THE QUANTUM COSMOS
We’ve looked at the whole universe. And it’s all weird

BEYOND FAST AND SLOW
The truth about how we think

NASAL DEFENCE
The secret weapon in your nose

PRINT ME A HEART
Living human organs from a 3D printer

SMART BABIES
IVF screening for intelligence is here

PLUS PICTISH WRITING / PRIVATE MISSION TO ENCELADUS
But only a few will read this.

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Standardised past performance to 30 September**::

<table>
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Past performance is not a guide to future returns.

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We can now test embryos for low IQ. But should we?

THIS WEEK
Would you want to choose your child’s IQ? What the US midterms mean for science.

Foldable phones
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We have the power to slash household emissions

THE REAL DANGERS OF AI
Iran’s jailed conservationists

PROBLEMS WITH HEALTH HEADLINES

ARTISTS ARE PLAYING CAT AND MOUSE WITH FACE-RECOGNITION SOFTWARE

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THE QUANTUM COSMOS
We’ve looked at the whole universe. And it’s all weird

THE ANCIENT WRITINGS OF THE PICTS

THE MONKEY THAT LIVED LIKE A SLOTH

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Time to talk designer babies

Should we screen embryos for traits like intelligence?

IT IS hard to think of an area of science more controversial than the genetics of intelligence. Now it is about to get exponentially more contentious.

For a long time, DNA testing couldn’t tell us anything useful about someone’s IQ or any other traits affected by multiple genes, such as diabetes or cancer risk. But new “polygenic” techniques for analysing many genetic regions at once have begun to make this possible. This week, we report on the first company offering fertility clinics a test for screening IVF embryos for disease risk and low intelligence (see page 6).

With this news, it is unlikely to be long before some clinic, somewhere, starts using a similar approach to offer prospective parents the ability to pick out embryos that look most genetically promising for a high IQ.

As if this isn’t controversial enough, it may only be the beginning. As our understanding of traits governed by multiple genes grows, it may also become possible to screen for embryos that are more or less likely to have a range of other features, be it sexuality, autism or susceptibility to depression.

We already live in a world where wealthy individuals are willing to cross borders to pay for procedures at the sharpest edge of fertility research. The first baby created using a particular three-parent technique was born two years ago to Jordanian parents helped by US scientists working in Mexico, for example.

While many prospective parents won’t want to genetically fine-tune their children this way, the idea of a near-designer baby will undoubtedly appeal to some. The desire to maximise a future child’s intelligence, mental health or physical attractiveness could be enough to prompt couples with no fertility problems to seek IVF, just to have this opportunity.

It might sound unlikely, but reproductive technologies designed to avoid medical conditions are already being used to find out more about our future children. A different kind of test, used to detect Down’s syndrome during pregnancy, is being used in private clinics to discern the sex of a baby very early in pregnancy. Concerns have been raised that this practice gives people more of a chance to opt for abortions on the basis of gender, although we don’t yet know to what extent the test is being used in this way, if at all.

All this means that politicians, regulators and the public need to begin debating the far-reaching implications of polygenic IVF screening. For so long, the mantra has been that DNA tests for individuals can’t tell us anything about complex traits so we haven’t yet decided what we should do when they can.

There is much for this debate to consider. Is it ethical to screen for disease risk, but not for predicted personality? What about mental health problems or a predisposition to autism? Should prospective parents be allowed to decide for themselves, or should societies as a whole determine what is most ethical?

It is a difficult conversation to have, but whether we like it or not, these technologies aren’t far from being a reality.
Choose your child’s intelligence

We can now predict low IQ long before birth, reports Clare Wilson

**How will screening for intelligence affect parents’ decisions?**

A study published in July found more than 1000 DNA regions at once to calculate something called a polygenic risk score (see “Predicting an embryo’s future traits”, below).

**Predicting potential**

Genomic Prediction is the first company to offer polygenic risk scores for embryos rather than adults. The firm is mainly promoting its tests as a way of screening out embryos at high risk of certain medical conditions. But the company’s polygenic test for “mental disability” is more controversial. It isn’t accurate enough to predict IQ for each embryo, but it can indicate which ones are genetic outliers, giving prospective parents the option of avoiding embryos with a high chance of an IQ 25 points below average, says Hsu.

“We don’t yet fully understand what other effects genes involved in intelligence may have”

“If we consider inclusion and diversity to be a measure of societal progress, then IQ screening proposals are unethical,” says Lynn Murray of Don’t Screen Us Out, a group that campaigns against prenatal testing for Down’s syndrome. “There must be wide consultation.”

Information from the same test could be used to go one step further and select whichever embryo is most likely to have a high IQ. “What that corresponds to is way-above-average intellectual potential,” says Hsu.

For ethical reasons, Genomic Prediction won’t help parents select high-IQ embryos in this

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**PREDICTING AN EMBRYO’S FUTURE TRAITS**

Genetic testing for complex traits used to be impossible. That’s because they are affected by hundreds of different genes, each with just a small influence, only a small fraction of which have been identified.

But thanks to studies involving hundreds of thousands of people, more DNA regions implicated in these kinds of traits have been found. A study published in July found more than 1000 DNA regions that together accounted for 13 per cent of variation in academic achievement.

And their influence can be higher in certain people. For example, a rare gene variant may only account for a tiny percentage of variation in intelligence across a population, but it may make a big difference to the IQ of those who have it.

As it becomes possible to estimate the future intelligence of an embryo (see main story), some prospective parents will discover that some of their IVF embryos have a high chance of intellectual disability, while others may find that one of their embryos is likely to be especially clever.

There are no certainties, but for a few this could make a big difference. The July study found that 60 per cent of those with a genetic score in the top fifth of the group got a university degree, compared with 10 per cent of those in the bottom fifth.
way. Nevertheless, it seems likely that other firms will do so in future. “If it doesn’t happen in the US, it will happen in another country,” says Kevin Mitchell of Trinity College Dublin, Ireland.

The idea of using such tests to select embryos predicted to have high intelligence is “repugnant, but technologically feasible”, says geneticist Peter Visscher at the University of Queensland, Australia.

Intelligence is only one trait the firm can give a polygenic risk score for. Others on offer include heart disease, breast cancer, type 1 and type 2 diabetes, and inflammatory bowel disease.

All the geneticists New Scientist spoke to agree that the principles behind polygenic testing are valid, but Mitchell says the service may be of limited use in practice, because many people using IVF have just a few embryos to choose from.

What’s more, if these embryos all share the same biological parents, they are unlikely to show much variation in their polygenic scores for various traits. Also, we don’t yet fully understand what other effects the many genes involved in traits like a higher intelligence or lower risk of heart disease might have. For example, some studies have suggested that people with higher polygenic scores for academic ability are also more likely to be autistic.

“You don’t know what you’re selecting for and what comes with it,” says Visscher. “But there are people who pay hundreds of thousands of dollars to have their dead pet cloned. I’m sure there are people who would do this.”

In the UK, screening embryos for polygenic conditions isn’t currently allowed — they can only be screened for simpler genetic conditions.

But some IVF doctors want that to change. “I take my hat off to what they’re doing, it’s a potential revolution,” says Simon Fishel, president of the Care Fertility Group clinics in the UK.

US votes on science

ALONGSIDE the US midterm Congressional elections last week, voters were asked to decide on various science-related measures. The results were a mixed bag.

Voters in Washington state rejected a proposed carbon tax, which would have charged oil firms and other large polluters $15 per tonne of emitted carbon. Had it passed, it would have been the first fee imposed on greenhouse gas emissions in the US.

In Arizona and Nevada, renewable energy was on the ballot in the form of measures designed to require electricity firms to get half their power from renewable sources. Nevada passed the measure by a large margin, while Arizona rejected it.

A Colorado initiative to limit fracking by banning the drilling of oil and gas wells within 762 metres of occupied buildings or protected land failed at the polls. But voters in Florida felt differently, at least where oceans are concerned, approving a measure that bans offshore drilling.

In California, voters rejected a proposal to spend $9 billion to repair dams and build water infrastructure for farmers. The drought-prone state is currently enduring the deadliest wildfire in its history. According to US officials, over 42 people have died in the Camp Fire and 7000 structures have been destroyed.

Abortion rights were also put to the vote in some states. In Oregon, a measure was rejected that would have curbed state funds being used to pay for abortion services and would have prevented public employees from receiving an abortion using their state-provided insurance. In Alabama, voters approved a policy to recognise the “rights of unborn children”, giving fetuses the same legal rights as a person.

Democrats won control of the House of Representatives, meaning they will head the House Committee on Science, Space, and Technology for the first time since 2011.

“The Democrats will head the Committee on Science, Space, and Technology for the first time since 2011”

In the US, screening embryos for polygenic conditions isn’t currently allowed — they can only be screened for simpler genetic conditions.

...
Space explosion is too bright, too fast

A SPACE explosion nicknamed “the Cow” keeps getting stranger. After months of observations, we still aren’t quite sure what it is but it may be part of a whole new class of blasts.

In June, astronomers spotted a remarkably fast and luminous explosion. It took just a few days to reach peak brightness, whereas most supernovae – which occur when stars blow up and die – take a few weeks or longer. And it was 10 to 100 times brighter than most normal supernovae.

Telescopes around the world were turned to face the blast, dubbed the Cow after it was officially listed as AT2018cow, simply because these cosmic events get three-letter labels in alphabetical order based on when they are seen. Initial observations couldn’t explain it, so lots of astronomers continued to watch.

Using 12 telescopes, Raffaella Margutti at Northwestern University in Illinois and her team examined the explosion in several wavelengths of light. None of those observations resembled a regular supernova, she says.

They found that high-energy X-rays from the Cow, which should die down as the blast goes on, were increasing. “That was a huge surprise,” says Margutti. They redid the analysis but the result was the same.

The visible light coming from the Cow added to the mystery too. “It was very blue, which means it was hot. And it stayed blue, which means something is keeping it hot,” says Brian Metzger at Columbia University in New York.

They also detected irregular X-ray frequencies, which suggest that the Cow is asymmetrical, and that it may also have a ring of dust and gas around it (arxiv.org/abs/1810.10720).

Another group led by Anna Ho at the California Institute of Technology came to similar conclusions. They found that radio waves emitted by the Cow suggest the explosion is spreading through a dense medium, like the clouds of gas that some stars belch out before becoming supernovae (arxiv.org/abs/1810.10880).

“It has some features in common with many different types of things, but it doesn’t fit neatly into any one category,” says Ho. “It’s really, totally strange.”

Together, the two sets of observations paint a picture of a very powerful explosion, blasting through gas clouds and lent extra oomph by a central energy source, or “engine”. The whole thing is ringed with debris.

We may not know for a while how the Cow gets its power. It could be a rapidly spinning neutron star, a newborn black hole, or a delayed shock wave from a failed supernova. The problem is a lot of central energy sources look alike, says Metzger.

The Cow sits in a not too distant dwarf galaxy. We have seen other explosions that look similar, but they have always been so far away that we haven’t been able to study them in any detail. Observations of the Cow may mark the first time we are witnessing the finer features of a new type of space explosion.

“We’re entering this era now where the zoo of astronomical events has just gotten out of hand,” says Metzger. “This is a rare opportunity to examine the bestiary up close.”

Blob’s ‘first animal’ claim could be about to go pop

A WEIRD sea creature from half a billion years ago may not be Earth’s first animal after all.

We may have to rethink where Dickinsonia, pictured, sits in the tree of life after evidence emerged of an unusual feeding strategy: inflating its body like a balloon. Because this isn’t seen in any animal today, it raises questions about whether it belongs in the animal kingdom, having been put in it after fossil analysis suggested an animal-like molecular fingerprint.

If Dickinsonia was an animal, it may have been a very odd one, say Nicole Law and Scott McKenzie at Mercyhurst University, Pennsylvania, who made the finding. It is one of the Ediacarans, a group of lifeforms that lived tens of millions of years before familiar early animals like sponges. Its fossils look like round, flat-ribbed blobs up to a metre long, but all are just a few millimetres thick.

Law and McKenzie studied unusual radial lines in rock fringing one Dickinsonia fossil. They say these suggest the organism shrunk when dead, leaving scratches in the sand below as it shrivelled up. “About 21 per cent of the total fossil area is taken up by this fringe,” says Law.

She thinks that a live Dickinsonia was longer, wider and taller than its fossils suggest. Its body was inflated, and most fossils show it in a smaller and thinner deflated state. Although the study hinges on one fossil, Law says Rex Powell at the University of California, Berkeley, has been working on this idea for about 10 years. Powell joined Law and McKenzie to present the inflatable Dickinsonia idea at a meeting of the Geological Society of America in Indianapolis last week.

Inflating could have been a feeding strategy. Dickinsonia has been viewed as a seabed grazer, absorbing organic material via its body wall, so the area of seabed it contacts is important.

“Inflating could have allowed it to cover more of the seabed,” says Law, meaning it could consume more before moving to a new grazing site.

A pufferfish can inflate its stomach to deter predators, but Dickinsonia seems to have inflated its entire body. As such, Law suggests it might fall not on the animal branch of the tree of life, but on an unidentified nearby branch. “Perhaps it wasn’t an animal,” she says. “But I don’t believe we have enough evidence to know for sure right now.”

Colin Barras
Civilisation shaped human evolution

Michael Marshall

ARE humans still evolving? Because evolution usually takes many generations, it is hard to tell. But two new genetic studies reveal DNA changes that took hold within the last few thousand years, suggesting that modern lifestyles have recently shaped our evolution – and are probably still doing so.

“During a short time, human genomes have changed a lot,” says Irina Morozova of the University of Zurich in Switzerland. “We think these changes are driven by human civilisation.”

Both studies looked for evidence of evolution favouring some DNA sequences over others, a process called selection.

Morozova and her colleagues compared the genomes of 150 Europeans from between 5500 and 3000 years ago with those of 305 modern Europeans descended from them. This allowed the team to identify various processes that evolution has acted on in Europeans within the past 6000 years (Molecular Biology and Evolution, doi.org/fgfj53).

The team found changes over time in the way that the body metabolises carbohydrates. Morozova suggests these happened when societies began farming, prompting a switch from a meat-heavy, hunter-gatherer diet to a starchier, more sugary one. She thinks human metabolism is still evolving, and may keep doing so for millennia. “It’s not like we’re completely adapted to this.”

There was evidence of evolutionary changes in several aspects of the immune system, too. It’s not clear what these changes do, but they could have been a response to exposure to new diseases some 6000 years ago, when people began living in more crowded conditions and spending more time with livestock.

But two processes stood out as showing very few evolutionary changes over the same period of time. These are how egg cells form, and long-term potentiation, a process in the brain that aids learning by strengthening the connections of commonly used neural pathways. It looks as if living with livestock may have shaped our immune systems and our learning capabilities.

Living with livestock may have shaped our immune systems and our learning capabilities. Morozova suggests these changes do, but they could have been a response to exposure to new diseases some 6000 years ago, when people began living in more crowded conditions and spending more time with livestock.

Evolution during the last few hundred years is harder to spot because the signals are weaker, but Racimo says humans are definitely still evolving. “The question is, what are the selective pressures that are driving the evolution? They’re probably very different from the selective pressures we were experiencing 5000 to 10,000 years ago.”

