New Scientist

WEEKLY February 25 - March 3, 2017

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The new age of quiet supersonic flight

RINGS OF MARS
The Red Planet is becoming like Saturn

DO GOOD BETTER
Using science to make benevolence go further

THE NEXT PLAGUE

WE DON'T KNOW WHERE IT'S COMING FROM

BUT WE KNOW HOW TO BEAT IT

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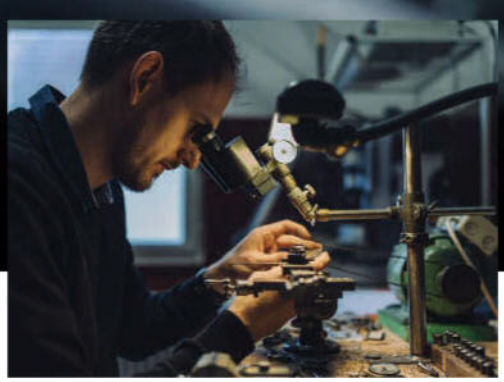
FORGET MAMMOTHS The extinct species we really could revive



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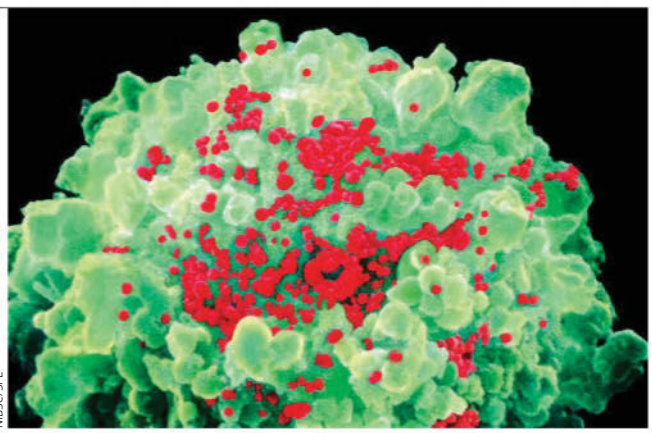

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NATAN DVIR/POLARIS/EYEVINE

Doing good, better

Does a networked world need a new approach to altruism?

CHARITY shouldn't begin at home. That, crudely put, is one of the tenets of a philosophy called effective altruism. Its adherents strive to do good as rationally as possible: for instance, moral philosopher Peter Singer asks if you would pass by a drowning child rather than spoil your expensive clothes. You wouldn't? Then why don't you donate their value to avert the death of a child you've never met?

To contradict another dictum: out of sight shouldn't be out of mind. If you accept that all human lives are equal, whether or not they are kith or kin to you, you should direct your altruistic effort wherever it will do most good. But this logic is contentious right now. The value of giving succour to distant strangers, from foreign aid to sheltering refugees, is being questioned around the world.

Effective altruism is against the tide in other ways, too. Follow it, and you might end up making surprising choices (see page 22). The most obvious objections arise from reductio ad absurdum. If we were all effective altruists, all our disposable income would go on a handful of big problems, because that would be the best way to make a big impact on suffering. Causes whose benefits are harder to measure – basic research, human rights or the treatment of rare diseases – might be left out in the cold. And if low-paid carers all quit their jobs for lucrative careers that let them give generously instead, who will look after the sick and infirm?

The obvious rejoinder is that not everyone will think this way. Fair enough, but where should we draw the line? Is there a threshold beyond which effective altruism should be the norm? Or is it up to individuals – in which case, aren't we right back where we started?

"If low-paid carers all quit their jobs for lucrative careers, who will look after the sick and infirm?"

One group already practises effective altruism by default: ultra-wealthy donors, like the Gates Foundation. Their brand of "philanthrocapitalism" sees charitable funds managed like investments. That makes sense: traditional charities can struggle to deal with huge sums, while donors want bang for their buck. The caveat is that aloof decision-making can instill dependency in those it seeks to help and apathy in the governments it bypasses.

At smaller scales, effective altruism's focus on dispassionate economic assessment also sits uneasily with the variety of roles altruism plays in human society. Biologists hotly debate why we are generous to people who share no genes with us, but altruism clearly cements our communities, and we find it powerfully rewarding.

Effective altruists respond that we need to update our notions of "community". They have a point. Charities co-opt our altruistic tendencies by "introducing" us to people who need our help. In our networked world, those introductions are becoming ever more frequent, while the rewards for helping can be less immediate.

How to react? One reaction is paralysis. Another is to withdraw the hand of kindness rather than extend it, for fear that far-flung charity may cost those near home. Effective altruism might help us choose rationally between these cries for help rather than pick the ones that pull hardest at our heartstrings – and is thus clearly defensible when it comes to politically charged issues.

It's a start. But so far, it is only that. Applied sloppily, effective altruism could threaten social cohesion at both local and global levels. The problem for most efforts to do good is that they attract too little support. For effective altruism, the problem may be attracting too much. ■

AP PHOTO/STEVEN SENNE

Standing up for science

THESE are anxious times. Last weekend, at the annual meeting of the American Association for the Advancement of Science (AAAS) in Boston, a session on defending science in the age of Trump was so popular that many had to stand or sit in the aisles.

Meanwhile, hundreds of scientists and supporters gathered in the city to protest against planned changes by the new administration. The rally was organised by two science activist groups and endorsed by more than a dozen national and regional scientific organisations. Bigger rallies are planned for 22 April in Washington DC and other cities.

At the packed AAAS session, Gretchen Goldman from the Union of Concerned Scientists offered a warning. "We know the playbook, but this is a different sport. We've seen that President Trump isn't going to respect scientists," she said.

"My biggest worry is about the consequences to society if scientists are muzzled and intimidated, if science is defunded, if data are deleted and scientific institutions are undermined," said Jane Lubchenco of Oregon State University, who ran the National Oceanic and Atmospheric Administration from 2009 to 2013.

Naomi Oreskes of Harvard University argued that scientists must speak out on topics such as climate change and vaccine safety, rather than hoping their findings would speak for themselves.

"I would say scientists have to redouble their efforts," said Rush Holt, chief executive of the AAAS. "Sometimes that will require courage."

Scientists were further disheartened when Scott Pruitt was confirmed on 17 February as head of the Environmental Protection Agency (EPA), which oversees regulations to control pollution.

In his previous role as attorney general of Oklahoma, Pruitt launched 14 lawsuits against the agency he now leads.

He has said he plans to reverse Obama-era policies on carbon emissions and water regulation, including the Clean Power Plan, which sets national limits on carbon pollution from power plants, and the Clean Water rule, which governs waterways that fall under EPA jurisdiction.

At the AAAS meeting, anonymous EPA scientists told *New Scientist* that the agency is still operating as usual, although concerns about future changes loom large. And at the rally, worries about climate and the EPA's fate were a recurring theme.

"We need bold action on climate change. The fact that we're ignoring it is backwards," said rally attendee and zooarchaeologist Emily Gilstrap.

Corals in hot water

IT'S a catastrophe for coral reefs. Sea surface temperatures are so high across much of the tropics that many reefs will suffer severe bleaching for an unprecedented fourth year in a row. Divers in Australia are already reporting new bleaching in the northern part of the Great Barrier Reef, where last year half of corals in the worst-hit areas died.

Corals bleach – and can die – when stress makes them expel their symbiotic algae, often due to heat. The ongoing global bleaching is the longest and most widespread ever known. It began in 2014, when global warming and a developing El Niño heated seas, and became the worst, as far as we know, when the strong El Niño of 2015 and 2016 hit. Surface waters remain so warm that NOAA's Coral Reef Watch is now predicting that many reefs will bleach in the next three months, although the El Niño has ended.

"NOAA's coral reef watch says many reefs will bleach in the next three months due to warmer waters"

It takes around a decade for an undisturbed reef to recover from bleaching, says Gareth Williams of Bangor University in the UK. So if bleaching occurs more often, reefs don't have time to recover.

