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WEEKLY June 25 - July 1, 2016

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Your genes are still working even when you're not

KANGAROO DOWN
Contraceptives keep bouncy beasts in check

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GIACOMO GAMBINERI

Who's afraid of AI?

Human motives, not intelligent machines, are the real threat

THEY started off by wounding our pride. Will AI end up taking our jobs – or even our lives?

Twenty years ago, IBM's Deep Blue beat Garry Kasparov at chess – then seen as the gold standard of human intellect. Now a new wave of AI seems poised to take over a wide range of human tasks, potentially putting huge numbers of people out of work. And an unlikely alliance of philosophers, technologists and movie-makers has stoked fears that the next generation of AI might snuff out humanity.

A reality check is needed. We are nowhere near the creation of a machine that replicates the full suite of a human's intellectual capabilities. And the threat of extinction by superintelligences, if and when they arrive, is only one of a number of esoteric possibilities (see page 18).

So where does paranoia about AI come from? In part, it's the challenge smart machines present to long-standing ideas about human exceptionalism, which survived the Copernican and Darwinian revolutions but may be fatally undermined by intelligent – or even conscious – machines. It's also a type of techno-pessimism: we can foresee the potential downsides, but the upsides aren't yet clear.

That doesn't mean the boom in AI gives us nothing to worry about. As ever, it isn't the technology itself that should concern us, but how humans design and use tools based on it.

On the issue of human exceptionalism, there's not a lot that can be done. Even cherished qualities like creativity and invention may well be outsourced to AI in the coming years. But we shouldn't feel threatened by this: we should feel exhilarated at the new things we can do with their help, just as the digital tools we use today have enhanced and diversified the ways in which we communicate and create.

"AI should be used to upskill workers rather than paring their jobs back to tedious piecework"

When it comes to jobs, the AI threat is probably overstated. On closer scrutiny, many seemingly straightforward jobs include cognitively taxing elements that AI cannot master – yet (see page 33). The "gig economy", pioneered by firms such as Uber, adds flexibility to the labour force and convenience to their customers via algorithmic management – but at a cost to workers' rights and conditions. AI could accelerate that trend. That matters: our work is integral to our identities, and preserving the dignity of labour should be central to our society (see page 30). We should strive to ensure that AI is used to upskill workers rather than paring their jobs down to tedious piecework: dehumanising workers is a poor use of the technology.

Tackling that is a social and political issue, rather than a technological one. AI may force changes on our economic system – witness the discussions over the introduction of a basic universal income for all (see page 35). But change should be people-centric, not led by AI-driven efficiency that enriches a few to the detriment of the many.

As for super-smart AI wiping us out, relax. For the moment we should worry more about semi-smart machines given too much power. Autonomous weapons may be in legal limbo, but that hasn't stopped their development. Drone warfare provides a taste of what's to come: how can machines that can't tell civilians from combatants do the "right" thing without human control?

In this, as elsewhere, the answers lie with us. AI can't strip us of our jobs, our dignity or our human rights. Only other humans can do that. ■

Yellow fever still surging

IT'S getting scary. On Monday a yellow fever epidemic was declared in Kinshasa, the sprawling capital of the Democratic Republic of the Congo. The disease, which kills in some 5 per cent of cases, spread there from Angola, where it persists even though millions have been vaccinated. There have been more than 4000 known or suspected cases in the two countries, and the true figure is probably higher.

In an unprecedented move last week, the World Health Organization announced that experimental evidence shows the vaccine can be diluted fivefold to make stocks stretch further, in a bid to control the outbreak in Africa.

Angola was not considered at risk, so few people there had been vaccinated when an urban outbreak began last December. Since February in Angola, and since March in Congo, 18 million doses of vaccine have been given to try to stop the virus spreading. Experts warn that there is not enough vaccine left to contain a major epidemic in Kinshasa without eating into stocks meant for child vaccinations. Producers cannot boost stocks quickly because they use the original 1930s method of growing the virus in pathogen-free chicken eggs, sources of which are limited.

The yellow fever virus normally lives in forest monkeys, but if transmitted to urban mosquitoes via humans an explosive outbreak can follow. The fear is that the virus could reach Asia, where mosquitoes can carry it and people have no immunity.

JOOST DERAEYMAEKER/EPA

Could Asia be next?

Russia banned

THEY'RE out. Russia's athletics team have been banned from the Olympics after the International Association of Athletics Federations (IAAF) decided last week to extend the country's exile from international competition.

The decision comes after a stream of revelations over the past 18 months of what the World Anti-Doping Agency calls "state-sponsored doping".

Last week, the agency also released details of how some of Russia's sportspeople avoided having their urine tested for banned drugs between November last year and May.

"One athlete simply ran away when they saw anti-doping officials at a competition"

One athlete, for instance, simply ran away when they spotted anti-doping officials at a competition. One runner even disappeared halfway through a race. Another athlete tried to provide a urine sample from a bag containing someone else's clean urine secreted "inside her body". Unfortunately, it leaked on to the floor, giving the game away. She then tried to bribe an official to overlook her misdemeanour.

There were also attempts by Russian officials to interfere with the testing programme. Contracts with testing companies were not signed until the last minute and payments were delayed, making it hard to find anyone willing to perform the tests. Life was made difficult for the testers, too, with security forces challenging their credentials and even threatening to expel them from the country.

The IAAF have offered an olive branch to any Russian athlete who can demonstrate that they have not been tainted by Russia's drug testing system – allowing them to compete under a neutral flag. The loophole applies to a handful of athletes living and training outside Russia.

Rune Andersen, chairman of the IAAF task force investigating the doping scandal, said that Russia is at least 18 to 24 months away from complying with the worldwide anti-doping code.

Zika abortion rise

"PLEASE help." Emails from women across South America suggest illegal abortions have soared where Zika is prevalent.

An analysis of emails sent to Women on Web, a charity that mails out abortion pills, suggests that since November requests have doubled from Brazil, the epicentre of the outbreak, as well as Ecuador and Venezuela (*NEJM*, in press).

The charity won't send pills to Brazil because the authorities intercept its packages, so the figures do not reflect actual abortions. But they give a picture of how people are reacting to Zika, says Abigail Aiken of the University of Texas at Austin.

Access to contraception varies in South America, and abortion is illegal or severely restricted in most of the continent. Although the abortion pills are safe, other illegal abortion methods can cause infections and death. Women who seek medical help after an abortion risk a jail sentence.

Comet perfume smells like...

EAU de comète, anyone? Rosetta researchers are to unveil the aroma of 67P/Churyumov-Gerasimenko, as sniffed by the Philae lander.

Colin Snodgrass of the Open University in Milton Keynes, UK, and colleagues commissioned The Aroma Company to develop a "perfume" inspired by readings from Philae showing the presence of hydrogen sulphide, ammonia and hydrogen cyanide – which smell of rotten eggs, cat urine and bitter almonds.

The smell isn't directly derived from these compounds – some are poisonous – but the scent should reflect the whiff of 67P.

"If you could smell a comet, this is what you would get," says Snodgrass, who will hand out samples at the Royal Society summer exhibition in London next month. "But if you are standing there without your space suit, you're not going to notice the smell, you're just going to notice the lack of air."

Timeshare in space

CHINA is launching a rival to the International Space Station (ISS) – and it wants to share its new toy.

The China Manned Space Agency and the UN Office for Outer Space Affairs (UNOOSA)

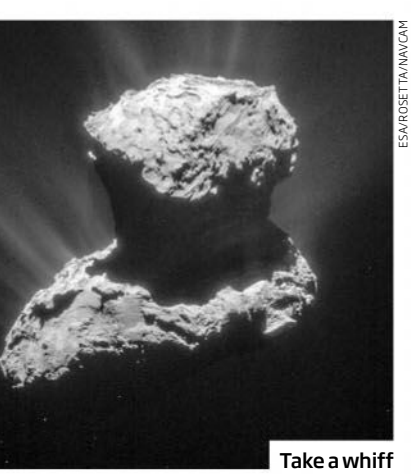
"This is an exciting opportunity to build the space capacity of developing countries"

have announced a partnership that will let UN member states conduct experiments on and even send astronauts to the Chinese space station, due to start operating in the 2020s.

The UN and China say they are keen to get more nations involved in space activities. "This is an exciting opportunity to further build the space capacity of developing countries and increase understanding of the benefits space can bring to humankind," said UNOOSA director Simonetta Di Pippo.

China is excluded from the ISS because of a US government ban on its participation. It's not clear if the other ISS partners – Russia, Japan, Canada and the member countries of the European Space Agency – will have access to China's station.

Later this year, China will launch the space lab Tiangong-2 to practise the skills needed to build the station.



ESA/ROSETTA/NAVCAM

Take a whiff

SCOTT OLSON/GETTY

An all too familiar protest

Gun law stalemate

THE impasse over gun control in the US holds steady in the wake of the mass shooting at the Pulse gay club in Orlando on 12 June. On Monday, the US Senate failed to pass four amendments proposed after the tragedy.

The Democrat amendment could have stopped people on terrorist databases from buying firearms; Republicans proposed that firearm purchases by those linked to terrorism be subject to

"The US Senate failed to pass four amendments proposed after the Orlando mass shooting"

a 72-hour delay and review process. Both were voted down, as were competing amendments on background checks.

One piece of good news is that the freeze on gun research has thawed a little. California has voted to set up a firearms violence research centre, and to provide $5 million of funding over the next five years. "California [has] taken a critical step toward developing the effective, evidence-based policies needed to save lives," said Marc Futernick of the American College of Emergency Physicians.

Less than $5 million a year is currently spent on gun violence research. This is the result of a 1996 amendment, pushed for by the gun lobby, that has been interpreted as banning all federal funding of such research. The California money comes from a different pot. "To my knowledge, this is the first such publicly chartered centre in the country," said gun violence researcher Garen Wintemute at the University of California, Davis.

Court for dirty UK

WHEN will the UK clean its dirty air? The answer depends on what happened in Thursday's vote.

The air in many places in the UK frequently breaches the nitrogen dioxide limits set by EU law. In 2015, ClientEarth, a group of activist lawyers, won their case against the UK government for failing to comply with this law.

But a year later, the government still has no adequate plan for reducing air pollution, ClientEarth says, so it has taken the case back to the UK courts. On 16 June, a high court judge agreed that the case should be fast-tracked due to its importance. It is now set to be heard in October.

Whether this will make a difference depends on the UK's referendum on EU membership, which took place after *New Scientist* went to press. If the leave vote has triumphed, the country may never have to clean up its act.

60 SECONDS

Worst bleaching ever

The bleaching of coral taking place across the world is officially the most widespread in history. According to the US National Oceanic and Atmospheric Administration, warm ocean temperatures mean the bleaching event is likely to last for a third year, and could soon hit reefs in Hawaii and the Florida Keys again.

Up and down again

OK Jeff, we get it, you can land a rocket. Blue Origin, a Texas-based firm owned by Amazon boss Jeff Bezos, has launched and landed the same sub-orbital New Shepard rocket four times in a row. The latest flight tested the effects of a parachute failure on an empty crew capsule; it returned to Earth safely.

Better together

A ground-breaking pair of cancer drugs that unleash the body's immune system on tumours will be paid for by the NHS in England. The approval decision is one of the fastest in NHS history. In trials, ipilimumab and nivolumab shrank the most deadly type of skin cancer in 69 per cent of patients. A fifth of patients had no sign of cancer after receiving the treatment.

Drug decriminalisation

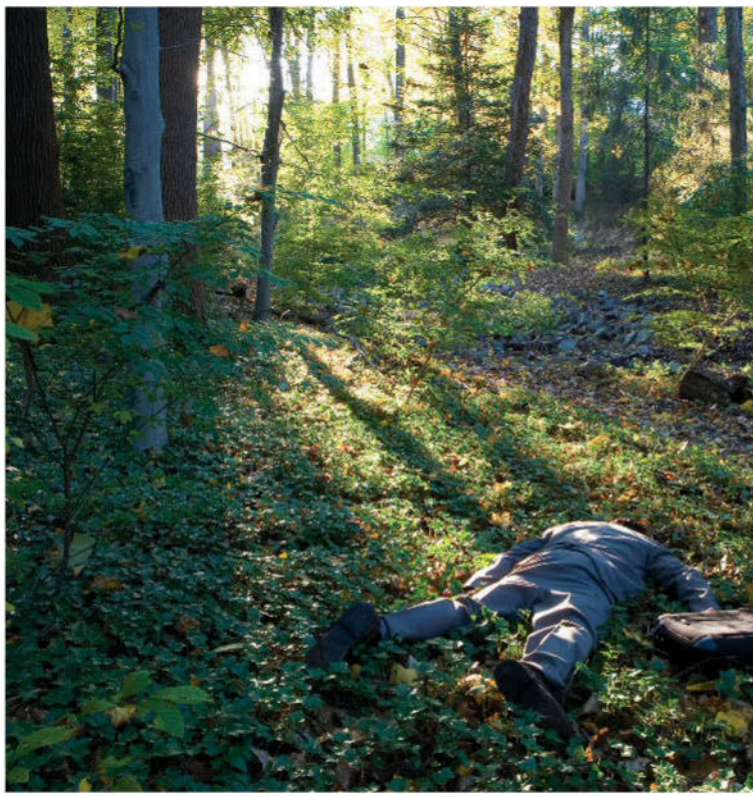
The UK's two leading public health bodies have called for drug use to be decriminalised. A poll of 2000 UK adults, supported by the Royal Society for Public Health and the Faculty of Public Health, found that more than half agreed that drug users ought to get treatment rather than be charged. Fewer than a quarter disagreed.

The lionfish is coming

Careful where you swim – the venomous lionfish is spreading through the Mediterranean. The invasive species has a nasty sting that can kill people. A native to the Indian and Pacific Oceans, it has now spread to waters off Turkey and Cyprus.

Genes get active after death

Some genetic functions seem to carry on after animals die. **Anna Williams** reports



ROBERT WARREN/GETTY

WHEN a doctor declares a person dead, some of their body may still be alive and kicking – at least for a day or two. New evidence in animals suggests that many genes go on working for up to 48 hours after the lights have gone out.

This hustle and bustle has been seen in mice and zebrafish, but there are hints that genes are also active for some time in deceased humans. This discovery could have implications for the safety of organ transplants as well as help pathologists pinpoint a time of death more precisely, perhaps to within minutes of the event.

Peter Noble and Alex Pozhitkov at the University of Washington, Seattle, and their colleagues investigated the activity of genes in the organs of mice and zebrafish immediately after death. They did this by measuring the amount of messenger RNA present. An increase in this mRNA – which genes use to tell cells to make products such as proteins – indicates that genes are more active.

Noble's team measured mRNA levels in zebrafish, and in brain and liver samples from mice at regular intervals for up to four days after death. They then compared these with mRNA levels measured at the time of death.

As you might expect, overall mRNA levels decreased over time. However, mRNA associated with 548 zebrafish genes and 515 mouse genes saw one or more peaks of activity after death. This meant there was sufficient energy and cellular function for some genes to be switched on and stay active long after the animal died.

These genes cycled through peaks and dips in activity in a "non-winding down" manner, unlike the chaotic behaviour of the rest of the decaying DNA, says Noble.

Hundreds of genes with different functions "woke up" immediately after death. These included fetal development genes that usually turn off after birth, as well as genes that have previously been associated with cancer. Their activity peaked about 24 hours after death (*BioRxiv*, doi.org/bj52; doi.org/bj53).

"Hundreds of genes with different functions woke up after death, including fetal development genes"

A similar process might occur in humans. Previous studies have shown that various genes, including those involved in contracting heart muscle and wound healing, were active more than 12 hours after death in humans who had died from multiple trauma, heart attack or suffocation (*Forensic Science International*, doi.org/bj63).

The fact that some genes associated with cancer are activated after death in animals, might be relevant for reducing the incidence of cancer in people who receive organ transplants, says Noble. People who get a new liver, for example, have more cancers after the treatment than you would expect if they hadn't had a transplant. The regime of drugs they need to take for life to suppress their immune system so it doesn't attack the new organ may contribute to this, but Noble says it is worth investigating if activated cancer genes in the donor liver could play a part.

So why do so many genes wake up after death? It is possible that many of the genes become active as part of physiological processes that aid healing or resuscitation after severe injury. For example, after death, some cells might have enough energy to kick-start genes involved in the inflammation process to protect against damage – just as they would if the body were alive.

Alternatively, a rapid decay of genes that normally suppress other genes – such as those involved in embryological development – might allow the usually quiet genes to become active for a short period of time.

KISS OF DEATH

What happens when we die? Well, that depends on where we end up. A body that has been refrigerated and encased in a coffin could take decades to completely decompose.

But out in the open, the human body can disappear in just months. Here, within minutes of death, carbon dioxide starts to accumulate in our blood, causing cells to burst open and spew out enzymes that digest tissues. Within half an hour, blood starts to pool at the lowest point, while the rest of the body turns pale. Rigor mortis then sets in as calcium ions diffuse into cells causing muscles to contract.

Three days later, putrification occurs as microbes that live in our gut break down proteins, creating a repulsive odour. They produce gases that bloat the body, which after two weeks collapses.

Our flesh is rapidly consumed by bacteria and maggots. Eventually, after months or years, only bones are left – minus their collagen – which succumbs to bacteria and fungi.

No pulse, but the genes are busy

For forensic scientists, knowing how gene activity rises and falls at different time points after death is useful for working out when someone died. Measuring mRNA would allow us to nail down the time since death to hours and possibly even minutes, rather than days, helping to reconstruct events surrounding the death.

It is good to see such progress being made in this area, says Graham Williams, consultant forensic geneticist at the University of Huddersfield, UK. "But substantial work is required before this could be applied to case work."

The research also raises important questions about our definition of death – normally accepted as the cessation of a heartbeat, brain activity and breathing. If genes can be active up to 48 hours after death, is the person technically still alive at that point? "Clearly, studying death will provide new information on the biology of life," says Noble. ■

Race to save brief bonanza of treasures

THOUSANDS of ancient relics unearthed by climate change could soon be lost forever, destroyed by weathering and pests. The crisis is so acute that some archaeologists are urging colleagues to abandon their current field sites and focus instead on these newly exposed treasures before they vanish.

Rising seas, raging storms, melting ice and forest fires are exposing artefacts that have much to tell us about our history on Earth – from sunken shipwrecks in Svalbard to the ancient waste dumps filled with bones, shoes and carvings that are emerging all over the Arctic and further south, including in Scotland.

"This material is like the library of Alexandria. It is incredibly valuable and it's on fire now," George Hambrecht, at the University of Maryland, College Park, told *New Scientist* at the Anthropology, Weather and Climate Change conference in London last month.

"Archaeology provides the longest record of humans on Earth," Robert Kelly, at the University of Wyoming, Laramie, told the meeting. "These sites matter because they contribute to understanding how ancient societies coped with climate change."