Extinct monkey evolved to live like a sloth

ABOUT 11 million years ago, monkeys somehow crossed the sea from South America to the island of Jamaica in the Caribbean. There they evolved into a new species that was unlike any other known monkey. It is a striking example of how living on an island can transform a species, and preserved DNA has let us glimpse the details.

The first remains of Xenothrix mcgregori were discovered in 1920 in Jamaica’s Long Mile Cave. The few bones found reveal a highly unusual monkey, with relatively few teeth and leg bones similar to those of a rodent. “What they suggest is a very slow-moving, perhaps even sloth-like lifestyle,” says Ross MacPhee at the American Museum of Natural History in New York.

X. mcgregori was related to South American monkeys, but it was so unusual that biologists were unclear which group it belonged to. To clear up the mystery, MacPhee and his colleagues extracted DNA from two X. mcgregori bones. They managed to recover the full mitochondrial genome – which animals only inherit from their mother – and seven chunks of the nuclear genome.

The team compared these samples with the equivalent sequences from 15 South American primate groups, and found that X. mcgregori belonged to a group called the titis. These monkeys live in forests, eat fruit and lack prehensile tails (PNAS, doi.org/cw2p).

X. mcgregori doesn’t look like a typical titi monkey, though, so arriving on the island evidently forced its ancestors to evolve. “The selective pressures on them must have been just extreme,” says MacPhee. “It looks like it got thrown into the mixer.”

For reasons unknown, X. mcgregori died out about 900 years ago. “What we think, but can’t demonstrate, is that Xenothrix was a victim of either direct or indirect impacts by the first humans who got there,” says MacPhee.

Michael Marshall
Roman inspiration for ancient script

Richard Kemeney

THE Picts, an enigmatic coalition of tribal kingdoms that inhabited the far north of what is now Scotland about 1700 to 1100 years ago, might have been inspired by the Romans to develop a writing system of their own.

We know about the Picts from the Roman written record. It was the Roman writer Eumenius who coined the name Picti – literally “painted people” – in 297, probably referring to their tattoos.

As far as we know, the Picts themselves left no surviving written records. One thing they did leave, though, is a collection of about 200 stone slabs adorned with symbols of varying complexity. There are carved bulls, eagles and fish, as well as geometric patterns.

Among the symbols are around 30 that appear often, almost always in pairs. Because the slabs were found in locations that seem to have been of importance to the Picts, these paired symbols are thought to be some sort of naming system for Pictish families, although there is no agreement on their precise meaning.

Dating the carvings could help solve the mystery, but it is hard to do so because stone carving leaves no convenient organic marker for carbon dating.

Gordon Noble at the University of Aberdeen, UK, and his colleagues have found a way around this problem. They dated organic material from an ancient fort called Dunnicaer, which lies on Scotland’s north-east coast and may have been a centre of Pictish power. The rubble from the fort’s ruined walls contains a few symbol-carved stones.

The results suggest the walls were built in the 3rd or 4th century, which is a few hundred years earlier than the symbol system was previously thought to have been in use. This surprised Noble and his team. They argue it might suggest that the symbol system arose through contact with the Roman Empire, as the Romans still had a presence in Britain when the wall at Dunnicaer was built (Antiquity, doi.org/cwwx).

“Where did the Picts learn about written scripts? The obvious connection is the Roman Empire,” says Noble.

Roman coins and pottery have been found in caves in northern Scotland, possibly gathered during Pictish raids. Noble’s idea is that seeing Latin script led the Picts to develop their own writing system.

There is precedent for this elsewhere in northern Europe. For instance, encounters with the Roman Empire are thought to have inspired the ogham script used in Ireland and the runes system of Scandinavia.

Karen Milek at Durham University, UK, thinks the argument is compelling. “The dating evidence and contextual analysis of Pictish symbols significantly enhance our understanding of Pictish symbols, their origins, uses and meanings,” she says.

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David Hambling
A NATURAL PROGRESSION.

In the all-electric BMW i3, naturally occurring kenaf fibres are used to replace some plastics in the cabin. These fibres can be harvested from fast growing Malva plants, which also convert carbon dioxide to oxygen at an above average rate.

Official fuel economy figures for the pure electric BMW i3: mpg N/A, CO₂ emissions: 0 g/km, nominal power output (electric motor) 75/102 kW/hp at 4,800 rpm; peak power output (electric motor) 125/170 kW/hp, total average energy consumption per 62 miles/100 km (combined cycle) 13.1 kWh (13.6 kWh with 20" wheels). Total range: 223 miles. Customer orientated range: up to 160 miles. Figures are obtained in a standardised test cycle after the battery had been fully charged. They are intended for comparisons between vehicles and may not be representative of what a user achieves under usual driving conditions. The BMW i3 is an electric vehicle that requires mains electricity for charging.
Secret weapon keeps nose safe

Michael Le Page

IT’S been right inside our noses all along. When cells in the nose sense potential invaders, they release tiny sacs that fight them off and prime other cells to resist an onslaught.

“We have demonstrated in a live patient that the immune system goes and attacks pathogens before they get into the body,” says Benjamin Bleier, a sinus surgeon at the teaching hospital Massachusetts Eye and Ear.

“It is the only example of this I know of.”

The nose is a crucial frontier: every breath we take may contain dangerous bacteria. So the cells lining the nasal cavity secrete a mucus that traps tiny particles. Hairs on the surface of these cells, called cilia, beat to move the mucus along.

What’s surprising, says Bleier, is that instead of being swept backwards so it can be rapidly expelled, the mucus is swept backwards towards the throat. “You swallow it, and then the gut deals with it from there.”

Bleier’s team and other researchers have recently found that, as well as secreting mucus, the cells of the nasal cavity release billions of tiny sacs called exosomes. Once in the mucus, these sacs can go on to fuse with other cells, delivering cargo such as proteins or RNA.

This made Bleier and his colleagues suspect that exosomes are part of a previously unknown defence system. Now, after studying tissue in the lab and people undergoing nasal surgery, the researchers have strong evidence for this idea.

They found that when cells at the front of the nose are exposed to a potentially dangerous bacterium, the number of exosomes released into the mucus doubles within 5 minutes.

Their experiments suggest that exosomes can kill pathogens directly, although we don’t yet know how (Journal of Allergy and Clinical Immunology, doi.org/cwzs). “They are as powerful at killing bacteria as an antibiotic,” Bleier says.

But not all exosomes kill. Many do not attack bacteria but instead fuse with cells towards the back of the nose. In doing so, the exosomes seem to both alert these cells and arm them with antibacterial proteins.

Bleier thinks this explains why mucus is swept backwards. “Mucociliary clearance is not just a garbage dump,” he says. “It’s actually a circulatory system.”

The team now hopes to identify how exosomes fuse with cells. This could allow us to develop artificial exosomes that deliver drugs more efficiently.

The findings make sense, says Cecilia Lässer at the University of Gothenburg in Sweden, whose team has also been examining whether exosomes have a role in the immune system.

Exosomes were discovered in 1983, but it is only in the past decade that interest in them has surged. As well as seeming to arm our noses against invaders, they are involved in all kinds of processes, from normal body functioning to diseases including cancer and asthma.

Glaciers may have built Pluto’s ridges

WHEN the New Horizons spacecraft flew past Pluto in 2015, it revealed an astonishing variety of terrain. Now, it seems some of these weird textures probably came from ice debris left behind by ancient receding glaciers.

“Washboard” and “fluted” terrain consists of parallel ridges a few kilometres across and less than 100 metres tall. The formations on Pluto are unlike anything we see on Earth.

To determine their origin, Oliver White at the SETI Institute in California and his colleagues turned to maps and images from the New Horizons fly-by. They found that the ridged areas coincided with a fault on the surface, indicating ancient tectonic activity there.

An analysis of craters in the same area revealed that the ridges were formed about 4 billion years ago. That was early in Pluto’s history and just after the formation of nearby Sputnik Planitia, the dwarf planet’s heart-shaped region of nitrogen ice.

Earlier studies had found that before Sputnik Planitia formed, Pluto hosted glaciers of nitrogen ice that later sublimated away, turning directly from a solid into a gas that then condensed on the colder plains.

The ridged areas are yet more evidence that such glaciers used to be spread across Pluto, says White. He and his colleagues suggest that washboard and fluted areas are built up out of water ice debris that broke off the crust during tectonic activity. The debris then got left behind as the glaciers sublimated (Nature Astronomy, doi.org/cwzs).

The ridges are of a similar size and shape to what we see in so-called pitted terrain elsewhere on Pluto, so these two alien landscapes may be connected, the researchers say.

Not all the mysteries are quite solved yet – the team couldn’t figure out why the ridges align the way they do, for example. Even so, the findings are a step towards understanding Pluto’s past.

Leah Crane ■
URGENT APPEAL: help Syrian refugee parents like Khitam to protect their children through the winter.

Khitam lives with her four young children, husband Abdelsalam, and his elderly parents in a single, damp room of a half-built apartment block near Tripoli, Lebanon. There are holes in the walls and ceiling and they share a toilet with other refugee families crammed into the building. Khitam and Abdelsalam are mentally and physically exhausted after years of struggling to survive, unable to earn a living and fighting a daily, relentless battle to feed their children. Right now, they are terrified by the prospect of another winter in their cold, uninsulated single room. Another winter where they will feel every blast of icy wind. Another winter where every time their children cough or sneeze they will fear they have contracted a lethal respiratory condition like pneumonia or tuberculosis.

UNHCR, the UN Refugee Agency, needs your support to help parents protect their children this winter.

Please will you give £75 to provide a refugee family like Khitam’s with a winter survival kit to protect against the freezing weather?

The kit contains essentials such as a heating stove, thermal blankets and a tarpaulin for insulation. It could mean survival for a family like Khitam’s. Last winter, as a result of their exposed and unsanitary living conditions, Khitam and all four of her children became ill. Baby Bilal had a high temperature and diarrhoea. Her sons Khaled (3, pictured) and Abdul Rahman (8) had chest infections and their sister Fatimah (4) contracted worms. Khitam herself developed painful growths on her throat and lost her voice. Without access to a free healthcare system like we have in the UK, Khitam became overwhelmed with worry about how to pay for the treatment and medicines her children needed. “I felt helpless. My children were coughing and crying and there was nothing I could do.” Khitam believes that without assistance from UNHCR “my children would be dead”.

Across Lebanon and Jordan, six of the last seven winters have brought heavy snowfall and temperatures regularly drop below 0°C. 1.7 million Syrian refugees are living, like Khitam’s family, in unfinished or derelict buildings, or in makeshift shelters, sometimes made of little more than wood and plastic sheeting. This coming winter, when temperatures are likely to fall below zero, the lives of the most vulnerable: young children, pregnant women and the elderly, are at grave risk from hypothermia, frostbite and diseases like pneumonia.

With a gift of £75 you could provide a winter survival kit containing a stove, blankets, jerry can and a tarpaulin to help a family insulate and heat their home. Please give today – you could save the lives of children like Khitam’s.
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Enceladus mission gains NASA input

Mark Harris

THE first private mission to deep space is gathering momentum. Russian-Israeli billionaire Yuri Milner wants to hunt for life on Saturn’s moon Enceladus, and planning with NASA is already under way, according to documents seen by New Scientist.

Agreements signed by NASA and Milner’s non-profit Breakthrough Starshot Foundation in September show that the two organisations are collaborating on scientific, technical and financial plans for the ambitious mission. NASA has committed over $70,000 to meet with equipment to detect extraterrestrial life. The agreements make it clear that Breakthrough would lead and pay for the mission, and have sole authority to determine whether it goes ahead. NASA’s role will be to provide scientific and technical consulting, including "expertise in the fields of astrobiology, planetary, biological, and Earth sciences, as well as planetary protection". That last item means the agency will ensure that Breakthrough’s mission complies with legal requirements to protect other planets and moons from damage by spacecraft and contamination by terrestrial organisms.

"It makes sense for Breakthrough to do this [mission] with the support of NASA," says Graham Lau at the Blue Marble Space Institute of Science in Seattle. "It’s not only good PR, but some of the best scientists in the world studying Enceladus are working at NASA."

The agreement doesn’t specify costs or timelines for a launch, saying simply that it is a near-term mission. However, one of the documents lays out milestones for the initial concept study. NASA and Breakthrough are expected to come up with preliminary project requirements by June 2019, provide a mission concept review later in the year, and arrive at a key decision point by next December.

Lau hopes that Breakthrough will consider something more ambitious than another fly-by. "If they can generate enough money, it would be wonderful to see an orbiter or a lander," he says. NASA and Breakthrough declined New Scientist’s request for comment.

Saturn’s moon Enceladus could be home to extraterrestrial life

"Scientists speculate that oceans hidden beneath the moon’s icy crust might harbour alien microbes"

to alien microbes. The hydrogen may be coming from underwater hydrothermal reactions, in conditions akin to those at deep sea vents on Earth where organisms thrive without oxygen.

Breakthrough is proposing another fly-by mission to sample the moon’s plumes, but this time with equipment to detect extraterrestrial life.

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Tackling cirrus cloud could best stabilise climate

IF GLOBAL warming should ever make us desperate enough to try artificially cooling the planet, cirrus clouds might be a natural target. Thinning out these feathery, high-altitude clouds could achieve the desired effect while leaving rainfall relatively unchanged.

As climate change begins to bite, research into geoengineering techniques that could artificially cool Earth is intensifying. However, such tinkering with the climate might have side effects, triggering droughts in some regions, for instance.

To better grasp these effects, Long Cao of Zhejiang University in Hangzhou, China, and his colleagues modelled three cooling methods: pumping aerosols into the stratosphere to help reflect sunlight back into space before it reaches the ground; marine cloud brightening, which whitens low-level clouds over the sea and so makes them more reflective; and cirrus cloud thinning, which reduces cirrus coverage and so allows more heat trapped in Earth’s atmosphere to escape into space.

In each simulation, the researchers first doubled the level of carbon dioxide in the air. Then they turned on one of the geoengineering methods and applied it intensively enough to offset all the warming caused by the CO₂ spike.

In line with previous studies, average global precipitation—the amount of rain, hail and snow—never returned to normal after geoengineering. However, the discrepancy was significantly smaller when cirrus cloud thinning was used (Journal of Geophysical Research: Atmospheres, doi.org/cww9).

"Broadly speaking, I think cirrus cloud thinning, if it works in reality, would be preferable to stratospheric aerosol injections,” says Cao. But he points out that applying the technique remains a challenge because we don’t fully understand how to thin the clouds.

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Michael Marshall

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Prehistoric killers had a softer side

Colin Barras

FEARSOme sabre-toothed cats may have shown a little tenderness to their own kind. These extinct predators risked damage to their jaws and teeth during hunts, but a study of their fossils suggests injured cats could rely on their peers for food.

That is the conclusion of a look at remains from the La Brea tar pits in Los Angeles. For most of the past 40,000 years, these pits have trapped and preserved animals wandering across this landscape. In particular, they acted almost like flypaper for top predators: they were attracted by trapped herbivores and then got caught themselves.