Twitter vs trolls

TWITTER has online harassment in its sights. Over the past month, the social network has announced several features aimed at curbing the abuse that has long plagued the service, and it has been busy rolling these out.

A "safe search" option will now hide "sensitive" content when searching the site, and collapse "potentially abusive and low-quality" replies in conversations. Twitter says it is also taking steps to stop people suspended

from the platform from creating new accounts.

But not all the changes have gone down well. Last week, Twitter said it would stop notifying people when they were added to lists users can create to organise the accounts they follow.

Such lists could be used to harass people by adding them to an offensively titled group. After users pointed out this would leave victims unaware they had been targeted, and therefore unable to report the abuse or block the offending account, the company acknowledged it was a "misstep" and backtracked on the change.

New primate found

IT'S a dwarf with big eyes, big ears and a big voice. The newly discovered Angolan dwarf galago belongs to the bushbaby family, members of which are found all over sub-Saharan Africa.

The creature's most distinctive characteristic is its call: a chirping crescendo followed by a twitter, report Magdalena Svensson of Oxford Brookes University, UK, and her colleagues. The team observed 36 individuals, although as yet they know little about their diet or lifestyle (*American Journal of Physical Anthropology*, DOI: 10.1002/ajpa.23175).

The locations where the animals were sighted are not protected, and their forests are under threat. "Logging is incredibly rampant in Angola at the moment," says Svensson.

"Logging is rampant in Angola at the moment, and the habitat of the new species is disappearing"

"The habitat is disappearing."

The Angolan dwarf galago is only the fifth primate species discovered in mainland Africa since 2000.

Push for space tech

EVERY piece of kit for a crewed space mission has to be better: lighter, stronger, multipurpose. Now NASA has funded two teams of researchers to form new Space Technology Research Institutes, working toward that goal.

One is called the Institute for Ultra-Strong Composites by Computational Design (US-COMP). It will focus on creating materials for vehicles, habitats, and whatever other structures astronauts will need on Mars. The materials will be based on carbon nanotubes, and will need to be just as strong as current options, but lighter.

The other institute, the Center for the Utilization of Biological Engineering in Space (CUBES), will aim to make the astronauts self-sufficient once they reach their destination. "CUBES will work on an integrated way to use biology, starting from the available building blocks, to create all the things that astronauts and settlers will need, from food to pharmaceuticals to fuel," says team leader Adam Arkin at the University of California, Berkeley.

The two institutes will each receive $15 million over the course of five years. The work of both could also have applications on Earth as well.

Bird flu on the rise

AVIAN flu is on the rampage in China again. There have been 424 cases in humans already since last October, more than a third of all those identified since the H7N9 virus emerged in 2013. And it is spreading.

This week it was announced that the virus has acquired mutations that could make it a much bigger problem.

H7N9 mainly infects birds and doesn't readily pass from human to human, but should it acquire this ability a deadly pandemic could ensue (for more on how to tackle the next pandemic, see page 29).

The virus spreads in poultry without making birds visibly sick, so it is often only found when people fall ill. But this week both mainland China and Taiwan reported human cases in which a surface protein on the virus has a mutation that makes it lethal to chickens. If that spreads, H7N9 will be "highly pathogenic" like H5N1.

While the mutation doesn't make people any more sick, it allows the virus to replicate much faster in chickens. With more in circulation, people, and perhaps pigs and other mammals, are more likely to catch it. Each case is a chance for H7N9 to adapt to mammals and perhaps become better at spreading from person to person.

Our only real defence is a vaccine. Last week, China launched clinical trials of four strains by a state-owned vaccine firm. But even if the vaccine works, the world can't yet make enough to cope with a pandemic.

STR/AFP/GETTY

Pandemic possibility

60 SECONDS

Exoplanet septet

A nearby star hosts seven small, rocky planets, all but one of which may have temperatures friendly to life. TRAPPIST-1, a cool dwarf star 36 light years away, had three known worlds already. Now four more have turned up packed close to the star, looking like a scaled-up version of Jupiter and its major moons (*Nature*, DOI: 10.1038/nature21360).

Eye tumours hit turtles

Turtles on Australia's Great Barrier Reef are coming down with a strange eye disease. Triggered by a turtle-specific herpes virus, it causes tumours to grow on the animals' eyes as well as their shells, flippers, tails and internal organs. Metals in run-off from mining might be affecting the turtles' immune systems.

Chill cancer away

Cancer could be tackled more effectively by putting patients into hibernation. Marco Durante at the Trento Institute in Italy argues that lowering body temperature to 15°C would slow tumour growth and reduce radiotherapy's side effects. The feat may be feasible within 10 years, Durante told the AAAS meeting in Boston last week.

Spaceport UK?

The UK government announced a draft Spaceflight Bill this week, aimed at creating a commercial spaceport. Under its terms, firms will bid for up to £10 million of funding to help launch satellites or passengers into space from the UK.

Cool way to save birds

A "frozen aviary" will help conserve rare birds. The Roslin Institute at the University of Edinburgh, UK, has collected primordial stem cells from more than 25 such species and is storing them at -150°C to keep them viable for decades. The researchers have also created hens that can lay other birds' eggs after having their stem cells implanted, they told the AAAS meeting.

HIV infection stopped in its tracks

Vaccine-based therapy may remove need for daily drugs, finds **Andy Coghlan**

FIVE people with HIV are currently free of detectable virus – and daily drugs – thanks to a new vaccine-based therapy.

Although it is early days, one participant has been drug-free for seven months.

Most people with HIV need to take antiretroviral drugs (ART) each day to stop the virus from replicating and causing damage to their immune system. These have to be taken over a lifetime because the virus can hide away in tissues such as lymphoid and gut cells; if ART is stopped, the virus quickly re-emerges from these cells.

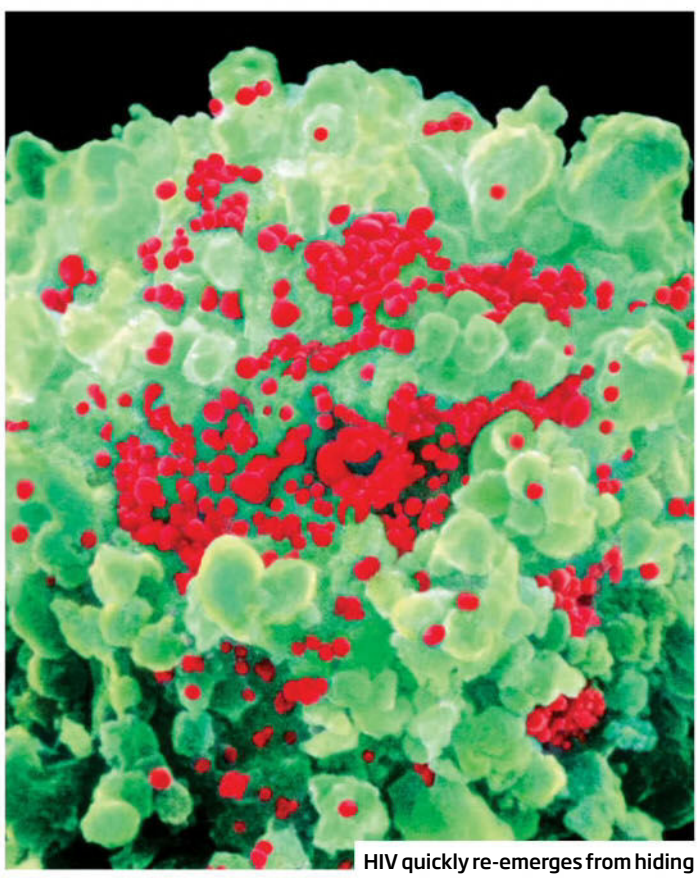
Although effective, ART is expensive, time-consuming and can cause nasty side effects.