In Norway's Svalbard archipelago, receding sea ice has opened up previously inaccessible areas. This has enabled Øyvind Ødegård at the Norwegian University of Science and Technology in Trondheim to start investigating the estimated 1000 shipwrecks in the region, dating from 1596 to the mid-20th century. Only one wreck had been examined before.

But in January, Ødegård was alarmed when a piece of driftwood was pulled out of Rijpfjorden Bay. It was infested with what he thinks is shipworm (*Teredo navalis*), a mollusc that is voracious in its consumption of wood but was thought to be absent from such cold waters.

"We don't know if this is climate-related," he says. "It's kind of a race now because if the shipworm is suddenly present due to climate change, it is a new threat to the cultural heritage on the seabed. It would be a complete disaster if we came too late."

Recent advances in archaeological techniques mean that we can now extract immense detail from old artefacts about the lives and environments of ancient peoples. For example, the isotopes found in dental plaque can reveal an individual's diet and where they travelled. And ancient DNA can uncover the genetic histories of crops and livestock – information that could help us adapt the species we rely on to climate change.

"The archive is being destroyed just as we are able to read it," says Thomas McGovern, an archaeologist at the City University of New York. Take Walakpa Bay in northern Alaska, he says,

"This material is like the library of Alexandria. It is incredibly valuable and it's on fire now"

where a frozen collection of artefacts, spanning 4000 years, of the native Alaskan Iñupiat people is thawing, its contents crumbling into the sea.

In 2014, a single storm washed away half the site. Archaeologists are now racing to retrieve a 3000-year-old frozen walrus stored for food. Isotope studies of lead in the animal's teeth could reveal its diet and foraging routes, and help build a picture of the ecosystem that existed at the time.

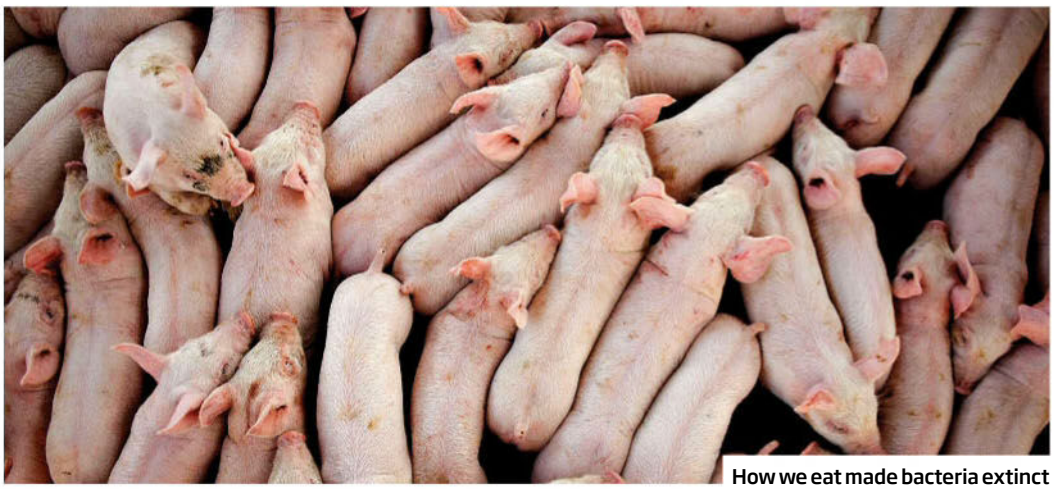
The ability to track ancient animals' distributions has only been possible in the past year, says McGovern. This ancient data can help us better understand creatures that are economically important today, such as cod, and how they lived before Earth's habitats were hugely affected by human activity.

Some archaeologists are now calling on their peers to postpone their work on better preserved sites and focus on these disappearing treasures before it is too late. Efforts are under way to collaborate on retrieving as much of the material as possible and storing it in warehouses to be studied by future archaeologists.

"We should concentrate our efforts in the places where we are losing the evidence," says Tom Dawson at the University of St Andrews, UK, who has fought to save thousands of crumbling sites along the coasts of Scotland. "It's a no-brainer." Aisling Irwin ■

COURTESY OF ANNE JENSEN

Defrosted and about to disappear



DANIEL ACKER/BLOOMBERG VIA GETTY IMAGES

How we eat made bacteria extinct

Civilisation, the enemy of bacteria

Andy Coghlan

IT'S not just elephants and tigers – we have been wiping out far tinier organisms too, with potential consequences for our physical and mental health.

That's the bleak message from an in-depth analysis of the effect our history as a species has had on Earth's microbes, especially those that live inside us. "Diversity of gut bacteria is declining with civilisation," Michael Gillings of Macquarie University in Sydney, Australia, told the annual meeting of the American Society for Microbiology in Boston this week.

The practices of the human era, known as the Anthropocene – including agriculture, sanitation and widespread antibiotic use – are probably to blame.

Gillings suggests that the microorganisms living inside us began to get less diverse 350,000 years ago, when we learned to use fire. Cooking unlocked more calories from our food, allowing us to evolve smaller digestive tracts with less space for microbes to grow.

Bacterial diversity probably declined further around 10,000 years ago, when the invention of agriculture narrowed our diets and pushed sheep, pigs, cattle and poultry to eventually become some of the most common vertebrates on Earth.

Around 12,000 years ago, before agriculture, most of the world's gut flora – with a biomass estimated at 200 million tonnes – would have been living inside wild animals. By the year 2000, the microbial biomass in wild animals was tiny compared with the 600 million tonnes in farm animals and the 200 million tonnes living inside us.

"We only use four species of livestock," says Antje Boetius of the Max Planck Institute of Marine Microbiology in Bremen, Germany. Farming the same animals and eating the same food means that microbes are less diverse, and valuable genetic sequences may have been lost forever, she says.

For humans, the biggest changes probably occurred after the industrial revolution. Disinfectants, sanitation, processed food, caesarean births, bottle-feeding, frequent international travel, and – most of all – antibiotic drugs together prompted a major homogenisation of the bacteria and other species that live inside humans worldwide.

Some researchers suspect that the sudden loss of so many species plays a role in a wide range of health problems, including obesity, asthma, psoriasis and even mental health conditions. "It's beginning to look like the microbiome has effects on brain activity, and anxiety and depression have been linked with irritable bowel syndrome," said Gillings.

But we could stop the trend, says Boetius. "By increasing crop diversity and [changing] how we live, we can decide how to manage this," she says. "It's about behaviour, and we can change that." ■

LIGO black holes may come from lifelong pairs

THE recent spate of gravitational waves may come from pairs of stars that lived and died together.

These gravitational waves are created when two black holes orbiting each other spiral inwards and merge, producing a massive burst of energy. Last week, the Laser Interferometer Gravitational-Wave Observatory (LIGO) announced it had found a second such ripple in space-time.

But how do you make a binary black hole in the first place? Start with a binary star, says Krzysztof Belczynski of Warsaw University, Poland.

Belczynski and colleagues modelled how binary star systems could evolve into binary black holes like the source of the first LIGO signal. They started with two stars formed around 2 billion years after the big bang, one 96 times the mass of the sun, the other 60 times.

After 3.5 million years, the stars got close enough to shift material from the larger to the smaller, collapsing the larger star into a black hole. For a few million years more, the black hole and the star shared an envelope of gas, drawing them closer before the second star collapsed, leaving two black holes of 37 and 31 solar masses. These happily coexisted for another 10 billion years before colliding.

The team calculates that there should be 218 such mergers each year in a particular volume of space. LIGO's rate of detection so far implies the universe produces between 9 and 240 black hole mergers in the same time and volume, so the model fits (*Nature*, DOI: 10.1038/nature18322).

"People are starting to do these studies as we actually have some data to play with"

But just last week, Carl Rodriguez of Northwestern University in Evanston, Illinois, and his colleagues suggested most binary black holes are created in a different way: from many individual holes thrashing around in dense stellar regions. They predicted a rate of between 5 and 10 mergers – still consistent with LIGO.

"The game now is to try to narrow down which classes of models are correct," says Mark Hannam of Cardiff University, UK. "People are starting to do these studies as we actually have some data to play with." Jacob Aron ■


Professor Dame Carol Robinson
2015 Laureate for United Kingdom
By Brigitte Lacombe
For Women in Science
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Get drugs to the brain with bubbles

Jessica Hamzelou

FOR the first time, doctors have shown that temporarily opening the protective barrier of the human brain helps to boost the delivery of cancer medication to brain tumours.

The therapy, which uses tiny bubbles and ultrasound to let chemotherapy drugs into the brain, could be used to treat Alzheimer's disease and stroke in the future.

Our brains are protected by a barrier of cells, which act to stop potentially harmful things from getting in. But this blood-brain barrier also blocks medicines, making it difficult for doctors to treat brain diseases with drugs.

The new approach can temporarily lift the barrier. Microbubbles – tiny bubbles of a gas wrapped in a lipid coating – can be injected into the bloodstream, where they stick around for about 4 minutes. If ultrasound is applied to a specific area of the body or brain within that time, it can cause the bubbles in its path to vibrate. This vibration has been found to temporarily open up the blood-brain barrier in animals, and last year, a team at Sunnybrook Health Sciences Centre in Toronto, Canada, said it had worked in one human volunteer.

Alexandre Carpentier at the Assisance Publique-Hôpitaux de Paris in France and colleagues have been running the first clinical trial of this technique in a group of people with a highly aggressive kind of brain tumour called glioblastoma. Doctors attached a tiny ultrasound device inside the skull of 15 volunteers. Each patient received their regular drug dose and a microbubble injection. The device was then switched on for 2 minutes.

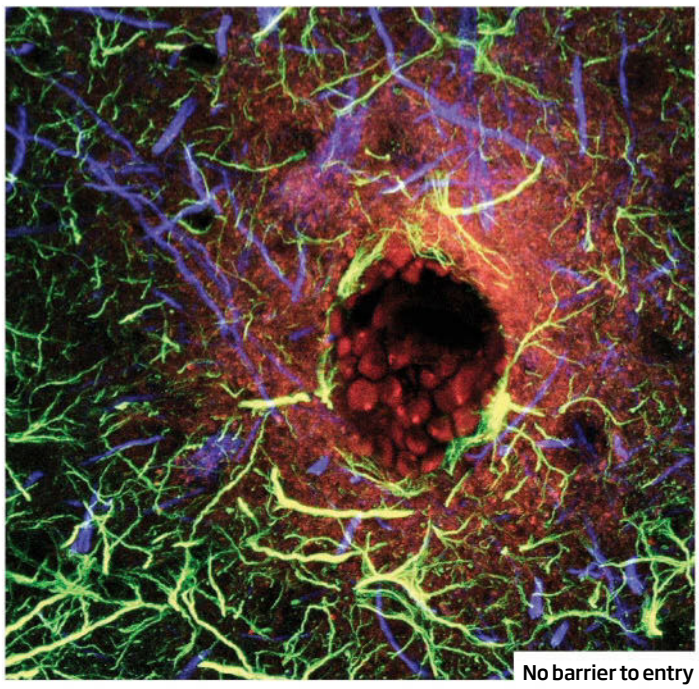
"Five times the amount of the drug reached the brain than through chemotherapy alone"

As a result, the blood-brain barrier was "leaky" for the next 6 hours. Patients were treated monthly for up to a maximum of six treatments. MRI scans taken before and after the volunteers received an injection of a liquid that lit up on scans suggested that five times the amount of the drug was able to reach the brain than through chemotherapy alone.

The trial is only an early-stage test of safety, and so the team cannot yet say whether the treatment improved survival rates, but they did show that the approach was safe. "I was very scared that they might not be able to speak, because the ultrasound was targeting the language area of the brain," says Carpentier. "But there were no effects. They don't feel anything."

There's a chance that the technique could help treat other diseases. Last year, a separate team found that the ultrasound approach could clear plaques from the brains of mice with a model of Alzheimer's disease.

Other teams have been investigating whether it could work in brain disorders caused by traumatic injuries or stroke. "It's a brand new field, and every month we're discovering new stuff," says Carpentier. "It's very exciting." ■



C.J.GUERIN, PHD, MRC TOXICOLOGY UNIT/ SCIENCE PHOTO LIBRARY

No barrier to entry

Wild kangaroo numbers cut by cont-roo-ception

A CONTRACEPTIVE has made the jump from women to kangaroos. A large trial of hormonal implants in roos in south-east Australia has reduced the number of the animals born, removing the need to cull them by shooting.

Australia has twice as many kangaroos as people. When numbers become high locally, more of the animals collide with cars, and they contaminate water supplies and damage grasslands. To control numbers – and supply kangaroo meat – more than 5 million wild kangaroos are culled a year.

But there is increasing opposition to this from animal welfare groups. To see if contraception could be an effective alternative, Michelle Wilson of the University of Melbourne has been giving kangaroos hormone implants usually used by women.

In 2013, Wilson put levonorgestrel implants under the shoulder blades of three-quarters of the female kangaroos in a 200 hectare area of the Western Plains of Victoria. "There were too many kangaroos so there wasn't enough food and they were starving and emaciated," she says.

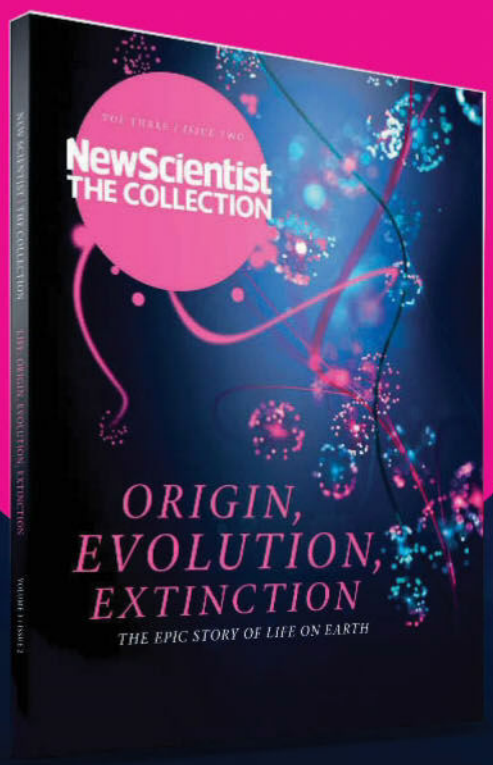
A follow-up study has now found that, of the 75 females that were implanted, only one has become pregnant since. The reproductive rate of this population is now about a third of what it was in 2012.

"It's prevented the need for us to go back and do any more shooting," says Phil Pegler of Parks Victoria.

The contraceptive method costs around $A 250 (£130) per animal, but is better in the long term, says Wilson. "The problem with culling is that the population bounces back afterwards." Alice Klein ■

NATIONAL GEOGRAPHIC CREATIVE/ALAMY STOCK PHOTO

Where have the joeys gone?



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DAVID CLAPP/GETTY IMAGES


DANIEL BELTRÁ

Magnets could quickly pull oil spills out of the ocean

HERE'S an attractive idea. Magnets could be used to mop up oil spills, stopping them from killing wildlife. All you need is a sprinkling of iron oxide nanoparticles.

The stickiness of oil makes it difficult to remove from marine plants and animals if it leaks from tankers or offshore rigs, so finding a method for quickly cleaning up spills is essential.

Now Yi Du at the University of Wollongong, Australia, and his team have found a way to do this, using tiny particles of iron oxide that tightly bind to droplets of oil.

When added to small water tanks polluted with oil, these 25-nanometre-wide particles turned the oil into a magnetic liquid that could be drawn towards a simple bar magnet (*Physical Chemistry Chemical Physics*, doi.org/bj4v; *ACS Nano*, doi.org/bj4t).

Du envisages sprinkling these particles over oil spills in the ocean. "Then, ships with small magnets could move around the spill, and all the oil would be sucked towards the magnets and collected," he says.

The particles are non-toxic, and any excess could be hoovered up with magnets and reused, Du says. "Iron oxide nanoparticles are already commonly used in medical imaging, so we know they're safe," he says.

The team plans to test the nanoparticles in larger tank experiments, before seeking permission to trial them in open water.

Naked black hole survived galactic crash

IT'S a supermassive streaker. When one galaxy zipped through a larger one, the lesser galaxy's stars were mostly stripped away by a gravitational rip tide. It fled the scene with just a thin veil of stars cloaking the gargantuan black hole at its centre.

That's what Jim Condon of the National Radio Astronomy Observatory in Charlottesville, Virginia, and his team think they have seen using radio telescopes: a bright fountain of radiation that only huge black holes can produce. Follow-up observations with the Hubble Space Telescope showed that the object has just a small belt of stars around it, rather than the sprawling galaxy that a black hole of its size ought to have (arxiv.org/abs/1606.04067v1).

If confirmed, it would be the first time astronomers have found a supermassive black hole stripped bare by a larger galaxy. His group has searched for nearly nude black holes for years, so it was exciting but not surprising for them to see one at last.

What is strange is that only one of 492 black holes they examined was in this state, Condon says. Cosmological theory predicts that scantily clad singularities should often form when galaxies collide, and Condon hopes to discover more examples.

Wily butterfly robs its ex-guardians

NEVER trust a butterfly. The metalmark butterfly of Peru cooperates with ants as a caterpillar, only to steal their food as an adult.

The caterpillar wins over the ants with gifts of sugary secretions. In return, the ants defend it from predators. But when the caterpillars become butterflies they turn on their protectors, plundering the ants' carefully tended supply of nectar.

Usually the ants fiercely defend this food source, which comes from the tips of rainforest bamboo shoots – except when metalmark butterflies are the ones drinking from it (*Journal of the Lepidopterists' Society*, doi.org/bj4z).

Phillip Torres of Rice University in Houston, Texas, thinks the butterflies get away with it because they smell the same as their caterpillar stage. The duped ants get nothing in return.

Rings are safe around asteroids

HOLD on to your belts. Asteroids cling on to their rings despite the prying gravity of giant gas planets.

In 2014, astronomers spotted rings around a large asteroid called Chariklo, which orbits in the chaotic region between Saturn and Uranus. "It's like pinball: the rings hit Saturn, they go around Neptune," says Othon Winter of Sao Paulo State University, Brazil.

Rings are unstable, so to find out if Chariklo's would survive, Winter and colleagues simulated 729 objects just like the asteroid. In more than 90 per cent of cases the rings remained intact, despite an average of 150 close encounters with giants (*Astrophysical Journal*, doi.org/bj44).

The next step is to find out where Chariklo's ring came from.

'Stomach tap' to treat obesity

PASS the sick bag. A device that allows people to empty some of their stomach contents into a toilet after a meal has just got the go-ahead from the US Food and Drug Administration. The device is approved for use by people who are severely obese.

The stomach-churning device involves a tube being placed into the stomach in a short surgical procedure. The end of the tube contains a valve that lies flush against the skin. After meals, the person can connect the valve to another tube to drain about a third of their partially digested food into the toilet. It cannot remove more than this because the end of the internal tube is positioned above most of the stomach's contents.