Many sabre-toothed cat (Smilodon) fossils have been pulled from the tar. Larisa DeSantis at Vanderbilt University in Tennessee and Christopher Shaw at the George C. Page Museum in Los Angeles have used these to understand how such animals lived.

The pair compared 21 Smilodon skulls that showed signs of jaw injuries with 135 skulls that looked uninjured. They found that the pattern of pits and scratches on teeth in the uninjured jaws looked like those seen on the teeth of living lions. The patterns on injured jaws were more like those on the teeth of living cheetahs.

That tells us something about the diets of the sabre-toothed cats, says DeSantis. “Lions are generalised feeders, they eat flesh and bone,” she says. “But cheetahs tend to avoid bone.” In other words, it seems that Smilodon usually crunched its way through entire carcasses – bones and all – but that once individuals had a jaw injury, they switched to a softer diet that was easier to eat.

DeSantis and Shaw say this indicates that injured cats ate fresh meat even if they couldn’t make their own kills, and that Smilodon was a social animal, with healthy cats sharing food with injured individuals. The pair presented their work at a meeting of the Geological Society of America in Indianapolis last week.

But not all the evidence points to cats with mouth injuries being dependent on others for food. A recent study suggests that Smilodon had strong enough forelimbs and paws that it would still have been able to kill prey even with a damaged jaw or teeth.

DeSantis and Shaw’s idea also assumes that Smilodon was a social cat – an idea that has been questioned by others. However, Shaw has recently found fossil evidence from La Brea that indicates Smilodon could roar like modern lions. This suggests communication was important for them, adding more evidence that it was a social animal, he says.

“I think that people have begun to abandon the idea that all sabre-toothed carnivores were solitary animals,” says Shaw. “Some of these injuries were so severe that injured animals would have benefited from living in a social group that nurtured injured members and provided food and protection.”

Stuart Sumida at California State University praised the new research, saying it shows that sabre-toothed cats could still live with the damage they sustained. “It gives a much richer picture of survival and biology during the animals’ lives.”

Humble lichen could make fuel on Mars

WHEN the first humans go to the Red Planet, they may want to bring lichens with them. It turns out they are good at surviving extreme conditions like those on Mars, and could help produce rocket fuel in space.

Kiriakos Kotzabasis at the University of Crete in Greece and his colleagues subjected lichen to brutal conditions similar to those on Mars.

That meant no water, low oxygen levels and temperatures as low as -196°C, induced by dipping them into liquid nitrogen.

They found that, as long as the lichen were deprived of water before they experienced extremely low temperatures, they could recover almost completely when they warmed up (Astrobiology, doi.org/cwwt).

“Despite their exposure to an unfavourable environment or to repeated extreme conditions, lichens remain alive,” says Kotzabasis. The researchers say that surviving these conditions may make lichens good candidates for lithopanspermia, the idea that life can spread from planet to planet or across interstellar space by hitching a ride on rocks.

While we don’t know exactly why lichens cope so well, Kotzabasis says that it probably has something to do with them being a partnership between a fungi and algae or bacteria. The partners are sensitive to different stressors – when one is doing badly, the other can shore it up.

After they were revived and placed in an environment with conditions more suitable for growth, the lichens went back to making hydrogen, just like they normally do.

That might be a boon on long space journeys, because hydrogen is a key ingredient in some types of rocket fuel. Explorers could bring lichens and produce their own fuel by reviving the organisms when they need more hydrogen. They could even leave lichens behind on Mars for the next group of astronauts to revive, Kotzabasis says. Leah Crane  ■
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GENOMES of ancient Americans have been sequenced to reveal how people first spread through the Americas. But the work has also deepened a major mystery.

Around 25,000 years ago, the ancestors of modern Native Americans moved from what is now Russia to Alaska. They stayed there for millennia, moving south when ice blocking the way melted.

Now an international team has shed light on what happened next by analysing the genomes of 15 ancient Americans, some more than 10,000 years old. The results suggest more southerly Native Americans split from northern ones around 16,000 years ago, and reached South America not long after. They also indicate that a previously unknown group split from northern Native Americans and also moved to South America, around 8000 years ago.

The findings add to an existing conundrum: that some groups in the Amazon are somewhat related to Aboriginal Australians and people from Papua New Guinea. The genomes show this genetic link is more than 10,000 years old (Science, doi.org/cwws).

“The more we look at it, the more puzzled we are,” says team member Víctor Moreno-Mayar at the University of Copenhagen in Denmark.

Ancient sketch of mystery beast is oldest of its kind

A FAINT depiction of an unknown animal on a cave wall in Borneo is the oldest known work of figurative art. The painting was made at least 40,000 years ago, predating portrayals of animals found in European caves.

The limestone caves of the remote East Kalimantan province of Indonesian Borneo are adorned with many images, including reddish-orange paintings of animals.

Their creation dates were a mystery, so Maxime Aubert of Griffith University in Australia and his colleagues analysed layers of calcite covering the art. This mineral is deposited by dripping water, and analysing the uranium in it gives a date for when the art beneath was created.

The team found that a faint unknown animal on a section of cave wall depicting large wild cattle had been painted between 40,000 and 52,000 years ago. This makes it the oldest known art depicting a real-life object.

The oldest drawing in the world is a 73,000-year-old pattern of crossed lines in a South African cave. In Europe, the oldest artwork is also abstract, comprising red lines and a hand stencil made by Neanderthals about 65,000 years ago. But such abstract designs are simpler than figurative art, which makes the Borneo discovery particularly significant (Nature, doi.org/gfgx88).

The finding adds to growing evidence that South-East Asia – and not just Europe as once thought – was a key site for the development of art.

Gene blocker slows brain illness in mice

WE ARE a step closer to a gene therapy for amyotrophic lateral sclerosis, a degenerative disorder in which nerve cells progressively stop working in the brain and spinal cord.

Ten per cent of people with ALS have an inherited version of the disease, and 20 per cent of those have a mutation in a gene called SOD1 that causes their condition.

Martin Marsala and Mariana Bravo-Hernández at the University of California, San Diego, and their colleagues inserted an SOD1-silencing compound into a virus, then injected the virus into adult mice with an inherited ALS-like condition. Symptom onset was delayed by 80 days in these mice, and they never reached levels of muscle stiffness seen in untreated mice. Now trials are planned in primates.

The work was presented at the Society for Neuroscience annual meeting in San Diego last week.

Bot gestures like a TED talks veteran

WAVING our hands about when we speak can make us look less stiff and mechanical – and now that is true for robots too.

Youngwoo Yoon of South Korea’s Electronics and Telecommunications Research Institute and his colleagues trained a machine-learning system to match hand gestures to different words and phrases. They showed it 52 hours of TED talks taken from 1295 videos on YouTube, and then tested the software in a humanoid robot.

The resulting system was able to generate gestures for words and phrases – and for any length of speech – including open arms to suggest inclusiveness and pointing gestures for “you” and “me” (arxiv.org/abs/1810.12541).
Wandering Earths pepper the galaxy

TWO new planets have been found drifting alone in our galaxy. One is among the smallest such objects we have seen, and it seems diminutive free-floating worlds may actually outnumber stars in the Milky Way.

Exoplanets are usually spotted from the light dip seen as they pass in front of their star. But this does not work for planets without stars. Instead, anyone looking for wandering worlds must rely on a phenomenon called gravitational microlensing. This occurs when a planet’s gravity behaves like a lens, warping and magnifying the light of a distant star behind it.

Przemek Mróz at the University of Warsaw in Poland and his colleagues used this method to find the two new worlds. One is either about twice or 20 times the mass of Jupiter, depending on how distant it is. The other is either about 2.3 times or 23 times Earth’s mass (arxiv.org/abs/1811.00441).

Based on the low number of Earth-mass worlds like this we have found, and how difficult they are to spot, the team calculated that there might be more of these small exile planets than stars in the galaxy.

Some researchers think these worlds could be habitable, even if their skies are always dark. They may be kept warm by radioactive decay in their interiors and by their blanket-like atmospheres.

A faster, less complex way to spot signs of cancer in blood

A SIMPLE blood test can detect eight types of cancer from DNA fragments shed by tumours.

Most screening tools are either limited to certain body areas, as with mammograms for breast cancer, or they can spot tumours anywhere but only when large enough, as with MRI and CT scans.

So labs are developing blood tests capable of identifying multiple types of tumour at an earlier stage, when they are smaller and more treatable.

One approach is to genetically sequence blood to look for telltale cancer DNA. But the non-cancer DNA in blood makes this hard.

Florent Mouliere at the University of Cambridge and his colleagues have devised a quicker approach. They found that bits of cancer DNA in blood are often a different size to fragments of non-cancer DNA. For example, bowel and ovary cancer fragments tend to be shorter.

Their test detected 94 per cent of breast, bowel, ovary, skin and bile duct cancers in 68 people with later-stage cancer. However, 2.5 per cent of the time it identified a tumour that wasn’t actually there. The test also found 65 per cent of pancreas, kidney and brain cancers in 57 other people (Science Translational Medicine, doi.org/cwwp).

In comparison, an existing blood test called CancerSEEK detected 70 per cent of common cancers on average, although it was tested on earlier-stage ones. Mouliere says his team’s test could, in theory, detect any type of tumour, and its simplicity means it could be available for use in the near future.

Frog gains power to regrow lost leg

A TYPE of African frog has had its weak limb regenerating powers beefed up.

If it loses a leg, the African clawed frog usually regrows a thin spike of rubbery cartilage. Now Michael Levin at Tufts University, Massachusetts, and his colleagues have coaxed the frog into regrowing a wider, paddle-like structure with bones, nerves and blood vessels, although no foot.

The team achieved its result with progesterone, which is best known as a female sex hormone but also plays a role in wound repair. It was delivered via a bioreactor, a small box holding progesterone-loaded gel that was sewn over the wound straight after amputation.

Leaving it in place for 24 hours triggered a cascade of regrowth that lasted nine months. The animals could use the resulting limbs in a basic swimming motion (Cell Reports, doi.org/gfgz7). Levin says his team has begun using more complex bioreactor cocktails, and found this leads to better-formed limbs with partial toes.

He says it might be possible to regenerate human limbs if we find the right chemicals to apply.

Many early disorders remain a puzzle

PARENTS who have a baby with a developmental disorder want to know if their next child will have it too. Unfortunately, giving an answer is looking harder than we thought.

About one in 100 children are born with unexplained deformities, learning or behavioural difficulties, or the likes of heart disorders. Even though neither parent is affected, genetic causes are suspected.

The Deciphering Developmental Disorders project in the UK found last year that nearly half of such disorders were due to a new mutation in the sperm or eggs of one parent. For the rest, suspicion fell on rare recessive mutations – ones that must be in both copies of a gene to have an effect.

Now the team has looked at 6000 children in Europe with these disorders and found that only 4 per cent were due to such mutations (Science, doi.org/cwwv). So around half the cases remain a mystery.

Team member Hilary Martin says the most likely explanation is that the effect of many rare genetic variants depends on other inherited variants. A parent might carry a mutation that only has an impact if the child has variants from the other parent.
Scanning the future of food

A lab-on-chip that fits inside a smartphone is set to change our relationship with food and the chemicals we use to make it.
fits into a smartphone,” says Valouch. The prototype spectrometer uses four small incandescent lamps to fire low-intensity infrared radiation, with wavelengths between 1 and 3 micrometres, at the product under investigation. Different molecules respond to infrared radiation by vibrating at different frequencies, and with different harmonics. That means each kind of molecule in the sample has an individual infrared fingerprint. The Hertzstück device sends the detected fingerprint to a computer, which searches a database for materials with the same signature. The first commercial application of Hertzstück will probably be in that area of agriculture and will give farmers the ability to make better decisions, for example about the right time to harvest or the products they are using. “There’s a real need for determining whether the herbicides they buy are the real deal or inferior counterfeit,” Bruder says. “European companies lose a billion euros a year to fake herbicides, and the farmers can have their crops ruined because of it.”

And that’s only the beginning: foodstuffs are also a common source of fraud (see “Seeing through the fakes”, right).

It’s not just about fighting crime, though. Within a few years, trinamiX thinks you will be pointing your Hertzstück-equipped phone at supermarket food to see if it contains non-vegan ingredients, for instance. You might even raise your phone to your cheek to see if that new moisturiser you bought really is holding in moisture.

Before then, supermarkets will be using Hertzstück to check product freshness on the shelves. This is already working, and it impressed Mosley at the London Restaurant Festival. “That means you can measure the fat or water content of a cheese without opening the packaging, and do the analysis right there in the supermarket,” he told the crowd.

Indeed, the Hertzstück sensors are already used for industrial applications that depend on the reliable detection of infrared light, like flame detection.

More at: www.BASF.com/hertzstueck

Seeing through the fakes

Counterfeiting is a multibillion-dollar business worldwide. It’s not just about works of art, money or branded clothing, though. Counterfeited food is such a major issue that the US House of Representatives has expressed concern and called for better ways of sampling and testing foodstuffs. Investigators have found olive oil contaminated with seed oils, for instance, and peanuts that were deliberately mislabelled as more expensive pine nuts. These are dangerous practices that can kill people who are allergic to the hidden contaminants.

One of trinamiX’s big hopes is that its Hertzstück device can overcome the growing problem with adulteration, in which valuable ingredients are mixed with cheaper, similar-looking chemicals. One example, particularly prevalent in Asian markets, is the adulteration of milk powder with melamine. Standard fraud detection equipment looks at the nitrogen content of the powder, but melamine is not different enough from milk in this respect – it still looks good. “But near-infrared spectroscopy can distinguish between pure milk powder and milk powder contaminated with melamine, so that’s something we can stop,” Valouch says.

The Hertzstück device can also distinguish between saturated and unsaturated fatty acids. If the sensitivity can be tweaked sufficiently, it might even be possible for future versions of the detector to tell apart the various grades of olive oil, something that could halt the world’s most widespread food fraud in its tracks.

Textiles importers will also be able to put the Hertzstück scanner to work. Near-infrared spectroscopy can tell the difference between a variety of fibres, sorting silk from cotton, and cotton from a polyester-cotton mix. Those equipped with the device will be able to tell whether manufacturers are using cheaper fibres than they claim.

Shoppers should benefit too as and when the device is embedded in smartphones. “In a clothes shop you’ll be able to use your phone to determine what kind of fabric their clothing is made from,” says Valouch.
Global cooling starts at home

Household heating systems are huge sources of carbon emissions – but we have the technologies to fix the problem, says Michael Le Page

WINTER is coming to the north. If you live in those climes, chances are you have already switched on your heating. Chances are, too, that your heating burns fossil fuels. If the world is to meet its climate goal of zero net carbon emissions by mid-century, that needs to change – and change fast.

“We are two boiler replacements away from 2050,” says researcher Lukas Bergmann of consultancy firm Delta Energy & Environment. It is a huge challenge. In the UK, for example, 85 per cent of homes use natural gas for heating, and a third of the country’s total greenhouse gas emissions are from heating. Across the world, hundreds of millions of homes, offices and factories will need major, often expensive, upgrades.

