 1980s and 90s.

Back then, enthusiasts suggested that, as well as relieving menopausal symptoms such as hot flushes and night sweats, its benefits extended to protecting the heart and bones, and boosting libido.

That all changed when, in 2002, the Women's Health Initiative, one of the biggest studies on the safety of HRT, showed that the treatment was not protective and might actually raise the risk of heart disease and breast cancer. The number of women using it dropped dramatically as a result (see graph, right). Around 6 million women take HRT in the UK and US at present.

In recent months, HRT has again made the news. A review, published in March, confirmed that HRT had no protective effect on the heart, and found it increased the risk of stroke in post-menopausal women.

It also slightly raises the risk of ovarian cancer, even if taken for just a few years, as is now the most common approach. For every 1000 women taking HRT for five years from around age 50, there would be one extra case of ovarian cancer.

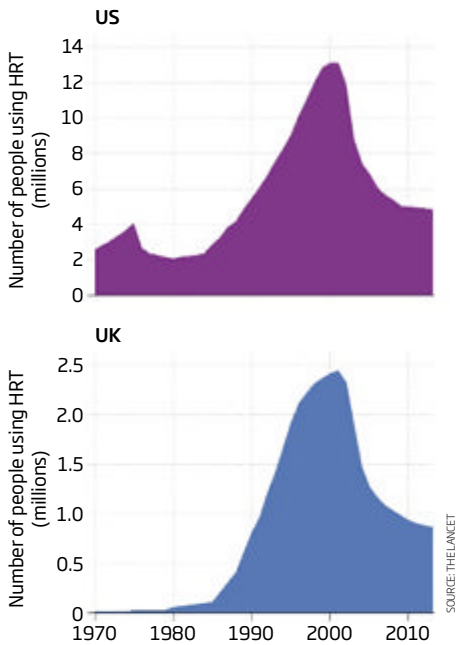
"HRT is important and very effective against menopausal symptoms for many women," says Phil Hannaford at the University of Aberdeen, UK. "However, the current advice is to use the smallest dose possible for the minimum period of time" – usually no more than two to four years.

Rod Baber, an obstetrician at Sydney Medical School and president of the International Menopause Society, says women who have had breast cancer should not take HRT, and those with heart disease should be treated "with great caution". Timing is important, too – the earlier a woman starts using it, the safer and more beneficial it is, Baber says.

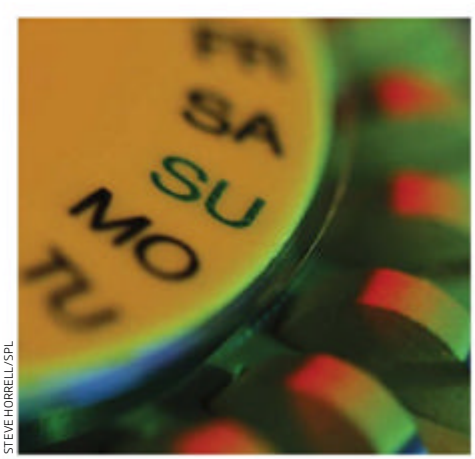
"Women should not start HRT over the age of 60 without consulting their doctor – but that is very different from a woman who started early and finds she needs to continue beyond 60, which is quite OK," he says.

Putting the brakes on HRT

There was a sharp drop in the number of women taking HRT in the US and UK after research showed it not to be as safe as previously thought



"The earlier a woman starts using HRT, the safer and more beneficial it is"



STEVE HORRELL/SPL

THE PILL

It's one of the most efficient forms of contraception and has revolutionised reproductive control for women. One in four women of childbearing age in the UK and the US takes the contraceptive pill as a routine part of their daily schedule, often for reasons other than contraception (see graph, top right).

The pill has drawbacks though. Last year, a review by the European Medicines Agency concluded that some of the bestselling combined contraceptive pills raise the risk of deep-vein thrombosis more than previously thought.

The packaging on these third-generation pills, so called because they contain new types of progestogen, has since been updated, and doctors were reminded to consider patients' individual risk factors before issuing a prescription. These include being overweight, smoking and high blood pressure. The risk of blood clots is still small so, on balance, it is deemed to be outweighed by the benefits of preventing unplanned pregnancies.

In March, it was reported that the pill may raise the risk of Crohn's disease, an inflammatory bowel condition, in women with a genetic susceptibility. And evidence also shows women on the pill have a higher risk of breast cancer.

There are hints that the pill might affect behaviour too, for instance, skewing what people find attractive in a partner. Perhaps ironically, some evidence shows that it can reduce libido.

The pill might also affect the way the brain functions. In April, a brain-scanning study found that two regions involved in emotion regulation, decision-making and reward response were thinner in women taking the pill, although the research gave no indication of whether this caused a real change in behaviour.

Confusingly, though, the pill has also recently gained attention for its health benefits. Data from 46,000 women observed for up to 39 years showed those who took the pill had a lower mortality risk. Lead author Phil Hannaford at the University of Aberdeen, UK, thinks this is because the pill protects against some cancers.

Although it does raise a woman's risk of breast cancer while she is taking it, Hannaford says most women take the pill during their 20s and early 30s, when the background risk is still low, so their chances of getting it are still very slim.

Other protective effects are longer lasting in women who take or have taken the pill. "They have a reduced risk of endometrial, ovarian and colorectal cancer and that effect seems to persist for many years after stopping – well into the age when those cancers become more common," Hannaford says.

On balance, he says, the benefits outweigh the disadvantages, but women should make their choices based on contraception, rather than possible long-term health benefits.

What is becoming clear now, though, is that not everyone responds to the various contraceptive pills available in the same way. "The pill is certainly not for every woman," says Rod Baber, at Sydney Medical School, who is studying its safety.

One of the hardest areas to pick apart is the effect on mood. Many women anecdotally report mood swings or low mood, but the evidence is woolly at best. One recent analysis actually found pill users were less likely to be depressed than non-users.

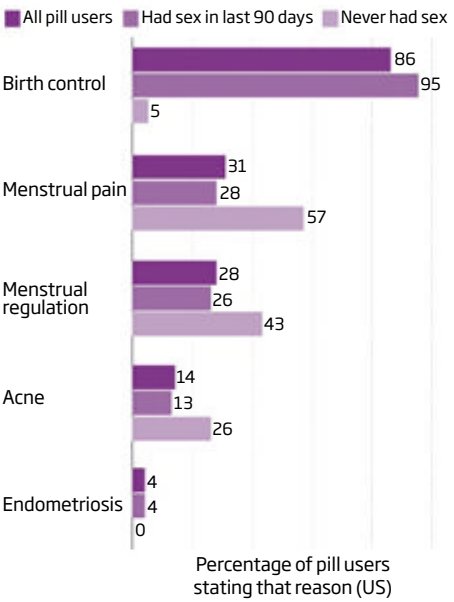
Ellen Wiebe, medical director of the Willow Women's Clinic in Vancouver, Canada, says around 30 per cent of women using hormonal contraceptives will experience emotional and sexual side effects. But it's hard to compare women on the pill with those who are not, because anyone who has experienced problems may just stop taking it without reporting this to their doctor, says Wiebe, which means the groups are self-selecting.

And often, she says, the studies are funded by the manufacturers themselves. They tend to look for symptoms of mental illness, such as suicidal thoughts, so subtler mood changes go unreported.

It's also easy to assume that mood changes are down to relationship issues or life issues. "Women sometimes tell me that they've been on the pill since they were a teenager, and then went off it for some reason and discovered they were a different person. Only then did they realise they'd been having emotional side effects," Wiebe says.

Pill preferences

Many women use birth control pills for reasons other than contraception



SOURCE: HTTP://WWW.GUTTMACHER.ORG/PUBS/FB_CONTR_USE

NATASHA V/MASTERFILE/CORBIS

"People respond to the pill in different ways. It is certainly not for every woman"

ASPIRIN

It's hard to keep up with the latest advice on aspirin. Known for its powerful blood-thinning properties, it is routinely prescribed in low doses to people who have had a heart attack or stroke to protect them from having another.

This has prompted some to argue that it could have a preventive effect in people who have no history of heart problems too. In the US, an estimated 40 million adults now take aspirin every day.

But last year, the US Food and Drug Administration warned against this practice, saying there was not enough evidence to warrant healthy people taking aspirin to help prevent heart disease, even those with a family history.

The key concern is a small but unquestionable risk of gastrointestinal bleeding and haemorrhagic stroke, caused by bleeding in the brain.

A study published in January found that out of 68,000 people in the US who had been prescribed aspirin for primary prevention – meaning they had a history of heart disease – one in 10 were inappropriately given the drug because their chances of heart attack or stroke were not high enough to warrant the risks.

Now the humble painkiller is attracting attention for a different reason – its apparently remarkable effects on cancer prevention. Last year, a review of the evidence led by Jack Cuzick at Queen Mary University of London found that more than 130,000 deaths from cancer would be prevented in the UK alone if all people aged 50 to 64 took a low-dose aspirin every day. Cuzick found that aspirin use led to a 30 per cent reduction in both the incidence and mortality of bowel, stomach and oesophageal cancer, with smaller effects on prostate, breast and lung cancer. The benefits took five years to kick in, but continued after stopping aspirin.

"The second most important thing you can do to prevent cancer, after not smoking, is to take a low-dose aspirin," says Cuzick. He expects NICE, the UK health advisory body, to review the data on aspirin and begin recommending it to the over-50s within two years.

The effect seems to be down to aspirin's anti-inflammatory properties. Inflammation is part of the body's natural reaction to an invader, but cancerous cells hijack it and use it to divide and spread.