Three years ago, Beatriz Mothe of the IrsiCaixa AIDS Research Institute in Barcelona, Spain, and her colleagues started a trial in which 24 people recently diagnosed with HIV were given two vaccines developed by Tomas Hanke and his colleagues at the University of Oxford. They were also given ART, then monitored to see whether the vaccines induced a strong immune response.

This year, 15 of them each received a booster dose of one of the vaccines, followed by three doses of romidepsin – a cancer drug that has shown potential for flushing HIV out of hiding. Finally, each person received another vaccine booster, and then stopped taking ART.

In 10 of the participants, the virus rapidly bounced back, forcing them to return to ART. But five of the participants no longer needed to take the drugs because their immune systems could suppress the virus unaided.

One person has been off ART for seven months now. The other four have been free of detectable virus for six, 14, 19 and 21 weeks, respectively. Mothe, who revealed the results at the Conference on Retroviruses and Opportunistic Infections in Seattle last week, says they will follow each participant to see how long they can control the virus themselves.



NIBSC/SPL

HIV quickly re-emerges from hiding

It isn't clear why two-thirds of the group didn't respond to the therapy – Mothe and her colleagues are investigating this now. But even a small number of people responding positively to the therapy is good news, says Sharon Lewin at the University of Melbourne, Australia, who specialises in HIV medicine. She says it is the first treatment to stop the virus from replicating without the daily use of ART.

"It is the first treatment to stop the virus from replicating without the use of daily drugs"

Both vaccines carry genes coding for proteins that are also produced by all known variants of HIV. Once these proteins reach the blood, they are recognised as foreign by the immune system, which primes a type of white blood cell called CD8 cytotoxic T-cells. If a cell becomes infected by HIV and expresses these proteins on its surface, the CD8 cells can recognise them and so attack and destroy the cell.

The second component of the therapy – romidepsin – flushes dormant HIV out of its hiding place so it can then be taken out by the CD8 cells. "If you have a prepared immune system, once a cell starts showing little parts of the virus, it should be recognised and eliminated," says Mothe.

While the results are significant, excitement should be tempered. Previous treatments have appeared to "cure" people with HIV only for the virus to later return. For instance, after being born to a mother with HIV, a baby in Mississippi was treated with ART for 18 months. This seemed to cure her of the virus but it returned when she was 4. HIV has also re-emerged months after ART was stopped in two men who appeared to have got rid of the virus after bone marrow transplants two years earlier.

Mothe says that this time might be different. Previous treatments involved either attacking the virus as early as possible or trying to replace the entire immune system to get rid of any dormant virus.

This time round researchers are launching a double-pronged attack: the vaccines focus on priming immune cells to rid the body of active virus as quickly as possible after infection, and the cancer drug flushes out any hidden dormant virus so it, too, can be targeted.

If the treatment were to prove successful, the savings could be huge. Costs of ART in low to middle-income countries hit $19 billion in 2015 – despite having only reached half of the 36.7 million people infected with HIV.

Mothe says her team is now working hard to unpick the mechanisms behind the response and simplify the treatment schedule. There's a long way to go, she says, "but we're on the right path". ■

Family tree of stars traces galaxy's past

THE red dwarf doesn't fall far from the tree. Astronomers are borrowing a technique from biology to build a family tree of the origins of stars.

A star's chemical make-up can tell you a lot about where it came from. The first stars were mostly made of hydrogen and helium, and they fused those elements together into heavier ones. When massive stars explode as supernovae, they disperse the heavier elements they have built into space, where they become the building blocks of the next generation of stars. Stars born after many generations have heavier elements in greater abundance than do older ones.

Stars move around the galaxy's spiral arms and disc, making it difficult to figure out where they came from. But if they were born in the same cluster, stars should have similar chemical signatures.

Astronomers use chemical tagging to try to identify stellar siblings even if they have drifted apart. But Paula Jofré at the University of Cambridge and her colleagues thought they could take this a step further by taking a page from evolutionary biology.

"This is an invitation for astronomers to think in a new way about the history of stars and interpret their past," Jofré says.

Combining traces of 17 chemical elements as stellar "DNA", the team categorised 22 stars in our galactic neighbourhood.

The team assembled a tree with three branches associated with stars of different origins. The group suggests that the thicker part of the galaxy's disc forms new stars more rapidly than elsewhere in the Milky Way. Some stars may have even originated in another galaxy that collided with the Milky Way long ago (arxiv.org/abs/1611.02575v2).

Joss Bland-Hawthorn at the University of Sydney in Australia likens this to DNA sequencing of humans, which can help trace people's origins. Ramin Skibba ■

PERSONAL ROBOTS GROUP/MIT MEDIA LAB

Kids try harder with Tega

Robot's can-do attitude rubs off on children

ARTIFICIAL intelligence has a new job: setting a good example for your kids. It seems that children's behaviour can be influenced by the personality of a robot companion – playing with an enthusiastic or attentive robot, for instance, makes them engage more and work harder.

Researchers ran a series of experiments with Tega, a companion robot that looks like a cross between a Furby and a Teletubby. To test how its personality could affect the children's behaviour, they programmed the robot with different responses.

"The goal is to have a companion that has all of the behaviours that we want to instil and promote in the child," says team member Goren Gordon at Tel Aviv University in Israel.

Forty children played a puzzle game against Tega. With half of them, the robot had a "neutral" personality, meaning that when it won it said something like "I solved the puzzle," and when it lost it said something like "That was hard". With the other half of the group, Tega had more of a can-do attitude. When it won, it might say "That was hard, but I tried hard and nailed it," and when it lost it might say "You worked hard and succeeded!"

The differences in the robot's personality were subtle, but the effect it had on the children's reactions was not. "We found that the children in the second group tried much harder, and when they lost they were far more determined to win – they had grit," says Hae Won Park at the Massachusetts Institute of Technology, who led the research. These children made more attempts to solve the puzzles.

"The differences in the robot's personality were subtle, but the effect on the children was not"

The researchers also trialled Tega as a storytelling partner. From footage of 18 children telling stories in pairs, a machine learning algorithm identified the traits they displayed most often when being attentive. "We found that children really lean in and gaze at you when they're engaged with a story. Adults don't really do this, but for children it's really important," says Park.

Children then told a story to two identical Tega robots placed next to each other. One was programmed to listen like a child – leaning forward, nodding and smiling, and reacting more when the storyteller was more energetic – while the other listened in a more reserved way. In surveys, the children said the childlike Tega was more attentive and they preferred telling it stories.

This was also evident in their behaviour. "When children sense attentiveness they tell longer stories with more complex narratives, and their vocabulary improves faster," says Park.

Storytelling is important for child development, so it is exciting if a robot can encourage that, says Liz Pellicano at the Institute for Education, London. "We need to be careful though," she says. "Not every child is the same, so in the future it would be good if the robots could tailor their behaviours to each child."

We can't know yet what impact a robot's personality has on a child's attitude to learning in the long term, says Park. The current findings could be partly down to a "novelty effect" from children first encountering this sort of robot. The team plans to explore longer-term effects in the future, and will present their work so far at a conference on Human-Robot Interaction in Vienna, Austria, in March.

Gordon says they hope the robot will be useful at home and in the classroom. "The goal is for the robot to be a companion that can learn with the child and behave in a way that positively influences the child," he says. "It can express that effort pays off and it likes challenges. We've shown that the child is influenced by this behaviour and will actually try harder after interactions with the robot." **Timothy Revell** ■

Arsenic in water? We're adapting

Ian Graber-Stiehl

PEOPLE in a south American desert have evolved to detoxify potentially deadly arsenic that laces their water supply.

For settlers in the Quebrada Camarones region of Chile's Atacama desert some 7000 years ago, water posed more than a bit of a problem. They were living in the world's driest non-polar desert, and several of their most readily available water sources, such as rivers and wells, had high levels of arsenic, which can cause a variety of health problems.