Many countries have only just begun to notice the problem. “It’s a huge consumer issue,” says Richard Lowes at the University of Exeter in the UK. “Yet if you asked the average person in the street about this, they would have no idea what you are talking about.”

The good news is that heating can be greened with existing technology. But can it be greened fast enough?

While coal and oil are the worst offenders as heating fuels, even natural gas must go. To help meet the Paris target of limiting warming to well below 2°C, the use of natural gas must be entirely ditched across the European Union by around 2035, according to a study last year co-written by Kevin Anderson of the Tyndall Centre for Climate Change Research in the UK. “An urgent programme to phase out existing natural gas and other fossil fuel use across the EU is imperative,” he says.

The broad outline of the fix for heating is clear: heat pumps powered by clean electricity in rural and suburban areas, and district heating systems in more densely populated locations.

Heat pumps can produce up to five times as much heat energy as they consume in electrical energy. There is nothing magical about this: they use electricity to suck heat from the air, water or ground near a building, just as your fridge extracts the heat from its interior. Even in countries where most electricity is generated using fossil fuels, replacing a gas boiler with a heat pump will reduce
Putting a price on carbon that reflects its true cost would make green heating options more appealing

Then there is the question of where the low-carbon electricity to power the heat pumps will come from. Cold, windless winter days. Sweden already generates most of the electricity it needs from dependable nuclear and hydropower. But for nations like the UK, where the peak demand for heat energy in the winter is already six times higher than the peak demand for electricity, this is a huge issue (see graph, below).

Two solutions have been proposed for cutting electricity use. One is to retrofit homes – for instance, with insulation – to make them zero emission for heating and cooling. That is costly. The other is to keep heating with gas, but make it lower carbon.

The simplest way to do this would be to generate methane from sources such as sewage. However, even using all available waste and all available crops to make biomethane would only meet a fraction of the demand – perhaps 5 per cent in the UK, according to an analysis by the Anaerobic Digestion and Biorenewables Association.

Do what works

An alternative proposed by gas companies is to replace natural gas with hydrogen. It produces only water when burned, so it is zero carbon. In principle, huge quantities could be made by using electricity to split water, or by converting natural gas to hydrogen, and capturing and storing the resulting carbon.

But both processes waste a lot of energy, and neither has ever been done on anything like the scale required. Nor do we have electricity to spare, at least for now. Unlike with biomethane, switching to hydrogen would also require upgrades to gas networks and the replacement of home appliances.

According to a 2018 study for the UK’s Committee on Climate Change, this wouldn’t be much more expensive than installing heat pumps. But Lowes is sceptical. “No one else in the world is going down the hydrogen route,” he says. “I don’t think it will ever happen.”

The best way forward may be to try everything and see what works: installing more heat pumps and district heating networks where that makes sense, insulating houses to cut energy demand and carrying out small-scale trials of hydrogen. Hybrid approaches, such as heat pumps that are powered by gas only on the coldest days, could take us a long way.

Putting a price on carbon that reflects its true cost would help raise money to support all these measures and make green options more appealing to consumers. In Sweden, adoption of heat pumps soared after a carbon tax was introduced in the 1990s.

Other countries are now getting serious. In the Netherlands, new networks using low-carbon energy sources are now common in its cities, and more than half of detached houses have a heat pump. Emissions from heating Swedish buildings have fallen by around 90 per cent since 1990.

It may be harder to achieve such change in other countries. In the UK, most houses leak lots of heat. Because electricity costs more than gas, if a heat pump replaces a gas boiler in a badly insulated house, energy bills can go up instead of down, upsetting householders.

Heat pumps are also not a straight swap for existing boilers. They warm water to temperatures around 20°C lower, meaning radiators may need to be bigger to keep houses warm, and storage tanks larger to supply enough hot water for showers and baths. On the plus side, though, heat pumps can cool your house in summer.

In the UK, peak winter demand for heat far exceeds that for electricity.
Beware an AI-fuelled world

Fears of an artificial intelligence apocalypse make the news, but it is AI-driven inequality we should worry about, says Andrew Simms

ONE of the biggest potential impacts of artificial intelligence is often overlooked. Rather than the frequently touted extremes of technological utopia or an end to humanity, AI could entrench and deepen the status quo, intensifying business as usual by ramping up overconsumption and inequality. For many scientists, this is a big concern.

Scientists for Global Responsibility, a campaign group for scientists and engineers that I work for, recently surveyed its 750 members about AI’s effects on the future. Nine out of 10 respondents thought that AI would deliver more power and economic benefit to corporations than to citizens. Eight out of 10 thought AI would lead to a dystopian future, rather than a utopian or unchanged one.

Mark Carney, governor of the Bank of England, recently said AI is part of a fourth industrial revolution, which will not only tilt the balance of power further away from low-paid workers to the owners of capital, but “substantially boost productivity and supply”. In other words, AI will enable us to make a lot more stuff using fewer people, and as a result is likely to worsen overconsumption and unemployment levels.

Predictions about how AI and automation will affect work suggest that anything from 35 to 50 per cent of all jobs could be at risk, according to the University of Oxford and the Bank of England. Profits from this change are likely to flow to corporations and their owners rather than their workforces, deepening inequality and exacerbating the decline in wages relative to global wealth seen over the past 20 years.

Alarm bells about an AI dystopia are already ringing. There

Radicals running riot

Only science can check Iran’s crackdown on environmentalists, says Kaveh Madani

EARLIER this year, nine Iranian conservationists were arrested by the country’s Revolutionary Guards on charges of espionage. Members of the Persian Wildlife Heritage Foundation, they are accused of using camera traps to monitor Iran’s ballistic missile programme, collecting sensitive data for “hostile nations”.

One of them, Kavous Seyed-Emami, died in prison in February. It was reported to be suicide, although his family strongly disputes that. Four have been charged with “corruption on Earth”, which can carry the death penalty under Islamic sharia law.

I am an environmental expert myself. At the government’s invitation, I returned to Iran after 14 years to serve as deputy head of its environment department. But just seven months later I went into hiding with my wife, after being arrested, detained and interrogated many times.

I was called a bioterrorist, water terrorist and spy for MI6, Mossad and the CIA. The Revolutionary Guards even claimed I was manipulating the weather to create a drought. They criticised me for supporting the ratification of the Paris Agreement on climate change, saying it would limit economic growth.

Biodiversity losses, soil erosion, drying rivers and wetlands, deforestation, desertification, air and waste pollution, and dust storms are just some of the environmental problems facing Iran. They did not arise overnight, but after decades of short-sighted development policies.

Iranians who were unhappy about the economy, politics or human rights could once vent their anger by speaking out on environmental issues, without fear of reprisal. But as these worsen, the voices are becoming
are fears about the development of weapons that decide for themselves who to kill — so-called killer robots — and about how AI could lead to a supercharged surveillance society, where everything you do is tracked and recorded. AI is also being used to intensify environmentally damaging resource extraction. An embattled oil and gas industry sees AI as a “godsend”, as one leading industry journal put it, and is now using the technology to help find new places to look.

The recent UN special report on meeting the 1.5°C climate target concluded that rapid, far-reaching and unprecedented transitions were needed across the whole of society, with low energy demand and low material consumption being the top priorities. This seems at odds with using AI to seek more fossil fuels.

But the worst effects will only happen if we let them. My colleagues and I are calling for 20 per cent of all AI research funding to be used to assess its potential benefits and harms, so that we can make informed choices. Technology isn’t destiny. We don’t have to do something just because we can.

Andrew Simms is assistant director of Scientists for Global Responsibility

more strident and environmental groups are being suppressed.

I have learned that if I spoke out, academics, journalists, activists and ordinary citizens found the courage to be more vocal. To rescue the imprisoned conservationists, we need the world’s scientists to challenge the ridiculous narratives of a radical, powerful minority in a country of 80 million people.

If the scientific community does not act, what is happening in Tehran today could happen elsewhere tomorrow.

Kaveh Madani is the former deputy vice president of Iran and now a visiting professor at Imperial College London

The trouble with grabby headlines about risk

**Tom Chivers**

**ANALYSIS Reporting risk**

HOW should scientists and journalists report risk? The way in which a statistic is presented can change how alarming it sounds. Too often, both newspapers and scientific journals choose the most alarming, but least informative, approach.

For instance, according to a widely reported study published in the BMJ this month, if a man fathers children at age 45 or older, his children are more likely to experience various health issues, including seizures. Specifically, if a man is aged 45 to 54 when he becomes a father, his children are 18 per cent more likely to experience seizures than a man who is 25 to 34.

That is an alarming but misleading statistic. It is presented as “relative risk”: how likely one group is to have seizures compared with the other. But it doesn’t tell an individual how likely his child is to have seizures.

That figure is known as “absolute risk”, and it is both more revealing and more reassuring. A child’s absolute risk of having seizures if their father is 30 is 0.024 per cent: that is, 24 out of every 100,000. If a man has a child at 50, it is 0.028 per cent. “An 18 per cent increase sounds shocking, but in reality, it will affect four people in every 100,000,” says Jennifer Rogers, a statistician at the University of Oxford.

The difference is vital. But too often, when scientific stories are reported we read about relative, rather than absolute, risk. New Scientist hasn’t been immune to the tendency, and the “older fathers” story isn’t the only one in recent weeks. The Today programme on BBC Radio 4 discussed a conference paper finding a “100 per cent increase” in breast cancer risk among women who prefer to get up late, compared with those who get up and go to bed early. But the absolute risk in a given eight-year window was 2 in 100 for “night owls”, compared with 1 in 100 for “larks”.

“Relative risk is fine for scientific inference,” says David Spiegelhalter, professor for the public understanding of risk at the University of Cambridge. So if you are interested in whether two things are associated, then it is helpful. But if you want to help people make decisions about their life, “it’s useless”, he says. “It’s totally the wrong measure. You cannot decide an appropriate action without absolute risk.”

This isn’t just an issue for the media: journals and scientists often fail to report absolute risk prominently. The study in the BMJ reported its findings in relative risk, in contravention of the BMJ’s own guidelines. And in August, The Lancet published a meta-analysis on the health impacts of drinking that concluded there was “no safe level”. But it, too, gave relative risks, also against the journal’s guidelines.

“If scientists and journals don’t make absolute risks easy to find, then journalists can only report the relative risk. If the study or story includes any recommendations about individual action or policy, then scientists and journalists should insist on reporting using absolute risk, says Spiegelhalter. “It’s so irritating that they don’t. We know from both experience and research that absolute risk, and especially the expected number of people – what does it mean per 1000 people or per 100 – is such a clear way of communicating.”

He added: “One must suspect that the reason it’s sometimes not done is because when it’s not put in those terms, the effects don’t seem very important.”
Various tools (above, below and middle bottom) are needed to keep the ADMX detector in good shape.
Detecting dark matter

NO, THIS isn’t a boiler room. This humble-looking machine in Seattle is searching for the universe’s missing ingredient: dark matter.

Dark matter is thought to account for 85 per cent of all the matter in the universe, but we don’t know what it is made of. The hunt for the front runners to explain its effects – weakly interacting massive particles (WIMPs) – has come up empty so far. So some physicists are searching for axions, a different type of particle, to explain the mysterious form of matter.

This detector, called the Axion Dark Matter Experiment (ADMX), takes advantage of a unique theorised property of axions: when they are exposed to a magnetic field, they can be converted into photons of light.

The detector’s powerful magnet is designed to do just that, collecting the photons in a box that is kept at less than a tenth of a degree above absolute zero. So small is the expected photon signal that the detector has the most sensitive amplifiers in use in any scientific experiment, ones developed to read out subtle microwave signals in quantum computers.

Looking for traces of axions that have turned to light, the ADMX team slowly cycles through different frequencies, hoping for a ping. “We’re listening for our favourite radio station, and we’re turning the dial really slowly so we don’t miss it,” says ADMX operations manager Andrew Sonnenschein.

And if they find that station, they will solve one of the universe’s greatest mysteries.

Leah Crane

Photographer
Tony Luong
tonyluong.com

Research engineer Nick Force works on ADMX’s largest magnet (above). It is fed by several valves (one is pictured top right) and produces a magnetic field 150,000 times stronger than Earth’s. When the detector is switched on, gauges display pressure and other measurements (bottom right) and a sign illuminates (middle right).
IT WAS Dominik Rauch’s birthday, and he was 2300 metres up a mountain in the Canary Islands when a freak winter storm nearly wrecked his PhD. It could have been worse. A few hundred metres away, his colleagues only just managed to scramble out as the wind picked up their aluminium-framed office container and slammed it against the dome of a nearby telescope, just above a steep drop.

“Nobody was hurt,” says Rauch. “We were pretty happy.” But the crystal they planned to use to prise out reality’s secrets was broken beyond repair.

Their experiment atop the Roque de los Muchachos on the Spanish island of La Palma was just the latest and most ambitious of many that have probed quantum mechanics, the inscrutable theory that describes nature’s most basic workings. With six telescopes, oodles of delicate optical equipment and the light emitted by galaxies billions of years ago, they aimed to test an assertion championed by Einstein: that the weirdness of quantum mechanics is just a cover for some deeper, hidden reality.

And test it not just for here and now, but for almost all time, and across virtually the entire observable universe. If any experiment could break quantum theory, this one could.

When quantum mechanics was formulated almost a century ago, it overturned two particularly cherished assumptions about the world’s workings. First was realism. Unlike classical physics, which says the world exists independently of observers and observations, quantum theory strongly implies that reality does not exist, or at least cannot be meaningfully described, until it is observed.

The second problem was “non-locality”. This stemmed from the phenomenon of entanglement – what Einstein termed “spooky action at a distance” – in which events in one region of space-time can seemingly instantaneously affect events elsewhere, even light years away. This goes against Einstein’s relativity, in which no influence can travel faster than the speed of light.

For Einstein, the anti-realism and non-locality of quantum mechanics meant the theory wasn’t complete. There had to be some concealed underlying physics that gave better explanations.

The arguments rumbled on even after Einstein died in 1955. In 1964, Northern Irish theorist John Bell finally gave experimentalists a way to pit Einstein’s local realism against quantum mechanics and see which better explained things. To start, you produce pairs of quantum particles, such as photons, in such a way that from the viewpoint of quantum mechanics they are entangled. You then separate every photon from its companion in space, and independently measure a specific quantum property of each.

Most such tests look at polarisation, measured in one of two directions. In classical physics, you would expect there to be no correlation between outcomes of measurements on photons of a pair, beyond what you would get by random chance. In Bell’s
test, any theory that preserves both reality and locality would permit only a certain maximum amount of correlation. Quantum mechanics, meanwhile, being non-local, would allow the correlations to exceed this bound.

In the 1970s, the experiments were finally done – and the answer seemed clear. Bell’s bound was busted. Quantum mechanics ruled. But these early experiments still couldn’t fully discount the possibility that a local-realistic theory was pulling the strings. For example, if the two people running the experiments – call them Alice and Bob – aren’t far enough apart, a hidden influence travelling at anything up to light speed could cause Alice’s measurement to influence Bob’s, or vice versa.