Aspirin may also help because it reduces the number of platelets in the blood – platelets can shield cancerous cells in the bloodstream so they are not recognised by the immune system.

So how do you weigh up the risks?

"We estimate that there would be one serious bleeding event for every 300 people that took aspirin for 10 years," says Cuzick. "But aspirin would reduce eight deaths for every one that might be caused, so it's a pretty strong case."

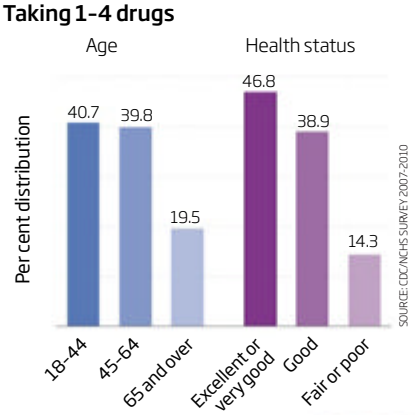
Cuzick found that to reap the benefits, adults would need to take a low dose-aspirin daily for five years – probably 10 – between the ages of 50 and 65. However, after the age of 70, the risk of side effects increases, so at this point aspirin would be likely to do more harm than good.

Peter Elwood at Cardiff University School of Medicine, UK, says the risk of bleeds has been "grossly exaggerated". His research suggests they tend to occur when patients begin taking aspirin without being properly assessed for risk factors, such as high blood pressure or a history of stomach ulcers, so anyone thinking of taking aspirin regularly should consult their doctor first. And because ulcers are often caused by the common bacterium *Helicobacter pylori*, treating that first could protect against the side effects.

Who takes prescription drugs?

Drugs aren't just for the sick. A US survey found that people who had taken 1 to 4 prescription medicines in the past 30 days, were likely to be relatively young and considered themselves to be in good health

Taking 1–4 drugs



DNY59/GETTY

AND THE REST...

ANTICOAGULANTS

Eleven million prescriptions of warfarin were dispensed in England in 2013. It helps stop the blood from clotting, and is recommended for conditions in which dangerous clots can occur, including atrial fibrillation, deep-vein thrombosis, pulmonary embolism and heart attack. There is a small risk of internal bleeding and excessive bleeding from cuts, and side effects include nausea and diarrhoea. Those taking it must have the dose checked frequently, usually once or twice a week. Recently, alternatives that don't require monitoring have been approved for atrial fibrillation but these are expensive, and don't have such a long safety record. Bleeding episodes caused by warfarin can be stopped with vitamin K; for newer anticoagulants, there is currently no antidote.

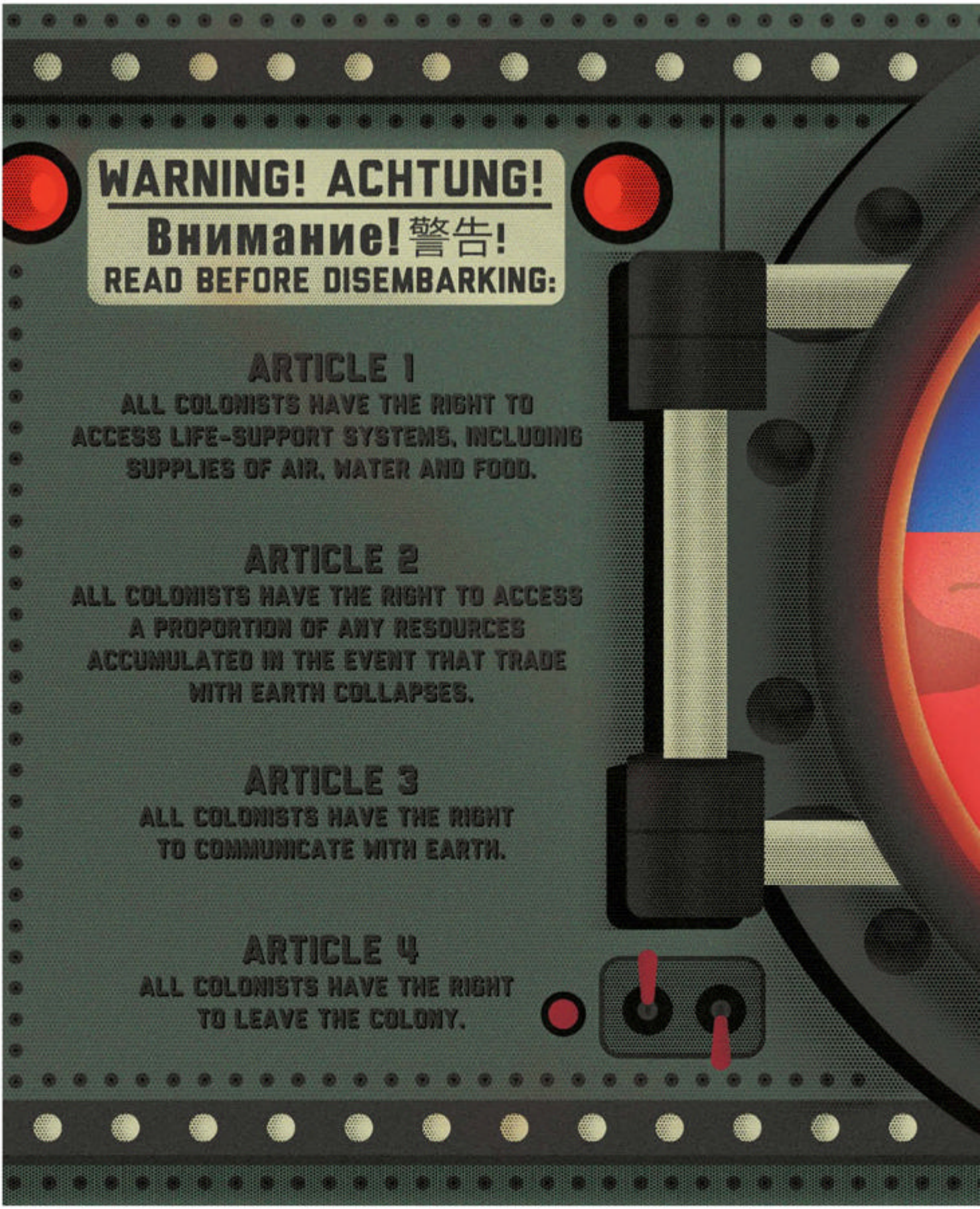
ACE INHIBITORS

Routinely given to people with high blood pressure, ACE inhibitors help lower their readings and prevent stroke, heart attack and kidney failure. Many people with mild hypertension are also on this medication – as many as 50 per cent are prescribed the drug in the US. Doctors are divided. Some believe that the lower your blood pressure the better, but research last year found mild hypertension to have little effect on mortality and morbidity. The US spends $32 billion every year treating high blood pressure. Critics say those with borderline readings should make lifestyle changes before starting on medication.

ANTIDEPRESSANTS

Antidepressants are big business: 10 per cent of Americans aged 12 and over are estimated to be taking them. That doesn't necessarily mean depression is on the rise – they are also given for other mental health conditions such as anxiety, eating disorders and post-traumatic stress disorder, and a significant proportion of prescriptions are now for physical problems. Antidepressants have become a mainstay in the treatment of painful long-term conditions, and can help with migraine, arthritis and even bedwetting in children. Side effects range from sleeping problems to erectile dysfunction. And long-term use has been linked to a raised risk of type 2 diabetes. ■

For more on these and other everyday medicines, including links to studies, see bit.ly/everydaymeds. Chloe Lambert is a freelance writer based in London, UK


WARNING! ACHTUNG!
Внимание! 警告!
READ BEFORE DISEMBARKING:
ARTICLE 1
ALL COLONISTS HAVE THE RIGHT TO ACCESS LIFE-SUPPORT SYSTEMS, INCLUDING SUPPLIES OF AIR, WATER AND FOOD.
ARTICLE 2
ALL COLONISTS HAVE THE RIGHT TO ACCESS A PROPORTION OF ANY RESOURCES ACCUMULATED IN THE EVENT THAT TRADE WITH EARTH COLLAPSES.
ARTICLE 3
ALL COLONISTS HAVE THE RIGHT TO COMMUNICATE WITH EARTH.
ARTICLE 4
ALL COLONISTS HAVE THE RIGHT TO LEAVE THE COLONY.

RADIO

A Magna Carta for Mars

The first humans to reach the Red Planet will face many threats to their survival – not least from each other, says **Andrea Maltman**

FOUR hundred kilometres up, tensions are best left behind. As they prepared to start their year-long tenure on the International Space Station, Russian cosmonaut Mikhail Kornienko and NASA's Scott Kelly were quick to dismiss concerns that the growing animosity between their countries might affect their work together. "There are no borders in space between us," said Kornienko.

Such issues loom larger as we inch closer to longer, more ambitious crewed missions. Mars One, for example, claims it will send a crewed mission to the Red Planet in 2026. It's well known that the seven-month journey to Mars will expose astronauts to DNA damage from cosmic radiation once they are outside the protective shield of Earth's atmosphere and magnetic field, and their muscle and bone density will deteriorate in the low-gravity environment. What's often overlooked, or diplomatically brushed aside, is the effects on the human psyche of boredom, prolonged close proximity to others and competition for scarce resources. This holds not just for the journey, but also once any space colony is established and growing.

For Charles Cockell, a space scientist at the University of Edinburgh, UK, that's a big omission. "The human aspect of space settlement will be as important as the scientific and technical dimension," he says. Cockell thinks it's time to expand our knowledge of human relationships in the extreme environment of space to find the principles that will prevent humanity's first extraterrestrial outposts from collapsing in chaos.