The arsenic contamination here exceeds 1 microgram per litre: the highest levels in the Americas, and over 100 times the World Health Organization's safe limits. There are virtually no alternative water sources, and yet, somehow, people have survived in the area. Could it be that arsenic's negative effects on human health, such as inducing miscarriages, acted as a natural selection pressure that made this population evolve adaptations to it? A new study suggests this is indeed so.

The body uses an enzyme called AS3MT to incorporate arsenic in two compounds, monomethylarsonic (MMA) acid and dimethylarsinic (DMA) acid. People who metabolise arsenic more efficiently convert more of it into the less toxic, more easily expelled DMA.

Mario Apata of the University of Chile in Santiago and his colleagues looked at variations in the gene coding for AS3MT in nearly 150 people from three regions of the country. They found higher frequencies of the protective variants in people from Camarones: 68 per cent there had them, as opposed to just 48 and 8 per cent of people in the other two. "Our data suggest that a high arsenic metabolization capacity has been selected as an adaptive mechanism in these populations in order to survive in an arsenic-laden environment," the researchers conclude (*American Journal of Physical Anthropology*, doi.org/bz4s).

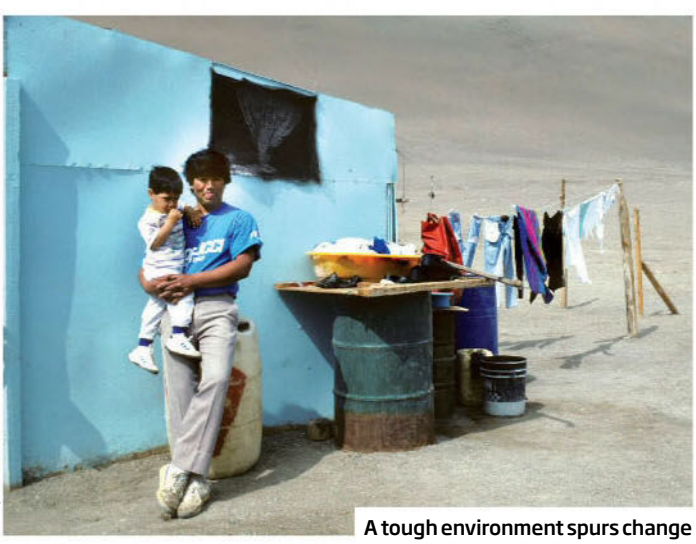
The variants that protect the Camarones people are called single nucleotide polymorphisms – changes in a single DNA letter of the genetic code. Anthropologist Lorena Madrigal of the University of South Florida in Tampa says these are such tiny mutations that they aren't telling us exactly how the changes affect the enzyme molecule and its detoxifying effects.

Previous studies found similar mutations in the AS3MT gene that contribute to improved arsenic metabolisation in Vietnam and Argentina. Sequencing the entire chromosomal region around this gene could reveal more, but there's still a long way to go before we fully understand the molecular mechanism for how arsenic resistance works.

Though it's a fascinating example of what appears to be contemporary evolution in humans, it also underscores the water quality problems that many populations face, says Madrigal. And many may not be able to evolve to deal with it.

Another notable example of recent human evolution is lactose tolerance. A mutation which allowed adults to keep producing the enzyme lactase to digest milk emerged around 7000 years ago, alongside dairy farming, and now 35 per cent of adults carry it and can digest milk as a result.

"I would say [the rise in arsenic tolerance] is comparable to the rapid spread of lactose tolerance. Certainly the timescales we are looking at for both cases are comparable," says Aaron Miller at Northwestern University in Evanston, Illinois. ■



PUKA JANLUKA / ALAMY STOCK PHOTO

A tough environment spurs change

Exercise can prevent breast cancer relapse

FOR women who have recovered from breast cancer, exercise appears to be the most important lifestyle choice to cut the risk of death from a relapse.

Around a quarter of all women with breast cancer will eventually die when the cancer spreads to other parts of the body. But living more healthily can reduce the risk of this happening.

To find out what lifestyle changes might have the greatest benefit, Ellen Warner and Julie Hamer of Sunnybrook Health Sciences Centre in Toronto, Canada, analysed 67 studies that examined factors such as diet, exercise and weight, and their effect on the health of women who had been successfully treated for breast cancer.

They conclude that physical activity can reduce the chance of death from a breast cancer relapse by up to 40 per cent. "Exercise had the most consistent and greatest [impact] on the relative risk of breast cancer death," says Warner. The ideal amount is 150 minutes of moderate physical activity spread over a week, she says.

It is hard to isolate why exercise confers such benefits, says Warner, but one possible explanation is that it suppresses inflammation that could otherwise damage cells and increase the risk of cancer spreading.

One potential problem with the study is that the women decided how much exercise to do, but those with undetected secondary cancers might have been too tired or in too much pain to exercise, skewing the apparent benefit of exercise on the death rate, says Anne McTiernan of the Fred Hutchinson Cancer Research Center in Seattle, Washington. "A randomised trial, with women assigned at random to an exercise or control group then followed over time, would be very helpful," she says.

"Exercise had the most consistent and greatest impact on the risk of breast cancer death"

Warner says the second most important lifestyle factor is limiting weight gain after cancer treatment (*Canadian Medical Association Journal*, DOI: 10.1503/cmaj.160464).

Andy Coghlan ■

Eating old food shortens animal lifespans

YOU are what you eat – so does eating old food make you old? It sounds far-fetched, but experiments on mice, flies and yeast suggest that it might.

The fundamental causes of ageing aren't understood. One leading idea is that throughout life, our bodies accumulate cellular damage. Vadim Gladyshev at Harvard University wondered whether this damage can be acquired through food.

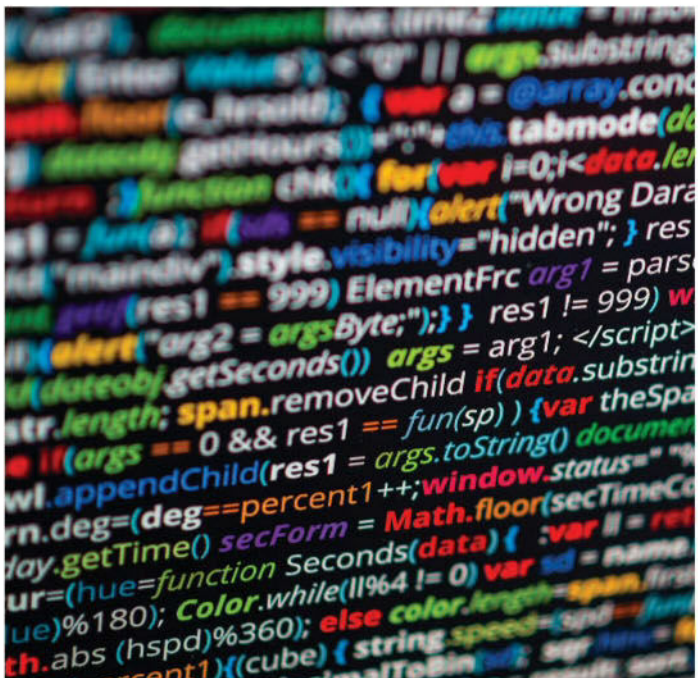
Food is broken down and used as the building blocks for many cellular processes, so eating older organisms – which have more cellular damage themselves – might cause an animal to age faster than one that eats younger organisms with less damage.

To test the theory, Gladyshev and his team grew yeast fed on culture media made from old or young yeast and fed fruit flies food made from old or young flies. They also studied mice fed meat from old or young deer. The animals were fed their particular diet from early adulthood for the rest of their lives.

The old diet shortened lifespan by 18 per cent in yeast and 13 per cent in flies. In the mice, the old diet shortened lifespan by 13 per cent in females, but had no effect on males (*Science Advances*, doi.org/bzzv). Gladyshev thinks that they may see an effect in both sexes if they increase the sample size – and believes the results seen in yeast, flies and female mice support his hypothesis.