Manufacturer Aspire Bariatrics in Pennsylvania says users need to chew their food well and eat more slowly to stop the 6-millimetre tube from getting blocked, and that this in itself helps reduce overeating.

As a safety feature, the device, called AspireAssist, can only be used three times a day for up to six weeks before one part stops working and needs to be replaced.

In a trial of 171 people, those who used the device alongside lifestyle counselling lost 14 per cent of their body weight after one year, compared with 5 per cent in people who received counselling alone.

MARTIN PARR/MAGNUM

Daisy-chain gene drive vanishes after a few generations

IT'S a catch-22. We have to field-test tools called gene drives to determine if they are safe to use to stop the spread of malaria, for example. But these bits of self-copying DNA could spread to every member of a species, making such tests risky.

Kevin Esvelt at the Massachusetts Institute of Technology and his team may have an answer. Normal gene drives insert a piece of DNA into one of two pairs of chromosomes. This DNA then copies and pastes itself into the other chromosome, meaning all offspring inherit the gene drive, which spreads rapidly through a population. To limit this, Esvelt's team split their gene drive into three or more elements to create a "daisy chain" effect.

Each element contains at least one gene essential for the whole drive. Element A can only copy and paste itself if element B is present. Element B can only copy and paste itself if element C is present. And element C cannot copy and paste itself at all – it only spreads by normal breeding, to half of all offspring.

The idea is to release thousands of mosquitoes, say, carrying all three elements. When they mate with wild mosquitoes, all offspring will inherit element A and B, but only half inherit element C. In the following generations, element A will spread rapidly, B slightly less so, and C will gradually die out. Once it does, B will start to disappear, and finally A (*BioRxiv*, doi.org/bj4w). If it works, it could allow a gene drive to be tested locally, to combat malaria, say, without spreading to other cities.

Lots of fibre keeps nut allergy at bay

BRAN lovers rejoice. Fibre-rich diets have been shown to protect against peanut allergy in mice. If the same holds true for humans, what we eat could prevent or even reverse allergies to peanuts.

Jian Tan of Monash University in Melbourne, Australia, and his colleagues found that mice bred to have this allergy are less likely to experience anaphylactic shock from peanuts if they are given a high-fibre diet.

The protective effect may be down to the fact that when gut bacteria break down fibre, short-chain fatty acids are released that bind to immune cells. This could stop them recognising peanuts as a foreign object, preventing an allergic reaction. Previous work in mice shows that high-fibre diets boost populations of gut bacteria that produce these fatty acids from fibre, bolstering the idea.

Tan's team bred mice without short-chain fatty acid receptors on their immune cells and found that a high-fibre diet no longer protected against peanut allergy (*Cell Reports*, DOI: 10.1016/j.celrep.2016.05.047). Studies suggest high fibre intake combats allergies in humans, although the evidence is still not definitive.

IMAGEBROKER/FLPA

Watch your grammar around budgies

BUDGERIGARS are grammar pedants too. Just like us, these parrots use the grammatical structure of unfamiliar phrases to work out what they mean.

There is evidence that some birds pay attention to the order of sounds in a song, but this grammatical behaviour has not been well studied.

Michelle Spierings and Carel ten Cate at Leiden University in the Netherlands made new songs by piecing together three different snippets of recorded bird melodies. They played budgies and zebra finches certain patterns – such as AAB or ABA – and trained them to peck only when they heard AAB.

The researchers then played new combinations to the birds. Because the zebra finches had learned not to peck for ABA, they also did not peck for CCA – apparently focusing on the final position of the A snippet.

But the budgies were different, focusing instead on the structure of the song. They pecked when they heard CCA, recognising that this is the same pattern as AAB (*PNAS*, DOI: 10.1073/pnas.1600483113). "They followed the structure and were not distracted by the positional changes," says Spierings.


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Outsmarted?

Scare stories about killer robots are missing the point: the future of artificial intelligence will be far stranger than that, says **Sumit Paul-Choudhury**

RELAX: the AI apocalypse has been cancelled. A rash of recent headlines blared that Google was developing a "kill switch to stop a robot uprising against humans", as *The Telegraph* put it, with a picture of a menacing metal army.

It may come as little surprise to learn that the technical paper on which the stories were based described a prosaic engineering problem, not ways to stop the Terminator in its tracks. But the excitable coverage reveals how deeply the challenges posed by artificial intelligence have seeped into public consciousness.

We have had machines that can out-calculate us for decades. Now a new wave is outperforming us on tasks ranging from image recognition to video-gaming. They might soon do our jobs better than we can (see page 33) and may even challenge us in areas as sacrosanct as creativity.

Such superintelligent machines could revolutionise everything from transport to social care. But their rise raises tricky questions about everything from human survival to theology. *New Scientist* went in search of answers at a private meeting of researchers, philosophers and ethicists organised by Rustat Conferences at Jesus College, Cambridge, UK.

Not so killer

Concern that smart machines might do away with us has been brewing since the advent of modern computers in the 1950s, but was confined to the wilder fringes of AI. In recent years, however, a school of thought led by the philosopher Nick Bostrom has made this "existential risk" a mainstream talking point. His 2014 book *Superintelligence* won over technocrats like Bill Gates and Elon Musk, and later public figures like Stephen Hawking.

One of Bostrom's more celebrated examples is of an AI bent only on making paper clips: it might use up all of the planet's resources in pursuit of its objective. Alternatively, an AI tasked with making humans happy might cut out parts of our brains associated with unpleasant experiences. So the challenge is to ensure that an AI's goals are compatible with our own.

"Existential risk boils down to values. The challenge is to ensure an AI's values are compatible with ours"

"Existential risk boils down to a question of values," John Naughton, emeritus professor of the public understanding of technology at the Open University, UK, told the meeting. The bad news, he says, is that those leading the AI charge take "a technocratic attitude that assumes data-driven decision-making is good and algorithms are neutral". Biases introduced by the systems' designers, input and processes go unremarked.

So how should we set goals and values for future machines? The simple answer is we don't yet know. Although current AIs are "trained" on data sets to perform specific tasks, their successors may be able to choose their own objectives, just as we do, and they might figure out better solutions to problems that way. But if we give them that freedom, we need the ability to stop them from taking undesirable paths – hence that so-called kill switch.

AHN YOUNG-JOON/AP/PA

One common assumption is that an AI should aim for the greatest good for the greatest number. That initially sounds attractive. For example, it is more cost-effective to buy malaria nets than develop drugs for rare diseases. But that could mean abandoning the kind of individual gestures we hold dear, and which are important for social cohesion. AIs might be able to "out-ethic us", making cold-bloodedly rational choices on our behalf, but we might not like the results. That will become more of a concern as they push into areas currently reserved for humans.

A glimpse at the new kinds of problem we can expect AI to start tackling came in March, when AlphaGo beat world champion Lee Sedol at the hugely complex board game Go. The tournament – which the AI won 4-1 – was reminiscent of Garry Kasparov's 1997 bouts with IBM's Deep Blue supercomputer. But whereas that joust demonstrated machines' superiority at brute-force calculation, AlphaGo's victory showed something else, Demis Hassabis, co-founder of AlphaGo's creator DeepMind, said at the meeting: creativity and intuition.

A creative triumph?

Getting human

Hassabis proposed that creativity be defined as the ability to synthesise knowledge to produce a novel idea, and that intuition is implicit knowledge acquired through experience that isn't consciously expressible.

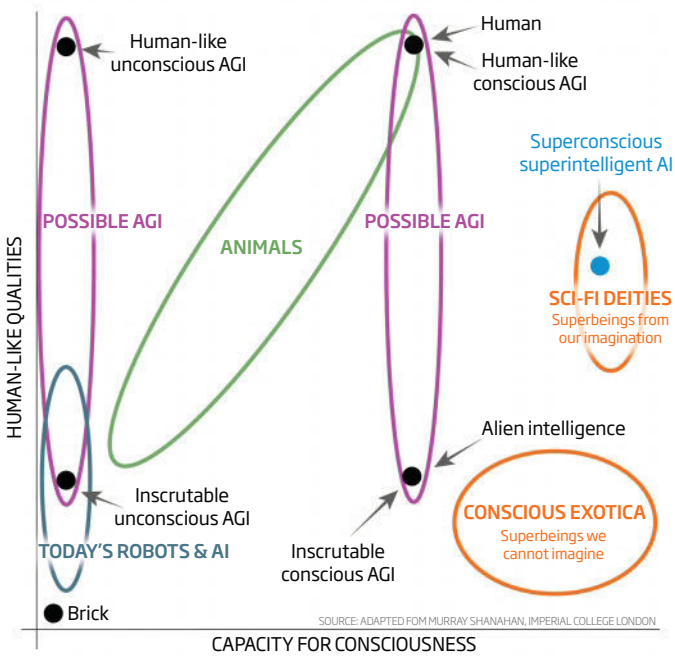
AlphaGo won one match by playing a move that departed from centuries of received wisdom. It can't express why it did this, but clearly had a rationale. So was it being creative and intuitive, albeit in a very limited way? If so, it might represent a new class of smart machine: "super-creators", say, rather than supercomputers.

But it is missing the point to describe creativity as an innate property, said Simon Colton, who studies computational creativity at Goldsmiths, University of London. While he looks forward to a future in which, say, your phone endlessly composes music, he says creativity is a social construct, "conferred on a person – or entity – by others". Colton has made machines that paint pictures and make up storylines, but says it can be impossible to evaluate computer-generated works without imposing an invalid human frame on them.

What about qualities we still think of as exclusively human – imagination, emotion and above all consciousness? Machines that probe these areas are in the works, but the AIs hitting the headlines don't get anywhere near them. While a system can be trained to perform new tasks, it can't usually transfer knowledge gained in one area to another, as humans do.

The spectrum of all possible minds

Super-smart machines – known as artificial general intelligence (AGI) – don't have to think like us or share human-like traits such as empathy. Here is how humans and robots compare, now and in the future



Many researchers agree that the way most people imagine AI – a machine that thinks just like a human – is a remote prospect, unlikely to be fulfilled without a better understanding of how our own minds work. And the field has a history of "AI winters", when development grinds to a halt after a period of rapid advance. There's a broad consensus that such "artificial general intelligence"

"How would the creation of conscious machines challenge our ideas about our place in the cosmos?"

(AGI) is achievable this century, but few believe it will result from just carrying on as we have so far.

But a superintelligent machine need not replicate all facets of humanity. The spectrum of future machines could include "zombie" AGIs that resemble humans but have no consciousness, says Murray Shanahan, who studies cognitive robotics at Imperial College London – or AIs that are more conscious than us, among other possibilities (see diagram, above). That puts them into company with extraterrestrial intelligences, which might also be super-smart but utterly inhuman.

There's a final conundrum: how would the creation of machines as intelligent and/or conscious as ourselves challenge our ideas about our place in the cosmos? Perhaps surprisingly, the religious might need less adjustment. Abrahamic faiths, at least, need not have a problem with there being non-human intelligences, said Cambridge theologian Andrew Davison, given that the Golem of Jewish folklore and immaterial superbeings in the Bible are examples of just that.

We have only just begun to live with smart machines. While we worry today about killer robots, the challenges to come may be turn out to be much stranger. One day, we may find ourselves living alongside aliens and angels. ■

Visibly lacking

Publicly funded egg-freezing isn't the way to address Japan's low birth rate, says **Angel Petropanagos**

THE population is shrinking and ageing amid a very low national birth rate. What's to be done? The government of the Japanese city of Urayasu thinks taxpayers should pay for women to freeze their eggs.

Working with Juntendo University Urayasu Hospital, the city has launched a three-year pilot project that will use public money to cover 80 per cent of the cost of egg-freezing for female residents aged between 25 and 34.

The aim is to boost fertility rates by facilitating delayed childbearing, with donors able to use their eggs up to the age of 45. This is the first "social" egg-freezing subsidy programme; I hope it is the last.

Egg-freezing is onerous and risky, and it's likely that most of the people who plump for it to guard against age-related infertility won't ever use the eggs to try to get pregnant.

Those who do will have to resort to IVF, which poses additional risks and costs. Furthermore, egg-freezing isn't guaranteed to work. Live birth rates following egg-freezing and subsequent IVF remain low. Equally worrisome, perhaps, is the uncertainty surrounding the long-term effects of these techniques on the women and any resulting offspring.

Social egg-freezing also raises ethical challenges of fairness: it uses resources that could instead go just to those who need to freeze eggs on medical grounds. There are also issues around informed decision-making, plus the overvaluing of pregnancy and genetically related children.

This is not a reasonable solution to the broad and complex "social problem", as Urayasu's mayor would have it, of low birth rates. It is a technological approach that

Coral grief

Election vows to save Australia's Great Barrier Reef are too little, too late, says **Tim Flannery**

BOTH major parties battling to govern Australia after next week's elections have done their best to ignore the most important issue of the moment: the fate of the Great Barrier Reef.

Only widespread public outrage about record levels of damage to this iconic habitat diverted both the Liberal and Labor parties from focusing on the economy and into doing something for the reef.

The Liberals last week promised to divert A$1 billion to the reef, with a focus on improving water quality. That was after Labor pledged half a billion dollars of new money. Neither is enough, and nor will it get to grips with the real problem.

Public concern was sparked after the recent El Niño warming of large parts of the Pacific. It led to severe bleaching and coral death in the northern part of the reef. The damage was different from that in the past. It was more extensive, and corals on the outer reef – normally safer because ocean water cools them – suffered.

Both Labor and Liberal pledges largely miss the point. The main peril the reef faces is global greenhouse gas emissions, which drive warming of surface waters that can damage coral in the absence of El Niño and also make extreme El Niños more likely.

"A government serious about giving the reef a chance would aim to close the worst coal-fired plants"

If we do nothing, in five years there will be enough greenhouse gas in the air for temperatures to hit 1.5 °C above the pre-industrial average. Only declaring a state of global emergency will then give the reef a chance of survival.

Australia is in a strong position to do something now. It has 21 coal-fired power plants, including some of the oldest, dirtiest and least efficient in the developed world. An Australian government that is serious about giving the reef a chance would announce the

benefits some women, not all. What's really needed are social and structural changes to make it easier and preferable for women (and men) to have children and to do so when younger.

Governments should invest in improved reproductive health and in programmes to give women and men information about fertility, infertility and family-building options, so they can better plan their reproductive lives. They should have access to paid parental leave and flexible work schedules or reduced workloads that are more conducive to raising children. And living costs such as housing and childcare should be affordable; financial and social stability can make it easier to have children.

Yes, Japan has a demographic problem. The population has been falling for several years, and the fertility rate is just 1.4 children per woman. By investing in egg-freezing, the city of Urayasu has effectively put all its eggs in the wrong basket. Its chosen intervention is risky to women and fraught with ethical dilemmas. ■

Angel Petropanagos is a bioethicist at Dalhousie University in Halifax, Canada. She spoke at the Progress Educational Trust UK egg-freezing debate last week

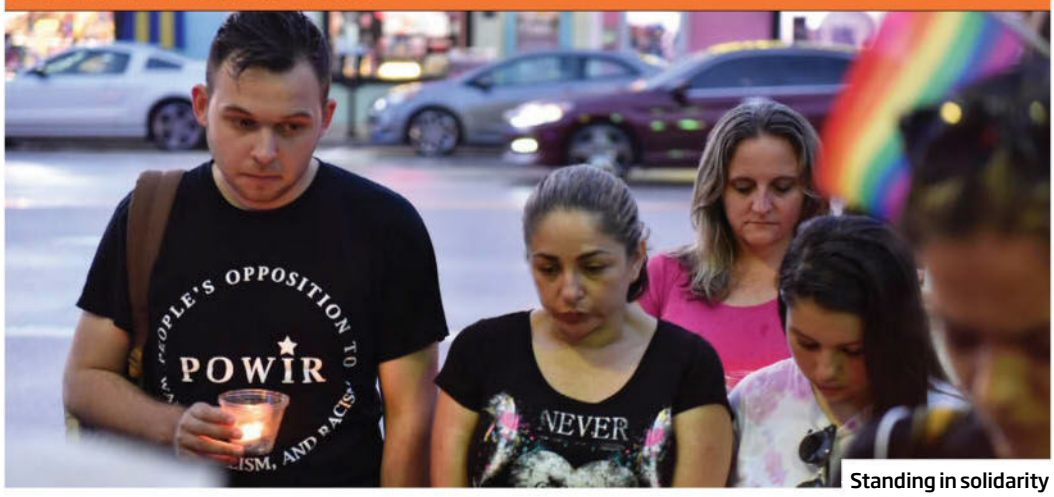
closure of the worst plants, giving it credibility on the world stage. It could use its foreign aid budget to help other countries close theirs.

More would need to be done to drive down emissions and deploy clean energy technologies, such as "third way" methods that could draw carbon dioxide out of the air at scale. Of course billions should go on research, water quality and other environmental outcomes.

But in the absence of other actions, the money pledged thus far to "save the reef" is simply fiddling while Rome burns. ■

Tim Flannery is chief councillor of the Climate Council of Australia

INSIGHT Hate crimes



MICHELE EVE / SPLASH NEWS

Standing in solidarity

Enshrine equality in law and it will pay off

Jessica Hamzelou

OMAR MATEEN'S attack on the Pulse gay club in Orlando, Florida, is the deadliest mass shooting in modern US history. It has been called many things – a terror attack, a consequence of lax gun laws, the actions of a man struggling with his identity. But it is also undeniably a hate crime.

Amid the shock and grief people asked why it happened. There are many responses to this question. One is whether high-profile debates over "bathroom bills" in the US played a role. The rationale is that discussing whether transgender people should be free to use bathrooms that align with the gender they identify with has brought people under the spotlight, making them more visible targets.

The bathroom bills are the latest in a slew of policy changes across many US states regarding sexual orientation and transgender status. Some have aimed to give lesbian, gay, bisexual and transgender (LGBT) people a more equal position in society, others have sought to restrict rights.

Some people understandably feel that discussion of laws that would inhibit their freedoms legitimise them as targets of violence. "When you are pushing forward a system based on a culture of hate, what do you expect to happen?" James Miller of the LGBT Center of Raleigh, North Carolina, said after the shooting.

Levelling the playing field with pro-equality laws can seem futile too, because it might trigger a vicious backlash. So it's damned if you legislate, damned if you don't.

Or at least that's how it has seemed. The first study investigating the effect of public policy on hate crimes based on sexual orientation suggests that

"There'd be a 27 per cent drop in hate crime if you went from no states to all states having these laws"

pro-equality laws do actually reduce hate crimes. The study focused on three pro-equality laws and tracked levels of reported hate crime in the years following their implementation between 2000 and 2012 (*Social Science Research*, doi.org/bj3t).