Early tests simulating long space missions have given us cause to think we can't always rely on experience or training. On New Year's Eve in 1999, one month into a 110-day experiment, festivities aboard a mocked-up spaceship on the outskirts of Moscow ended in a female crew member making an accusation of sexual assault, and a drunken brawl between Russian cosmonauts that reportedly left blood spattered on walls. A Japanese crew member walked out in disgust.

Subjects in the Mars 500 experiment fared better. Between 2010 and 2011, a team of six spent 520 days confined in another spaceship mock-up, experiencing little conflict beyond the petty jealousies you might find in the average office. But this and the earlier test were just ground-based simulations.

Mission fatigue

NASA's One-Year Mission, which started on 28 March, takes things to the next level. Though Kelly and Kornienko will not break cosmonaut Valeri Polyakov's all-time record of 438 days on the Russian space station Mir from 1994 to 1995, their stay is set to be the longest aboard the ISS. During their mission, the pair will be monitored constantly to assess their physiological and psychological states.

By comparing blood and saliva samples taken from Kelly and his twin brother – who is also an astronaut but will remain on terra firma – the effects of time spent in space can be disentangled from genetic factors, for ›

example. Changes in bone and muscle mass, sleep patterns and cardiovascular fitness will also be compared. To monitor their mental health, Kelly and Kornienko will face a battery of tests that assess the impact of microgravity and sleep deprivation on cognition and behaviour. They will also each keep a journal that will be analysed to assess their emotional and psychological well-being.

These measures should tell us a little more about how astronauts cope in such a confined environment, orbiting just above Earth. But taking humanity to Mars is a challenge in a different league: for a start, it would be seven months before anyone else could arrive to restore order if things began to fall apart.

In the pressure cooker of an off-world colony, that might justify the use of precautionary measures such as round-the-clock psychological profiling. For example, NASA is currently funding the development of wearable technology that will help astronauts proactively manage their mental well-being and relationships with other crew members.

> "Power would naturally fall to whoever controlled the life-support systems"

Steve Kozlowski, a psychologist at Michigan State University in East Lansing, is designing sensors that constantly monitor a set of variables, including an astronaut's movements, vocal activity, heart rate and face-to-face interaction with others. Any repeated red flags – such as a raised voice, spiking heart rate or lengthy periods spent alone – would be picked up by an algorithm that monitors team dynamics and would trigger what NASA describes as "countermeasures". For instance, the system could notify a team leader who would then check up on the crew member. The goal would be to give individuals the tools to keep themselves in check – but would it be enough? "You can't take a walk to get some air," says Kozlowski.

That's why Cockell and others think we need to do a little more work investigating how human relationships should be managed in space. Cockell's main research interest is how colonies of microbes survive in extreme environments, but he started thinking about the structure of human societies 10 years ago – particularly the issue of freedom. "It occurred to me then that very little thinking had been done on liberty in space," he says.

Space could be a hotbed for tyranny. "The extremity of the extraterrestrial environment is likely to lead to dictatorial conditions," says Cockell. That's partly because power would naturally fall to whoever controlled the life-support systems. Everyone would need access to limited supplies of food, water and air that may be rationed out by just a few people. The lethal conditions would also encourage safety procedures and levels of oversight unseen on Earth, says Cockell.

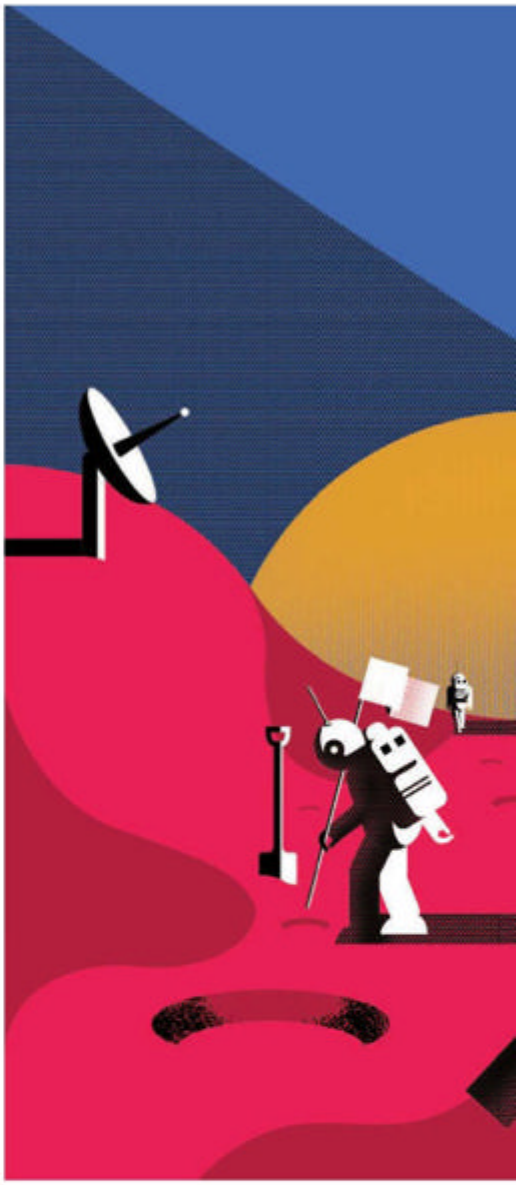
It might be tempting to say that in such an environment, personal freedoms are just luxuries we have to dispense with. But for Cockell, that could jeopardise the success of an early scientific outpost, let alone a thriving society. "If a colony of people degrades into a small group of tyrannically controlled slaves, then that will affect what type of science they do," he says.

The challenge is to carve out a role for the individual among the conformity and rigid controls that would be necessary for survival in an off-Earth settlement, he says. Cockell now helps organise the annual Extraterrestrial Liberty conference, where like-minded researchers meet to discuss the dangers for independence, democracy and good governance when humanity finally drives its flag deep into Martian soil – or indeed elsewhere. At last year's conference, researchers began to draft a provisional social contract – something like a bill of rights and responsibilities for space explorers.

Javier Martin-Torres at Luleå University of Technology in Kiruna, Sweden, who works with NASA's Curiosity rover, was one attendee. For him, the number-one concern is the question of equal access to life support. "Unless comfortable environmental conditions are reached, the colony will always be in a constant state of panic," he says. "A fear of space will only empower those controlling the conditions."

Martin-Torres thinks this can be addressed by ensuring that environments are redundantly protected. For example, life-support systems should be designed so that a loss of pressure or an oxygen leak can be contained in an area that can be shut off without affecting the colony's operation. "None of the provisions should be one-of-a-kind," he says.

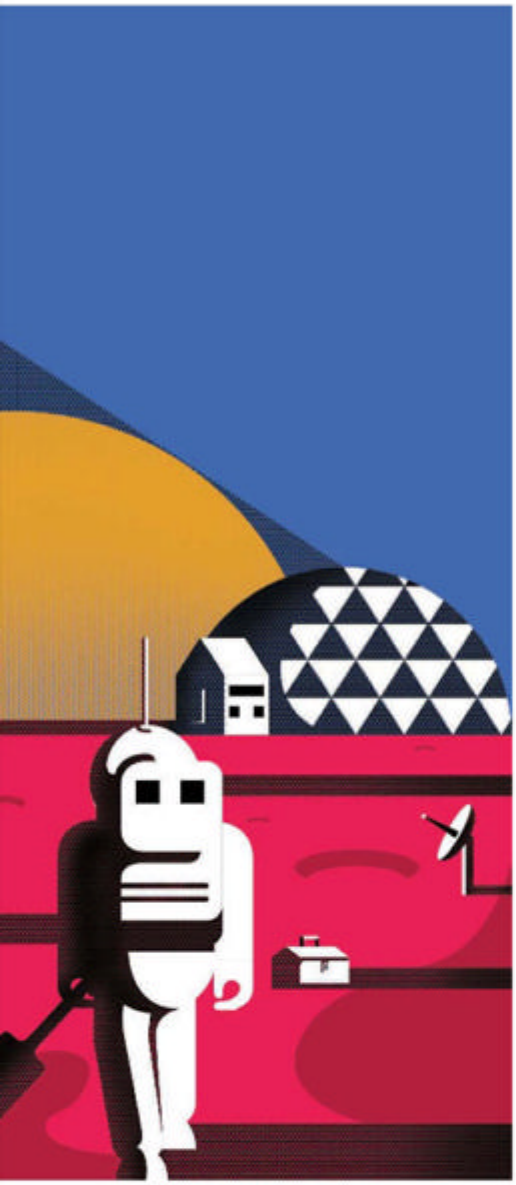
Ensuring the survival of the whole should be everyone's responsibility. Each activity – whether pressurising chambers, cleaning spacesuits or reporting scientific findings – should always be performed under the principle of "colony first". "In such an unfriendly environment, the spirit of community would be absolutely essential," says Martin-Torres.



RADIO

If that sounds a little touchy-feely and, ultimately, unenforceable, there is another factor at play. Stuart Armstrong at the University of Oxford's Future of Humanity Institute thinks that any tendency towards tyranny would be tempered by a settlement's dependence on its Earth-dwelling partners. This would dissuade colonies from slipping into social structures or adopting political processes that differ radically from those of affiliated terrestrial governments.

"Most colonies are likely to be a bit socialistic," says Armstrong. Colonists would be obliged to work for their society's greater interests, but they should also expect considerable social welfare – and high levels of surveillance. For colonies to survive long-term, they must create conditions in which individuals can lead happy lives in spite of such constraints. "Sending someone to Mars



will be very expensive, so you'll only send skilled people," says Armstrong. "But skilled people will only go if they think the benefits outweigh the costs."