Closing the loopholes

Alongside this “locality loophole”, there’s also the fair sampling loophole: if the detectors that Alice and Bob use are, as is likely, inefficient and detect only a small fraction of the photons, something in their sample might skew the results towards a non-existent correlation. Then there’s the freedom-of-choice loophole: a watertight implementation of Bell’s test requires that Alice and Bob are absolutely free to choose their measurement settings independently of each other.

By 2015, a slew of experiments claimed to have plugged these loopholes, by separating Alice and Bob in space, using high-efficiency detectors, and employing separate, ultra-fast random number generators with which Alice and Bob determined the experimental settings. The results remained the same.

But in 2011, Michael Hall at the Australian National University in Canberra had already floated the idea that using random number generators might not be enough to close the freedom-of-choice loophole. If the random number generators and the photon source had interacted via a hidden mechanism any time in the past, that could have influenced the choice of measurement settings and maybe even the properties of the photons, creating the observed correlations. Hall’s work eventually forced the experimentalists to think again. “I wanted to say to people: stop saying quantum mechanics is non-local as a matter of fact,” he says.

But how could you exclude this possibility in an experiment? “There was a feeling at the time that the freedom-of-choice loophole was simply unaddressable,” says Morgan Mitchell at the Institute of Photonic Sciences in Barcelona, Spain.

Mitchell and his colleagues came up with
an innovative answer: they outsourced the choice of detector settings to people playing video games. In the “Big Bell Test”, each gamer was required to rapidly generate a sequence of 0s and 1s, while a machine-learning algorithm tried to predict what they would do next. The more unpredictable their sequences were, the higher the gamers scored on the game.

On 30 November 2016, about 100,000 players produced nearly 100 million random digits, which were piped to 13 experiments on five continents performing different variants of Bell’s test.

As the Big Bell Test team revealed earlier this year, all the experiments, fed with the random digits over 12 hours, broke Bell’s bound. “If we assume that humans have free will, then we have closed the freedom-of-choice loophole,” says Mitchell.

That, however, is the kind of assumption that keeps philosophers awake at night. And there was a way of avoiding it. Every event in space-time, such as Alice and Bob making a measurement, has a “past light cone”: a volume of space-time from which a hidden influence moving at the speed of light or slower, can have travelled to affect it. So what you needed to do was ensure the random events used to choose the measurement settings were from as far back in the past as possible, excluding such meddling.

That’s where Andrew Friedman, Jason Gallicchio and David Kaiser had a brainwave. “We tried to outsource the random number generator to the universe itself, make the universe work for us,” says Kaiser, of the Massachusetts Institute of Technology.

The idea was simple, but radical. Alice and Bob could use telescopes to receive photons from distant astronomical objects, and exploit each photon’s colour to generate random digits for the measurement settings. For example, photons redder than some threshold wavelength could trigger a polarisation measurement in one direction, while bluer photons could trigger a measurement in the other. By using cosmological photons to determine the measurement settings, and demonstrating that the Bell bound was still broken, you could show that no hidden influence could have affected the detector settings in all the time the light was travelling towards Earth.

To do this, Kaiser and his colleagues teamed up with Rauch’s supervisor, Anton Zeilinger of the Institute for Quantum Optics and Quantum Information in Vienna, Austria. Their first experiment placed the source of entangled photons on the rooftop of the institute on Boltzmanngasse in the city, and Alice and Bob in two buildings with a clear line of sight to the source: Bob on the fifth floor of the University of Natural Resources and Life Sciences roughly north, about 1150 metres away, and Alice on the ninth floor of the Austrian National Bank some 550 metres in a southerly direction. “They print money in the basement there,” says team member Thomas Scheidl.

Each night, once darkness set in, the team used small telescopes to observe stars in opposite directions in the sky. The photons collected by these telescopes were piped through optical fibres to special mirrors that sent them one way if the photon’s wavelength was less than 700 nanometres, and another way otherwise, randomly generating 0s and 1s used to determine the measurement settings.

Like all others before it, the Vienna rooftop experiment broke Bell’s bound, showing that any hidden influence could not be at work.

**Sorry, Einstein**

In experiments atop the Roque de los Muchachos on La Palma in the Canary Islands, researchers have measured weird quantum correlations between pairs of generated photons – excluding the possibility the correlations could be explained by conventional physics. Quantum characters Alice and Bob show how they did it...
now, or in the past 600 years or so, the time the starlight had taken to reach Earth.
But the original proposal by Kaiser and his colleagues was more ambitious. It envisaged using light from very luminous galactic sources known as quasars, billions of light years away.

“Quasars are the objects furthest away from us that are still visible with optical telescopes,” says Scheidl. They were going to need a bigger telescope. It was time to climb a mountain.

Just as in Vienna, the experiment required three sites, with Alice and Bob both hooked up to telescopes, a source of entangled photons in the middle, and a clear line of sight between the three. The Roque de los Muchachos on La Palma, a mountaintop pockmarked with telescopes, had the perfect configuration.

Alice could use photons from the Italian-run Galileo National Telescope, and Bob photons from the William Herschel Telescope, jointly funded by the Netherlands, Spain and the UK. Meanwhile, the car park for the Scandinavian-run Nordic Optical Telescope, situated almost exactly halfway between, roughly 500 metres from each, would house a container office with the optics to produce photons and beam them towards Alice and Bob (see graphic, left).

It took a while to persuade the astronomers to give quantum physicists time on the two telescopes, but eventually three days of observing time were scheduled in January – with news that a team in China was doing a similar experiment setting the European competitive juices flowing.

It was during final preparations, on 13 December last year, that disaster struck. Zeilinger, Scheidl and others were in Vienna when they heard the news of the overturned container. “You will eventually have your PhD and you will at least have a story to tell,” Rauch recalls Zeilinger telling him. “I could not quite share his optimism at that point.”

Even as construction workers were securing the container, the wind blew it away again. This time, it almost fell over the edge. “I thought everything that wasn’t broken before was broken now,” says Rauch. Over the next few days, the team fixed most of the experimental apparatus, and re-established the links between the photon source and Alice and Bob. But the light crystal that generated the photon pairs was beyond repair. Rauch ordered a new one and flew home for Christmas.

Almost miraculously, the team managed to get the experiment up and running again to hit the allotted observing time. But the first night was lost to another storm: it was hailing and the telescope dome couldn’t be opened. Bad weather ruined the second of the allotted nights too. On the third night, things cleared up. With the moon below the horizon, and the sky dark except for the stars, the large telescopes began tracking quasars.

But a problem with Alice’s equipment meant she couldn’t collect enough photons from her quasar – and before the team could fix it, telescope time was up. The next day, they went begging for more. The Galileo telescope was available, but at the other end it took the largesse of one Herschel astronomer, who gave up 2 hours of his allotted time to the quantum physicists. “We bought him some beer and wine,” says Scheidl.

That night in mid-January, the two telescopes locked into quasars in opposite patches of the sky to trigger the measurement settings for Alice and Bob. One had emitted its light 7.8 billion years ago and the other 12.2 billion years ago. The researchers were able to collect and analyse data for nearly 18,000 pairs of photons. Bell’s bound was yet again broken, and strongly so.

Because the quasar sources are in different directions in the sky, their past light cones only overlap 13.15 billion light years in the past. That rules out any local-realistic mechanism pulling the strings from all but 4 per cent of the space-time it might have existed in – “virtually the entire past light cone of the experiment extending all the way to the big bang”, says Kaiser.

The final word? Not quite. Even though the experiment closed the locality loophole and pushed the freedom-of-choice loophole to an extreme, “we were not even trying to close the fair sampling loophole”, says Kaiser. The need to transmit the photons from the source to Alice and Bob through the air meant too many were lost to ensure watertight detection efficiency.

Meanwhile, the competing team in China, led by a former student of Zeilinger’s, Jian-Wei Pan at the University of Science and Technology of China, made a stab at shutting all three loopholes. Losses of photons were minimised by using optical fibres to transmit them from the source to Alice and Bob, all situated on the outskirts of Shanghai. To generate the random numbers, the team used light from stars only 11 light years away, but still, “our experiment conclusively rules out local hidden variable models taking place 11 years before the experiment”, says Pan.

Both teams are now thinking how to push things further, for example by using photons from the cosmic microwave background, the radiation left over from the big bang.

“It’d be a delicious technical challenge, a really beautiful, really hard experiment,” says Kaiser. “There is no earlier source of light in the cosmos that one could try to use.”

Niggles aside, however, the conclusion already seems clear. It comes as little surprise to most physicists, but it’s as well to check: Einstein’s local-realistic universe, if it exists, has been pushed into a tiny corner of the cosmos. Elsewhere, there seems little room for doubt that quantum mechanics, or something based on it, is the correct description of nature. The theory’s mysteries may remain as unfathomable as ever, but for Kaiser that is cause for celebration. “I think ordinary quantum theory looks as good as it ever has – which is to say, it looks terrific.”

Anil Ananthaswamy is a consultant for New Scientist
I hadn’t thought a scientific expedition would involve cockroaches or pirates, and certainly not both. And yet there we were, our team of four, sailing through a part of the Indian Ocean synonymous with Somali piracy, aboard a wooden cargo ship filled with a population of many thousands of grudging insects.

We shared our sweaty cabin with a crew of 12 Gujarati sailors. In between watching for other vessels and clambering among the bags of cement on deck, our three days at sea were punctuated only by visits to the ship’s “toilets”: two wooden boxes strapped to the outside of the hull. Glamorous it wasn’t, but none of us would have wished to be anywhere else.

We were on our way to the Socotra archipelago. Largely unknown in the wider world, this group of islands is a UNESCO World Heritage Site on account of its rich endemic flora and fauna. More than a third of its 800-plus plant species are unique to Socotra, whose westernmost island is just 100 kilometres from Somalia and the Horn of Africa. Some 400 kilometres to the north is Yemen, to which the territory belongs. With both countries torn apart by civil war, getting there isn’t easy. But that’s no reason not to try.

Our team’s leader was archaeologist Ella Al-Shamahi of University College London. She was in search of secrets about our ancestors’ migration out of Africa that might lie in caves on the archipelago’s main island, also called Socotra. I’m an author and filmmaker, and my job was to digitally...

Political instability and freak weather threaten the natural and cultural heritage of a group of islands known as the Galapagos of the Indian Ocean. Words by Leon McCarron. Photos by Martin Edström
map the major thoroughfares and tracks that cross the island.

The archipelago has been prized for its unique resources for at least two millennia, and it is said to have supplied much of the ancient world with frankincense and aloes used in perfumes and medicines. But the volume of scientific work done there is a mere fraction of what has been possible in the few comparable places on Earth. It had seemed like increased political stability in Yemen in the 1990s would improve things, but now the geopolitics of the region looks to be closing the door once more. Add in the increasingly extreme and frequent cyclones that hit its shores, and Socotra’s future as a refuge of natural and cultural heritage is far from assured.

Our scouting expedition, funded by the MBI Al Jaber Foundation, departed from the UK and Sweden to the Gulf in March, continuing via a sea route that we are unable to fully disclose for security reasons. There is an airport on Socotra, but the few available flights either transit through the United Arab Emirates (UAE), requiring special permits that are almost impossible to come by, or pass through an area of Yemen rife with al-Qaeda activity.

One night in early April, the northern coastline of the main island of Socotra came into view. Moonlight illuminated huge, white sand dunes swept by fierce winds against limestone cliffs. It was the first time any of us had been there, but for Al-Shamahi it was a homecoming of sorts. She grew up in the UK, but her Yemeni parents regularly took her back to Yemen and their extended family. On those childhood holidays, she heard about the natural beauty of Socotra, the “Jewel of Arabia”, and also the story that people there still lived in caves.

When she became an archaeologist, that connection with the country of her ancestors led her to increasingly question the standard narrative of human migration out of Africa. “We were always told that humans left via the Sinai peninsula,” says Al-Shamahi. “But because my family were from Yemen, I knew that the Bab al Mandab Strait, between Djibouti and Yemen, was really just a little gap. As far as I was concerned, crossing that wouldn’t have been that much of a feat for our ancestors.”

Previous page: Lonely beaches and granite cliffs surround the isolated main island of Socotra

Above: Socotra’s position between Africa and Arabia piqued archaeologist Ella Al-Shamahi’s interest in the islands’ possible role as a stepping stone for humans’ journey out of Africa

Above, right: The densely packed crown of Socotra’s iconic dragon blood tree Dracaena cinnabari reduces evaporation and allows it to thrive in the islands’ arid conditions. The red resin that gives the tree its name is highly prized as a medicine and dye
The thought spawned a project to search for palaeolithic fossils to work out which human species had made it to Yemen. But war broke out again on the mainland in 2015, and later a coalition led by Saudi Arabia and the UAE began widespread air strikes. This made it too dangerous for Al-Shamahi to return. Reluctant to stop working on Yemeni projects completely, however, her thoughts returned to the caves of Socotra.

“Caves are the original prime real estate,” she says. They are also a great environment for preserving fossils, which could answer the question: when did humans first get to Socotra?

Genetic data gathered from islanders suggests that a common ancestor arrived on the island about 6000 years ago, but it may have been much earlier. Al-Shamahi points to the work of local archaeologists in this regard, and the recent piecing together of the history of Socotra’s ancient inhabitants through rock art, carried out by anthropologist Julian Jansen Van Rensburg at the University of Exeter, UK, and independent geologist Peter de Geest.

On our arrival in Hadiboh, the windswept and searingly hot capital of Socotra, Al-Shamahi began by asking if the rumours from her youth were true: did anyone still live in caves? “Most people said no,” she says, “but a few strong voices said yes.” She pulled on this thread, and got a description of where they might be. Based on this, Ahmed Alarqbi, director of the Department of Antiquities on Socotra, helped us locate where in the island’s interior this was likely to be.

After a 3-hour jeep ride deep into the mountains, we arrived at a community of families living in brick buildings attached to caves where their parents’ generation had lived. But in monsoon season – which was imminent – they would all retreat to the caves for shelter, just like their ancestors. “This was so interesting to me, because we’d arrived at a transition point,” says Al-Shamahi.

The other two members of our team were busy at work, too. Martin Edström, our photographer, was gathering material for 3D virtual reality models of some of the most important natural features on the island, including its iconic species, the dragon blood tree (Dracaena cinnabari, pictured above). Our film-maker, Rhys Thwaites-Jones, shot the otherworldly landscape from dawn till dusk.

Al-Shamahi made initial explorations of promising cave sites, but time was against us. Each day, we waited for news from the port as to when the cargo ship that we arrived on would leave again. We had to be
Above: Socotra is home to many rare plant species. The resin from the Socotran frankincense tree *Boswellia socotrana* (background) was much prized in the ancient world, as the bottle tree *Adenium obesum* (foreground) is today as an ornamental plant.

Right and facing page: Al-Shamahi’s scouting expedition into the interior of Socotra’s main island will be followed by a longer trip next year.
on it. Once the monsoon began, travel by sea would be impossible for another four months. After only a week on the island, we had to depart.

Next year, we plan to mount a bigger expedition: a month-long transect of the island by a large team of specialists. The cave houses we saw are, as yet, unexplored. On our return, Al-Shamahi will seek permission to dig test pits to investigate the sediment that forms their floors.