"If you went from no states having these laws, to all states implementing them, you'd see a 27 per cent decrease in reported hate crimes," says co-author Brian Levy of the University of North Carolina in Chapel Hill.

The introduction of employment discrimination laws and laws that deem crimes motivated by sexual orientation to be hate crimes were followed by a drop in hate crime. But when laws recognising same-sex partnerships were passed, more hate crimes were reported. These increases were highest about two years after the law was introduced, suggesting they had little to do with the preceding debate. Rather, the authors think that people became more confident in reporting such incidents.

This has been seen before. A 1999 report into the murder of black teenager Stephen Lawrence triggered a change of the UK legal definition of hate crime. Such crimes then surged. This should be taken as a hallmark of success, says Michael Sutton at Nottingham Trent University in the UK. "When laws are passed, the crimes are seen as unacceptable."

There are other caveats to Levy's study. Data was collected until 2012, so it doesn't reflect the greater visibility in the past few years of LGBT people in the media, or the rise of Donald Trump and the backlash against political correctness. Still, it offers hope. Debating new laws might come with terrible consequences, but if the laws enshrine equality and freedom, they might herald a better future. ■

Printable electronics for all

Circuits can now be 3D-printed directly into smartphones, finds **Hal Hodson**. It means that the era of smart factories is here

BLOOMBERG/GETTY IMAGES

Start of the 3D printing revolution

FOR the past few months, a factory in China has been spitting out a new kind of smartphone. Inside each is an antenna that was 3D-printed directly onto the plastic housing.

It doesn't sound like much, but this ability to print electronic components at the scale and speed required by the smartphone industry is new. It has the potential to usher in a world where sensors and electronics are embedded in everything around us.

The technique was developed by a company called Optomec in Albuquerque, New Mexico. It is working with Lite-On in Guangzhou, China, which makes phone components for companies like Huawei, HTC and Sony.

Normally, a phone's functional parts, such as the antenna, are etched into the housing by scraping away material until the desired shape is achieved. Etching uses solvents that can be harmful to the environment, which 3D printing avoids. The key advantage of 3D printing, however, lies in its flexibility. It lets factories reconfigure the whole production line – to produce a new antenna design, say – just by rewriting the code that controls the printing system (see "Data on the floor").

The Optomec system atomises an ink made from conductive metal. Tiny blobs of metal are then blasted out of a nozzle at 180 kilometres per hour onto a surface, forming the antenna – or any other electronic parts.

The ability to print electronics on this scale is a sign that the technology has matured to the point where consumers should start to see the difference. Phone manufacturers operate on tight margins. If it's cheaper for them, it means we are closer to a world where sensors and antennas turn up in other products too.

"Optomec's process can be adapted to all other tech – it's really cutting edge," says Woo Soo Kim, who studies printed electronics at Simon Fraser University in British Columbia, Canada. One of the main areas that could get a boost from 3D-printed electronics is wearable computing, he says. Flexible electronics have been around for a while, but have not yet made it into consumer products.

"The ability to print electronics on this scale means sensors could be embedded in everything"

3D printing has existed mainly in the lab until now. The fact that Optomec's system works in a real factory is a big step forward, says Kim. A 3D-printed battery could be created that fits the curves of the wearer's body, for example.

Optomec is also printing sensors to monitor the health of the giant turbines in gas-fired power stations. Each one contains hundreds of blades to harness the energy produced by burning gas. "One failed blade would take out $10 million worth of equipment," says Mike O'Reilly from Optomec.

Usually, that means turbine operators have to remove these blades for inspection every 75 hours. Now, instead of removing blades, Optomec is printing sensors onto each one. They can withstand the high temperatures of turbine operation, and detect small changes in the blade's metallurgy, indicating possible defects.

O'Reilly says the firm could also print sensors for bridges to send out information about stresses and strains on the structure. "We could print sensors everywhere," he says. ■

DATA ON THE FLOOR

A more flexible production process (see main story) opens the door to automated factories managed by software. Silicon Valley start-up dfxMachina – founded by Anna Shedletsky, who led the team behind the Apple Watch – is planning to apply machine learning to the factory floor. The company is developing software to constantly monitor assembly lines, analysing what's happening and learning how to make processes more efficient.

The idea is that assembly lines will react quickly to changes in parts and processes. Machine vision systems will also keep an eye out for manufacturing glitches at every stage, potentially saving billions in scrap and rework costs.

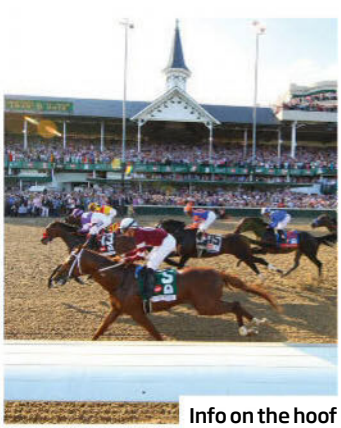
Wearable tech for racehorses can prevent injuries

AT ROYAL Ascot it can be hard to see the horses for the hats. Still, during this annual horse-racing event in the UK – which took place last week – the world's top thoroughbreds and riders compete for a prize pot that this year totalled more than £6.5 million.

It's a dangerous sport. More than 150 of the UK's 14,000 racehorses are killed each year and thousands more are injured. Many deaths are due to overexertion or fractures that result in a horse being put down. A device that monitors a horse's well-being during a race could help reduce fatalities.

The Equimètre, made by start-up Arioneo in Paris, France, fits into the girth – a strap around a horse's middle that keeps the saddle on – and records data such as heart and respiratory rate, plus acceleration and speed. It also monitors conditions such as humidity. The Equimètre then compares the stats with past performances.

"This tool will give trainers information they don't have today," says Arioneo co-founder Valentin Rapin. "It can prevent overtraining." The device could also catch common injuries such as inflamed shins, which can cause stress fractures. "The early detection of problems can only improve diagnosis," says Hervé Moreau, a horse vet based in La Ferté-Saint-Cyr, France. Frances Marcellin ■



USA TODAY SPORTS/REUTERS

Info on the hoof

DAMON WINTER/NEW YORK TIMES/REDUX/EYEVINE

You have been hacked

Cyberwar becomes official

What does NATO's move into cyberspace mean, asks **Aviva Rutkin**

PEOPLE are hacked off. On 14 June, news broke that someone had hacked into computers at the US Democratic National Committee, exposing opposition research on Republican presidential candidate Donald Trump, as well as a trove of chat logs and emails. Some blamed Russia – although as ever details are unclear.

The same day, NATO announced that it was designating cyberspace as an "operational domain" for war alongside land, sea and air.

Reports of one country attacking the computer systems of another – like this week's hack on the Democrats, last year's Chinese breach of the US Office of Personnel Management, or North Korea's attack on Sony in 2014 – have become common. The details of hacks may differ, but the story is a familiar one.

Does NATO's announcement change anything? "It means that we will coordinate and organise our efforts to protect against cyberattacks in a better and more efficient way," NATO secretary-general Jens Stoltenberg told a press conference in Brussels, Belgium, last week. In principle, under NATO's Article 5, a cyberattack on one member state could be regarded as an attack on the alliance as a whole. Yet NATO has only invoked Article 5 once before, after the 9/11 attacks. "When and if it happens, it'll be a big deal," says Paul Rosenzweig at Redbranch Law and Consulting in Washington DC.

By spreading into cyberspace, NATO is simply acknowledging the state of the world today, says Rosenzweig. "It's like recognising that the sun is rising."

"Singapore plans to protect itself by cutting off internet access to government computers"

The internet poses different challenges to other domains for war, says Amy Zegart at Stanford University in California. For a start, the territory open to attack is enormous. Potential targets include not only government systems, but also power or telecommunications companies. Taking out a city's power grid would cause chaos, for example. What's more, we probably won't see the enemy coming. Hacks can occur without warning, carried out by parties who are difficult to trace.

We tend to think of hacks as single events, says Richard Bejtlich at the Brookings Institution, a think tank in Washington DC. But in many cases, computers are breached and information is stolen in repeated incursions that take place over the course of years.

So countries and companies are adopting defensive strategies. This month, Singapore said that it plans to protect its computer systems by cutting off internet access to computers used by government employees.

Meanwhile, NATO member Estonia – which was the victim of a series of Russian attacks in 2007 that effectively knocked the country offline – has taken a different tack. It is uploading backups of government data to the cloud and to servers at Estonian embassies around the world in case of another devastating attack.

"The companies that are doing the best these days are the ones who recognise that this is a campaign problem and run their own campaigns to defeat the adversary," says Bejtlich. It requires constant vigilance: it's not enough just to deal with an attack when you notice it, he says. "You're going to lose every single time." ■

Plucked from the skies

Smart drones make sky-policing tricky, finds **David Hambling**

HOW do you bring a bad drone down? New kinds of drones that can fly autonomously can't be stopped with traditional techniques, the US Air Force has warned. It has put out a call for ideas to yank drones out of the sky.

Millions of drones are sold each year. Most are flown for fun, but a few have been put to criminal use: carrying cameras to bedroom windows, flying into secure airspace over nuclear power stations, and smuggling contraband into prisons.

There are also fears for public safety, after a number of near misses with commercial aircraft. Some terrorist groups are reported to have experimented with turning drones into flying bombs.

The typical counter to this threat is to jam the signal between the drone and its operator. For example, Colorado-based firm Liteye Systems is developing a drone-jamming defence for US airports. And French authorities have drone-jamming devices at all 10 of the stadiums hosting the Euro 2016 football tournament.

But when a drone can fly on its own, there is no operator's signal to jam. So the US Air Force has put out a call for proposals to detect and defeat autonomous drones that are resistant to jamming.

While simply blowing the drone out of the sky may seem attractive, this could detonate an explosive payload or release chemical or biological weapons, warns the US Air Force. Instead, it wants ways to capture drones physically, taking them out of the sky with minimal force.

EPA/KOEN VAN WEEL

Take down

The SkyWall100, developed by UK company OpenWorks Engineering, does exactly this. It's a bazooka-like launcher that fires a net projectile. The net envelops the drone, then safely parachutes it to the ground.

Robert Bunker, a counterterrorism expert at TRENDS Research & Advisory in Abu Dhabi, says that there are likely to be two distinct occasions when autonomous drones need to be stopped: for public safety and during war.

> **"Net launchers, rubber-ball guns and even trained birds of prey could safely catch drones"**

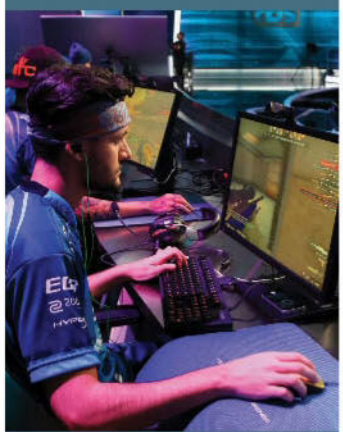
Public safety is the more challenging arena. Bunker says that dealing with drones in public spaces requires approaches that have a low risk of inadvertently harming bystanders.

These will include net launchers like SkyWall, net-carrying drones such as those deployed by Japanese police in Tokyo last year, and possibly even trained birds of prey, which Dutch police have tested as a means of safely catching drones (see photo).

Bunker also mentions handheld lasers capable of damaging drones' optics, and rubber-ball guns based on existing non-lethal weapons. In each case, a miss wouldn't cause collateral damage.

Military operations are different. Here, Bunker suggests counter-drone weapons will draw on more violent existing capabilities like the C-RAM system used in Iraq. This shoots threats out of the sky with a stream of 20 millimetre cannon fire. Its challenge will be spotting and targeting small, autonomous drones as they approach. ■

ONE PER CENT



DANIEL SHIREY/GETTY IMAGES

Gamers on TV

Sports fans looking for something other than football and tennis on TV this summer will soon be able to indulge in round-the-clock action. This month, Sky is launching the UK's first mainstream TV channel dedicated to video games. Ginx eSports TV – which is also being funded by UK broadcaster ITV – will show competitive gaming and other games coverage 24 hours a day.

186m

The **number of driving licence photos** that the FBI can trawl with facial recognition technology, according to a report by the US Government Accountability Office, an agency auditing government activity.

Spoilers are coming

A site called Spoiled.io is offering a service that lets you "anonymously and ruthlessly" ruin the hit HBO show *Game of Thrones* for your enemies (or friends). For a fee of $0.99, the site promises to send text messages detailing twists in the show to any phone number you provide. The texts will be sent each week while the show is on air for the duration of the current season.

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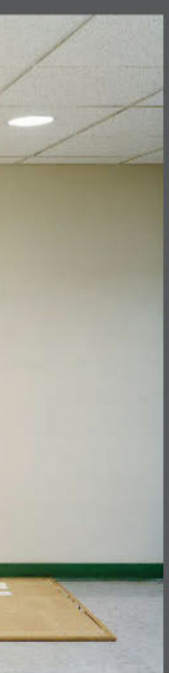

Then there were none

IS THIS what it looks like when machines come for our jobs?

Photographer Will Steacy has charted the changes at US daily newspaper *The Philadelphia Inquirer* following the advent of computerisation and the internet. The story reflects wider disquiet about technology and its ability to transform work (see "The Future of Work", page 29).

Steacy's images show the hollowing out of the 18-storey art deco building that housed the broadsheet from 1925 to 2012; a reduced staff moved to a single floor of an office block after merging operations with a sister title. For Steacy, the *Inquirer* is a microcosm of a world in which automation and the internet have the power to change society, sometimes for the worse.

Since 2000, the industry has shed 30 per cent of its workforce in the US in the face of changing reader habits, making it the fastest-shrinking industry in the country. This is no rapid revolution; it is creeping change. In Steacy's eyes it diminishes an institution vital to democracy: quality, in-depth journalism. "This is about catastrophic changes that society is in the midst of," he says.

Shown here is deputy science and medical editor Don Sapatkin at his desk in 2009, next to the same view once that floor had emptied. A pile of boxed iPhones for staff – the very devices that helped hasten the end – can be seen bottom right. Steacy's images are collated in the book *Deadline* (b.frank books). Jon White

Photographer

Will Steacy

willsteacy.com/store/deadline-book/


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SPECIAL REPORT

FUTURE OF WORK

Work is a constant in most of our lives – but it is changing as never before. Artificial intelligence that could automate most jobs already exists. Over the next eight pages, we look at what happens if it does. While opinions differ about the likely impacts (page 33) and what society's response should be (page 35), one thing is sure: the deep influence of work on the human psyche means all of us will feel the effects (overleaf)

I WORK
THEREFORE I AM

In the Western world work defines us as never before. That might be a good thing, argue **Michael Bond** and **Joshua Howgego**

"WHAT do you do?" It's simultaneously the most common and least elegant way to begin a conversation with a stranger. But it sure gets to the rub. Our work permeates our sense of self. Often that begins with our names: if you are an English Smith, a German Schmidt or an Italian Ferraro, you are just one of many with a brand identity determined by the employment your ancestors took.

In the rich countries of the world, where switching jobs is often routine and opportunities for self-expression and development outside of work are greater than ever before, you might expect this identification with work to be diminishing. Not so. In a 2014 Gallup survey, 55 per cent of US workers said they got a sense of identity from their job, a figure that rises to 70 per cent for college graduates. In an increasingly automated world where the nature of work is in flux, that could present a problem. But it is also an opportunity: start to unpick the reasons why what we do means so much to us, and the effects it has on us, and we can begin to make work work better for all of us.

In doing so, it's important to first realise how that work has meant very different things at different times. We have evidence for employer-employee relationships stretching back thousands of years (see "The past of the pay cheque", right), but the concept of working in a distinct profession for a set number of hours each week is a relatively recent one. Even in medieval Europe, when the rise of differentiated professions led to the invention of surnames, our sense of belonging was more likely to be determined by our family, religion or the place we lived, says Benjamin Hunnicott, who studies the history of work and leisure at the University of Iowa. It was only with the rise of paid employment in the 19th century that the notion of work as an end in itself – and a source of identity – begins to crop up, he says.

Wind forward to today and one thing is for sure: work does fill a lot of our lives. Although in rich countries the average amount of time people work each year has declined over the past half-century – from around 2100 hours in 1960 to below 1600 hours in 2005, according to a 2011 OECD report – factors such as the rise in paid leave account for a lot of that. For white-collar workers not on vacation, work dominates. In 2005, the proportion of high-skilled people in the UK working at least 50 hours a week hit 20 per cent. That has since gone down a bit, but an analysis published last year shows that such extreme working hours have been on an overall upward trajectory in the US, Canada and Europe since 1970.

Even when we aren't at work, it can feel like we are. Smartphones mean

3000 BC

THE WEALTHY BEGIN EMPLOYING OTHER PEOPLE IN SPECIALISED TRADES

TESSA BUNNEY/MILLENNIUM IMAGES, UK

white-collar workers are connected to their jobs at all times. "Modernist distinctions like home-office, work-leisure, public-private and even self-other no longer hold fast," wrote New York University sociologist Dalton Conley in his 2009 book *Elsewhere, USA*. Since then, the proliferation of mobile technologies means this always-on culture has spread enormously, he says.

It's easy to see that as a bad thing for ourselves and our relationships with others. And sure, work can be long, stressful, boring and just plain hard. But it's not all bad.

"The miserable effects of unemployment are pretty well documented by social scientists," says David Frayne at Cardiff University, UK. That goes beyond simply the poverty that usually accompanies unemployment. In 2005, Brian Faragher, then at the University of Manchester in the UK, and his colleagues looked at 485 previous studies of the relationship between job satisfaction and health. They showed that people who were happy in their jobs were more likely to be healthy, and in particular were less likely to experience depression, anxiety or low self esteem compared with those less satisfied with their jobs. A review carried out for the UK government in 2006 showed that any stress work creates is, on balance, likely to be outweighed by the problems of not having a job.

Live to work?

That tallies with an idea first articulated by the Austrian psychiatrist Viktor Frankl in the 1940s. While held in concentration camps during the second world war, he helped fellow prisoners endure the horror around them by getting them to focus on the lives they might later lead. In his 1946 book *Man's Search for Meaning*, he argued that these future lives could hold meaning, and that one way of finding it was through work. "Everyone has his own specific vocation or mission in life to carry out a concrete assignment which demands fulfillment," he wrote.

In 2014, Patrick Hill at Carleton University in Ottawa, Canada, and Nicholas Turiano at West Virginia University set out to test this relationship between purpose and well-being. They used data on over 6000 people, captured in the late 1990s as part of a US longitudinal survey. They had been asked how strongly they agreed or disagreed with three statements: "Some people wander aimlessly through life, but I am not one of them"; "I live life one day at a time and don't really think about the future"; "I sometimes feel as if I've done all there is to do in life". Following up on the participants' subsequent life histories, the researchers found a strong link between mortality and the way the volunteers had answered the questionnaire. Those who had more ›

THE PAST OF THE PAY CHEQUE

Perhaps it's no surprise that one of the earliest known examples of writing features two basic human concerns: alcohol and work. About 5000 years ago, the people living in the city of Uruk, in modern day Iraq, wrote in a picture language called cuneiform. On one tablet excavated from the area we can see a human head eating from a bowl, meaning "ration", and a conical vessel, meaning "beer". Scattered around are scratches recording the amount of beer for a particular worker. It's the world's oldest known payslip, implying that the concept of worker and employer was familiar five millennia ago.