Yet it is about responsibilities as much as rights. At first, the glue of space colonies is likely to be science. With research the sole purpose of the early settlements, decisions would typically be made in the interests of this goal. The well-being of the settlers would, of course, be paramount, but ensuring that areas of scientific interest are not contaminated or irreversibly damaged would be a prime directive.

When it comes to human rights and responsibilities beyond Earth, we aren't going in blind. "Space is not a blank canvas," says Cockell. There are established legal systems and dedicated United Nations agencies with remits to ensure that the zeal of spacefaring nations remains benign. It's written in that rights and sustainability should remain clear goals, no matter how lucrative the heavens are as a tool for economic and scientific development.

The exploration and exploitation of space should only be done for the betterment of humanity as a whole, says Simonetta Di Pippo, Director of the UN Office for Outer Space Affairs. Her agency serves the UN Committee on the Peaceful Uses of Outer Space, which was established at the outset of the space race and was instrumental in drafting the 1967 Outer Space Treaty.

Fresh start

This multilateral agreement laid down some ground rules, banning weapons of mass destruction and preventing individual states from claiming sovereignty over celestial bodies. Joanne Gabrynowicz, former editor-in-chief of the *Journal of Space Law*, says that the spirit of the treaty should guide would-be Mars settlers. "Going into space is an opportunity for humans to avoid repeating some of the destructive results of the colonisation of North America and other continents, such as land grabs and disregard for indigenous life," she says.

So, as well as protecting human well-being, colonies on Mars would need to protect the planet. Thanks to data collected by four decades of rover exploration, we know that indigenous life there will be microbial at best. Still, Gabrynowicz points to specific clauses in the Outer Space Treaty that spell out colonisers' obligations. For example, the treaty demands "due regard" and "consultation" in the event that one party's activities threaten those of another – however tiny.

Of course, much of this remains wishful thinking. Even if all parties involved can agree on a bill of rights, there is no guarantee that distant colonies will stick to it. After all, international laws are violated on Earth. Yet despite the difficulties, some think our mass migration into space is an inevitability – and that it will involve adapting our existing norms well beyond the needs of a mere space colony (see "To boldly go forth and multiply").

Meanwhile, Cockell and others have started a conversation about what freedom will look like when we eventually do leave home. Their collective efforts might one day lay the foundation for a bill of rights – a Martian Magna Carta – that ensures the only thing the first off-Earth colonists miss are home comforts, not basic human rights. ■

Andrea Maltman is a freelance journalist based in Melbourne, Australia

To boldly go forth and multiply

"FROM a biological perspective, interplanetary colonisation is the nature of life," says writer Rhawn Joseph. "By colonising other worlds we are merely fulfilling our cosmic and biological destiny – to go forth and multiply." However, we know little about how low gravity and cosmic radiation will affect colonists' fertility and reproductive success.

Joseph has contributed a chapter on human reproduction to a book called *The Human Mission to Mars: Colonizing the Red Planet* – a collaborative manifesto that draws on the ideas of dozens of scientists, academics and astronauts. At worst, he says, children born on Mars could suffer from serious genetic, physical and intellectual abnormalities. Alternatively, adaptive gene selection might, over time, result in the evolution of a new species: the first Martians.

In what other ways might these people be different? Would humanity's fundamental systems of belief alter when they put down new roots in extraterrestrial soil, for example? "Religious practices would have to evolve," says David Weintraub of Vanderbilt University in Nashville, Tennessee. "Over time, they would change in response to the psychological pressures felt by the people living in these off-Earth colonies."

Customs would have to adapt too, he says. The Martian year, for example, is 687 Earth days long. Given that most religious holidays are tied to our calendar, Martian settlers might invent holidays to fill the yawning gap between one annual celebration and the next. It would be important for humans on Mars to be given the freedom to update thousands of years of tradition without feeling like they were severing ties with their heritage.

KEVIN MOLONEY/THE NEW YORK TIMES/REDUX/EYEVINE

HALF SHARK, HALF CHAINSAW

Can we get to know the world's weirdest fish before it goes under, asks **Lesley Evans Ogden**

Sawfish populations have plummeted in the past 50 years

IT WAS an afternoon in January, during a break in the weather, when a Florida State University research vessel headed out towards the Queen of Nassau shipwreck off the Keys. There had been sightings of smalltooth sawfishes in the area and ecologist Dean Grubbs was keen to investigate. Resembling a chainsaw with a shark-like body, sawfishes are extremely rare. With luck, Grubbs might catch one or two for tagging and study. It never occurred to him that he would soon have six snagged on a single line. That was when things started to get tricky.

Adult sawfishes can be more than 4 metres long and weigh over 300 kilograms, which meant reeling them in wasn't an option. The animals needed rescuing, and fast. So Grubbs jumped in. Holding his breath 6 metres underwater, he began to lasso their toothy snouts while trying to avoid being slashed to bits. "[It] was a little nerve-racking," he says.

Grubbs's heroic response was not misplaced. Sawfishes are the world's most imperilled marine fishes; over the past half century, smalltooth numbers have declined by at least 95 per cent, and the four other species are faring little better. They are also among the strangest of animals, their weirdness extending far beyond their looks. Until recently, we knew little about their unusual habits. But with numbers plummeting, there's a growing urgency to discover more so that we can try to work out if, and how, these extraordinary creatures can be saved.

Sawfishes are distant relatives of sharks, more closely related to rays. Once common across tropical and subtropical waters, all five species are now on the International Union for Conservation of Nature's Red List of Threatened Species. Narrow and dwarf sawfish are classed as endangered; green, largetooth and smalltooth as critically endangered. As well as being dangerous to handle, they spend most of their lives in muddy coastal waters, making them very difficult to study. As a consequence, much about these animals is as murky as the waters they inhabit.

Take the hallmark snout, or rostrum. It has between 18 and 37 pairs of teeth, depending on the species, but until a few years ago, its function was uncertain. Now we know that sawfishes use it for both sensing prey and rendering their prey insensible. They slash their snouts around on the muddy bottom of shallow waters, using specialised organs in them to detect tiny electrical signals generated by small schooling fish, shrimps, crabs and any other animals present. "The saw essentially gives them a very big antenna," says Colin Simpfendorfer at James Cook University in Townsville, Australia. Electric sensing serves them well in low visibility, he adds, and once they have located their quarry, the rostrum becomes a club to stun and lacerate prey before they "hoover it up".

Grubbs is trying to fill another gap in our knowledge of sawfishes. Within living memory, the smalltooth could be found along a wide swathe of the eastern coastline of North and South America as well as off Africa's west coast. Now, it is largely restricted to south-west Florida and the Bahamas. It was listed as endangered under the US Endangered Species Act in 2003 on the assumption that the US population is distinct. "But we don't really know if that is true," says Grubbs. To find out, he and his colleagues are working in Florida and the Bahamas to track sawfishes and discover whether the two populations intermingle.

That means tagging adults – perilous work, even when you don't have to dive in to rescue them. "I tell everybody that sawfishes require more respect and are potentially more dangerous than any of the sharks we deal with," says Grubbs, who handles some 3000 sharks a year. The main threat comes from their rostra, which they swing around like swords when captured. "The angular momentum on the end of the rostrum is unbelievable," says Grubbs. "And the teeth, especially on the large ones, are very, very sharp."

"Sawfishes use their hallmark snout, or rostrum, for both sensing prey and rendering their prey insensible"

To minimise the handling risks, the researchers typically secure the fish by tying one rope around its rostrum, another around its tail and perhaps a third on its mid-section. They then take its measurements and attach a pop-up satellite tag to its dorsal fin. The tag collects information on depth, light levels and temperature, and is programmed to come away after 45 to 180 days, when it floats to the surface and sends its data to a satellite.

The project began in 2001 and Grubbs' team is allowed to tag just 20 animals a year. So far the indications are that Floridian sawfishes are not long-haul travellers, preferring to stick ›

A FISH TO FETISHISE

Matthew McDavitt is not your typical cultural anthropologist. For a start, he has a day job as a lawyer. But when he's not navigating legalese in Charlottesville, Virginia, he is often found fossicking for evidence of human interactions with sawfish. It's "just a hobby", he insists, although he has been dabbling in it almost daily for 20 years.

McDavitt's interest began in childhood, when he was drawn to the sawfishes' toothy snouts or rostra, but an undergraduate comparative religion course at the University of Virginia really ignited the spark. Exploring the last surviving divinatory almanacs of the Aztecs, "I kept seeing what I thought were sawfish snouts," he says – symbols that researchers of Aztec iconography had oddly missed. Digging deeper, he discovered that archaeologists had found dozens of sawfish rostra interred beneath the main Aztec temple in Mexico City.

McDavitt had uncovered a lacuna in our cultural knowledge of sawfishes and decided to fill it. He has since travelled the world looking for sawfish art and cultural symbolism, documenting artefacts from West Africa, South America, Indonesia and elsewhere. On Groote Eylandt in northern Australia, he found an aboriginal group for whom the sawfish is an emblem. "You see it on both their civic crests and traditional art all the time," says McDavitt. "It's as prominent to them as the bald eagle is to America."

Other stories have come from trawling the archives. In one account dating back two centuries, a traveller to Lake Maracaibo, Venezuela, describes baby sawfishes so plentiful it was difficult to walk in the shallows without stepping on them. Sawfishes have now been absent there for 150 years. More documents revealed a thriving sawfish fishery in Lake Nicaragua in the 1970s, as well as flesh and fins sold locally and in Chicago restaurants and supermarkets.

Art and folklore are now often the only reminders of how widespread and plentiful sawfishes once were. Depictions of these mysterious, revered creatures are found on ancient jewellery, tapestries, paintings and even on 5000-year-old clay seals found in Iran. In Gambia and Senegal, they were numerous in the 1970s, but are now rarely seen. Local ecological and cultural knowledge has declined too, reported Ruth Leeney of Benguela Research and Training in Namibia. These days, people in West Africa are more likely to know sawfishes from images on bank notes than as living creatures.