Yet the scouting mission was invaluable, and not just for her research. It gave our team first-hand experience of the bigger picture: the Jewel of Arabia is changing. In 2015, it was hit by two cyclones within a week. Their power and close timing was unprecedented, and up to 18,000 people—nearly a third of the island's population—were displaced. Yemen's ability to respond was severely hampered by the ongoing war. Although other Gulf states, in particular the UAE, contributed to the aid effort, Socotra was left with critical damage to infrastructure as well as to homes, fishing boats and the natural environment.

The aftermath of the 2015 cyclones also contributed to a new political storm. The UAE had provided much-needed assistance after the disaster, but its continued presence on Socotra in the aftermath led to accusations that it was seeking to increase its influence on the island, which is strategically positioned at the mouth of the Gulf of Aden.

In May this year, the UAE deployed more troops in response to a visit to the island by the Yemeni prime minister, and Saudi Arabia dispatched a delegation too. Although Socotra remains as yet unaffected by the conflict on the mainland, there are now military representatives from three Gulf states on this small island that lies far from the shores of the Arabian peninsula.

May also saw another cyclone hit, killing 20 people and causing more mass destruction and displacement. Weather patterns here are also understudied, but climate change has been blamed for these extreme shifts.

When we return, our team will, in conjunction with people on the islands, look at how to build resilience to the effects of climate change, and how to bring the natural and scientific wonders of Socotra to the notice of the wider world. “This is adventure science,” says Al-Shamahi, “and Socotra lends itself to that. But it’s adventure science with a purpose.” With the threats now present on Socotra’s shores, that purpose is clearer than ever.

Leon McCarron is a writer, film-maker and adventurer from Northern Ireland. Martin Edström is a photographer based in Stockholm, Sweden.
A bat and a ball together cost $1.10. The bat costs $1 more than the ball. How much does the ball cost?
Intuitive ideas about how our mind works have permeated popular culture and shaped everything from economics to advertising. But have we got it all wrong, wonders Madeleine Finlay

How much does the ball cost? If you instantly guessed 10 cents, you’re in smart company: more than half of students at Harvard University and MIT jumped to the same conclusion. But you’d be wrong – the answer is actually 5 cents.

For years, this puzzle has been held up as the perfect example of the way we think being ruled by two types of mental processes: fast and intuitive, versus slow and analytical. If you arrived at the wrong answer before you had time to really ponder the problem, you might blame it on intuitive thinking leading you to make a snap judgement before slower, rational thinking had kicked in.

This idea that our thoughts can be split into two distinctive camps has become so popular it now influences many areas of everyday life. Marketeers try to tap into our automatic impulses with emotive adverts and special offers, while governments attempt to appeal to our deliberative sides, by doing things like putting calorie counts on menus.

These “nudges” are often based on the assumption that fast, intuitive thinking is likely to get you into trouble, so we need to cultivate the slower kind. The US National Academies of Sciences, Engineering, and Medicine and the World Bank have both issued reports urging decision-makers to use the slower type of thinking to avoid the expensive, or deadly, mistakes of the other form.

But a more complex picture of our mental processes is beginning to emerge. Categorising all our thoughts as one of these two types might in fact be leading us astray on all sorts of policies and practices. Armed with a new understanding of how we make decisions, we could all benefit.

From Descartes’s mind-body dualism to Freud’s infamous unconscious mind, a distinction has long been drawn between the two opposing factions of instinct and conscious reasoning. Yet it wasn’t until 1975 that psychologists Michael Posner and Charles Snyder presented the first dual-process model of the mind. In a paper, they described an efficient, automatic thought process that can operate without intention, and an inefficient, conscious process.

However, it was Nobel prizewinner Daniel Kahneman who turned the idea into a popular concept in his 2011 bestseller Thinking, Fast and Slow. In it, he describes our mental processes as typically belonging to system 1 or system 2 (see “Ways to think”, page 41).

Compare the difference between a joke and a riddle. A good joke is funny without needing to think about exactly why. This taps into system 1. A good riddle, however, requires us to lean on system 2, taking some time and brow-furrowing to get to that moment of satisfaction.

Since the book’s publication, the dual-process model of mind has blossomed into one of the most widely accepted ideas in psychology, becoming pervasive in research, with real-world implications. “The popularity of the book is [due to] the intuitive appeal of the two systems,” says Kahneman, who is at Princeton University. Those studying topics such as political beliefs, criminal decision-making and lie detection have used the model to investigate the source of our behaviours and beliefs. Research on binge drinking, for example, suggests that this impulsive behaviour is caused by an overactive system 1, which has also been identified as the source of interviewers’ false impressions of job applicants. The model has also been at the heart of evidence given to policy-makers about the implicit effects of advertising.

But despite its popularity, it can lead scientists astray. For several years, there was consensus that diagnostic errors were caused by system 1 type reasoning, and clinicians were advised to think more slowly. However, later reviews found that experts are just as likely to make errors when attempting to be systematic and analytical.

Now, spurred on by new evidence from neuroscience and problems reproducing some experimental results linked to the dual-process model, a growing number of psychologists are starting to wonder whether our most complex organ really operates in such a conveniently simple fashion.

“It’s such a sticky idea because it makes intuitive sense and resonates with people’s experience,” says Magda Osman, an experimental psychologist at Queen Mary University of London, “but having a false
conception of the mind can be damaging.” How we think – or think about thinking – can challenge or entrench our biases, help us avoid mistakes, or cause them.

One example Osman gives is something she calls the Prince Charming effect, in which we separate automatic thoughts from conscious, intentional ones to absolve – or rescue – ourselves from our mistakes and biases. “If something goes wrong, it saves us and excuses our behaviour,” she says. Take the bat-and-ball problem. People tend to feel better if they believe that coming up with the answer of 10 cents was an uncontrollable, unconscious response.

At a personal level, this might seem a minor consideration, but it raises serious questions for society as a whole. “If someone commits a crime and says in court, ‘I didn’t do it intentionally, I just wasn’t thinking. It was an automatic response’, we recognise that and we might be inclined to see them as less responsible for their actions,” says Osman. “We might even feel that it wasn’t really ‘them’ at all.” However, if our minds have more than two clear-cut modes, then deciding when something is intentional and worthy of blame is much more challenging.

David Melnikoff at Yale University agrees. “For over a decade, there was this idea that because stereotyping was a type 1 process it is much more challenging. Something is intentional and worthy of blame but in 2014, participants in another experiment were asked to predict the strength of their biases before taking the test. It turned out their guesses were pretty accurate. Our biases aren’t as unconscious as we would like to believe.”

Findings like these have led Osman, Melnikoff and others to question the binary model of our minds. For them, the critical point is that there is little evidence that the features of these two kinds of thinking, such as automatic and quick, or deliberative and conscious, actually go together at all. “This idea is taken as fact, but it’s never been tested,” says Melnikoff. “Plus, there’s reason to suspect that these features aren’t correlated. There are plenty of examples where they aren’t aligned.”

Take language. We deliberately communicate, but in the flow of conversation we don’t consciously rehearse what we are going to say or the grammatical rules we need to use. It is intentional and, at the same time, unconscious. The same can be said of driving on a familiar route, typing, or playing a well-rehearsed tune on an instrument.

We can even solve novel problems without being aware of how we do so. “People think that rules can’t be processed unconsciously,” says Melnikoff. “That isn’t true either.” Just take a look at the deck of cards, opposite.

You probably guessed intuitively, without needing to cogitate, that the next card should be the 10 of spades. Studies involving puzzles like this show we can process logic and rules in an unconscious but effortful manner.

In contrast, think about the bat and ball again. We can also be purposefully trying to solve a puzzle and yet still come up with a compulsive but erroneous response.

Unconscious influence

Other studies are further blurring the boundary between conscious and unconscious mental processes. In an experiment in which participants were given an identical-tasting drink containing either glucose or a calorie-free sweetener, those who had consumed sugar perceived a hill to be less steep when asked to estimate its slant. It indicates that on an unconscious level, your body is telling you how the world looks based on what it is capable of at that moment, says Simone Schnall at the University of Cambridge, who led the study. “Unconscious factors can influence our perception.”

To people like Osman and Melnikoff, these examples all point to a bigger question: is it really possible to distinguish between the two systems? In fact, we may be barking up the wrong tree altogether. “There’s still debate over many of the features, let alone the categories,” says Osman. “Demonstrating that things are unconscious or conscious is unbelievably hard. Usually you end up drawing arbitrary distinctions, like how fast ‘fast’ is.” Without good evidence to resolve such difficulties, opponents argue that there is no reason to assume that system 1 and system 2 exist at all.

Yet, Kahneman believes critics have missed the point. “It is a framework and not a theory, which can be used to make sense of phenomenological experience,” he says.
He argues that his metaphor of system 1 and system 2 can go a long way in describing thinking and aiding understanding of how we think. For him, the bat-and-ball problem is one of the best illustrations. “The number 10 is produced associatively, like 2+2=4. That’s clearly system 1. The computation part, where you take away the 10 cents from $1, calculate the difference and so on, that’s very clearly system 2. In that example, there is no ambiguity.”

Even when things are less clear-cut, argues Kahneman, almost all processes are a mix of both systems, each of which represent a list of characteristics that are likely to apply – but aren’t set in stone. For him, counterarguments fail to address the main reason the idea is so popular: we all have experience of two very different ways of coming up with thoughts and making decisions, passive association or active thinking. And because of this intuitive appeal, it is going to be tough to change public acceptance that this is how it is, says Osman, even if researchers are divided on the subject. “There’s still a lot of uptake by governments and industry,” she says. “It’s going to be hard to shift such a popular view.”

In the meantime, what most critics and protagonists agree on is the need to dispel the “good/bad fallacy”. This is the assumption that because system 1 is automatic and unconscious, it is error-prone, whereas system 2 is analytic and therefore correct.

“I think this is ridiculous,” says Kahneman. “It’s a common misunderstanding that system 1 is irrational and system 2 is rational.” In fact, he regards the automatic system as the more developed, complex and useful. “System 1 is not a machine for making errors,” he says. “It usually functions beautifully.” Unconscious processing can let us perform well-practised skills more quickly and easily. As Melnikoff puts it, “Don’t tell an athlete to think about their swing during a match.”

As well as giving our unconscious too much of a bad rap, the fallacy increases the risk of us not holding our conscious thinking to account. Humans have a lot of bad habits. We ignore evidence we dislike, rationalise our biases and produce questionable justifications for bad decisions: I only had a small breakfast, so it is fine to have a big slice of cake.

Often, we end up “overthinking”. In a recent study looking at deliberation, four cars were described using positive and negative attributes. The terms were 75 per cent positive for the first car, 50 per cent positive for the next two and just 25 per cent positive for the last vehicle. After reading the descriptions, some people were told to think about the cars for 4 minutes before choosing their favourite, while others were asked to solve anagrams during that time. When the list of attributes was long – 12 rather than four – the anagram group of “unconscious thinkers” consistently made better decisions than those who pondered the information.

This implies it might often be beneficial to delegate more complex matters to the unconscious. Similar tests have shown the same with posters, and assessments of job applications and strawberry jam.

If we can’t always trust our instincts, but our conscious mind isn’t all it’s cracked up to be either, how should we think about how we think? According to Osman, no type of reasoning should be consigned to the scrapheap. Our gut feelings and intuitions, as well as our explicit reasoning, have been informed by the evidence around us, even when we aren’t consciously aware of it.

Instead, she advises being critical about thinking. This means you should challenge all types of thinking, and not just your instincts, says Osman. “It’s useful to look at how well we scrutinise the information available, to what degree we’re motivated in making a decision and what our motivations are,” she says. “Just saying, ‘why do I think that?’ or imagining yourself in the opposite position can be useful.”

Kahneman agrees it is a good idea to be sceptical, particularly when statistics are involved. “If there’s a statistical angle, don’t trust yourself.” However, he isn’t convinced about people trying to “think better”. He has hope in other areas though. “When it comes to institutions and organisations making decisions, these are much slower and so there is more room for improvement.”

This might involve people challenging views in discussions, taking time to review all the evidence between meetings or inviting in people with a fresh perspective. Unfortunately, for most day-to-day choices, measured deliberation just isn’t possible.

So if you fell for the bat-and-ball problem, don’t beat yourself up about getting it wrong. Next time you might outsmart your own thought processes. Just take a moment and ask whether it is time for a rethink.

**WAYS TO THINK**

The bestselling book *Thinking, Fast and Slow* captured the idea that our thought processes relate to two distinct systems.

**SYSTEM 1**

Jumping to conclusions, quick, automatic, effortless, intuitive, implicit and emotional.

**SYSTEM 2**

Slow and demanding, does the mind’s heavy lifting. It is deliberate, demanding, analytic, explicit and logical.

Madeleine Finlay is a writer based in London

Answer to card puzzle: the 10 of spades
THE 3D-printing revolution is here. From guns and houses to prosthetic limbs and vehicle parts, if you can think it, you can print it. Or you can as long as it is inanimate matter.

But imagine being able to print a kidney, or a brand new beating heart. Jennifer Lewis of Harvard University, who runs a team working at the living edge of 3D bioprinting, is aiming to do just that.

What do you see as being the long-term goal of bioprinting?
The ability to print and implant vital organs. Perhaps the first step will be an implanted tissue patch that would augment or repair a damaged organ. But clearly the holy grail would be to engineer vital organs, such as the kidney, the heart, the liver. To do so for those three organs would be of tremendous value. That’s what people are chasing, and what the research group I’m part of is focused on.

How close would you say we are to printing an organ?
We’re still decades away. It’s not enough to just print liver cells or cardiac cells or kidney cells. These cells have to function, they have to mimic the high densities of the living tissue. An organ performs many functions in the body, so we have to be able to replicate all of that and also put it into the body without the body rejecting it. There are so many challenges.

So we are also pursuing goals with immediate impact. As an example, the pharmaceutical industry spends about $1 billion bringing a single drug to the market, yet 20 per cent of all drugs fail clinical trials because they are toxic to the kidney. What the industry lacks is physiologically authentic models of human tissue to test drugs on. So we see the ability to print kidney tissue as an important focus.

What progress have you made on kidney tissue?
We’ve been working with collaborators at Brigham and Women’s Hospital in Boston to create mini-kidney building blocks, which have many of the key features of kidneys.

We want to try to use those to build up a volume of tissue that is big enough to essentially function like your kidney. Using this approach, we ultimately want to create three-dimensional organs with their own blood vessels.

Will these organs look like normal human organs?
I think from the perspective of capturing imaginations, it’s very important for people to see this tissue printed in a shape that they’re already familiar with, otherwise it might freak them out. But there are a lot of interesting shapes you could print that don’t correspond to the actual shapes of human organs.

What brought you to the idea of bioprinting organs in the first place?
Colleagues at the University of Illinois wanted to make self-healing materials. The idea was to emulate the body: if you cut yourself, blood flows from the blood vessels of your vascular network and forms clots, so your skin heals. Together, we figured out how to 3D print a network of channels — microvasculature — inside a synthetic material. This advance enabled a new class of self-healing polymers.