It was not ever thus. Çatalhöyük in what is now Turkey was one of the first towns. Houses and human remains dating from its foundation some 9000 years ago are all very similar, suggesting equality. "Everyone was involved in small-scale farming or hunting," says Ian Hodder, an anthropologist at Stanford University in California who has excavated at Çatalhöyük since 1993. No one owned the land, and produce was shared. The residents of this city are unlikely to have considered their daily chores "work", says Hodder. "My view is that they would see it as just part of their daily activities, along with cooking, rituals and feasts that were such an important part of their lives."

Change came a few thousand years later. The trigger seems to have been an agricultural revolution in which new methods of cultivation and animal domestication increased food production and allowed some individuals to build up wealth. The surplus food freed some from toiling in the fields to focus on specialised tasks such as carpentry or pottery. By the time our beer ration card was written, a professional class had been born, a transition that seems to mark the beginning of what we know as work.

These same conditions set the scene for other working practices that still endure. "There was a change from social sharing to hierarchies," says Hodder. "This was an inevitable consequence of living in large communities and intensifying agricultural production." Throughout the Middle East and China between 6000 and 4000 BC, as towns became bigger, a powerful elite commandeered not only resources, but labour.

Back then you didn't work for money, but rather food, shelter and protection. Since then work has slowly morphed into the employment we have today. Our human needs, for food and shelter, haven't changed – but the way we get them has. Alison George ■

of a sense of purpose lived longer, even when other psychological and health conditions were accounted for – and the trend held for people of all ages.

Why that should be remains unclear. Hill thinks having a direction, something work provides, may give people a reason to take better care of themselves and thus lead them to adopt healthier lifestyles. It may also help us cope with stress. "People who have a strong sense of meaning in life view stressors differently," says Neal Krause, of the University of Michigan in Ann Arbor. "They are more likely to see them as challenges rather than unwanted and painful setbacks." So although work may be a source of stress, it might also help us face whatever else life throws at us.

Work to live

Meaningful work seems to stave off cognitive decline, too. A study led by Carole Dufouil at INSERM, the French national health research institute, showed that for every extra year someone works before retiring, their risk of developing dementia decreases by 3 per cent. This follows a previous study by researchers at King's College London and elsewhere that found that people with dementia who had worked beyond age 65 delayed the onset of their symptoms by more than six weeks for every extra year worked.

This is not just about staying cognitively active. Patricia Boyle, a neuropsychologist who works with Alzheimer's patients at the Rush University Medical Center in Chicago, says a sense of purpose appears to make older people more resilient on many levels, perhaps because it improves immune function and decreases the risk of vascular diseases – though the biological mechanism is unknown.

All this presumes we can find meaningful employment that allows us to enjoy work's positive psychological benefits. Brent Rosso at Montana State University has come up with a list of six attributes that make work meaningful, based on years of academic surveys. mechanisms, reckons Rosso. Almost any job can exhibit at least one of these attributes (see "Find your meaning", right), although Rosso reckons that an individual's culture and personality will influence which ones they find meaning in.

One important point is a sense of belonging: identifying with the people you work with has been shown to increase not only job satisfaction, but productivity, too. Alex Pentland of the Massachussets Institute of Technology, for example, has shown that the more cohesive and communicative a team is – the more they chat and gossip – the more they get done.

As the nature of work changes over the coming years, its effects on our psyches will no doubt continue to evolve. The key will be to change work so that we can continue to find meaning in it – because not all work is made equal. As the American poet and philosopher Henry David Thoreau once said: "It is not enough to be industrious. So are the ants." ■

1400s

SURNAMES REFLECTING A PERSON'S TRADE BECOME WIDELY USED IN EUROPE

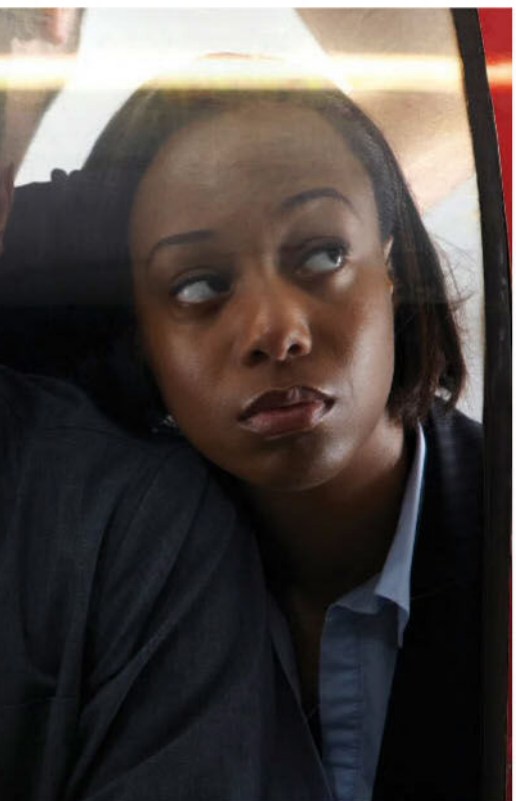
LOUIS QUAIL/PICTURETANK

Michael Bond is a consultant for *New Scientist*. **Joshua Howgego** is a feature editor at *New Scientist*

NICE WORK

IF YOU CAN GET IT

Technology has always been seen as a threat to human jobs. **Jon White** asks if this time it's serious



CHRIS TURNER/GETTY

FIND YOUR MEANING

People find meaning in work in six main ways; which aspects someone finds most important depends on them and their society

AUTHENTICITY Going to work makes you feel you are accessing your "true self" – maybe that you are following a calling or can be yourself.
AGENCY You are able to make significant decisions and feel as if you "make a difference". This taps into our desire to believe that we have free will.
SELF-WORTH Your job make you feel valuable; you are able to see milestones of achievement, no matter how small.
PURPOSE You see your work as moving you closer to a strongly held goal. The downside is that you are more likely to sacrifice pay and personal time too.
BELONGING It's not what you do, it's who you do it with. You belong to a special group of colleagues, even if your job seems mundane or poorly rewarded.
TRANSCENDENCE Your job is about sacrifice for a greater cause. Your meaning comes from following this, or perhaps a truly inspirational boss.

JOHN MAYNARD KEYNES always assumed that robots would take our jobs. According to the British economist, writing in 1930, it was all down to "our means of economising the use of labour outrunning the pace at which we can find new uses for labour". And that was no bad thing. Our working week would shrink to 15 hours by 2030, he reckoned, with the rest of our time spent trying to live "wisely, agreeably and well".

It hasn't happened like that – indeed, if anything many of us are working more than we used to (see "I work therefore I am, page 30). Advanced economies that have seen large numbers of manual workers displaced by automation have generally found employment for them elsewhere, for example in service jobs. The question is whether that can continue, now that artificial intelligence is turning its hand to all manner of tasks beyond the mundane and repetitive.

Fear of machines taking jobs dates back at least as far as the Luddites, a group of British weavers who went on a mill-burning rampage in 1811 when power looms made them redundant. Two centuries on, many of us could face the same predicament. In 2013 Carl Frey and Michael Osborne of the Oxford Martin Programme on the Impacts of Future Technology at the University of Oxford looked at 702 types of work and ranked them according to how easy it would be to automate them. They found that just under half of all jobs in the US could feasibly be done by machines within two decades.

The list included jobs such as telemarketers and library technicians. Not far behind were less obviously susceptible jobs, including models, cooks and construction workers, threatened respectively by digital avatars, robochefs and prefabricated buildings made in robot factories. The least vulnerable included mental health workers, teachers of young children, clergy and choreographers. In general, jobs that fared better required strong social interaction, original thinking and creative ability, or very specific fine motor skills of the sort demonstrated by dentists and surgeons.

Others find that list overblown. A recent working paper for the rich- ›

1860s

THE FIRST COMPANY PENSION SCHEMES START TO APPEAR

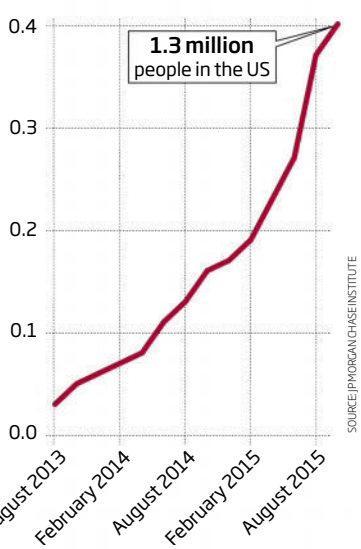
world OECD club suggests that AI will not be able to do all the tasks associated with all these jobs – particularly the parts that require human interaction – and only about 9 per cent of jobs are fully automatable. What's more, past experience shows that jobs tend to evolve around automation.

According to this more Keynesian view, technological progress will continue to improve our lives. The most successful innovations are those that complement rather than usurp us, says Ben Shneiderman, who founded the human-computer interaction lab at the University of Maryland. Witness for instance the prominence of "cobots" at last month's annual automation expo in Chicago. Such robots are designed to work alongside people, making their work safer and easier, not replacing them. "Technologies are most effective when their designs amplify human abilities," says Shneiderman. They could help us solve problems, communicate widely, or create art, music and literature, he believes.

The weight of expert opinion is behind him. In 2014 the Pew Research Center, a US think tank, asked 1896 experts whether they thought that by 2025, technology would have destroyed more jobs than it creates. The optimists outnumbered the pessimists.

Get the gig

The **percentage** of the US population earning some income from online labour platforms such as Uber is rising fast



1880s

GERMANY INTRODUCES THE FIRST STATE WELFARE SYSTEM

That's not to deny that AI is spreading into some surprising settings – whether it be organising nightly maintenance on Hong Kong's subway system, or helping out with subtle legal research, as does ROSS, an AI assistant built on IBM's Watson computer. This suggests that AI could still cause short-term turbulence in the labour market.

One unfolding example is the gig economy. Here AI systems serve up a platter of casual labour to a convenient app for consumers. Examples include the taxi firm Uber and outfits like TaskRabbit, which helps people find casual labourers to complete all sorts of chores. Although the gig economy is still small in absolute terms, a recent study of 1 million people who bank with JP Morgan Chase suggested that the number of people getting some of their income from the gig economy has increased tenfold in two years (see graph, left).

In such set-ups, workers are typically considered self-employed contractors, so the company has no obligation to keep supplying work or provide benefits like holiday pay or pensions. That has already led to strikes.

How can we adapt? The answer might simply be to update our social frameworks to reflect the new reality of work. Many countries are considering new regulatory frameworks for the gig economy. In the US Uber and Lyft, another taxi service, face ongoing lawsuits about the classification of drivers as contractors rather than employees. Drivers may vote with their wheels, too: Transunion Car Service, established in New Jersey last year, is an Uber-like taxi business owned by its drivers that promises health and retirement benefits.

Others are thinking more radically about how to reconfigure our whole relationship with work (see "All play and no work", right). That speaks to an important point: ultimately we, not AI, are in charge of our own destiny. Given the benefits of work for our health and well-being (see "I work therefore I am," page 30), maybe we'll opt not to abolish fulfilling, rewarding work. "There will be inequities and disruptions, but that's been going on for hundreds of years," says Shneiderman. "The question is: is the future human-centred? I say it is." ■

Jon White is comment editor for *New Scientist*

STEPHEN WILKES/GETTY

ALL PLAY AND NO WORK

The rise of automation could require a radical rethink of how we distribute the fruits of labour, says **Hal Hodson**

EACH month, Nathalie Kuskoff repeats the process that ensures her family's security. Her two young children both have chronic illnesses, so their apartment in southern Finland is mostly paid for by the government, which also helps with childcare, medical bills and education. "I get a lot of different social benefits because of my situation – I mean a lot," she says. They come at a price: relentless form-filling.

Most developed economies have some form of welfare state to redistribute wealth from the economically active to those who are unemployed or can't work. People differ about who they think should get what, but few dispute the principle of a basic safety net.

But as Kuskoff and many others find,welfare on the basis of need is a cumbersome, bureaucratic affair. And as automation continues its march, many more of us may find ourselves caught in its net (see "Nice work if you can get it", page 33). This is the background to a radical idea to rejig the way we distribute welfare that has recently been in the headlines: universal basic income.

At its simplest, the premise is to replace welfare with a contract promising everyone the same money unconditionally, covering basic human needs – food, shelter, clothing – which people can add to by working. Its proponents cite an array of advantages including higher employment, better community cohesion and improved health. Others see it as an excuse to shirk. Now, as the debate rages, several huge social experiments could settle these differences.

Universal basic income has a long history. Thomas Paine, a US founding father, believed that natural resources were a common heritage and that landowners sitting on them should be taxed and the income redistributed. While the idea has never fully materialised, neither has it entirely gone away. In a few corners of the world variants are discreetly part of the furniture. In Alaska, for example, an annual dividend from state oil revenues is paid to citizens each year – a windfall of $2072 per person in 2015.

The idea has been gaining adherents across the political spectrum. In the UK, for example, proponents include the left-wing Green party and a right-wing think tank, the Adam Smith Institute. The main opposition Labour party is also toying with the idea. In Canada, testing the approach forms part of the policy platform of the Liberal party, elected to government last year.

Licence to laze

The perceived threat of automation is a timely spur to revisiting universal basic income, but it isn't the only one. First, conventional welfare systems are not just bureaucratic but also costly. Even though basic income pays out more money, it cuts the costs of red tape. Various schemes have been proposed that look affordable, including one last year from the RSA, a UK think tank (see chart, page 36). Basic income also promises to eliminate financial disincentives to work that bedevil many welfare systems – under a basic income system, you always earn more if you work.

The most entrenched criticism is that too many would exploit a guaranteed income to sit on their hands, grinding the economy to a halt. There are signs, though, that this is too gloomy a view.

For four years beginning in 1975, the 10,000 citizens of Dauphin in Manitoba, Canada, were guaranteed a basic level of financial security: if their monthly income dropped below a certain level, the government would top it up. Support for this experiment soon dried up, and it was never properly analysed.

Evelyn Forget at the University of Manitoba in Winnipeg recently revisited the experiment, comparing public records from Dauphin with those from similar small towns. Forget found the only groups that spent less time in work during the trial were teenage boys and new mothers. The boys were staying in school rather than bowing to pressure to take agricultural jobs, and the mothers were nursing. What's more, Dauphin had noticeably lower hospitalisation rates and fewer depression-related illnesses.

That was just one small-town trial. But in Alaska, experience suggests ›

Basic income

15 million

Number of UK jobs threatened by automation

SOURCE: BANK OF ENGLAND

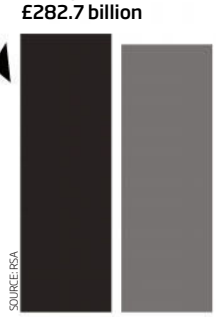
One way to ease the impact of job losses is for the state to pay everyone a basic income. Here's how much people would get under a scheme devised by the RSA, a UK think tank

SOURCE: RSA

The total cost of this scheme is only slightly more than the cost of the present welfare system, which it would replace

Package would cost: **£282.7 billion**

Estimated 2016-17 UK welfare bill: **£270 billion**



SOURCE: RSA

The RSA points out that tax breaks handed out by the UK government last year were worth almost double the extra money needed to introduce their version of basic income

£12.7 billion shortfall

£19.5 billion cuts in corporation tax and fuel duty in 2015-16

SOURCE: INSTITUTE FOR FISCAL STUDIES

that a basic income could help reduce the rising inequality that has been hobbling world economies. Economist Scott Goldsmith at the University of Alaska Anchorage points out that the state is the only one in the US in which the income of the poorest 20 per cent grew faster than that of the top 20 per cent between the 1980s and 2000.

Now experiments are afoot to test such effects more exactingly. One, in Finland, is one of the grandest social experiments ever conceived, says social scientist Jurgen De Wispelaere at the University of Tampere. "There's nothing like it happening anywhere." Starting next year, as many as 10,000 Finns will get a no-strings-attached monthly income of €600 for two years. That sum is designed to guarantee subsistence, says Ville-Veikko Pulkka of Finland's social insurance department Kansaneläkelaitos (Kela), covering housing, food and services like water and electricity.

Kela will publish the full trial design in November, but the point is to test whether a basic income gets more people working. "Removing disincentives to joining the labour force is the key task given to us by government," says Pulkka. The ideal is to give people a platform to enter the labour market on their own terms.

In Finland, that taps into a well-anchored social principle called universalism: that the same services and education should be available to everyone. "At some level, people want to believe in this system," says Pulkka. Kuskoff would certainly be interested in participating. "Getting the money without all the paperwork sounds like heaven," she says.

Reducing bureaucracy is the driver of a similar large-scale experiment kicking off in the Netherlands next year. It started when the Dutch government passed a law giving municipalities the responsibility for administering welfare. Their staff baulked at taking on the job of continually vetting welfare applicants as the central government had been doing. "People realised this was going to do their heads in and they needed to change it," says De Wispelaere.

Nineteen municipalities are now changing how they administer welfare payments, says Sjir Hoeijmakers, who is coordinating the experiments. Each will test different supposed benefits of a basic income like those Forget flagged in Dauphin. In Eindhoven, for example, the focus is on whether the changes help build strong neighbourhoods, while other municipalities are concentrating on randomised controlled trials to determine how individuals fare. A certain amount of freeloading is expected, says De Wispelaere: "In any policy you have good and bad. We want to know how many people move to the couch, and then compare the positive effects."

Private companies are also getting in on the act. Y Combinator, a venture

SOURCE: OFFICE FOR BUDGET RESPONSIBILITY

1929

THE WALL STREET CRASH CUTS THE WORKING WEEK TO FIVE DAYS

THOMAS DWORZAK/MAGNUM PHOTOS

capital firm with stakes in the taxi app Uber, has announced that it will run a basic income experiment, with a pilot phase slated to begin in Oakland, California.

The most important arguments in favour of basic income are about improved health and well-being, says Louise Haagh, a social economist at the University of York, UK. These too are now coming under more scrutiny. For example, a study of 1000 children by Kimberly Noble of Columbia University in New York found a strong positive correlation between family income and brain development. One theory is that families with a secure income can focus extra resources on their children. "But with purely correlational data we can't say which way the arrow is pointing," says Noble.

To find out, she is now running an experiment in which 1000 low-income mothers across the US will receive a basic income for three years. One group will receive a nominal $20 a month, the other $333. Noble's focus is on brain development, not economics, but a pilot study in New York in which money was handed out on trackable, prepaid debit cards suggested freeloading wasn't a problem: of 1100 transactions, most of the money went on groceries. Just three happened at a liquor store.