SIMON WEARNE

Ceremonies in west Africa still feature sawfish, which are no longer found there

"Rostra are sold as curios on eBay and teeth fashioned into spurs for cockfighting sell for as much as $220 a pair"

LUIS MARDEN/NGS/ALAMY

close to home. The researchers are also taking small tissue samples for genetic analysis to confirm whether the US population is truly distinct from the Bahamians. "It could only take one or two sawfish [interbreeding] every generation to keep the two populations mixed," says Grubbs.

As with all small, isolated populations, Floridian sawfishes are in danger of becoming inbred, but other research suggests the smalltooth has retained much of its genetic diversity despite the crash in numbers. Other sawfish species may not have fared so well. Working mostly off the coast of northern Australia, Simpfendorfer and his team are trying to discover whether the narrow sawfish has experienced a genetic bottleneck. Studying sawfishes here is particularly tough because researchers must be constantly vigilant not just for swinging sawfish rostra, but also for saltwater crocodiles. However, these waters are a magnet for research because they are the strongholds of four of the five sawfish species (see "On the slide", right).

One thing everyone is keen to find out more about is the sawfish's highly unusual way of reproducing. Unlike most fish, it goes for internal fertilisation. Maturing males develop pelvic fin extensions called claspers that they insert into the female during copulation. The embryos develop inside the mother's body without a placenta, feeding only on the yolk of their egg. After a gestation period of 4 to 6 months, the mother gives birth to several offspring – around a dozen is common, but the smalltooth can have up to 20. It sounds like a tall order. "Obviously, if you've got a rostrum with these little pointy teeth on it when they're being born, that would be a problem for mum," says Simpfendorfer. But evolution has provided an elegant solution:

DEAN GRUBBS

Lake Nicaragua (far left) was once a thriving fishery for these strange creatures

Trying to tag sawfishes in Florida without getting slashed (left)

a protective gelatinous sheath for the saw that dissolves away a few days after birth.

Producing young in this way poses another problem, however. The newborns are 60 to 90 centimetres long, depending on the species, making them vulnerable to being caught in fishing nets. Here again, we don't yet know enough about sawfishes to assess the scale of the problem. What we need to find out, in particular, is when females become sexually mature and how often they conceive, so as to judge their ability to rebound from population crashes.

Unknown quantities

To get a window on these matters, the researchers take a blood sample from each female they catch, measuring levels of the hormones estradiol and progesterone to discover whether she is reproductively mature, has developing eggs or is pregnant. The findings so far indicate that female narrow sawfishes develop fastest, reaching sexual maturity at 3 years old. Female green, smalltooth and largetooth sawfishes all mature at around age 9, give or take a few years. For dwarf sawfish we still don't know. How often they conceive is even more of a mystery, although the hormone tests may reveal the answer in the future.

Even the lifespan of these fish is uncertain. What we know suggests the narrow sawfish lives for just 9 years, dwarfs and smalltooths may reach their 30s, largetooths their mid-40s and green sawfishes can live beyond half a century. More precise knowledge of fecundity and lifespan will help conservationists work out how quickly a sawfish population could grow if protected. As relatively long-lived and slow-reproducing fishes, they may take a long time to recover.

"Sawfish are an example of species that slipped through the cracks," says John Carlson at the US Southeast Fisheries Science Center in Panama City, Florida. "[Populations] have been fragmented all over the globe." Historically, sawfishes were caught for eating, with their rostra sold as curios, and although they now enjoy some legal protection across most of their range, they still face big threats. Their snaggle-prone snouts make them vulnerable to being accidentally caught in trawl and gill nets. The habitats they rely on, such as mangroves and seagrasses, are being degraded as coastal zones become ever more developed. And some are poached.

The fins are highly prized for shark fin soup, and a recent investigation found them on sale in China, Indonesia, Australia, Bangladesh and Madagascar. Rostra are still sold as curios and powdered for folk medicines, including a tea taken for asthma. They are even available on eBay, with buyers and sellers in the US, UK, Australia, Germany and Belgium. In Ecuador and Peru, sawfish teeth fashioned into spurs for cockfighting sell for as much as $220 a pair.

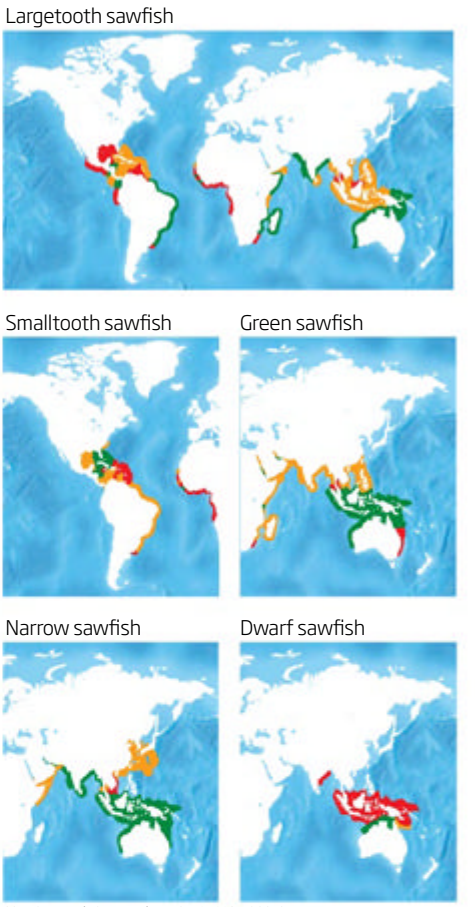
In the US, the biggest killer is shrimp trawling. With the pop-up tags, Grubbs and his colleagues are getting a better understanding of the locations of critical habitats at various stages in the sawfishes' life cycle. Their findings could some day make it possible to pinpoint the best times and places to temporarily close fisheries so as to promote sawfish recovery with minimum commercial disruption. For now, the aim is to teach fishers to safely release any sawfishes caught accidentally, since they can survive if quickly freed. To that end, the US and Australian governments have developed safe-release guidelines for commercial and recreational fishers.

Saving sawfishes is going to require a concerted effort, despite their cultural significance (see "A fish to fetishise", left). In the US, the public is encouraged to report sightings to the international sawfish encounter database, hosted by the Florida Museum of Natural History in Gainesville. But mustering support for conservation remains a challenge, especially in developing countries. Even when caught unintentionally, sawfishes are often retained because their fins and rostra fetch such a good price. Financial incentives to exploit these fishes won't go away no matter how well fisheries are managed, says Simpfendorfer. "We need to find ways to incentivise conservation… so that we can break that cycle." Just like handling these magnificent beasts, saving them will be no easy task. ■

Lesley Evans Ogden is a writer in Vancouver, Canada. She tweets @ljevanso

On the slide

Populations of all five species of sawfish have slumped in the past 100 years. They are now **extinct** in some of their former ranges, and in others their status is **unknown**. **Remaining strongholds** are limited



SOURCE: Aquatic Conservation/ DOI: 10.1002/AQC.2525

Who are we really?

Genes and culture may be at cross purposes. **Mark Pagel** explores

Mixed Messages: Cultural and genetic inheritance in the constitution of human society by Robert A. Paul, University of Chicago Press, $30

IMAGINE the fate of identical twins separated at birth, one reared among the indigenous Munduruku of Brazil, the other in the UK. Despite being genetically identical, they will be culturally as different as night and day: indeed, up until recently, the Munduruku used to decapitate their enemies and live a stone-age existence in the Amazonian rainforest.

The striking cultural differences between these twins can only happen to humans. That's because unlike all other animals, we have two distinct and fully fledged systems of inheritance: one genetic and one cultural.

Our genetic inheritance affects our physical and psychological make-up, including our intelligence. But our cultures give us our languages, religions, belief systems, technologies, lifestyles and ways of life. They even determine who we fight or kill in wars. You could say it is our cultures that determine who we are – the "I" or "me" we see when we look inside ourselves.

Most of the time our genetic and cultural inheritances both work to enhance our Darwinian fitness – our survival and chances of reproduction. In fact, having these two relatively independent streams of inheritance has been key to human success.

Where most biological species are confined to the small areas of the world to which their genes are adapted, humans have been able to occupy nearly every habitat on Earth by adapting at the cultural level. Thanks to culture, we are as varied in our technologies and lifestyles as collections of different biological species.

But in his engaging new book *Mixed Messages*, anthropologist Robert Paul argues that, owing to their independence, our genetic and our cultural inheritances will often be in conflict. He even goes so far as to say "their agendas are… at cross purposes".

To illustrate his point, Paul describes a cultural practice among the Mbaya people of South America that gets them to eschew sex, procreation being seen as a vulgar practice, beneath the dignity of this locally dominant tribe. Forgoing sex creates a dilemma for the perpetuation of the group, so Mbaya society has acquired the additional cultural belief that adoption of children from nearby tribes is a good thing.

"Neither of our inheritances deserves privileging: both are streams of information flowing down the ages"

The Mbaya's solution is a practical one, but on closer inspection we realise it allows the cultural system to survive at the expense of its biological carriers. Mbaya culture floats along on a steady stream of unrelated genes, all the while maintaining Mbaya society as a cultural, if not genetic, entity.

The celibacy practices of some Catholic orders, or of the fundamentalist Shaker people in the US, aren't really any different – they too survive by attracting a steady stream of new, genetically unrelated adherents.