João Pedro de Magalhaes at the University of Liverpool, UK, says the results could be explained by nutritional differences in the composition of old and young meat. Gladyshev's team tried to control for this, but admits it could be a factor.

Whatever the reason, we shouldn't be too hasty in drawing conclusions about human nutrition from the study, Gladyshev says. There was only a small effect on animals fed on old animals for their entire lives; people don't tend to eat old animals and our diets are more varied. Sam Wong ■



IUNEWIND / ALAMY STOCK PHOTO

Set a machine to program a machine

Computers are learning to code for themselves

OUT of the way, human, I've got this covered. A machine learning system has gained the ability to write its own code.

Created by researchers at Microsoft and the University of Cambridge, the system, called DeepCoder, solved basic challenges of the kind set by programming competitions. This kind of approach could make it much easier for people to build simple programs without knowing how to write code.

"All of a sudden people could be so much more productive," says Armando Solar-Lezama at the Massachusetts Institute of Technology, who was not involved in the work. "They could build systems that it [would be] impossible to build before."

Ultimately, the approach could allow non-coders to simply describe an idea for a program and let the system build it, says Marc Brockschmidt, one of DeepCoder's creators at Microsoft Research in Cambridge, UK.

DeepCoder uses a technique called program synthesis: creating new programs by piecing together lines of code taken from existing software – just like a programmer might. Given a list of inputs and outputs for each code fragment, DeepCoder learned which pieces of code

"It could allow non-coders to simply describe an idea for a program and let the system build it"

were needed to achieve the desired result overall.

One advantage of letting an AI loose in this way is that it can search more thoroughly and widely than a human coder, so could piece together source code in a way humans may not have thought of. What's more, DeepCoder uses machine learning to scour databases of source code and sort the fragments according to its view of their probable usefulness.

All this makes the system much faster than its predecessors. DeepCoder created working programs in fractions of a second, whereas older systems take minutes to trial many different combinations of lines of code before piecing together something that can do the job. And because DeepCoder learns which combinations of source code work and which ones don't as it goes along, it improves every time it tries a new problem.

The technology could have many applications. In 2015, researchers at MIT created a program that automatically fixed software bugs by replacing faulty lines of code with working lines from other programs. Brockschmidt says that future versions could make it very easy to build routine programs that scrape information from websites, or automatically categorise Facebook photos, for example, without human coders having to lift a finger

"The potential for automation that this kind of technology offers could really signify an enormous [reduction] in the amount of effort it takes to develop code," says Solar-Lezama.

But he doesn't think these systems will put programmers out of a job. With program synthesis automating some of the most tedious parts of programming, he says, coders will be able to devote their time to more sophisticated work.

At the moment, DeepCoder is only capable of solving programming challenges that involve around five lines of code. But in the right coding language, a few lines are all that's needed for fairly complicated programs.

"Generating a really big piece of code in one shot is hard, and potentially unrealistic," says Solar-Lezama. "But really big pieces of code are built by putting together lots of little pieces of code."

Matt Reynolds ■

Smart meter knows if you need help

Matt Reynolds

IS YOUR electricity meter keeping an eye on you? An energy monitoring system can track the activity of an older person by building a profile of their electricity use and sending alerts to concerned relatives if, for example, they don't switch on the kettle when expected.

UK-based firm Intelesant has developed Howz, a system that plugs directly into electricity meters to detect which appliances are in use, and how long they are switched on for, just as a smart meter does. It also collects data from light and temperature monitors and sensors that detect whether doors are open or closed.

After a few days, Howz learns the daily routine of the people in the house and watches out for deviations. "Rather than trying to spot problems when they've already occurred, our real interest is in trying to understand trends and detect things that can help people early on," says Jonathan Burr, Intelesant's CEO.

If the system detects something out of the ordinary – such as someone leaving the oven on for much longer than usual – it sends a notification to the phone of a nominated person to let them know something might be wrong.

Howz is already being tested in nearly 100 homes in Manchester, UK, and is set to run in a further 350 homes in Surrey. This project, undertaken in collaboration with Surrey and Borders Partnership NHS Foundation Trust, will put the system in the homes of people with mild to moderate dementia, most of whom live with a carer.

The data will be monitored by a team of clinicians, as well as the nominated alert receivers.

Burr says electricity monitoring is a good way to keep tabs on people's routines because this information offers a high level of detail and is inexpensive. Other remote monitoring systems on the market opt for different approaches. San Francisco-based Lively uses motion sensors to look for signs of activity, such as pill boxes being picked up or fridges being opened, and UK start-up Canary uses motion sensors to track how much time a person spends in each room.

"One of the things that most people want when they get older is to retain their independence," says Karen Lowton, a professor in ageing and health at the University of Sussex, UK. Monitoring systems could be a safety net that allows people to stay in their own homes for longer. Electricity monitoring can give hints about how well someone is functioning, says Lowton. But wearables that measure heart rate or sleep patterns provide deeper insight into a person's health, she says, and could be used in combination with electricity monitoring to give a more rounded picture of a person's well-being over time.

However, there are obvious privacy concerns over monitoring someone's behaviour so closely, and Lowton emphasises the importance of visiting older relatives in person, since just checking in via an app could lead to greater social isolation. "This has the potential to reduce human contact, if you just rely on an app to tell you that mum's up and she's had a cup of tea," she says.

Security consultant Chris MacCallum points out another potential drawback of such a system. "If you can infer someone's activities within a house, you can also infer when they're not active," he says. If the information were hacked, it could be used to organise burglaries or help cold callers target their activity for times they know people are going to be home. ■

SIMON DACK / ALAMY STOCK PHOTO

Tracker: teatime and all is well

Ceres serves up an organic feast on its surface

CERES is doing some home-brewing in the asteroid belt. Located between Mars and Jupiter, the dwarf planet boasts organic material – made in-house.

NASA's Dawn space probe, in orbit around Ceres since early 2015, has spotted pockets of carbon compounds on its surface. The identity of the tar-like substances can't be pinned down precisely, but their mineral fingerprints inferred from their spectra match the make-up of kerite or asphaltite. Such chemicals can't have been left by an incoming meteoroid or comet as they wouldn't have survived the heat of impact – and if they had hitched a ride on another object, we would not expect them to end up in pockets.

"Anything else, you would expect it to be more widespread," says Michael Küppers at the European Space Agency, who was not involved in the findings. That suggests they must have come from within Ceres itself, says the Dawn science team (*Science*, doi.org/bzw9).

This, along with recent discoveries of water ice and bright mineral deposits on Ceres, points to a more complex picture of the dwarf planet than we once had, says team leader Chris Russell at the University of California, Los Angeles. "It's not just an accumulation of rock, but in fact, it's been doing things," he says. What is going on inside is not fully clear yet, but the surface organic material indicates processes regulated by heat and water.