So is a basic income a panacea?

FINE ART IMAGES/HERITAGE IMAGES/GETTY IMAGES

2003

THE BLACKBERRY 6210 MOBILE PHONE MEANS PEOPLE CAN CHECK WORK EMAILS ANYWHERE

Some, like Kuskoff, who have special care needs, worry that such a system might push them to a harsher edge of the welfare state in the name of homogenisation and efficiency. And Haagh thinks that a half-hearted implementation might entrench, not dissolve, social inequalities by offering rich and poor the same. Governments could end up subsidising companies that give few or no benefits to their workforces, while the lucky few with more conventional employment receive far more. The problem is that a poorly designed basic income "might not end up changing society that much", says Haagh.

Other variants do exist. Negative income tax is a means-tested version of universal basic income: poor people receive a guaranteed income from the government, middle earners aren't taxed, while the rich are.

It sounds fairer, but could have a significant disadvantage, as the work of Silvia Avram at the University of Essex, UK, hints. She recently asked people to perform a tedious task to earn money under different taxation models. The participants were divided into two groups. One group started with a lump sum that was reduced as they earned – much as would happen under a negative income tax – while the others were taxed as they earned. Both groups ended up with the same money for a given amount of work, but the first group was far quicker to quit the task, suggesting that a well-documented human tendency to loss aversion was kicking in: we are wired to place more importance on minimising losses on what we already have than realising gains of the same value.

For Anthony Painter, director of policy and strategy at the RSA, and author of its report on how basic income could work in the UK, it is an indication that negative income tax wouldn't be as effective at getting people into work as a basic income. Painter and others also think a basic income could benefit society in other ways, freeing up people to look after older relatives and children, or to pursue creative and innovative work that traditionally pays less, like music, arts and invention.

Such supposed whole-society benefits aren't easy to test objectively, and that might be the most crucial point. If the referendum on basic income that took place in Switzerland on 5 June is any indication, basic income has a long way to go to gain public acceptance. During the debate, triggered when a group of citizens collected more than the necessary 100,000 signatures for a vote on such constitutional change, no political party endorsed the idea: it was widely seen as indulging shirkers. In the end, 77 per cent of voters rejected it.

However, basic-income campaigners were celebrating that evening, saying their objective was to get people talking. The conversation continues. Maybe the mark of ultimate success for the proponents of universal income, says Hoeijmakers, will be if at parties the unfashionable question "what do you do?" morphs into: "why do you do?". ■

Hal Hodson is a reporter for *New Scientist*

EERO LAMPINEN

Soon we could cure blindness, pain and brain diseases all at the flick of a switch, discovers **Teal Burrell**

Fixed by light

ED BOYDEN was a graduate student at Stanford University when he sparked a revolution. It was August 2004, 10 o'clock in the morning, and he was still in the lab, peering down a microscope at a single nerve cell. Curious to see how it would react, he flashed a blue light at it. Instantly, it fired. It was a defining moment, the birth of a technique that would revolutionise the study of brains and behaviour.

You may have heard of optogenetics. It's a procedure that makes neurons sensitive to light, enabling researchers to turn them on or off at the flick of a switch. Karl Deisseroth, who pioneered optogenetics with Boyden, gave an early demonstration of its power when he flashed a blue light on a mouse's brain – the right motor cortex to be precise – and found that the animal ran in circles, anticlockwise. When he turned off the light, it stopped.

Fast forward to February this year, and the revolution is upon us. In the first trial of its kind, doctors injected DNA from light-sensitive algae into a blind woman's eye in an attempt to restore her vision. This is the first time optogenetics has been tried in humans. It surely won't be the last. There are already other medical applications in the pipeline, including plans to alleviate chronic pain, nurse diseased brains back to health, and possibly even treat cancer – all at the flick of a switch. Boyden and Deisseroth's discovery is set to come out of the lab and into our lives.

Even without these developments, optogenetics has set the scientific world alight. The technique is used to study everything from learning and moving to seeing and breathing. It isn't just a step forward; it's a leap into new ways to address neuroscience's biggest mysteries. In 2010, optogenetics was called the "method of the year" by the journal *Nature Methods*. And this year Boyden, now at Massachusetts Institute of Technology, and Deisseroth were awarded the Breakthrough Prize in Life Sciences, worth $3 million each.

What makes optogenetics so exciting is the control it gives. Neurons are supplied with a gene, derived from algae or bacteria, that creates channels in their membranes. These open in response to light of a certain colour (often blue), allowing ions to pass into the neuron, either activating or deactivating it (see diagram, page 41). Researchers can control which neurons get the gene by tweaking the benign virus that delivers it. They can also control the application of light, supplied via a fibre-optic cable inserted near the light-sensitive cells. In research, this makes it possible to discover which circuits are responsible for different behaviours. Like puppet masters, researchers can take control: turn the light on and a mouse runs left, a rat remembers the path to a treat, a monkey looks directly at a target; off and the mouse stops, the rat forgets, the monkey stares into space.

Pinpoint precision

There are obvious hurdles to using this method in humans. But the precision it offers is tantalising. Current treatments for neurological diseases, such as drugs and electrical stimulation, are "a bit like playing the piano by hitting it with a mallet", says Andrew Jackson at Newcastle University in the UK. Optogenetics provides far more control. "We can actually start playing particular notes and at the same time be listening to what the rest of the orchestra is doing," he says.

Some researchers and doctors recognised the clinical potential of optogenetics right from the start. The eye is a logical place to start because it is open to light, removing the need for a fibre-optic implant. It's 10 years since Zhuo-Hua Pan of Wayne State University in Detroit, Michigan, showed that optogenetics could be used to restore vision to blind mice. "We talked at that point about some day in ›

TINY SOLUTIONS TO BIG PROBLEMS

Optogenetics is a revolutionary way to manipulate nerve cells. It is used widely in the lab to explore how brains work, and has huge potential in medicine (see main story). But there are two main barriers to using it in humans: first, it requires gene therapy to make neurons sensitive to light; and second, you often need an implant to supply light to the sensitised neurons. Both these hurdles might be surmounted using nanoparticles.

Francisco Bezanilla at the University of Chicago is using gold nanoparticles to stimulate neurons without gene therapy, a method that has been called "optogenetics without genetics". When nanoparticles are exposed to light, they heat up, and neurons can be activated by heat. Bezanilla's method tags gold nanoparticles with antibodies so that they bind to specific types of neurons. He then applies light to heat the nanoparticles, stimulating the attached neurons. Bezanilla emphasises the technique's benefit to research, but sees no reason it couldn't work in the clinic.

Gang Han at the University of Massachusetts is using nanoparticles to tackle the second problem, the need for an implant to deliver light. Optogenetics generally uses blue light, which doesn't penetrate far into tissues because of its relatively short wavelength. But nanoparticles can be activated by infrared light, which penetrates deeper. Han calls the approach wireless optogenetics and is attempting to use it to treat cancer. He binds his nanoparticles to dendritic cells – immune cells that initiate an attack on cancerous cells – that have been made sensitive to blue light by gene therapy. When infrared light is shone on the nanoparticles, they convert it to blue light, activating the dendritic cells.

This method has not yet been tried in humans. But because it allows you to control exactly when and where the immune response is activated, it might result in a cancer treatment with fewer side effects. It also moves therapeutic optogenetics beyond the neuron, which means we can potentially use it to treat a whole host of conditions. Already, others are starting to manipulate heart tissue in animals, creating optogenetic pacemakers. "There is a lot of promise relevant to optogenetics, not only in neuroscience," says Han.

the far-distant future contemplating human trials," says David Birch, at the Retina Foundation of the Southwest in Dallas.

That time has come. Birch, working with the company RetroSense Therapeutics, injected a virus carrying genes from light-sensitive algae into one eye of a woman with retinitis pigmentosa, an inherited form of blindness in which the retina's light-sensing cells degenerate. The hope is that ganglion cells – a few stops further down the visual pathway but still in the retina – will take up the virus, develop light-sensitive channels, and send visual signals to the brain, bypassing the lost retinal cells (see diagram, below right). The trial is in its first phases, so safety is a priority. To begin with, the woman has been given a relatively low dose of the gene. Her progress will be monitored over the coming year and she may get two further doses. RetroSense hopes to treat 15 people in all.

Turning off pain

At this early stage there are no controls or placebo groups. Participants are warned of the risks and told there's no guarantee, with many motivated to take part in the hope that research on the inherited disorder will help family members. If anyone does regain some vision, it will be a gradual rather than instantaneous process, as the brain learns to interpret signals straight from the ganglion cells. "We're making a brand new light-sensitive palette," says Birch. "It's going to be a whole new way of responding to light and they're going to have to learn to see." That may sound drastic, but there are currently few therapeutic options for blind people. "This is by far the most promising," says Birch.

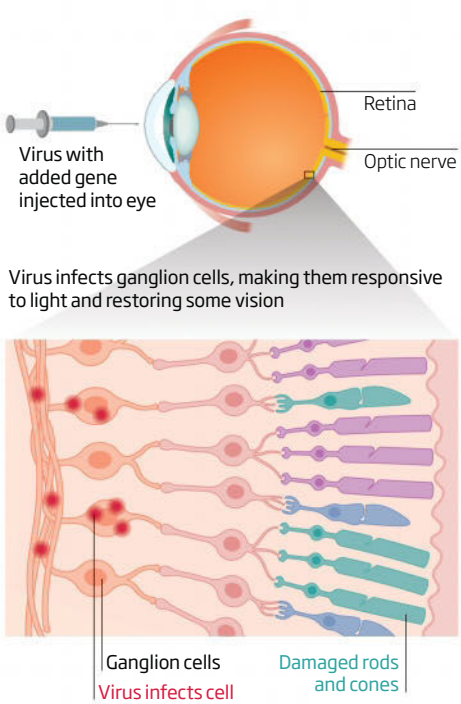
Another area where optogenetics has potential is in the treatment of chronic pain. This is traditionally treated with drugs, but these are limited by side effects, such as drowsiness and lethargy, and the potential for addiction and overdose. Optogenetics could sidestep these problems by targeting pain directly, and with no need for an implant. That's because the sensory neurons that transmit touch and pain signals to the brain lie just under the skin, so light can reach them. "They are tantalisingly poised, just sitting there waiting to be optogenetically modulated," says Chris Towne. Having achieved this in mice in Deisseroth's lab, he has now joined biotechnology company Circuit Therapeutics in Menlo Park, California, to try to move the technique to the clinic.

Last December, Circuit Therapeutics received a $2.7 million grant from the DARPA, the US military's research agency, to develop a treatment for chronic pain, both for the many veterans with pain from nerve trauma and the general population. The company is currently doing animal studies and hopes to start a human trial within two years. First in line are likely to be people with mechanical allodynia, for whom a soft touch can feel intensely painful. After receiving the gene therapy, they will wear a light patch on their skin that can be turned on to deactivate the nerves below whenever they are in pain.

Getting a gene into a neuron involves harnessing your gene to an adeno-associated virus (AAV), which is small and harmless, and allowing the virus to infect the neurons in question. Otherwise known as gene therapy, it worries some people because it introduces a foreign gene into the body. But with neurons, Jackson points out, the risk is minimal because they don't divide as other cells do. It only goes into the neurons you want, so the new gene should spread no further. Even so, we don't yet know how the human body will react to genes from bacteria and algae. Studies in monkeys show no signs of toxicity or immune reactions, so Towne is optimistic.

A cure for blindness?

A woman with the eye disease retinitis pigmentosa recently became the first person to receive optogenetic therapy



"People have been very surprised by how tolerated these foreign proteins have been," he says.

AAV-based gene therapy was approved in Europe in 2012. Although not yet allowed in the US, Towne thinks that will change soon, following some successful clinical trials. It is already approved for trials in Parkinson's disease, another condition that could be a prime target for optogenetic therapy. Parkinson's is a degenerative disease

"This is the first time optogenetics has been tried in humans"

that affects brain cells connected with movement, causing tremor and problems with coordination and movement. It is currently treated using deep brain stimulation (DBS), in which an electrode is implanted into the damaged area. Although this method reduces the tremor, it is a blunt tool, stimulating all the cells near the electrode and leaving some people with severe mood changes and depression.

More recently, researchers have tried to mend faulty neurons in people with Parkinson's using gene therapy, so an optogenetic clinical trial could follow soon. The plan is to implant an optical fibre smaller than the DBS electrode within an existing DBS device. The risks could still outweigh the benefits, though. "I think the bar's kind of high for an optogenetic therapy," says Boyden. "Since it needs a gene therapy, there has to be a good reason for doing that."

Others have a more fundamental concern about gene therapy: it is irreversible. "No one would want to remove [an added gene] given the current knowledge that we have," says ethicist Frederic Gilbert of the University of Tasmania, Australia. "That would be too complicated, too risky." This concern may eventually be allayed by the development of "optogenetics without genetics" (see "Tiny solutions to big problems", left). For now, one group of researchers has found a workaround.

The project, called Controlling Abnormal Network Dynamics using Optogenetics (CANDO), aims to use optogenetics to treat focal epilepsy – a form of epilepsy in which seizures begin in a specific area of the brain. Surgically removing this region is currently a treatment of last resort if the condition fails to respond to medication. The optogenetic approach would involve continuously monitoring the brain via an implanted electrode. When a seizure begins, flashes of light would act to regulate the network back to normal, turning neurons on or off as necessary. Only particular cells within the seizure focus would be genetically engineered, leaving the surrounding networks intact. "If it didn't work for whatever reason, the person could then have the seizure focus surgically resected, which would mean cutting out both the implanted device and also any of the tissue that had been genetically modified," says Jackson, a principal investigator on CANDO. In this case, reversing the therapy follows similar steps to an existing treatment.

Blindness, chronic pain, Parkinson's and epilepsy are all promising places to start, but this is still highly experimental research. "It's pretty exciting; it's great innovative science," says Gilbert. "But we have to keep our feet on the ground." Gene therapy and implant surgery are not the only concerns. "We don't know yet what it means for brain cells to get a laser shooting at them for a long time," he says. In the lab, animals have responded well, but scaling up to the larger human brain could require more light. "Getting enough light into the brain without also heating the brain to a point that might be dangerous is one of the big engineering challenges," says Jackson.

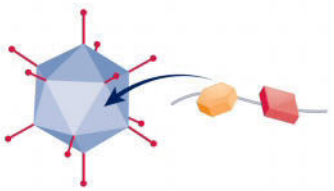
Then there's the sheer complexity of the human brain. "You really have to know a lot about which cell types are involved and how you want to control them to help repair a disease," says Boyden. "We just know so little." So while he's excited by the prospects for optogenetics, he is continuing to use it to find out more about how the brain works.

Nobody doubts the potential of this breakthrough technology. But the idea that it could ever be used to treat human disorders has been hotly contested for years – 2016 will bring some answers. ■

Teal Burrell is a writer based in Washington DC

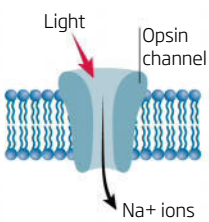
Mind control

Optogenetics allows researchers to turn nerve cells on and off at the flick of a switch

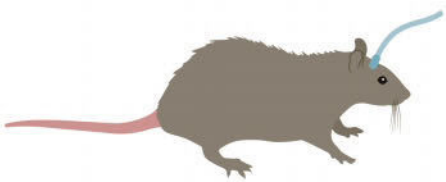


1 A gene encoding light-sensitive ion channels is inserted into a virus

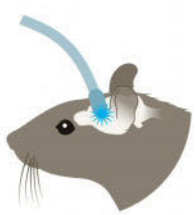
2 The virus is injected into an animal's brain, where it infects only the type of neurons it is designed to target



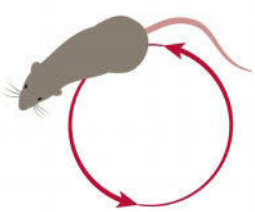
3 The neurons express the gene, creating ion channels in cell membranes



4 A fibre-optic cable and electrode are inserted near the target cells



5 When laser light of a specific wavelength is switched on, the ion channels open and ions pass into the neuron, either activating or deactivating it



6 Researchers record how this affects the animal's behaviour

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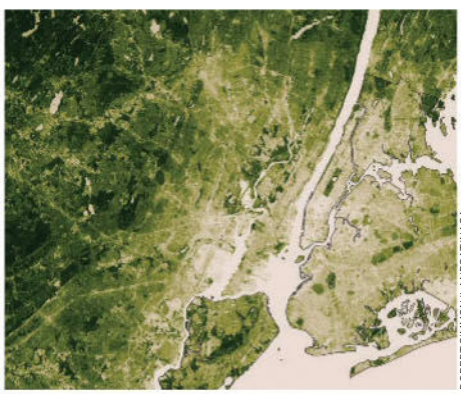
NPL National Physical Laboratory | Centre for Carbon Measurement | Metrology for Earth Observation and Climate



ROBERT SIMMON/LANDSAT/NASA

Anyone who has seen a satellite image of Earth knows what a unique perspective space has to offer. That view is going to become increasingly important as we strive to understand our future in the face of global forces such as climate change.

Using the spectra of light reflected from the planet, for example, we can identify trends such as deforestation, desertification and shrinking areas of ice. This kind of intelligence will be essential to our efforts to measure, plan for and alleviate these effects.

Enter the National Physical Laboratory (NPL) and its Centre for Carbon Measurement. Through the Metrology for Earth Observation and Climate project it plays a critical role in improving the quality of information that can be extracted from satellite observations.

At New Scientist Live, NPL will give you the chance to move a model satellite to see how the spectra it receives change as it travels over plants and other types of land cover. You'll see for yourself why plants are green.

Many plants have unique spectra and, as the resolution of satellites increases, this fact could reveal the types and health of agricultural crops, perhaps even informing farmers of when and where to fertilise and irrigate their fields. More widely, this technology could help to spot oil slicks at sea.

While you're visiting NPL, fill in a short survey that is tracking attitudes to climate change. It's part of a large European study which should reveal how those attitudes vary across population groups and countries.

COME AND HEAR...

COSMOS STAGE SATURDAY 24 SEPTEMBER

The truth is out there

"I think that our first signs of other civilisations could well be their ruins," says Duncan Forgan, an astronomer at the University of St Andrews who specialises in the search for extraterrestrial life. That may seem pessimistic, but what is bad news for aliens could be good news for us, because their remains could leave long-lasting signatures visible to our telescopes. Join him at New Scientist Live to hear how unconventional approaches could identify life in the vast emptiness of the cosmos.

PLAINPICTURE/PONTON/ROBERT LLEWELLYN

TECHNOLOGY STAGE
THURSDAY 22 SEPTEMBER

I can see you are getting upset...