The Mbaya's behaviours are startling to us because they are so obviously maladaptive. But they are only maladaptive from the perspective of genetic inheritance; the culture is flourishing. So why, Paul asks, do we give priority to the genetic system over the cultural one? Doing so treats genes as the real inheritance while our cultures are relegated to being mere passengers on the genetic train.

It's true that cultural information largely piggybacks on our biological existence. But neither one deserves to be privileged: both inheritances are just streams of information flowing down the ages.

Our genes evolve ways to create and then use our bodies as a form of transport into the next generation. Our cultures are freer, readily able to effect their transmission by jumping from mind to mind rather than having to reproduce and then wait for a body to mature and have sex. Both genes and culture outlive their human hosts.

While neither form of inheritance has a literal agenda, it is this difference in routes of transmission – one via bodies, the other by symbols and word of mouth – that grants our cultural instructions greater scope for harming our genetic interests. Like the spread of a virus, whether it is getting you to whistle *Dixie* or give up sex, cultural traits can

TAYLOR WEIDMAN/LIGHTROCKET VIA GETTY

NINA LEEN/THE LIFE PICTURE COLLECTION/GETTY

Shakers survived by attracting genetically unrelated recruits

Cultural force: the Munduruku halt work on a dam in Brazil

oppose your genetic interests so long as they can jump to a new mind before the host mind dies or somehow nullifies the trait. Adopting children, as the Mbaya do, is just a way of creating new host minds to colonise.

Still, just how common is it that our cultures succeed in opposing the interests of our genes? Here the jury is decidedly out. Some think it common – such as when we die defending our country, which lives on in our absence – while others think it likely that in most cases a genetic advantage can be found.

Language, for example, can be used to trumpet your actions far beyond those who witness them. This could mean, for instance, that the reputational glory attaching itself to one of Japan's fabled kamikaze pilots was passed along to family members, enhancing the survival of genes they shared with the pilot, even if the copies residing in the pilot were less fortunate.

So, who are you? The choices are stark. Are we robots controlled by our genes, primed to have sex as a way of ensuring their representation in future generations? Or are we robots of our cultures, possessed by thoughts that can even get us to risk our lives to promote the survival of our "tribe"?

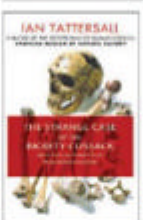
The answer will only cheer the existentially minded: we can in turns be both of these things. Paul's rich exploration of the myriad ways that genes and culture can collide make his book well worth reading. ■

Mark Pagel is professor of evolutionary biology at the University of Reading in the UK, a Fellow of the Royal Society, and author of *Wired for Culture: Origins of the human social mind* (W. W. Norton, 2012)

A ridge too far

A human fossil is a stark reminder of how science is really done, finds **Simon Ings**

The Strange Case of the Rickety Cossack, and other cautionary tales from human evolution
by Ian Tattersall, Macmillan, $27



THE odd leg bones and prominent brow ridges of a fossil hominid found in Belgium in 1830 clearly belong to an ancient relative of *Homo sapiens*. But palaeontologist August Mayer wasn't having that: what he saw were the remains of a man who had spent his life on horseback despite a severe case of rickets, furrowing his brow in agony as a consequence, who hid himself away to die under 2 metres of fossil-laden sediment.

The "Cossack" in Ian Tattersall's new book, *The Strange Case of the Rickety Cossack*, exemplifies the risk of relying too much on the opinion of authorities and not enough on systematic analysis. Before they were bureaucratised and (where possible) automated, several sciences fell down that particular well.

Palaeoanthropology made repeated descents, creating a lot of entertaining clatter in the process. For example, Richard Leakey's televised live spat with Donald Johanson over human origins in 1981 would be unimaginable today. I think Tattersall, emeritus curator at the American Museum of Natural History, secretly misses this heroic age of simmering feuds and monstrous egos.

The human fossil record ends with us. There are many kinds of lemur but, as he writes, only one kind of human, "intolerant of competition and uniquely able to eliminate it". As a result, there is an immense temptation to see humans as the acme of an epic evolutionary project, and to downplay the diversity our genus once displayed.

Matters of theory rarely disturbed the 20th-century palaeontologists; they assigned species names to practically every fossil they found until biologist Ernst Mayr, wielding insights from genetics, stunned them into embarrassed silence. Today, however, our severely pruned evolutionary tree grows bushier with every molecular, genetic and epigenetic discovery.

Some claim the group of five quite distinct fossil individuals discovered in 1991 in Dmanisi, east of the Black Sea, belong to one species. Use your eyes, says Tattersall; around 2 million years ago, four different kinds of hominid shared that region.

Tattersall explains how epigenetic effects on key genes cascade to produce radical morphological changes in an eye blink, and why our unusual thinking style, far from being the perfected product of long-term selective pressures, was bootstrapped out of existing abilities barely 100,000 years ago.

"The 'Cossack' exemplifies the risk of relying on the opinion of authorities and not enough on analysis"

He performs a difficult balancing act with aplomb, telling the story of human evolution through an accurate and unsparing narrative of what scientists actually thought and did. His humility and generosity are exemplary. ■

Memento mori

Death turns out to be one of the great motivators of our behaviour, finds **Caroline Morley**

The Worm at the Core: On the role of death in life by Sheldon Solomon, Jeff Greenberg and Tom Pyszczynski, Random House, $28

Smoke Gets in Your Eyes: And Other Lessons from the Crematorium by Caitlin Doughty, Canongate, £12.99

DEATH is part of everyday life. There are reminders everywhere – from novels and newspapers to that mole you've been meaning to get checked out. It's too grim to contemplate, so we try to forget. But researchers have long known that awareness of death and the fear it inspires affects decision-making. The question is how?

Now social psychologists Sheldon Solomon, Jeff Greenberg and Tom Pyszczynski have some answers. In *The Worm at the Core,* they claim death motivates us in almost everything we do – from yearnings for immortality to voting. Voting sounds odd until the authors cite an experiment in which they assessed subjects' intentions in the run-up to the 2004 US election. When they were reminded about death (strongly associated with George Bush after 9/11 and Iraq), the subjects were more likely to vote for Bush than Senator John Kerry. Hardly surprising, then, that individual existential crises shape cultures and fuel change.

The answer from the coalface, however, is a little different. In *Smoke Gets in Your Eyes,* Caitlin Doughty recalls her floundering first years as an undertaker in the US. We are spared none of the gruesome details. Describing a badly decomposed corpse she handled on her second day, Doughty writes: "Padma was more like a creature from a horror film, cast in the lead role of 'Resurrected Voodoo Witch'."

The colours, smells, sounds and textures she describes are a far cry from the sanitised version of death with which we are familiar.

By contrast, *The Worm at the Core* deals in emotions. Its authors argue that our feelings of self-worth normally shield us from morbid thoughts, but that when reminders of our mortality do penetrate, we protect ourselves by fiercely guarding our world views. This may explain why terrorist attacks can provoke outpourings of patriotism and xenophobia.

Much of the science in this rather academic book is cherry-picked from 500 studies by the researchers, former students and followers. But the authors try to make it palatable by describing the key experiments through the eyes of fictionalised subjects.

That said, I'm not sure why I needed to know about "Steve", a rock guitarist and student, who became reluctant to use a crucifix to bang a nail into the wall after being asked about death. I would rather have known what Padma would have thought.

"Individual existential crises have shaped cultures and fuelled progress"

JÉRÔME GALLAND / PICTURETANK

Awareness of mortality shapes individual lives and whole cultures

While *The Worm at the Core* uses modern research to explain human culture over history, Doughty does the opposite. She argues that we understand the realities of death less than we did 150 years ago, and she has campaigned for us to take back the process of mourning from a culture that denies decomposition and an industry in which making a corpse look "natural" requires a startling amount of intervention.

With the dark wit you might expect of an undertaker and the compassion and insight you might not, Doughty traces her own preoccupation with death from childhood, through "Deth Skool", via the macabre side of medieval history at university. With strong story telling and vivid descriptions, she displays a protective mechanism that the psychologists seem to have forgotten – humour.

Solomon, Greenberg and Pyszczynski, on the other hand, advocate coming to terms with death by contributing to a society that outlives us all. They remind us to "grasp that being mortal, while terrifying, can also make our lives sublime by infusing us with courage, compassion, and concern for future generations".

I prefer Doughty's assessment. "Accepting death doesn't mean... you won't be devastated when someone you love dies," she says. "It means you will be able to focus on your grief, unburdened by... bigger existential questions... Death isn't happening to you. Death is happening to us all."

Just get that mole checked out. ■

Caroline Morley is a writer based in London

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Candidates must have earned a Ph.D. (or equivalent) in physics, optics, or a related field by the time the position begins. Preference will be given to candidates with experience in one or more of the following areas: laser development (particularly optically pumped gas lasers), spatial mode analysis of lasers, power beam combining, optical frequency combs and laser frequency stabilization, optical trace gas detection, fiber lasers, and microstructured optical fibers.

The appointment will be a term appointment. The successful candidate(s) should also demonstrate a strong commitment to mentoring of graduate and undergraduate students and to serving a diverse population. Screening of applications will begin **June 1, 2015** and continue until the positions are filled. **Candidates should submit a letter of application and a vita including a list of publications to: lumospostdoc@phys.ksu.edu. Candidates should also arrange to have three letters of reference sent to the same address.** For inquires about the position, please contact Assoc. Profs. Kristan Corwin (**corwin@phys.ksu.edu**) and Brian Washburn (**washburn@phys.ksu.edu**).