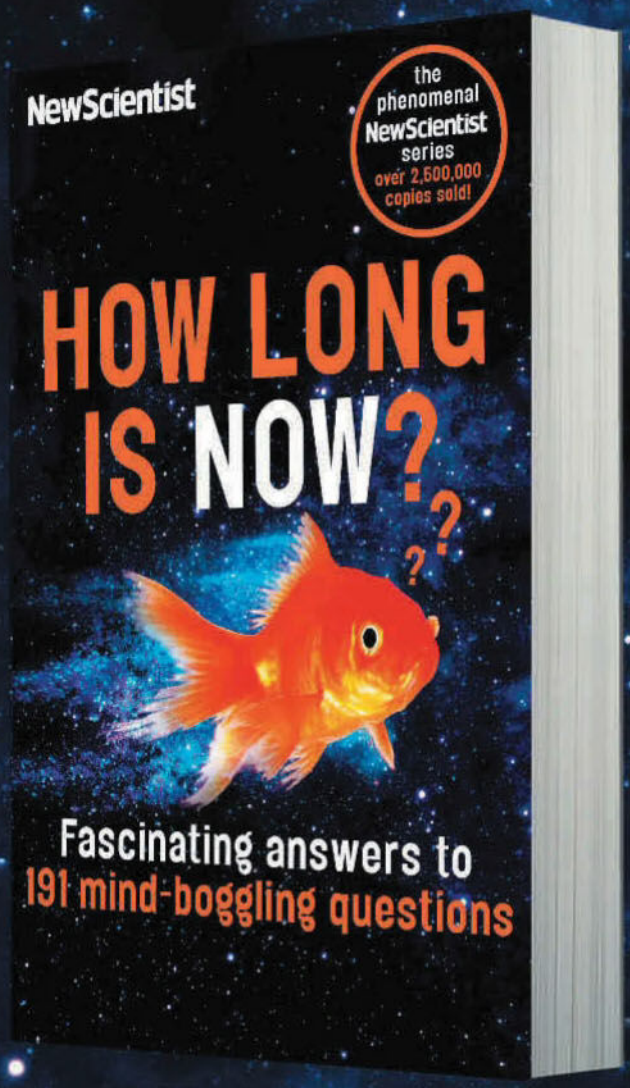
"The stuff found on Ceres is prebiotic, something made before biology… It's sort of on the road to biology"

It might sound as if Ceres has the building blocks for life, but Russell is reluctant to go that far.

"This is a different type of material," he says. "It's prebiotic, which means that it's something you would expect to make before you had biology. It's sort of on the road to biology."

Chelsea Whyte ■

WHY ARE DOGS' NOSES WET?



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Fish fake egg release during prolonged sex

FAKE it 'til you make it. Female lampreys mate hundreds of times but secretly withhold their eggs until they are sure their suitor is worthy.

During the mating season, male and female Siberian brook lampreys (*Lethenteron kessleri*) meet for orgies in specially built nests in the streams where they live. Individual female fish appear to mate up to 200 times, with 10 or more different males.

Until now, the benefit of these marathons for female lampreys has been unclear, because they require lots of energy. Now Itsuro Koizumi at Hokkaido University in Japan and colleagues have found that in most sexual encounters, the female brook lampreys do not release eggs.

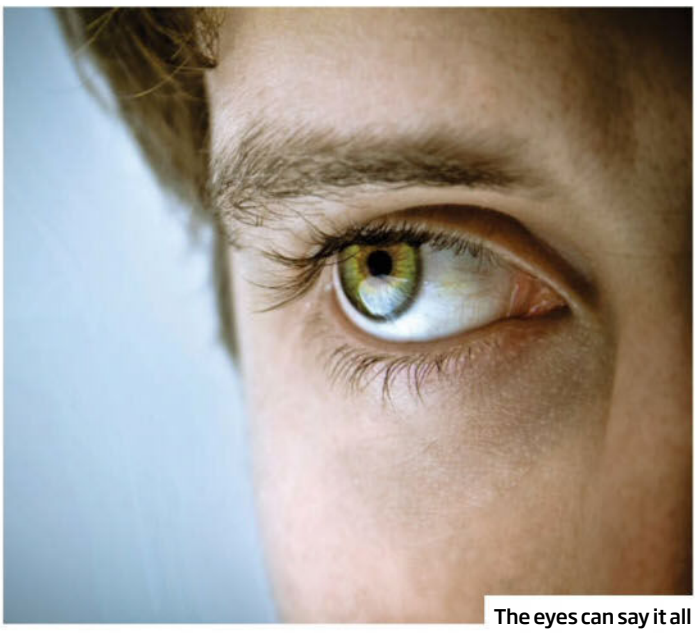
The would-be fathers appear not to notice when their female partners trick them by withholding their eggs, Koizumi says, as they still release clouds of sperm into the water.

Female lampreys were more likely to engage in sham mating when grouped with lots of males, hinting that they were pickier when they had more choice. This fits in with the idea that sham mating allows the females to select the father of their offspring.

Some female birds and mammals also mate with multiple males – a process known as cryptic choice. But this involves sperm selection once it is actually inside the female's reproductive tract. Cryptic female choice in species where the eggs are fertilised outside the body has only been reported in a handful of animals.

Despite the mating marathons female lampreys may not choose the father of their offspring based on sexual prowess. Instead, it could be to do with how many stones males can move during nest building, Koizumi says.

Brook lampreys only grow eyes as adults, and the females have larger eyes than males – possibly because they need them to scope out the best mate (*Journal of Ethology*, doi.org/bzzp). Alice Klein ■



MEAGHAN BROWNING/GETTY

The eyes can say it all

App lets paralysed users speak with their eyes

IT CAN be difficult to communicate when you can only move your eyes, as is the case for many people with conditions that affect movement. Now an app called GazeSpeak can convert eye movements into speech, so a conversation partner can understand what is being said quicker than with other methods.

To use the app, the listener points their smartphone at the speaker as if they are taking a photo. A sticker on the back, visible to the speaker, shows a grid with letters grouped in four boxes corresponding to looking left, right, up and down. As the speaker gives these eye signals, GazeSpeak registers them as letters.

"For example, to say the word 'task' they first look down to select the group containing 't', then up to select the group containing 'a', and so on," says Xiaoyi Zhang, who developed GazeSpeak while he was an intern at Microsoft.

GazeSpeak selects the correct letter from each group by predicting the word the speaker wants to say, similar to predictive text messaging. The top four word predictions are shown on-screen, and the top one is read aloud.

"We're using computer vision to recognise the eye gestures, and AI to do the word prediction," says Meredith Morris at Microsoft Research in Redmond, Washington.

The app is designed for people with motor disabilities like motor neurone disease (also known as ALS), which progressively damages nerves. In this condition, the eye muscles are often some of the last to be affected.

Currently, the most common communication method for people with ALS is to use boards displaying letters in groups, with a person tracking the speaker's eye movements. But it can take a long time for someone to learn how to interpret these eye movements effectively.

GazeSpeak proved much faster to use in an experiment with 20 people trying both the app and the low-tech boards. Completing a sentence with GazeSpeak took 78 seconds on average, compared with 123 seconds using the boards.

The people in the tests did not have ALS, but the team also got feedback on the technology from some people with ALS and their interpreters. One person typed a test sentence in just 62 seconds and said he thought it would be even quicker in a real-life situation, as his interpreter knows what he is more likely to say.

Other systems currently use software to track eye movements with infrared cameras, but these are often expensive and bulky, and infrared cameras don't work well in sunlight. The GazeSpeak app is portable and comparatively cheap – it only requires an iOS device with the app installed.

Microsoft will present the app at the Conference on Human Factors in Computing Systems in Colorado in May. The researchers say it will be available to download before the conference. **Timothy Revell** ■

JUST THINK AND TEXT

Three people with paralysis have learned to type by thought alone using a brain implant – at the fastest speeds recorded using such a system.

Each had ALS or a spinal cord injury. To help them type, Jaimie Henderson at Stanford University Medical Centre in California and colleagues placed a silicone patch – covered in electrodes – on the outer layer of their brain. The device measures activity in the primary motor cortex, involved in movement. It was then connected to a computer.

As the participants thought about moving different body parts, the computer translated the associated brain activity into cursor movements – allowing them to type at almost half the speed at which people without ALS can text (*eLife*, DOI: 10.7554/eLife.18554). One participant said they preferred it to an eye-tracker device, calling it "quite intuitive".

NEW SCIENTIST DISCOVERY

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Mars might have early signs of rings

Rebecca Boyle

IN A few million years, Mars's gravity will shred its moon Phobos, the pieces settling into a flat ring like those around Saturn. But bits of the Red Planet's two moons may already be circling it, partly in the form of nascent rings.

Astronomers have long thought that Mars could be encircled by rings made of bits of rock kicked up from its moons Phobos and Deimos, but no one had ever seen them. This may be because the rings lie in planes not easily viewed from Earth or space telescopes – or because they aren't there at all.