Conversations are about much more than words. Our brains are furiously interpreting facial expressions and body language, and analysing tone for signs of sarcasm or insincerity. "People who can't do this are at a social disadvantage," says Peter Robinson, a technologist at the University of Cambridge. Computers largely suffer the same drawback. Robinson and his team aim to remedy that by building machines capable of sensing your mood and responding appropriately. Hear at New Scientist Live why those aggravating self-service checkout machines may soon be consigned to the dustbin of history.

BRAIN & BODY STAGE
THURSDAY 22 SEPTEMBER

What are the chances of that?

"The Titanic disaster of 1912 was seemingly foretold in a book written 14 years earlier," says physicist and science writer Robert Matthews. The fictional ship, named the SS Titan, was around the same size as the Titanic and described as "unsinkable" – at least before an iceberg collided with it one April on its starboard side.

The parallels are astonishing, and yet, as Matthews will tell New Scientist Live, such coincidences happen all the time. Indeed, it would be astonishing if they did not. To make sense of everything from everyday chance events to the latest scientific advances, the laws of probability will help you keep your head above water.

MARCO SCHMIDT/GETTY

EARTH STAGE
SUNDAY 25 SEPTEMBER

I wanna be like you

Katie Slocombe was sitting among a group of chimpanzees in a forest when a high-ranking male took exception to her presence. Before she had time to move, he reared up and charged straight at her, only changing course at the last minute. "My heart took several minutes to slow down!" says Slocombe, a psychologist at the University of York specialising in chimpanzee communication.

From the ways chimpanzees make friends to the methods they use to communicate, she will share her insights at New Scientist Live. The similarities between us and them may take you by surprise.

AND DON'T MISS...

PLAYING TRICKS ON YOUR MIND
Test the limits of your perception with psychologist and magician Richard Wiseman

FROM THE BIG BANG TO THE END OF TIME
Join David Tong on a rollercoaster ride to the very edges of reality

WHY WE NEEDN'T FEAR DEMENTIA
We are far from powerless in the fight against this most destructive of diseases, says June Andrews

COULD YOU HANDLE LIFE ON MARS?
Beth Healey spent a year living in simulated Martian conditions. Find out how she got on

WHAT DID DINOSAURS REALLY LOOK LIKE?
Go back in time with Darren Naish, who will show you these beasts look nothing like we ever imagined

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Our sense of time is our ignorance

Carlo Rovelli reflects on how physics is like art that lifts the veil from reality – and how time may be something we create ourselves

What's the biggest open question in theoretical physics at the moment?
The central frontier is quantum gravity. Einstein understood relativity, which explains gravity, and we have understood quantum mechanics: the problem is in bringing these two things together. We have a broken picture, so it is an exciting time to be a theoretical and experimental physicist.

Recently, there has been great public interest in a range of scientific breakthroughs, from the Higgs boson to gravitational waves. How are such difficult ideas penetrating so deeply?
These things resonate because they are at the core of our knowledge. These are not details; these are the ingredients out of which everything we see is made, and discovering more of these ingredients means we can change our basic picture of reality. It's like when people learned that Earth is round, and that all human beings are actually part of the same family. Science has a way of unravelling mysteries, then things change.

Do you think people relate to abstract physics in the same way they relate to art?
Physics is a lot like the arts. But not just because of its sheer beauty, even if it is beautiful. It's not just because it's hard and you want to do it better, even if that's also true. Physics is like the arts because art has the ability to open our eyes to a different perspective on the world. When you listen to Shakespeare, when you read Dostoevsky, then your vision of humanity is changed. Physics does the same thing – it opens our eyes to something new, more wide and true.

Over the course of your career, has the way people approach your subject changed?
When I was a kid growing up in Italy, science was very much high in everybody's perception. It was even so in the 1950s and 60s: people were fascinated. Many kids wanted to be scientists when they grew up. Then its popularity decreased and there were suspicions because science, like every human activity, has good and bad sides – wonderful gifts and problems that it raises.

Take the atomic bomb, for example, with its ability to cause catastrophe. People questioned if science, because it led to that, was a force for good. Later on, some people blamed science for food perceived as unhealthy, like in the GM debate. But I feel that now the wave is changing: people realise that even with all its defects and limitations, science is the best tool we have, and that it is unbelievably fascinating.

Still, for many people, physics is difficult and intractable – even boring. How can you convince them otherwise?
One should distinguish the actual job of doing physics, solving problems, learning how to do equations, from the sheer beauty of what physics is actually describing. Take music: if you want to learn how to play an instrument, build an instrument, or read or write music, that is a long complicated process that some people may like and some people may not like. But then there is the music itself, which anybody can appreciate.

Science is the same – there's all the process of making it advance, but the results can be appreciated by everybody.

PROFILE
Carlo Rovelli is a theoretical physicist at Aix-Marseille University in France and author of the bestselling book *Seven Brief Lessons on Physics* (Penguin, 2015)

IAN HANNING/REA

If you had to pick one scientific idea you would like people to know, what would it be?
That, fundamentally, time does not exist. Time exists for us. Up and down exists for us but there's no up and down in the universe. The idea that time is not integral to the structure of reality is not something everybody agrees with, but many people are working on it. It might be true, and this would mean that the universe is something very different from what we think.

What do people misunderstand about the nature of time?
It is uncontroversial that time is different from our intuition – time passes faster on the mountains than by the sea. This can be measured and just happens to be true. Our usual intuition about a single time flowing all over the universe is just wrong.

In trying to understand quantum gravity, we find that there is no time at the fundamental level. As I said, not everybody agrees, but this may mean that instead of time, there is only the change of things with respect to one another. A more speculative idea is that our feeling of passing time depends on us, not on the universe, and is due to our imperfect knowledge of the world. In a sense, time is our ignorance.

What about our grasp of nature more widely? You've said reality may be better understood as a web of interactions…
I think this is true at many levels. If we learn to move from thinking of the world as an ensemble of distinct things to thinking of it as a network of interconnected processes, we will grasp it better. We better understand life as a relation between animals, or cells, or molecules. We better understand particles as interactions between fields. We better understand ourselves as nodes in social interactions, and so on.

You not only tell the stories of physics on vast scales, but also explore where humans fit into those stories. Why is that important to you?
Scientific ideas leave people to wonder – are we just a combination of atoms and nothing else? I don't want to take down science in the name of emotions and on the other hand I don't take down emotions in the name of science.

Nature is so complex; there's no need to deny that we have emotional, psychological and spiritual lives. ■

Interview by **Alok Jha**

A genius of place

Matthew Cobb watches natural and human histories collide in a compelling new book

The Wood for the Trees: The long view of nature from a small wood
by Richard Fortey, HarperCollins, £22

HAVE you ever wondered what TV presenters do with their fees? Richard Fortey, the palaeontologist and author whose recent BBC4 series was the excellent *Nature's Wonderlands: Islands of evolution*, has a simple answer – he splashed his cash on 4 acres of beech wood in Oxfordshire.

The Wood for the Trees tells the story of the past, present and future of that wood, through an informal monthly diary. The result is a delightful ramble through natural and local history, fusing scientific knowledge with a profound and poetic sense of place and time – David Attenborough meets Alan Garner.


BIRGIR BOHM

Month by month, the story of Richard Fortey's 4 acres unfolds

Fortey links his biological insights with the story of the wood's past, in particular its place in local and national history. It was, for example, a bystander during key events in the internal wars that racked England, such as the 15th-century wars of the roses, and the 17th-century civil war.

While the natural history is necessarily tied to the seasons, the historical insights follow a chronological order, beginning with the effects of the Ice Age on what were then treeless uplands, through to Iron Age deforestation and the impact of the Roman occupation.

Later chapters deal with an unsolved Victorian murder, the changing effects of demand for wood on the forest and the robbers who lurked there in the 18th century. There are even some delicious recipes here, and a healthy wariness of fungi.

Various pals and ex-colleagues from London's Natural History Museum (Fortey was the trilobite man there until his retirement in 2006) turn up to help him identify the local inhabitants. These include 40 species of moth, eight species of tiny snail, and seven (or perhaps eight) species of bat.

Ultimately, though, it is the trees that make this marvellous book: the beeches that dominate, the wild cherry that created a beautiful collection cabinet (and is used to smoke food at Raymond Blanc's restaurant), and the ash and oak used in long-forgotten wars. Fortey's love of the area is such that you can practically smell the dankness under the trees and hear the scrabbling of the beetles.

The history of nearby Henley-on-Thames comes close to overwhelming the September chapter, but Fortey soon returns to his main themes, with superb detail about truffles and amazing facts about the crane fly. There are, it turns out, more species of crane fly than of birds, and the vast majority of those species (11,278) were described by Charles P. Alexander, a US crane fly fiend who published 1054 scientific papers. "I don't imagine he had much of a social life," remarks Fortey, drily.

His examples may sound serendipitous, but they are linked by the way each life form adapted so exquisitely to its niche. One truffle species, for instance, is found only in mouse faeces. Fortey's unique perspective as a geologist, amateur historian, naturalist and scientist enables him to describe a kind of evolutionary terroir – the word winemakers use to describe the totality of conditions that produce an individual wine.

I wish I had written this book. I wish I owned 4 acres of woodland. Any TV producers out there looking for a presenter? ■

Matthew Cobb is a zoologist and author of *Life's Greatest Secret: The race to crack the genetic code*

Playing, not drowning

Sandrine Ceurstemont saw the debut of the first underwater band

AquaSonic, debut of Between Music at the Operadagen festival, Rotterdam, the Netherlands

HAUNTING yet melodic music emerges from five giant aquaria on a stage. In each tank, a submerged musician is playing an instrument underwater or singing, seemingly defying the laws of nature.

I'm in Rotterdam at the world premiere of *AquaSonic*, the culmination of 10 years' work by singer-composer Laila Skovmand and her band, Between Music. Given that producing sound in water isn't easy, few musicians have taken on the challenge. The acoustics are completely different, so most instruments don't work underwater, and singing doesn't sound quite right because it is accompanied by the crackle of popping bubbles.

But Skovmand has come up with a hack – she keeps an air bubble in her mouth and sings through it. The small amount of air inside the bubble restricts her to short tones, and she avoids low notes, which she says sound nasal. Every minute or so, she rises to the top to take a breath and a new bubble.

Skovmand wanted to take musical instruments underwater too. In early experiments, she tested the water-worthiness of a cheap violin. Although the instrument collapsed after a few days' dunking, it produced an interesting sound. "It sounds more muffled than in air, but it reminds me of a recording from the 1930s," says Skovmand. "I like it a lot." A carbon-fibre model was built for the performance, which the band's violinist plays seamlessly sitting at the bottom of his tank.

Most of their other instruments had to be invented, with help from Andy Cavatorta, who made a novel harp for Björk. He had never worked with water before, but was aware of some of the constraints.

Water is much denser than air, thus dampening sound waves. Sound also travels about four times faster underwater, making it hard for an instrument to resonate without it being impractically large. Friction also affects materials differently: a bow's interaction with a string becomes slippery, and smooth bearings become sticky.

Sourcing materials was another challenge. Because the performers are in water, Cavatorta had to make sure that nothing was toxic. In addition, combining two metals at opposite ends of the galvanic series, such as zinc and brass, creates an electric cell in water that could kill the performers.

By embracing these quirks, Cavatorta created two new instruments. The rotacorda, inspired by a traditional hurdy-gurdy, has six strings that can be plucked like a guitar or struck by turning a crank to produce a continuous sound. The second instrument, the crystallophone, is a version of Benjamin Franklin's glass harmonica and is played like singing bowls. The sound, picked up by hydrophones in the corners of the tank, is other-worldly.

"In the end, the band has pulled it off. And most importantly, nobody drowned"

AquaSonic also features a hydraulophone (the only "woodwater" instrument in the mix), a "drum kit" of modified gongs and cymbals, and a percussion aquarium with singing bowls. The performers rely on earphones to synchronise their sound.

Although watching the band often felt precarious, they always came together musically just as it seemed like it could all go wrong. Knowing the technicalities added an extra layer of suspense. How long could the musicians hold their breath? Would there be still more surprises?

Yes. In one memorable interlude, the lighting dimmed as the performers rubbed their hands against the glass to create the eeriest sound I've ever heard.

At the end of the mesmerising 50-minute show, it's clear: the band has pulled it off. And most importantly, nobody drowned. ■

How to sing under water: just keep an air bubble in your mouth

AQUASONIC

SPOTLIGHT ON ...

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The MERIT program

With all of the changes going on in STEM, it's hard for post-docs to know which path they should choose. **Steve Connor** explores one possible option in the world of biomedical sciences

So you're about to earn a newly minted PhD. But what comes next? Well, one option is to continue with post-doctoral research, combining this with informal teaching on the side. And if you've chosen the biomedical sciences as your specialist field, an even better alternative may be available: join a dedicated fellowship program where teaching and research combine within a formalized setting. Complete with workshops and seminars on how to improve your own teaching, mentoring and job-seeking skills, these programs are also designed to encourage minority students to look upon you as a role model.

The Mentored Experiences in Research, Instruction and Teaching (MERIT) program at the University of Alabama, Birmingham (UAB), is one of 20 such initiatives across the US aimed at improving the diversity of young researchers entering the biomedical sciences, which historically have been underrepresented by African-American and Hispanic students. The four-year post-doc program helps post-docs to improve their research and teaching skills, as well as acting as a showcase to get disadvantaged school students interested in taking a biomedical degree.

"It's a fellowship that combines experience in teaching with research," says Lisa Schwiebert, MERIT program director at UAB. "It's also about helping students who may be thinking about the biomedical sciences. MERIT acts as a mechanism to really drive that pipeline from undergraduate to graduate and, ultimately, to a career."

The post-docs on the MERIT fellowship spend about 75 per cent of their time on research, and 25 per cent on teaching at Alabama's historically black Oakwood University and Stillman College, where they act as mentors as well as teachers. The MERIT fellows are also given courses in grant writing, lab management, translational science and job skills such as interviewing and negotiating. Finally, they can enter a number of career-enhancement and travel awards.

"They are busy people. It makes them very marketable for teaching jobs. In addition, a lot of the teaching skills are directly transferable to other career paths, for example in industry or communications," Schwiebert says.

Women and individuals from diverse backgrounds, including underrepresented racial and ethnic groups, and people with disabilities or from disadvantaged backgrounds, are actively encouraged to apply. In the case of UAB, some 30 or 40 people typically apply for the six positions a year on the fellowship program, Schwiebert says. The stipend of $48,000 plus benefits, paid for by the National Institutes of Health, is more than enough to live on, she adds.

So has the dual aim worked in terms of furthering people's careers and improving biomedical science's uptake of disadvantaged students? "It has definitely heightened the conversation," Schwiebert says, adding that the MERIT program is still in its relatively early days. "We've also seen an increase in the number of applications, and our own recruitment has greatly increased."

Tabitha Hardy, assistant professor of biology at Stillman College and a MERIT program alumna believes it was most important in helping her forge connections. "I was able to not only build relationships with members of my cohort but also with the post-doc association at UAB and members of the scientific community," she says. "The MERIT program made it very easy for me to meet people with similar interests and make connections with experts in the field." ■

Steve Connor is a freelance science writer

THE SKY'S THE LIMIT

The MERIT program's future ambitions include:

- Expanding the online teaching instructions for the MERIT scholars.
- Facilitating collaborations across the MERIT program's partner schools for faculty research.
- Preparing to host the 2017 National NIH Institutional Research and Academic Career Development Awards (IRACDA) Conference, a national convention of 300 scholars and administrators for all 20 programs: www.nigms.nih.gov/Training/CareerDev/Pages/TWDInstRes.aspx

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1401614766 Postdoctoral Position in **Computational Systems Biology Novartis Institutes for BioMedical Research**

1401613046 Postdoctoral Associates - **Penn State**

1401611687 Postdoctoral Research Fellow Weitz Laboratory, **Harvard Medical School**

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THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

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Birmingham is a mid-size city centrally located in the southeast near beaches and mountains and enjoys a moderate climate for year round outdoor activities with a cost of living rate lower than most metropolitan areas.

Visit our website at www.uab.edu/postdocs and select Postdoctoral Opportunities to view posted positions. Send your CV and cover letter to the contact name for those positions for which you are qualified and which interest you.

University of Alabama at Birmingham, Office of Postdoctoral Education, 1720 2nd Avenue S, Birmingham, AL 35294-2182, 205-975-7020/975-7021.

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Executive Director, North Pacific Research Board

Congress created the North Pacific Research Board in 1997 to recommend marine research initiatives to the U.S. Secretary of Commerce, who makes final funding decisions.

Primary Responsibilities:

Under the direction of the North Pacific Research Board (NPRB), provide leadership for a nationally recognized scientific organization to maintain and enhance the organization's reputation for excellence in marine research. To meet this goal, manage the staff and established processes to administer sub-awards with funds made available to the Secretary of Commerce from the Environmental Improvement and Restoration Fund (EIRF). EIRF funds provide for Federal, State, private and foreign organizations or individuals to conduct; research activities for cooperative marine research projects and activities on, or relating to, the fisheries or marine ecosystems in the North Pacific Ocean, Bering Sea, Gulf of Alaska and Arctic Ocean (including lesser related bodies of water) as set forth at 43 U.S.C. §1474d(e)(1) and in accordance with criteria and priorities for grants established by the North Pacific Research Board, as set forth at 43 U.S.C. §§1474d(e)(2) and (e)(4)(B).

Specific Duties:

Work jointly with the parties of the Memorandum of Understanding pertaining to the North Pacific Research Board (NPRB) and the North Pacific Marine Research Institute; the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), and the Alaska SeaLife Center to meet the overall objectives of the EIRF.

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Manage the overall NPRB budget, and track and report on the budget in synchrony with Board meetings.

Provide NPRB with all information necessary to approve research, education and demonstration projects in accordance with 33 U.S.C. §2738 and oversee implementation and monitoring of all approved grants to ensure compliance and timely conduct; report to Board timely on issues associated with grant implementation.

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Coordinate Advisory Panel meetings and reports to the Board and foster community and public input to the Board as appropriate.

Oversee a public process of communications and outreach and develop a biennial report of NPRB activities for Board approval. Oversee, in conjunction with the ASLC HR manager, performance appraisals of NPRB staff; submit to the Executive Committee an annual performance report for this position and meet annually to agree on personal business goals and priorities for the year ahead.

Represent the Board at appropriate public, professional, and scientific meetings and symposia.

Ensure compliance with applicable laws and regulations and work with the Fiscal Agent for the NPRB (the Alaska SeaLife Center) to ensure compliance with all Federal, State and local regulations pertaining to NPRB operations; comply with all NPRB policies, procedures, and programs and all ASLC financial agent requirements relating to human resources, fiscal management, risk management, etc.