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UC San Diego
HEALTH SCIENCES

FACULTY POSITION
Department of Pharmacology

University of California, San Diego School of Medicine

The UCSD Department of Pharmacology (**http://pharmacology.ucsd.edu**) seeks highly qualified applicants for a tenured appointment at the **Full Professor level**. Applicants must hold a PhD and/or MD degree. The ideal candidate will be an internationally recognized investigator who uses novel research approaches or analytic technologies that complement and substantially expand current efforts of department faculty in areas relevant to signal transduction, drug discovery, molecular mechanisms of therapeutic or environmental agents, drug disposition and action, structural and computational biology, cancer biology and inflammation. Candidates must have substantial research accomplishments, sustained research funding and a commitment to leadership and training. Applicants will be expected to teach aspects of pharmacology to graduate and professional students, to mentor thesis studies of Ph.D. students and to oversee a contemporary and scholarly laboratory research program. The ideal candidates will also have demonstrated contributions to diversity, equity and inclusion in a scholarly environment. Salary will be commensurate with qualifications and based on University of California pay scales.

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Interested applicants must electronically submit a curriculum vitae, list of publications, reprints of up to five representative articles, and a personal statement that includes a summary of research plans and any teaching or training experience as well as their past and/or potential contributions to and leadership in promoting equity, inclusion and diversity at **https://apol-recruit.ucsd.edu/apply/JPF00796**. Please select the following recruitment: **10-979 Full Professor - PHARMACOLOGY**. Candidates should arrange to have three letters of reference addressing research, teaching and professional service submitted at the above-mentioned URL.

More information about the application process and required materials is locate at:
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EDITOR'S PICKS

Education and human values

From Dewi Jones
Ian Morris is non-committal about the likely outcome of the struggle between the egalitarian and the privileged in this world (18 April, p 28).

Underneath the hierarchical values of agrarian society there was always the egalitarian hunter/gatherer nature. To overcome it the liars, cheats and bullies that ruled over us had to spin many a nonsense.

Education brought about the rise of the middle class – necessary for production and the wealth of countries to grow. It has also worked a permanent change that alongside new means of recording and transmission means we won't be so easily bamboozled again.
Aberystwyth, Ceredigion, UK

From Carl Zetie
I was astonished by the parallels between Morris's historical account and the present political landscape in the US. Democratic-leaning friends are frequently baffled by the fact that many working-class Americans support Republican policies that would seem to be against their own best interests. "Perhaps they don't think of themselves as poor," they joke, "but as temporarily embarrassed millionaires?" Could they rather hold, in Morris's terms, the "farming values" of approval of a strong hierarchy and acceptance of economic inequality? Do Democratic voters hold "fossil-fuel values"?
Waterford, Virginia, US

Why trickle-down doesn't follow

From Tony Castaldo
I would like to suggest reasons for the failure of "trickle-down" economics that Ha-Joon Chang describes (25 April, p 28). The rich put most of their excess income (which is most of their income) into the stock market and into businesses that are already earning a profit. No jobs are created if two investors trade money for shares of stock. Given a tax break, the excess money just goes to a bigger portfolio and more stuff owned; it doesn't change the risk sums for the rich.

A higher income tax changes that risk calculation, because in all fiscal systems money spent on expanding a business is tax-deductible. Thus if income tax is high the rich are better off reinvesting excess revenue in actual job creation by trying to grow their businesses, advertise them and compete for customers.

Higher income tax does not necessarily result in greater government income: it can just be the reason for the rich to reinvest. Thus the opposite of trickle-down is true; the higher the income tax, the more attractive job creation is.
San Antonio, Texas, US

From Shelley Charik
The survival of the concept of "trickle-down economics", in the face of all the evidence, testifies to the power of vested interests. Herbert Hoover, US Republican president from 1929 to 1933, cut taxes for the wealthy. In 1931, after the 1929 stock market crash, he embarked on major programmes to stimulate the economy, such as the Hoover dam. To help pay for them he reversed the tax cuts.

Against the background of the Great Depression, he lost the 1932 election to Democrat Franklin D. Roosevelt. American humorist Will Rogers commented that this election "was lost four and five and six years ago, not this year. They didn't start thinking of the old common fellow till just as they started out on the election tour. The money was all appropriated for the top in the hopes that it would trickle down to the needy. Mr Hoover was an engineer. He knew that water trickled down. Put it uphill and let it go and it will reach the driest little spot. But he didn't know that money trickled up. Give it to the people at the bottom and the people at the top will have it before night anyhow. But it will at least have passed through the poor fellow's hands."
London, UK

Neanderthals didn't need pots

From Sandra Craigie
Your article on Neanderthal chefs spicing up their diet had an intriguing final sentence: "we've never found a Neanderthal pot" (18 April, p 14). In New Zealand Maoris boil or steam their food without pots, either by placing it in woven flax baskets and immersing these in hot pools, or by wrapping it in leaves and steaming in earth ovens.

It avoids having to wash dishes.
Upper Hutt, New Zealand

Dogs of the old Stone Age

From Richard Crane
The Chauvet cave puts a nice minimum age on the domestication of dogs that Pat Shipman describes (14 March, p 26). In it there are footprints of a teenager with wolf-dog footprints running in parallel. Since these run side-by-side and are not overlapping, it is reasonable to suppose they were simultaneous and thus a sign of friendship, not predation. The rockfall that sealed the cave is dated 21,500 years ago.

Shipman links domestication of the wolf to the demise of the Neanderthals. The youngest well-dated Neanderthal site is 39,000 years old, while the Chauvet paintings are dated just 3000 years later.

The proximity of these dates might be coincidence. But it may be that the wolf-dog that finished off the Neanderthals was by then so domesticated that humans could use it to keep bears out of caves – and could now experiment with art.
Vallon Pont d'Arc, France

The seductive appeal of toxins

From Craig Sams
The discovery that nectar toxins are attractive to bees is not totally surprising (25 April, p 42). We're all attracted to toxins. Fruit toxins and vegetable toxins are part of the "5 a day" that health authorities recommend. They are a key part of the aromas that our noses have evolved to identify as "delicious".

Plant defences against pathogens and parasites evolved long before sophisticated animal life forms emerged. So instead of manufacturing antimicrobials ourselves, we obtain them when we eat health-enhancing fruits and vegetables. True, they are poisons, but Paracelsus's adage that it is "the dose makes the poison" applies.
Hastings, East Sussex, UK

The varieties of colour blindness

From Martin Savage
Veronique Greenwood's article on colour vision reminded me of something that has puzzled me for a long time (18 April, p 40). I take a camera when scuba diving. If I leave the "white balance" set for daylight, then the deeper I go the more the colours recorded by

"I, for one, welcome our new carbon nanotube spider overlords!"

@welbournd responds on Twitter to reports of spiders spinning enhanced silk (9 May, p 18)

the camera diverge from what I see. At 15 metres everything in the photos looks green; at 30 metres it is all blue and brown. Yet to my eye the colours look relatively normal. If I reset the white balance of the camera at depth using a white card, then it "sees" colour much as my eye does.

I conclude that my brain does a sophisticated job of adjusting white balance. But, given that the human brain-eye system did not evolve to see things 30 metres below the sea, how can my brain "know" what the "right" balance of red, green and blue is? Perhaps the number of opsin types in our eyes is less important than the processing running behind them?
Jomtien, Thailand

From Gerrie Brown
I have been told that I am red-green deficient yet I cannot detect any number in the right hand panel of your Ishihara test for colour blindness, which apparently I should be able to do. More curious still, I cannot reveal any number by using chromatic vision simulator software.
Holmfirth, West Yorkshire, UK

The editor writes:
■ We now discover that the Ishihara test in question was supplied to us on its side, which may have affected the effect. None of us were able to spot this. Also, the other three readers who wrote to say they could not see the number may have sub-types of red-green colour blindness that produce different responses to the Ishihara test.

Radicalising depression

From Mehmood Naqshbandi
Kamaldeep Bhui's valuable article identifies depression as one of the very few common factors among those expressing extremist sympathies (11 April, p 24).

He is completely correct to debunk the conventional wisdom that religious zeal, social deprivation or political grievances are motives. A UK Security Service report leaked by *The Guardian* demonstrated no ability to profile terrorists along these lines, showing that such simplistic notions are confined to populist politicians and the populist press.

A difficulty is that since depression affects a high proportion of the population, whereas violent extremists are, by their actions, outliers from the normal distribution of the population, depression offers little to guide counter-extremist activity. It does mesh well with my own work, published on the Countering Extremism pages of www.MuslimsInBritain.org.
Wimbledon, Surrey, UK

All roads lead to ruin for wildlife

From Terence Hollingworth
Curtis Abraham describes the risks of redrawing borders of wildlife reserves (18 April, p 26) and William Laurance the role of roads bringing in poachers (also on p 26). But simply building a road through a forest effectively divides it into two.

So if the whole forest was just big enough to support, say, tigers, neither half is: the tigers will eventually die out. The loss of one species leads to the loss of others until a new, less diverse, equilibrium is reached.