After it arrived at Mars in 2013, the Mars Atmosphere and Volatile Evolution (MAVEN) satellite spotted a cloud of high-altitude dust around the planet. The MAVEN team could not tell the size of the particles or their source, but they were spread out uniformly rather than concentrated into rings. That diffuseness suggested they were coming from interplanetary space.

A fresh analysis of the MAVEN data now suggests Mars is also surrounded by proto-rings of dust, and some of the material is coming from its moons.

Jayesh Pabari of the Physical Research Laboratory in Ahmedabad, India, and his colleagues compared the MAVEN dust measurements with models based on existing assumptions about how many meteoroids hit Mars and its moons. They argue that Mars's gravity collects the larger particles thrown up by these strikes into proto-rings located along each moon's orbit, while smaller particles are often swept away by the solar wind.

The team found that about 0.6 per cent of the dust could be ring-like material that escaped from Phobos and Deimos (*Icarus*, doi.org/bzxb).

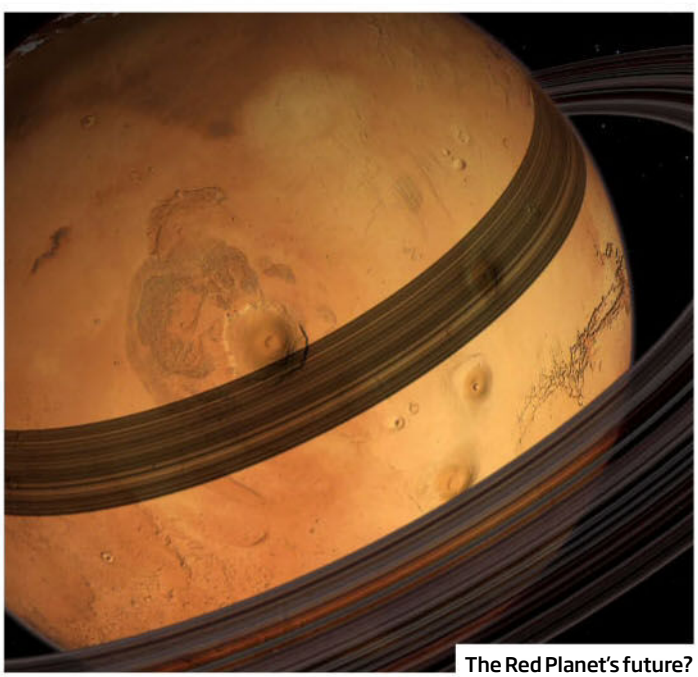
The dust shedding due to meteoroid impacts would continue even as Mars's gravity pulls Phobos inward over the next 20 to 70 million years and starts to break it apart. That means much of Phobos will not end up ringing Mars when the moon finally collapses.

The MAVEN team is not convinced that any proto-rings exist. MAVEN sidled up to Phobos in 2016, and mission managers didn't see any increase in dust along its orbit, says principal investigator Bruce Jakosky at the University of Colorado Boulder.

Much about the dust cloud is hazy, too, since MAVEN was not designed to look for dust and no dust-collecting probe has visited the planet. A Japanese probe called Nozomi was equipped for the task, but electrical problems meant it failed to go into Mars orbit in 2003. Pabari has designed and proposed a dust investigation mission called the Mars Orbit Dust Experiment (MODEX) that could launch on a future orbiter.

"To say anything definitive about the dust, you really need to have a dedicated dust detector," says Laila Anderssen, also at the University of Colorado Boulder. She is still analysing the MAVEN dust findings, which are based on electrical readings.

"We still haven't seen a good indication that there is significant material in the vicinity of the moons. So I think it's a long shot," Anderssen says, "but one should never say never." ■



TUSHAR MITTAL

The Red Planet's future?

Military mental health checks don't help

MENTAL health screening doesn't help soldiers with psychological problems after they return from war. So says the first test of such check-ups.

The surprise result suggests other kinds of psychological screening, on schoolchildren or new mothers, for instance, may also be flawed.

Several nations perform psychological check-ups when military personnel get home. There are calls for the UK to do so too.

But in other areas of medicine, for example with prostate cancer, screening has come under scrutiny. It is generally accepted that screening should only be introduced once trials show it does more good than harm.

Now such a trial has been carried out on British soldiers, paid for by the US Department of Defense. After returning from Afghanistan, nearly 9000 soldiers filled in a questionnaire about symptoms of depression, post-traumatic stress disorder, anxiety or alcohol problems.

About two-thirds were then placed in a screening group and offered a letter revealing if their symptoms pointed to a mental health condition. If so, they were urged to seek help, such as by making a doctor's appointment. The rest got a letter of thanks including sources of support.

Over the next one to two years, the rates of mental health conditions were the same between the two groups. In the screening group, about a third declined to see the results letter (*The Lancet*, doi.org/bzzn).

"If not beneficial, screening is likely to do harm – risking misdiagnosis and unnecessary treatment"

If screening brings no benefits, it is likely to do harm overall, says Simon Wessely of King's College London. Risks include misdiagnosis leading to people taking unnecessary drugs.

But the screening may have seemed ineffective because those in the control group also did the questionnaire, which could have prompted them to seek help or at least focus on their symptoms, says Alexander McFarlane at the University of Adelaide, Australia. Clare Wilson ■

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Gulliver ants live happily among the Lilliputians

IT'S an unusual living arrangement: a massive black ant shares its nest with a much smaller brown ant.

Most social insects don't tolerate strangers. But the 15-millimetre-long *Platythyrea conradti*, which lives in the forests of Ivory Coast, builds nests inside holes in trees that it shares with the 2.5-millimetre-long *Strumigenys maynei*.

"This is a remarkable and rare example of cooperation between two ant species that share little in common," says Thomas Parmentier, an evolutionary biologist at the Catholic University of Leuven (KUL) in Belgium. "One is large and the other minuscule, they belong to unrelated genera and have markedly different behaviour."

Parasitic species often sneak into nests by producing odours that match those of the nest builders. But Parmentier and colleagues have shown that both species have unique odours. Despite this, the species almost never attack each other (*Behavioral Ecology and Sociobiology*, doi.org/bzzm).

Why they live together isn't clear. But a clue could be in their behaviour: the small ants are highly aggressive, attacking and repelling any invaders, while the large ants avoid direct confrontations. It may be that the larger ants lack a soldier caste and the smaller ants have effectively taken on this role. In return they get a home and food in the shape of other small creatures found inside the nest.

A dormouse with ultrasonic 'sight'?

A RARE rodent isn't just blind as a bat: it may navigate like one too. The Vietnamese pygmy dormouse seems to make ultrasonic calls to guide its motion. If so, it would be the first tree-living mammal – apart from bats – known to use echolocation.

Keepers at Moscow Zoo noticed that the dormice can climb with remarkable agility despite having poor eyesight. "We suspected that they use echolocation," says Aleksandra Panyutina at the Russian Academy of Sciences.

Her team filmed the zoo's two dormice in cages filled with branches. The soundtrack revealed that they often produced a series of quick, ultrasonic pulses similar in structure to bat echolocation calls but much quieter. The dormice typically made the sounds while moving, which suggests they use them for navigation (*Integrative Zoology*, doi.org/bzzd).

Gareth Jones, a bat researcher at the University of Bristol in the UK, thinks the results are interesting, but not conclusive just yet. "It is important to determine whether the mice can hear echoes from the calls," he says.

Besides bats, whales and birds, there is also evidence that some rats, tenrecs and shrews can echolocate.

Seagrasses kill off harmful bacteria

COME on in, the water's lovely – at least, where seagrass beds still line the coast. Microbes found in sewage that can cause disease in humans and marine organisms are far less common in these areas than elsewhere.

Joleah Lamb at Cornell University in New York state and her colleagues sampled seawater off four islands in the Spermonde archipelago, Indonesia. They found that the level of *Enterococcus* bacteria in areas with seagrass was just a third that in areas without seagrass. This is good news for swimmers, but also for coral. The team's field surveys of coral health showed a twofold reduction in coral disease near seagrass compared with areas with no seagrass (*Science*, doi.org/bzzg).