It was also a light-bulb moment. I had never tried printing live cells before, but I had been watching the tissue-engineering field closely, and realised that we had overcome the obstacle that had been holding it back. So I decided to translate this approach to living materials. That was around 2010.

So what was that breakthrough?
You can’t print living cells in 3D if there’s no vasculature to carry nutrients or blood to those cells. They will simply die. So we used a “fugitive ink” to create patterns of tiny cylinders within a 3D-printed tissue. The crucial thing is that this ink is erasable – after you’ve printed your tissue, you can remove that part, leaving behind open channels akin to vasculature.
What is fugitive ink and how does it work?
It is a substance designed to be a gel at room temperature. It comes out of the printer nozzle in a cylindrical shape and it keeps that shape within a printed structure. However, if you cool it down to 4°C, the gel goes from being a solid to being a liquid, which is the opposite of how materials normally behave.

That was the secret sauce in a way, because if you’re printing a structure with living cells at room temperature and you have to heat that structure up to liquefy the fugitive ink, then all the cells would die. But, crucially, cells stay alive when you cool them down. It’s a very simple idea, yet it also gave us the ability to vascularise 3D-printed human tissues, overcoming a huge challenge for the field.

“When the tissue fuses together, it starts beating as a collective unit”

It seems like things are progressing fast. Think of Moore’s law, which predicts exponential gains in computing power. The number of transistors on a computer chip has been roughly doubling every two years or so since the 1970s. The question is, does bioprinting follow its own version of Moore’s law? Without vascular networks, researchers could only really print tissues that were less than 1-millimetre thick. We have shown that you can print vascularised tissue that is around 1-centimetre thick. That means bioprinting is starting to scale exponentially.

When you print heart tissue, does it just start beating by itself?
Heart cells within the printed tissue do start beating synchronously. But it doesn’t happen immediately. First they beat asynchronously, until the tissue fuses together and beats as a collective unit, which is what your heart does. It takes several days or so for this process to happen. Then the tissue starts beating more strongly and the synchrony increases.

So you sort of set the scene for a living tissue, giving it what it needs to get going and then step back and let nature take over?
That’s right. We believe that to create these organ-specific tissues means printing some minimalist architecture that contains the appropriate cells, their vasculature and a support scaffold. But you let biology do as much of the building and assembly as possible, because we’re already programmed to create our own tissues. If you give these cells the right cues, they can do a lot on their own.

Could your technology displace animal testing by letting us check out drugs on printed organs?
Yes. But you don’t need a full organ to test drugs. We are currently focused on creating three-dimensional human tissue models that could be used for both drug toxicity testing and disease modelling. Specifically, we are creating 3D kidney tissues housed within chips in collaboration with a major pharmaceutical company.

Jennifer Lewis’s pioneering work could allow us to engineer organs from scratch

Sean O’Neill is a writer based in Bristol, UK.
Timely lessons

Today’s impulsive politics needs a dose of geology’s long-term mindset, finds Mick O’Hare

Timefulness: How thinking like a geologist can help save the world
by Marcia Bjornerud
Princeton University Press

THE first thought that springs to mind when picking up Marcia Bjornerud’s *Timefulness* is that the title is a nod in the direction of mindfulness, the notion of paying more attention to the present as our busy lives whizz by. Our psychological health, argue enthusiasts, benefits from living that way, offering a clarity that is absent when we worry, or concern ourselves with the past or future.

If that was the intention, then it takes only a few pages to discover that Bjornerud’s book is arguably the geological antithesis of such a modern-day affectation. Instead, she wants us to consider the past very deeply, and to learn its lessons so we are better prepared for the future. The book’s subtitle, *How thinking like a geologist can help save the world*, is both an explanation of its contents, and a stark warning that we cannot sit back in the present and merely hope for the best.

Essentially, her idea is both sound and simple to grasp: very long timescales are hard for us to comprehend. Timefulness, she tells us, gives us “a clear-eyed view of our place in Time, both the past that came long before us and the future that will elapse without us”. In other words, don’t just concern yourself with the here and now.

She wants us to learn what happened long before people occupied Earth, and consequently to teach us about the long-term processes shaping our future. Time is not our enemy, she argues, accusing humanity of fearing its passing. Drawing on Woody Allen, she notes that “Americans believe death is optional”, an example of our “chronophobia”. She fears short-term selfishness in politics and our personal lives may doom our species and others.

“Bjornerud’s book is a manifesto for humanity – but on a very long timescale”

Her pleas to think long-term take aim at religion, too, especially the notion of “creation science”. This not only contends that the world is a mere few thousand years old, but suggests life is preordained, so there is no point in fighting things such as species destruction or climate change. She has zero tolerance for such “brain-fogging pseudoscience” and “despairs at the existence of atrocities like Kentucky’s Creation Museum”. All, as you can imagine, get in the way of timefulness.

The geological stories are frequently wonderful. Bjornerud writes about zircon crystals found in the Jack Hills in Australia – the oldest terrestrial minerals ever discovered – and what they teach us about ancient Earth and its formation and behaviour. It is a lesson in how to make an obscure subject fascinating. Another triumph is her portrayal of the “great oxidation event”, the time when changes in the composition of Earth’s atmosphere transformed the possibilities for life. She makes it so interesting.

Her comparison of high levels of carbon dioxide today with similar levels 55 million years ago teaches us what climate processes to expect if we continue down our current, destructive path.

It is always a challenge to make geology accessible to a popular audience, but *Timefulness* is never impenetrable and is sparing in its use of jargon. *New Scientist* readers will have little difficulty following the heartfelt narrative.

Bjornerud’s book is a manifesto for humanity – but on a very long timescale. Yet despite her impeccably argued appeal for a new geological awareness that could help us think beyond next week, it seems destined to fall on deaf ears. We are, after all, living in the ad-hoc time of Donald Trump and Brexit, and of the pugnacious spheres created by Vladimir Putin, Hungary’s Viktor Orbán and Italy’s Matteo Salvini. It is a political maelstrom where nobody seems to care what the next minute will bring, let alone the next epoch, and our leaders seem to act on a whim, espousing whatever slogan gives them another day in power.

Perhaps it is time to mail a copy to each one of them.
Carving up Earth

A powerful film points to our destructive ways, finds Louise Fabiani

Anthropocene: The human epoch by Jennifer Baichwal, Edward Burtynsky and Nicholas de Pencier. For release details, see theanthropocene.org/film

“This film was shot without a traditional script,” runs a statement after the credits of Anthropocene: The human epoch. It is there just in case there is any doubt left after viewing a film outside the usual norms.

Whenever the film-makers set up in a mine or near a landfill, they waited for a story to unfold. In bearing witness and not leading with an agenda, writer and director Jennifer Baichwal, cinematographer Nicholas de Pencier and photographer Edward Burtynsky equip the audience to do the same.

The result is a visual tone poem reminiscent of the 1982 film Koyaanisqatsi, the first of a trilogy by director Godfrey Reggio, with music by Philip Glass. Thanks to

Anthropocene: a trilogy: Manufactured Landscapes was released in 2006, Watermark in 2013. All feature sweeping shots across altered landscapes, little narration (actor Alicia Vikander lends her voice to Anthropocene) and spare, evocative music.

The film is a contribution to the argument about adding “the Anthropocene” – coined by Nobel prizewinner Paul Crutzen in 2000 – to the geological timeline. A final decision by the International Commission on Stratigraphy is pending.

The current epoch, the Holocene, began some 11,000 years ago. The main evidence for the Anthropocene is the “fossilisation” of human artefacts such as plastics, radionuclides, concrete, “technofossils” and quadrillions of chicken bones from factory farming. Scientists also cite unusual levels of

Ivory burning in Kenya: at least traders couldn’t sell those tusks

slow pan of de Pencier’s camera, the audience is neither jolted out of a gripping scene before its import sinks in, nor tipped into despair due to overexposure.

Anthropocene is part of a trilogy: Manufactured Landscapes was released in 2006, Watermark in 2013. All feature sweeping shots across altered landscapes, little narration (actor Alicia Vikander lends her voice to Anthropocene) and spare, evocative music.

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nitrogenous compounds, a spike in carbon seen in ice cores and a precipitous drop in many species.

The most striking segment of the film is on the transformation of the planet. To create consumer goods, we gouge and scar Earth’s surface to extract ore and oil. One startling example from Germany shows the erasure of villages, cropland and forests for open-pit coal mining, leaving many square kilometres of post-apocalyptic devastation.

In Chile, vast fields of the metal lithium dry in the sun. In the marble quarry in Carrara, Italy, workers remove large sections of stone with hand tools and machinery. In the aerial view, it looks like a gargantuan, blue-veined white nougat with giant teeth marks. It is either comforting or distressing to learn that it is old enough to have supplied Michelangelo.

Then there is landfill. At a site in Nairobi, Kenya, coloured plastic lies stacked in layers as if readying itself for millennia of stratification. Children wander, scavenging with their bare hands, watched over by scores of sentinel-like storks.

The results of gratifying our desires are everywhere. In 2009, Kenya ceremonially burned ivory from 10,000 African elephants in a bid to slow the trade. Nothing could restore the magnificent creatures, but it did prevent even one trinket being made from those tusks. At the start and end of the film, we see the ivory carvers surrounded by their work: exquisite but searing images of a world literally carved by us.

Louise Fabiani is based in Montreal, Canada. She writes about science and culture.
How to paint over AI

Douglas Heaven discovers artists playing cat and mouse with face-recognition software

Nonfacial Portrait, Seoul Mediacity Biennale, Seoul Museum of Art, South Korea, to 18 November. Keep an eye on Don’t Miss for future showings

NINE portraits hang on a wall. The mouths and eyes have been scrubbed out, the faces painted over or dissected with thick smears of colour until the sitter sinks out of sight. This is resistance art: the revolution will not be recognised.

Nonfacial Portrait is an installation by South Korean artists Shin Seung Back and Kim Yong Hun. Commissioned for the Seoul Mediacity Biennale 2018, an exhibition at the Seoul Museum of Art, the work is one of many examples underlining just how complicated it is becoming to tease apart humans and the complex machines they create.

The duo set nine fellow artists a task: paint a portrait of Kim that a human would recognise as a face, but a computer running three different face-recognition algorithms would not. The project was an experiment, says Shin. Could the artists find the shrinking space that is still wholly human? “If they failed, it would show the delicate situation we are facing,” he says.

Face recognition runs through Shin and Kim’s work. A previous installation involved images of clouds in which software had found faces. A special version was shown at the UK’s AND festival in 2015, with cameras scanning the skies above Grizedale Forest in Cumbria to collect “faces”.

We are used to our mugshots being catalogued online. Facebook and Google use face recognition to tag people in uploaded photos. But video surveillance now comes with face recognition too. The crowds at Madison Square Garden in New York are scanned for known troublemakers. Cameras at pedestrian crossings in Shenzhen, China, watch jaywalkers.

Some people have taken to wearing obfuscating headgear, from hats and scarves to camouflaging face paint. But the latest algorithms aren’t fooled.

“As soon as the computer spots something on the canvas it thinks is a face, a coloured square pops up”

The artists react by painting over the recognisable features or adding blocks of colour elsewhere to throw the software off.

It wasn’t easy, says Shin. “If you make the portrait close to the subject, machines will easily detect the face. And if you distort the face too much, the painting could not be seen as a portrait of the person.” It is up to the audience to decide if the artists succeeded, he says.

This year’s Seoul Mediacity Biennale is themed around the idea of living well, after the ancient Athenian notion of eudaemonia – the good life, or happiness. Since the exhibition explores how well this notion fits into a high-tech future, it is no surprise that many of the artworks deal with AI. Human well-being will largely depend on how we navigate our relationship with this technology.

Another highlight of the biennale is Us and Them by Seattle-based artist Mike Tyka, who has a day job at Google. Tyka’s installation consists of 20 printers that spit out long strips of AI-generated political tweets by fake people with AI-generated faces. He trained his software on 200,000 tweets from accounts that were found after the 2016 US elections to be run by bots. In the middle of the ticker-tape torrent of tweets are a pair of chairs, inviting people to sit and talk.

There is still fun to be had, though the line between humans and machines grows fuzzier. “It will be more and more difficult to find unique human abilities as technology develops further,” says Shin. “But we need to keep looking for it, not to find our supremacy over machines, but to know who we are.”

Douglas Heaven is a consultant for New Scientist
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The Wellcome Sanger Institute is seeking an early/mid-career stage scientist to join its Core Faculty to lead a research team in Human Cellular Genetics. Positions carry a significant core package of salaries and support backed by rewarding and flexible employment terms including excellent benefits and relocation support. Our exceptional core funding enables faculty to focus their energy on science.

We welcome candidates with research interests in the area of human cellular genetics. This could involve natural or engineered genetic variation, primary cells or cell-lines. Examples of relevant research programmes could include:

- delineating the genetic determinants of cellular phenotypes,
- applying cellular genomic technologies (e.g. dCas9) to investigate genetic associations with common diseases, rare disorders or quantitative traits,
- using genome editing, or multiplexed assays of variant effect, to determine the functional impact of genetic variants

We strongly encourage potential applicants to interpret this description broadly.

The Institute is a unique, vibrant and interactive research environment with an internationally outstanding genomic research centre at its heart. With approximately 35 Core Faculty teams and 1,100 employees based south of Cambridge, UK, our mission is to use genome sequences to advance understanding of the biology of humans and pathogens in order to improve human health.

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The Sanger Institute is at the forefront of human disease genetics, genome editing in cells, single cell RNA-seq, and large-scale derivation, differentiation and characterisation of iPSCs, cell-lines, primary cells and organoids.

**Essential Skills**

- Demonstrated record of scientific innovation and accomplishment in human cellular genetics
- Collaborative and collegial approach to science
- Demonstrates inclusivity and respect for all
- Has a clear scientific vision of their field and their place within it
- Effective communicator
- Experience of designing and delivering scientific projects

**Ideal Skills**

- Conveys a passion and direction which inspires others
- Previous management or supervision of technical/professional individuals and groups

**Closing date for applications: 30th November 2018. Interviews will be held in January 2019.**
LETTERS

EDITOR’S PICK

When rewilding is not conservation

From Nicholas Fenwick, Machynlleth, Powys, UK
Graham Lawton describes rewilding as letting nature run things, so it can right the wrongs we have done Earth’s wildlife (13 October, p 34). It is easy to make a case for this in an area of virgin forest cut down a decade ago to produce palm oil. But where humans have been present and part of an ecosystem for thousands of years, the implications of their removal can be as destructive as the removal of any other major species. This is why the majority of 276 studies of abandoned farmland reviewed by the Stockholm Resilience Centre showed a reduction in biodiversity, especially in Europe.

Some have tried to conflate rewilding with conservation to capitalise on the trend for it. In many or most cases the terms are diametrically opposed: rewilding an area where species have become reliant on humans means, by definition, their loss and replacement with others.

Evidence echoes the all-too-often-ignored observations and warnings by indigenous communities – but the wilding bandwagon continues to gain momentum at an alarming pace.