The road itself will bring about extinctions, before considering the human interference which it brings. The absolute size of the habitat or biotope is crucial.
Blagnac, France

The very first weather station

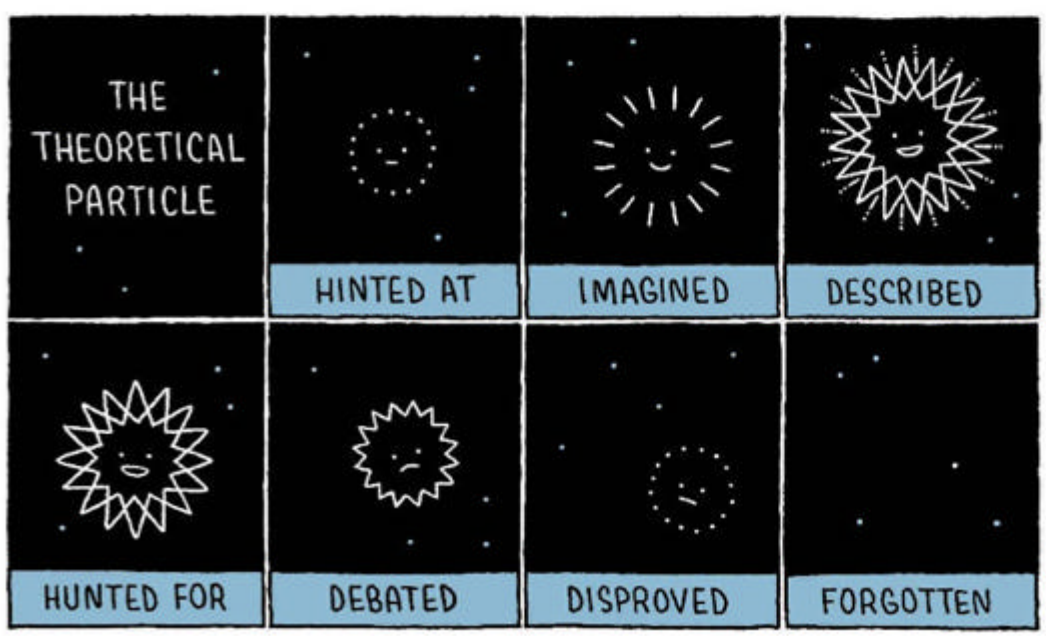
From Heinrich Falk
You say that Mount Washington has since 1870 hosted "the world's first mountaintop weather station" (11 April, p 22). But the *Meteorologisches Observatorium Hohenpeißenberg* was opened on 1 January 1781 and thus predates the US example by 89 years.
Friedberg, Germany

Information is not wisdom

From John Crowhurst
Your report on Google's plan to rank its search results by "facts the web unanimously agrees on" (28 February, p 24) and the subsequent letters (14 March) remind me of a comment by the author and broadcaster Clive James.

Interviewed on ABC Radio, he acknowledged that he used the internet extensively. Asked his opinion of its facilities, I recall him replying: "For information the internet is unsurpassed; but for knowledge…?"
Linden Park, South Australia

TOM GAULD



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PAUL MCDEVITT

OCCASIONALLY Feedback points at coverage of celebrities and, from the lofty viewpoint of mathematical and empirical rationality, giggles (for example, 23 January 2010). It's nice to see the compliment returned.

Returned, specifically, by Sophie Heawood in the Lost In Showbiz column of the UK's *Guardian* newspaper, reporting breaking news on the diet of Jennifer Aniston (an actress). Jennifer, it seems, "stays in shape" by "eating five meals a day". Before inquiring further, Sophie insists that "we must ask the question on everybody's lips: which shape? (A rhombus? A dodecahedron? Surely not a degenerate tessellation of a Euclidean 3-space?)"

We suspect that Sophie found the last-named on the Wikipedia "list of mathematical shapes". We hope (and expect) that she looked further and marvelled at the name of a member of this set, the hosohedron (a stripy beach ball, since you ask). Here's hoping that this helps make topology cool with da yoot.

MICROSOFT'S management seldom come down from their mountain to take questions from the press. So when one Bryan Biniak was billed to give a "Special Power Session" at a tech event in Malta, Feedback's colleague jumped on a plane. Biniak's theme: Microsoft is now seen as "cool" with the youth. To prove it he showed a video of surfing in California, and then painted a rosy future in which the Windows 10 operating system, to go on sale later this year, will be the bedrock of all things computing.

Our colleague chimed in to suggest that with hundreds of tech writers, from 55 countries, in the same room, this was a golden opportunity to learn first-hand what they thought of Windows 8, the previous computing panacea. Biniak estimated, on a show of hands, that around 60 per cent had tried it; and 30 per cent used it. And who liked it? Two, maybe three, hands went up. "So… less," said Microsoft's obviously shaken general manager of developer experience, swiftly moving on to take safer questions.

SCHOOL students in the UK have been sitting examinations since 11 May. Feedback confidently predicts a spate of articles bemoaning dumbing-down as grades rise, neglecting the possibility that the kids actually are getting smarter (1 February 2014).

Some will be smart enough to query an assumption in the "GCSE Science B" specification from the OCR examining board: "Describe scientific evidence which supports or refutes the idea of man-made global warming… Explain how it is possible to have good agreement between scientists about the greenhouse effect, but disagreement about whether human activity is affecting global warming."

Ruth Ashbee worries that this "seems to pander to climate-change deniers". How statistically significant are the actual scientists who dissent on causes of global warming, anyway?

NEUROSCIENCE is powerful: mentioning it persuades people of the quality of adjacent reports. Feedback is grateful to Rebecca Rhodes and colleagues for their review of literature on the subject of persuasiveness, introducing us to formal studies of such concepts as "seductive detail" and "illusion of explanatory depth".

The "methods" section of their paper (doi.org/38m) opens: "We constructed a news-like article that… claimed that listening to music while studying was beneficial for learning…" They introduced this either with a non-specific mention of neuroscience, or the mere observation that people like to listen to music while reading. Study volunteers who read the version alluding to neuroscience showed a smallish but significant increase in their rating of the "quality of the researcher". They were 2.3 times as likely to claim they understood the mechanism behind the claim about music and learning.

ALSO, only 34 per cent of participants in the above study spotted the flaw in the fake "music study" that it presented. The made-up report was very clear that it was a comparison between self-selected groups. The authors do not report how many of these sceptics were among the 54 per cent of participants who claimed to have taken a university statistics course. It seems you can get away with claiming just about anything. Except here, of course…

FINALLY, and disappointingly, the study of the persuasive power of the word "neuroscience" did not also test the impact of showing pictures of bits of brain "lit up" in magnetic resonance imaging. Feedback imagines such images evoking the subconscious reaction: "Look! I see actual evidence! It does *that*, *there*!"

We face here a methodological difficulty, namely: what graphic should the "control" group be shown? Should it be equally

colourful and randomly sciency: a galaxy simulation? Or perhaps the remarkable image of a fish brain apparently sparking into life when shown emotionally laden photos of people (5 March 2011)? The caption that springs to mind is, "We have a motive which is money and a salmon which is dead." As was the fish in the scan.

Alan Oliver sends a report from the Adelaide *Sunday Mail* that "During last week's mouse census farmers made more than 250 reports of mice using their smart phones." Clever mice!

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.

Off colour

I spotted this blackbird in the garden (see photo). It is not black but light grey, and it did not have pink eyes so I guess it is not an albino. It spread its wings and lay in the sun; in due course it flew off. I've never seen a blackbird with this colouring before. Can anyone tell me more about it?
(Continued)

Further to earlier answers, it appears that the off-black blackbird is "anting". Some birds deliberately lie with their wings outstretched on top of an ant's nest so that the insects and the formic acid they release kill parasites clinging to the bird's feathers.

Anting is quite unusual and many of your readers may have never seen it or recognised what is happening. Birds often stay in this position for some time, giving people the opportunity to both observe and photograph them.
Andrew Carruthers
Quebec, Canada

Optic aquatic

Humans cannot see clearly under water without goggles. How do aquatic mammals solve this problem?

For light reflecting off an object to be perceived as anything more than dim diffuse illumination, it must be focused on a single point on the light-sensitive retina at the back of the eye.

The divergent light rays that strike the front of the eye must therefore be bent (refracted) to varying degrees in order to form an image. Light is refracted when its waves cross at a glancing angle from one medium to another with a different refractive index.

In terrestrial vertebrates, light is refracted mainly by the curved surface of the cornea, whose refractive index is considerably higher than that of air. The eye's lens has a similar refractive index to that of the surrounding parts of the eye, and is responsible only for around one-third of the refractive power of the human eye, serving mainly to adjust the fine focus of the image seen.

"Next time you eat a fish, take out the lens and you will see it is shaped just like a marble"

Underwater, the cornea becomes ineffective as its refractive index is very close to that of water.

The underwater world becomes very blurry because light is focused a long way behind the retina, and we become, in effect, very long-sighted. This can be rectified by putting air back in front of the cornea with a face mask or a pair of swimming goggles.

The same obviously cannot be true for animals that live underwater because otherwise their eyes would be of little use.

Animals such as fish, cephalopods and aquatic mammals overcome the loss of a refractive cornea underwater by possessing more powerful, spherical lenses that can deal with this problem, unlike the lens in the human eye. Next time you eat a fish, take out the lens and you will see it is shaped like a marble.

The real question is how some animals, such as diving birds, see clearly in both air and water.
Ron Douglas
Saffron Walden, Essex, UK

This week's questions

DROWNING SUN
Could all the water in the universe put out the sun?
Maya (aged 6)
San Mateo, California, US

FOAMING MAD
I have a handheld milk foamer for my coffee. I can foam milk to twice its volume when it is cold, out of the fridge, but it barely foams at all when heated. Why is that?
Mark Alberstat
Halifax, Nova Scotia, Canada

HAZY BLAZE
The worst sunburn I ever received was on a beach in Wales on a dull, misty day. I have holidayed many times on Greek islands in the height of summer but have never experienced sunburn like it. What could be the cause?
Neil Macnaughtan
Edinburgh, UK

FLUFF STUFF
Why do some woollen cardigans or jerseys produce a lot of pilling, whereas others don't? Is there any way to know beforehand if a wool garment will be prone to pilling?
Gabi Simon
Via email, no address supplied

CATS' EYES IN SIGHT
The irises of domestic cats' eyes are ovoid, but those of big cats such as lions and leopards are round like human irises. Why is this and do the differences confer any advantage either way?
John Neimer
Weymouth, Dorset, UK

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