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Candidates should submit a letter of application, curriculum vitae, a two-page summary of their philosophy on guiding collaborative research and contact information for four references at

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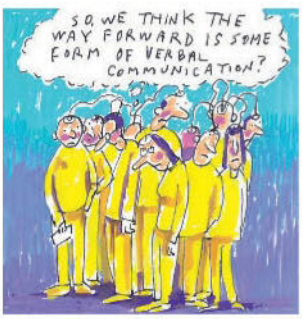
EDITOR'S PICK



Talking before technotelepathy

From Mary Midgley

MacGregor Campbell describes a future in which a vast network of brains communicate directly via sensors and implants (4 June, p 28). If we can train the neocortices of our brains to understand signals from others' brains and communicate directly, do we end up communicating with each other so thoroughly that we then merge into what he calls a single "noosphere" of cooperative individuals?

Unfortunately, this can't work. Our current difficulties about cooperating mostly do not arise from a failure of communication. They usually come from people not agreeing about what it is they want to do.

For this evil, a partial but often effective cure already exists. It is called "speech". The appropriate uses of it are being carefully studied, and there are already plenty of examples where it has been used successfully on problems that were certainly more complicated than the one that you quote, in which some (presumably unanimous) scientists managed to induce three monkeys to move a virtual arm.

So, as usual, what we shall need to work on is ourselves.

Newcastle upon Tyne, UK

To read more letters, visit newscientist.com/letters

What renewable energy needs

From Maarten van der Burgt

Michael Le Page mentions that there are problems associated with large-scale renewable power sources when the grid gets overloaded (21 May, p 19). Thus their success depends on having some means of distributing the load. This could be, for example, a high-voltage direct current network enabling the transport of power over distances of up to 5000 kilometres.

Akersloot, The Netherlands

From Ted Webber

Le Page is on the money as far as he goes, but the way to make renewable energy sustainable lies in developing cheap storage options. It is true that lithium-ion batteries are expensive and likely to remain so, and suitable only for small-scale industrial or household applications. But they still offer the possibility of storing power from the grid overnight when it is cheap. This can reduce daytime and evening demand peaks and thus reduce the demand for more fossil fuel power stations.

There are more energy storage options, although they still require consumers to stay on-grid. These include flywheels, hydroelectric pumped storage, compressed air, gravitational potential energy storage (hauling weights uphill) and thermal storage such as melted salts.

Extensive research is needed to find which of these gives the best cost-benefit yield in particular circumstances. An example is the push by Beyond Zero Emissions to replace a fossil fuel power station at Port Augusta in South Australia with a solar power station that stores energy in molten salts.

Buderim, Queensland, Australia

From Paul Vann

The renewables revolution is indeed unstoppable, because it has to be. Alternatives that emit carbon or create nuclear waste are in reality much more costly than is reflected in their pricing, because they are literally costing the Earth. This is where the real subsidies are at present.

Harrold, Bedfordshire, UK

From John Wallace

Le Page points out that the global energy market is not a free market, and that renewables need subsidies in order to compete with fossil fuels. Ha-Joon Chang draws attention to the dangerous myth of the free market in his book *23 Things They Don't Tell You About Capitalism*. There are no free markets, and we wouldn't want one if there were.

Renewables need subsidies to compete with fossil fuels because of the subsidies governments give (and try to hide) to the fossil fuel industries. In the UK, oil and gas companies only have to hint that the North Sea may be past its prime and the government of the day showers incentives on them to remain. And, if you count the cost of waste storage and disposal, we don't even know yet the cost of subsidising the nuclear power produced in the 1950s.

Liverpool, UK

A new community for science

From Andrea Saltelli, Jerome R. Ravetz and Silvio Funtowicz

We would like to complement your analysis of a crisis in science relating to studies that can't be replicated (16 April, p 5 and p 38). One of us, Jerome Ravetz, predicted in 1971 in his book *Scientific Knowledge and its Social Problems* that the system of internal quality control of science would not easily withstand the evolution toward big science.

Quality in science depends on the existence of a community of scholars linked by norms and standards, and willing to stand by these. The historian Philip Mirowski in *Science-Mart* (2011), fills in the blanks of Ravetz's analysis with details of how science's internal quality control system stalled when "market" replaced "community" as a unifying principle, driven by firms funding research.

The crisis has deep significance, since the contract between science and power is a basis of modernity. Science offers legitimacy to power via its guarantee of "truth". If trust collapses within the research sector, how can public trust be maintained for the many policy-relevant functions of science?

Reform will depend on the emergence of a new "polity" of science including citizen scientists who take responsibility for rooting out corruption of all sorts, scientist-citizens working primarily in the policy arena and concerned journalists and teachers. Issues of ethics and quality, previously largely restricted to coffee-time grumbles, now attract public debates and activist campaigns.

Bergen, Norway; Barcelona, Spain; and Oxford, UK

Unpopular books wanted here

From Paul G. Ellis

For me, Tom Gauld's cartoon of unpopular science books has it wrong (Letters, 21 May). I would very much like to know "why you'll never truly understand" quantum theory, which diseases and disorders "could strike at any moment", and learn more than Steven Weinberg has already said about "the pointlessness of life".

As for "Mathematics which is probably way over your head", trying to make some sense of such, along with quantum theory, is indeed how I spend the most enjoyable (and perhaps Alzheimer's-preventing?) time of my retirement.

Chichester, West Sussex, UK

"The technology has always been there: dipping hands in paint and smushing them on paper in preschool"

Kimberley Gordon is less alarmed than some about the fingerprinting of very young people (18 June, p 22)

That is a very watery steak

From Guy Cox

Arjen Hoekstra tells us that producing 1 kilogram of beef requires 15,000 litres of water (23 April, p 42). I have found a wide range of published figures, with an amazing 27-fold difference between the highest and lowest.

I estimate that a steer slaughtered when 2 years old will have drunk 90 litres of water per kilogram of body weight (so about 150 litres per kilogram of lean meat), based on figures for water requirements of cattle from the New South Wales Department of Agriculture.

Even that doesn't tell us much, since most of it will re-emerge as urine: the urea will be grabbed by the paddock and clear water will return to the creek. The remaining water requirement is what is used to produce feed. The lowest published figure of 3682 litres per kilogram counts only irrigation water because that is all that has alternative uses. Hoekstra's figure adds in rainwater that is taken up by the plants eaten by the cattle. Higher figures include all water taken up by the plants in the pasture, whether eaten or not. The highest appear to include all rain that falls on the grassland raising the cattle and on land for growing feed, even what runs off unused.

What is rarely acknowledged in this debate is how many cattle (and sheep) are raised on land that is unsuitable for arable farming – if it wasn't raising animals it wouldn't contribute to feeding the world.

Sydney, New South Wales, Australia

Together, we go faster than light

From Brian Horton

Timothy Revell tells us that optical fibres are "rolling off the production line at a rate nearly 20 times the speed of sound" (28 May, p 28). My mind boggled at the machinery needed to handle these speeds – until I realised how they were calculated. Using the same logic, a quick check on the number of kilometres driven per vehicle each year showed that collectively all the car drivers and passengers in the world must be exceeding the speed of light.

West Launceston, Tasmania, Australia

Bring me my arrows of desire...

From John Healey

Dave Hulme suggests that the word "toxophily" for the practice of archery arose from the fact that the yew from which bows are made is poisonous or toxic (The Last Word, 21 May). But right from the start, in classical Greek, "*toxikos*" meant "relating to the bow or archery".

Scythian archers smeared a mixture of dung, snake venom and human blood on the tips of their arrows. The Greeks called this "*toxikon pharmakon*" – "the archery drug". The adjective entered the Latin language as "*toxicus*", and the meaning of the noun "*pharmakon*" – drug or poison – attached itself to the adjective "*toxicus*", which thus came to mean not "of the bow" but "poisonous".

Semaphore, South Australia

Roman forts really are card-shaped

From Jean Wynne-Jones

Feedback is puzzled by a "playing-card-shaped fort" (4 June). These forts are commonly rectangular with curved corners. If the corners were right-angled, a defender at the corner would be able to observe only one side and would not see an attacker approaching from the other side.

Rushall, Herefordshire, UK

Why no mention of the birthday boy?

From James Stone

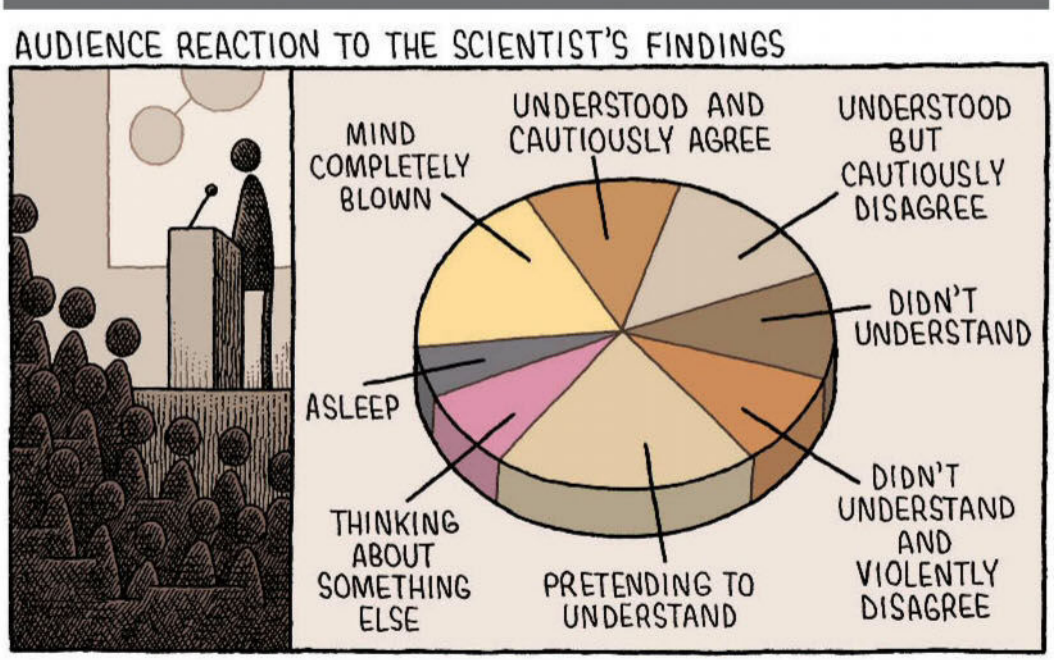
I was disappointed to see no mention of Claude Shannon in your article about information (14 May, p 28). Shannon created information theory almost single-handedly, and this year is the hundredth anniversary of his birth. In "A Mathematical Theory of Communication" he showed that information is a well-defined, and, above all, a measurable quantity.

Sheffield, UK

For the record

- **Fat fingers: the data for a high-fat diet should have been credited to Trudi Deakin (graphic , 11 June, p 28).**

TOM GAULD



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PAUL MCDEVITT

WE LAST featured veteran British TV presenter and positivity philosopher Noel Edmonds on these pages when he was singing the virtues of the EMPpad, a computerised yoga mat that promises to recalibrate your electromagnetic fields, and shield you from the dangers of electrosmog (22 August 2015).

This time the *Deal or No Deal* host has gone further, tweeting a glowing review of the device, which he claimed was "a simple box that slows ageing, reduces pain, lifts depression and stress and tackles cancer. Yep tackles cancer!" Unfortunately, this only provoked many patients, cancer charities and scientists to direct their own negative energies at Edmonds.

Meanwhile, the osteopaths behind the EMPpad were positively unhappy with the press. "The opinions of Mr Noel Edmonds are his alone," a glowering banner on their website now reads. "We had no discussion, input or prior knowledge of the content of Mr Edmonds' statement and we do not agree with it in any way, shape or form." Poor Edmonds. Maybe a few minutes on his EMPpad will dispel these negative vibes?

CONFOUNDING Feedback's ongoing examination of strange units of measurement, Richard Koskela writes with the news that Toronto's major league baseball stadium, the Rogers Centre, proudly declares that "743 Indian elephants or 516 African elephants can comfortably fit on the… field".

Good news for pachyderms that can swing a bat, but Feedback must now include elephants as a unit of both weight and area. We wonder if there are any other units of measurement that serve two different dimensions. A yard of ale, perhaps?

PREVIOUSLY, Rory Allen asked why UK passports are sent to their recipients with a square yellow label attached, and instructions to "remove this label" (4 June). Stephen Jorgenson-Murray suggests that the sticker "contains a mini-RFID tag to make sure that the passport gets sent to the right person." Though he admits this is strange, as modern UK passports already contain an RFID tag for automated border control booths.

Ian Chapple, however, thinks that the sticker "is a shield that prevents the RFID chip in the newly issued passport from being read while the passport is in transit." Worryingly, Tom Roberts points to a stern warning on the page that "tampering with a passport may constitute a criminal offence". To remove the sticker or not? Feedback thinks it best to avoid all risk and resign yourself to never leaving the country.

GUY ATCHINSON alerts us to the fact we have overlooked one of the best-known incongruously fragrant animals, namely the North American beaver, whose anal glands boast a delicious vanilla aroma. The chemical responsible, castoreum, has been variously used as a food additive, medicine and perfume – though only the latter in any significant amounts these days.

IMPROBABLE research supremo Marc Abrahams reminds us that the 2005 Ig Nobel Prize for biology was awarded to five researchers "for painstakingly smelling and cataloguing the peculiar odours produced by 131 different species of frogs when stressed" (bit.ly/ns_frog).

ANOMALOUS entities have been spotted hovering above the tax collector building in Tallahassee, Florida. This news comes from Thunder Energies, the same folks whose previous discovery of aliens in blurry, abstract images were chronicled by the *Daily Express* science reporter Jon Austin (10 February).

Is something evil under way? Or are the "anomalous entities" merely submitting some tax paperwork? A cautious Feedback is scouring our filing system for tinfoil hats.

A KITCHEN sink drama: where do missing teaspoons go (28 May)? Wes Black reports that when he worked at the Burnet Institute in Australia, all the teaspoons were numbered. It turns out this was part of a "longitudinal cohort study of the displacement of teaspoons".

Published in the *BMJ* in 2005, it determined the half-life of teaspoons was 81 days, though this dropped to 42 days for those kept in communal break rooms. "At this rate," the authors conclude, "an estimated 250 teaspoons would need to be purchased annually to maintain a practical institute-wide population of 70 teaspoons."

FROM the Department of Two Nations Divided by a Common Language, Eleanor Mayfield reports the existence of a catering and restaurant supply business located in the suburbs of

Pittsburgh called Nappies Foods. Feedback isn't sure if this is exactly the kind of delivery we look forward to.

A POSTER spotted by John Cleveland declares "Now hiring. Flexible hours". He wonders if the company is warping space-time. Feedback can think of many menial jobs we held in our youth where time seemed to drag; perhaps the tedium of the Swiss Patent Office led to a similar revelation?

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.

A 2000 year old, 10 kilogram lump of butter has been found in a bog in County Meath, Ireland. The *Irish Times* reports, rather intriguingly, that the discovery is "not unusual".

Mystery lith

This very heavy, non-magnetic boulder was unearthed from swampy land near limestone caves in northern New Zealand (see below). What is it?

■ It is most likely to be a concretion – a hard, solid mass of matter formed in a softish rock such as mudstone by the near-spherical growth of a harder mineral cement. This material is usually a carbonate of calcium, magnesium, manganese or iron that collected during shallow burial of the sediment before it became fully lithified.

These objects are quite common in some of the mangrove areas of Northland, New Zealand, where repeated washing by a tidal water flow has removed the soft mudstone. They are also found in soils away from the coast, so this one could have come from a mudstone or shale underlying the limestone where the caves formed.

No scale is given in the picture, but such concretions can range from as small as a centimetre to several metres in diameter. Even the iron carbonate in concretions is not ferromagnetic, so all forms of these objects would appear non-magnetic if a magnet were held to them.

Michael Pearson
Crieff, Perthshire, UK

■ I have seen this boulder outside the caves at Waiomio, north of the city of Whangarei. It appears to be a concretion, probably weathered out of the rocks of the Northland Allochthon. These rocks overlie the Oligocene limestone in which the caves occur but have been removed locally by erosion.

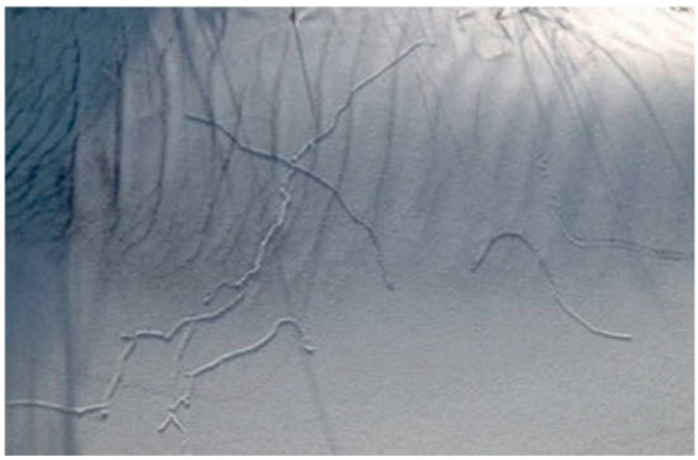
Such concretions are common in parts of Northland. Some well-known examples are on display near the Stanley Street entrance to the Auckland Domain park, where they were relocated from their original location in the Auckland suburb of Silverdale. The heaviness of these concretions is caused by the dense mineral baryte (barium sulphate), a common mineral in concretions.

"The cave proprietors were claiming the boulder was a meteorite, probably misled by its high density"

The formation mechanism is the same as that for the much more famous Moeraki Boulders on New Zealand's South Island. A nucleus (usually a fossil) causes precipitation of cementing minerals from water percolating through a permeable sedimentary rock. If the sediment is reasonably homogeneous, the zone of cementation will grow equally in all directions, producing a solid sphere of rock. The cemented volume is more resistant to erosion than the surrounding strata and can eventually be left behind as an isolated spherical boulder when the rest is removed.

When I last visited the caves where the photo was taken, the proprietors were claiming the boulder was a meteorite, probably misled by the rock's high density.

Paul Keestra
Auckland, New Zealand



This week's questions

UNDERGROUND LINE

On a March visit to the North Carolina seashore, I encountered this tableau (above) of two types of markings on an otherwise pristine sand dune. One of them seems to be a trail left in the surface by a passing arthropod. The other has a mound-like relief and it appears to have been made by the sand being pushed upwards from below. The mounds' height and width are generally uniform along their length, at perhaps 1 and 1.5 centimetres, respectively; there are branches at several points; and nowhere do there seem to be openings to the surface. Does anyone have an explanation?

Howard Ritter
Fuquay-Varina, North Carolina, US

ANT HILL MOB

While mowing the grass, I noticed that in several places ant nests were situated under clumps of daisies. Do the ants choose to nest under daisies, or do these flowers grow where they do because of the ants' activity?

Peter Waller
Bristol, UK

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