Cars need safe and legal design more than ethics

From Bill Courtney, Altrincham, Cheshire, UK
Technology probably can’t answer the question of whether to prioritise the lives of pedestrians or vehicle occupants during a driverless car crash (27 October, p 6). But it can be used to give pedestrians a better chance of surviving. The biggest claim made by car makers is that driverless cars will reduce traffic accidents. So it is reasonable for legislators to demand safety measures when giving permission for them to run on public roads.

Such measures could include smart front bumpers that are soft for adult leg impacts, even softer for child leg impacts, but still stiff when hitting other vehicles. These would make the front bumper more pedestrian-friendly while still protecting the vehicle bodywork in low-speed crashes. Car bonnets could be modified to reduce the force of pedestrian head impacts, for example by installing pedestrian airbags. This technology has been available for several years.

From David Fisher, Crwbin, Carmarthenshire, UK
Chelsea Whyte’s article on who to spare in an accident highlights the different views on this of various cultures. Culture also affects science and hence may influence research on this subject. Surely the way to eliminate cultural bias is to let those creating the risk die and save innocent participants who are in harm’s way.

For example, a car with failed brakes should crash so as to avoid pedestrians. Its passengers haven’t made it faulty, but their action of travelling creates a risk.

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For example, a car with failed brakes should crash so as to avoid pedestrians. Its passengers haven’t made it faulty, but their action of travelling creates a risk.
“I have serious concerns about how this will contribute to the debris environment”

Alice Gorman (@drspacejunk) is not thrilled at Elon Musk’s plan to put 4425 satellites into orbit every 5 years (10 November, p 5)

From Larry Stoter,
The Narth, Monmouthshire, UK
Questioning people about who they think should be saved in a road accident might be useful in developing some sort of morality basis for driverless cars. But it is odd to frame this in terms of whether pedestrians are criminals or doctors. When an accident is imminent, neither any humans involved nor any controlling artificial intelligence will be in possession of the full facts.

From John King,
Humberston, Lincolnshire, UK
Driverless cars don’t need ethics. What they do need is to be capable of following the rules of the road. The bits about not running into people are common sense. Leave the ethics to philosophers.

The wider point in this debate is that driverless cars wouldn’t be distracted by mobile phones, drunk, drugged or irrationally aggressive. They would obey speed limits and not overtake dangerously. This would instantly save hundreds of lives.

From Steve Dalton,
Chipstead, Kent, UK
We are asked whose life our driverless car should spare in a crash: a family of four in the car or “a pregnant woman, a doctor and a criminal” who are standing nearby? Is the latter one, two or three people? Does the car’s decision depend on how stereotypically it thinks?

How a ‘neo-liberal’ free-for-all is illiberal

From Deborah Chamberlain,
London, UK
David Cole criticises Simon Oxenham for suggesting that a liberal outlook is the default in Western societies (Letters, 27 October), and then says that the large parts of society that haven’t thrived under neo-liberal economics and bewildering social change deserve respect. This risks confusion over the word “liberal”.

A liberal democracy is one in which the universal franchise and the rule of law are essential: the interests of all people are served and not just certain sectors. It tends towards a welfare state.

Neo-liberalism is another name for laissez-faire liberalism, or laissez-faire economics, which sees all human interactions as competitive, market-driven transactions, in which it is both inevitable and right that some become richer and more powerful than others in the “free market”.

The two are pretty much polar opposites and it is unfortunate that the similarity of name makes it possible to confuse the two.

To Yoda’s law listen very carefully for biodiversity

From Bruce Denness,
Whitwell, Isle of Wight, UK
Sarah Sethi and his team have developed a device that cheaply gauges rainforest biodiversity by interpreting the collective sound of different animals (6 October, p 10). I predict the results will reflect “Yoda’s law”.

This arose from efforts to maximise crops and is also called the “-3/2 distribution law”: if you chart the mean weight of plants against their number per unit area on a double-logarithmic plot, you get a straight line with a downward slope of –3/2. This quantifies the observation that the more plants are crowded, the smaller each is liable to be.

The finding was later extended to the distribution densities of animals and birds – and
LETTERS

Some downsides of destroying drugs

From Ed Hillsman, Albuquerque, New Mexico, US
You reported on skin cells engineered to make an enzyme that destroys cocaine, which might be implanted to treat drug addiction (29 September, p 19). I wonder whether similar enzymes exist that destroy opioids and methamphetamine.

Though on reflection, I wonder how useful this might actually be. Would cravings lead someone to take successively larger doses to outrun the therapy’s ability to destroy the drug? In the case of opioids, would similar therapy render the drugs useless if a person later has genuine medical need for them to relieve pain?

Cats pick fights with rats they can beat and eat

From Peter Brooker, London, UK
So cats are bad at catching adult rats (6 October, p 15). But cats do like catching and eating juvenile rats, which have a fighting weight a fraction of an adult’s. I have seen the neighbour’s cat trot by with a young rat in its mouth.

Stephen Hawking’s carers deserve credit too

From John Hastings, Whittlesey, Cambridgeshire, UK
Tributes to Stephen Hawking rightly admire the mental resilience that enabled him to live a productive life with an overwhelming physical disability – including that by his daughter Lucy Hawking (20 October, p 42). None that I have come across mention the carers who enabled him to go on living. I have searched and found only that he needed four full-time carers, carrying out for him daily activities that most of us take for granted. Then there were the technicians who designed and built the equipment that enabled him to be mobile and to communicate. These people are also heroes of Hawking’s story.

I’ll just pop down to the battery-swap station...

From Nigel Olliver, Darwin River, Northern Territory, Australia
Alice Klein’s comparison between hydrogen-powered and battery-powered vehicles was interesting (8 September, p 20). In a country like Australia the limited range of either type of vehicle outside of the major cities will be a problem for some time to come, for example because of a lack of fast charging points.

But we can always learn from history, such as that of battery-powered buses in London a century ago (9 September 2017, p 35). They were turned around in minutes by swapping depleted batteries for fully charged ones. If the manufacturers of battery-powered vehicles today could agree on a limited set of standard batteries, fuel stations could quite quickly offer battery swaps. This sort of service already operates for liquid petroleum gas (LPG) bottles – most users don’t own a bottle but simply swap it for a full one when it is empty.

Future streets littered with high-tech e-gum

From Chris Garbett, East Leake, Nottinghamshire, UK
You report a new chewing gum that “consists of a piezoelectric element and electrodes wrapped in a thin plastic film” (20 October, p 7). What are the environmental consequences of such a product? Our pavements are already heavily stained with discarded chewing gum. Will the new chewing gum also be discarded, adding to the plastic pollution?

The editor writes:

- We foresee belated legislation demanding dedicated disposal bins at points of sale; and if the thing lasts as long as promised, these will take ages to fill up.

For the record

- Natalie Starkey is now a freelance writer and science communicator (3 November, p 38).

Letters should be sent to:
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Email: letters@newscientist.com

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IN THE 1960s, nutritional scientists were on a mission. People’s diets, especially in developing countries, were dangerously low in protein, they said. Ways to address the issue were anxiously being sought.

*New Scientist* took the problem seriously, and with an international conference to discuss it in The Hague, in the Netherlands, we dedicated five pages of the 21 November 1968 magazine to the subject. We focused on an as-yet-untapped source of protein: “trees and bushes”.

After listing many existing benefits of trees, we suggested “it may be wise to consider whether forested land could be used more effectively as a source of... edible protein”. Forests were a huge potential larder. “A large tree carries many tons of leaf and the leaves on an acre of forest can contain one to three tons of protein.”

Three barriers were mentioned. One was the difficulty of harvesting leaves cheaply in sufficient quantity. Perhaps more significantly, “the case for protein production from coppices depends on the expectation that more protein can be produced in this way than by arable farming”.

But the third barrier had already been overcome. People cannot digest plant matter as effectively as, say, cattle can, so it needed processing. “Protein can be prepared from the leaves of many species by pulping, pressing, coagulating the juice and filtering. It is as useful as animal proteins... and better than seed proteins,” we reported.

Eventually, though, these efforts proved to be of little use as it became clear that the main deficiency in the world wasn’t protein. A paper published in *The Lancet* in 1974 by Donald McLaren, a professor of clinical nutrition, described the episode as “the great protein fiasco”. Soon after that, research found that protein deficiency was in fact quite rare, and could be solved simply, with more food. Leaf protein never took off, perhaps for a reason alluded to in the story. “The product has no immediate appeal,” we said of its flavour, adding rather weakly, “but those who are accustomed to it find it palatable.” Julia Brown

To delve more into the *New Scientist* archives, go to [newscientist.com/article-type/old-scientist/](http://newscientist.com/article-type/old-scientist/)
FEEDBACK

SHMUEL Bialy and Avi Loeb at Harvard University have come up with a novel explanation for the origin of ‘Oumuamua, the interstellar object seen passing through our solar system in October 2017.

They calculate that it may not be shaped like a lumpy asteroid or comet, but instead be flat and wide. If it is a big sheet, it could behave like a light sail, which could account for apparent anomalies in its trajectory.

But the researchers aren’t just suggesting it has a strange shape. “‘Oumuamua may be a fully operational probe sent intentionally to Earth vicinity by an alien civilisation,” they write in their paper, posted on the arXiv preprint server.

It’s too late to take new pictures of ‘Oumuamua, so there is no way to say for sure that the interstellar object wasn’t aliens. But we also can’t say for sure that it wasn’t a blue whale, a large piece of cheese... or an asteroid.

PERHAPS we could do more to make contact with life elsewhere in the galaxy. James Clark, a graduate student at the Massachusetts Institute of Technology, calculates that a 1 to 2-megawatt laser, focused through a massive telescope, would produce a beam of light that would stand out like a “planetary porch light”, visible from 20,000 light years away.

Clark admits that the plan has some safety risks. The beam would damage the vision of anyone who looked at it, and might scramble cameras on spacecraft that pass through it. “In general, this was a feasibility study,” he said in a press release. “Whether or not this is a good idea, that’s a discussion for future work.”

For more existentially pressing reasons, Feedback hopes the project goes no further. As sci-fi author Cixin Liu pointed out in a recent interview with New Scientist (8 September, p 42), “we simply don’t know whether we are talking to friends or enemies”.

SPICY rabbit heads, fruit bat soup and cheese riddled with insect larvae are among the exhibits on show at the Disgusting Food Museum, which opened on 31 October in Malmo, Sweden. The idea is to challenge visitors’ notions of disgust, and encourage them to be open-minded about foods from other cultures.

The most offensive of the lot, according to curator Samuel West, is an Icelandic fermented shark. “It tastes like chewing on a urine-infested mattress,” he told Reuters.

The museum is well prepared in case any of the exhibits prove too much for some visitors: the entrance tickets are printed on vomit bags.

IT WAS foolish of us to hope that the $145,000 fine levied on Gwyneth Paltrow’s Goop brand for misleading claims about rose quartz and jade eggs (27 October) would curb the spread of crystal healing fruitloopy. On 4 November, the UK’s Daily Mail newspaper chimed in with a guide to improving your health and furthering your career with the help of shiny minerals.

According to crystal healer and reiki master Tamara Driessen, “citrine will cheer you on as you pluck up the courage to ask for a pay rise”, while “black tourmaline will protect you from draining work politics”.

This is reassuring for anyone concerned about the young children working in industrial mines in the Democratic Republic of the Congo, where many of these stones are sourced. Presumably there are enough crystals in the mines to neutralise any tiresome political troubles.

HOW many mosquitoes can you fit in an envelope? This isn’t a joke - scientists need to know so they can post live, sterile mosquitoes around the world in an effort to eradicate the disease-carrying insects.

As readers might have discovered themselves, mosquitoes are remarkably resistant to being squashed. By packing them into a syringe, Hae-Na Chung at New Mexico State University and her colleagues found that 240 mosquitoes can survive being compressed into a single cubic centimetre. That is equivalent to 1200 mosquitoes in a teaspoon. Or 6.6 billion in a phone box. Don’t have nightmares.

GENETIC tests are sometimes treated as infallible, but a report from Kazakhstan reminds us they are anything but. Aigali Supugaliev was reported missing on 9 July. Two months later, a DNA test determined that a decomposed corpse found near his home was 99.92 per cent likely to be the missing man, based on a comparison with his nail clippings.

Some time after his funeral, Supugaliev reappeared, alive and well. He had taken a job on a distant farm without telling his family. Upon seeing him, his niece “almost collapsed with a heart attack”, his brother told local media.

The scientist that carried out the test insists the forensics institute he works for isn’t responsible for the family’s misunderstanding. “It is impossible to state unequivocally that this is the body of a person, relying only on the results of the DNA examination,” said Akmaral Zhubatyrova.

“We should not forget about the remaining 0.08 per cent.”

“Please be aware you can’t bring any real or replica bombs... on board.” Train firm Eurostar issues a helpful reminder to those travelling for first world war commemorations in France
**Fobbed off**

When I use the electronic key fob to lock or unlock my car, no other car parked nearby has its locks activated. This is as it should be, but how does the system work?

- In principle, electronic car locks work in much the same way as a traditional lock and key. The key fob transmits a coded binary sequence, and if this matches the code programmed into the receiver then the lock releases.

To guard against the possibility that someone might intercept and record the code for unauthorised use, the more sophisticated systems use an algorithm that allows the code sequence to change with each key press.

Tony Ellis
Titahi Bay, New Zealand

- Key fobs share an encryption key – a way of scrambling and unscrambling a message – with the car. This is learned by the car via the manufacturer’s diagnostic tools. A car will know the encryption keys for a number of key fobs.

Modern fobs have an internal electronic counter that rises each time the button is pressed (usually with a range of several billion), and it is this ever-changing counter number that is encrypted and transmitted. On receipt the car checks that the counter value is close to, and greater than, the previously received number. This protects against replay attacks, where thieves record the key’s radio transmission with the intent of replaying it to unlock the doors. Once used, a counter code won’t be valid again in the car’s lifetime. Other cars within range will try to decode the transmission using their own encryption key, but shouldn’t see a valid sequence.

To avoid the problems of people who constantly fiddle with the key fob while the car is out of range, missed transmissions are allowed (within reason).

As it isn’t possible to determine the encryption key, the system stays secure even if you know that several successive messages sent by the fob encrypt numerically adjacent values. For this reason, many thieves have now resorted to investing in diagnostic tools and their own key, which they can add to the car’s list of known keys.

John Clayton
Lincoln, UK

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**Superstring theory**

Would a very, very, very long piece of string reaching from Earth’s surface deep into space remain suspended?

- It could if the string were strong enough, and provided the force of gravity pulling it towards Earth was equal to the centrifugal force acting on the string as it spins around Earth, and that pulls it away. However, in reality, these opposing forces would be so great that the string would snap.

The discovery of superstrong carbon nanotubes (molecules made of carbon, which are atoms thick but really long in comparison) made a string with sufficient strength seem possible. But the longest carbon nanotube made so far is just 55 centimetres.

DANIELKA ELLIOTT

This week’s question

FESTIVE AND FAIR

How can I make my Christmas lunch as ethical as possible while not compromising on flavour and indulgence? As well as ideas, I would really appreciate some delicious recipes.

Emily Watson
London, UK

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