Lamb is now trying to pin down why this is the case. It could be, for example, that the oxygen released by seagrass kills the bacteria.

Vitamin D prevents cold and flu

PRONE to sniffles? Some vitamin D might help. More than 3 million people in the UK would avoid having colds and flu every year if they took vitamin D supplements. That's according to an analysis of data from nearly 11,000 people.

The analysis used data from 25 clinical trials and found that vitamin D supplements can cut the proportion of people getting respiratory infections by 12 per cent (*BMJ*, doi.org/bzw7).

The study's authors say the results strengthen the case for fortifying foods in the UK with vitamin D.

Public Health England already recommends that people consider taking vitamin D during the autumn and winter to protect musculoskeletal health.

How buttercups have hot sex

BUTTERCUPS have a trick for warming their flowers that may be unique to this group of plants.

Inside each flower petal, special cells create two layers of air that deflect the light reaching them sideways. This makes the petals act together like a parabolic reflector, focusing visible and infrared light on the flower centre. "The flowers act as heat concentrators," says Doekele Stavenga of the University of Groningen in the Netherlands, whose team discovered the trick (*Journal of the Royal Society Interface*, DOI: 10.1098/rsif.2016.0933).

Warming the pollen-producing stamens has previously been shown to boost their growth and the chance of fertilisation, he says. Insect pollinators prefer warmer flowers, for instance, perhaps because it allows them to keep their own temperature up.

Buttercups get their bright colour from yellow pigments in the petals' surface layer. But the petals' shiny gloss is due to the double layer of air just beneath the surface. This reflectivity is what turns people's chins yellow when they hold a flower underneath.

Some other plants also warm their flowers. A few burn food like warm-blooded animals, and one rhubarb species has translucent leaves that act like a greenhouse.

NIGEL CATTLIN/FLPA

'Meditating mice' reveal how mindfulness decreases anxiety

CAN a mouse be mindful? An experiment shows how using pulses of light to trigger a specific type of brainwave seems to make the animals less anxious. The brainwaves, known as theta waves, are the same ones associated with meditation in humans.

Human experiments show that meditation reduces anxiety and levels of stress hormones, and improves attention and cognition. Studies indicate that meditation affects communication around the anterior cingulate cortex – a brain region that regulates the fear response.

Michael Posner at the University of Oregon and his colleagues wondered how meditation could do this. They thought it might be related to changes in theta brainwaves, a type of brain activity that increases after meditation, even when people are no longer meditating.

To test the theory, the team genetically engineered certain mouse brain cells to be switched on by light. In this way, they were able to use pulses of light on mice to stimulate theta-brainwave-like activity around the anterior cingulate cortex.

The mice underwent 30 minutes of this stimulation for 20 days. They were less anxious in behavioural tests than mice given light pulses that induced other kinds of brainwaves, or who had no treatment at all (*PNAS*, DOI: 10.1073/pnas.1700756114).

It is unknown whether the mice would have experienced mental states similar to mindfulness during the light stimulation.

Uranus follows its asteroid buddy

AN ASTEROID is being chased through space by Uranus. The rock is know as a Trojan asteroid, which follow the same orbits around the sun as planets – just 60 degrees ahead or behind them.

Jupiter and Neptune have many Trojans, some of them in place for billions of years and so they hold data about the solar system's birth. NASA has plans to visit several in the 2020s and 2030s.

But Saturn and Uranus live in a rougher neighbourhood: the gravity of the planets on either side of them yank Trojans away. So Saturn has no known Trojans, and Uranus seemed to have only one, called 2011 QF99.

In July, though, astronomers reported an asteroid, 2014 YX49, that shares Uranus's 84-year orbital period. Now computer simulations by brothers Carlos and Raul de la Fuente Marcos at the Complutense University of Madrid, Spain, indicate that the asteroid has maintained its position ahead of Uranus for thousands of years (arxiv.org/abs/1701.05541).

2014 YX49 was found by accident, so there should be hundreds more Trojans waiting to be discovered, Carlos says.

NASA

Turn space junk into giant fireworks

THE chemistry that gives sparklers their sparkle could reduce the threat posed by falling space junk.

Most defunct satellites completely burn up in our atmosphere, but some metal pieces can survive re-entry. This is because they are often made of titanium, which has a high melting point of about 1670 °C.

Now, Denis Dilhan at the French space agency and his colleagues have a solution: make metal satellite parts burn up more efficiently as they enter the atmosphere by using thermite. This mixture of metal powder, fuel and metal oxide releases heat when ignited and is best known for its role in fireworks and welding.

The team say bits of thermite attached to titanium components would self-ignite when a satellite, or a piece of it, hit the upper atmosphere. That could melt holes in the metal, changing the shape of components and making them more likely to break up (*Acta Astronautica*, doi.org/bztd).

Does altruism need science?

Effective altruism is a movement that seeks a scientific revolution in how we do good. But are some things beyond science, asks **Niall Firth**

GREG LEWIS wanted to make the world a better place, and training to become a doctor seemed like the obvious path. But Lewis was curious: exactly how many lives could he expect to save with his chosen career?

When he crunched the numbers, he was shocked. Assuming he was of average ability, over his entire medical career, he could expect to save the equivalent of around four lives. Put another way, his entire life as a doctor would have as much impact as donating £600 per year to a global health charity. "That was surprising," he says. "And a little bit depressing to be honest." He decided to change career.

Lewis subscribes to the philosophy of effective altruism, which seeks to use science and rationality to overhaul what it means to give and to do good in the world. Proponents run websites that evaluate charities based on empirical research, create tools to help would-be philanthropists calculate donations – and even help people assess their skill sets to decide how they can benefit the greater good.

The appeal of effective altruism is clear in its growing popularity, and next month sees the launch of a new tool that will suggest effective causes that chime with a person's values. But is philanthropy really in need of a rational overhaul?

"We are trying to create a scientific revolution – not for the pursuit of truth but for the pursuit of good"

If you live in the West, you are one of the richest 5 per cent of people on the planet. That makes you one of the richest people history has ever known. This fluke of fate gives you the opportunity to save hundreds or thousands of lives.

But benevolence can be tricky. Billions are donated each year, but charities vary widely: some are more than a hundred times more effective than others, while others have little or no effect – even intuitively appealing projects can end badly (see "Paved with good intentions", below).

Effective altruism started as a way to cut through some of this uncertainty. Helpful information is out there, thanks to organisations like MIT's Poverty Action Lab, which evaluates the impact of various global health initiatives to determine which approaches are the most effective, using data from clinical trials.

But few of us have time to comb through all this data to weigh up how much difference a donation will make. So the people behind GiveWell, an effective altruism organisation, have done it for you. Their website uses this information to create a league table of top charities they believe offer the most bang for donated buck.

The results can be surprising. The best-ranked charity on GiveWell is The Against Malaria Foundation, which provides insecticide-treated bed nets that cost around $5 each. However, otherwise well-regarded projects, like one that donates textbooks to rural African schools to boost attendance, didn't make the list. Trials showed they were ineffectual. If you wanted to boost attendance, instead of donating books – a well-meaning but ultimately unsuccessful tactic – the website suggests giving to the highly ranked Schistosomiasis Control Initiative, a deworming charity that operates across sub-Saharan Africa. Deworming medication, according to clinical trials, is a far better way to keep kids in school than extra books.

Thanks to its focus on empirical research, effective altruism has also flagged up some general rules for would-be philanthropists. Due to the disparity between Western incomes and those in the developing world, for example, you stand a better chance of maximising your money if you send it to places where dollars or pounds have greater buying power.

"When it comes to global health, that's the easiest case where you can quantify your impact," says William MacAskill at the University of Oxford, the author of *Doing Good Better* and one of the movement's founders. "Ultimately what we care about is how many people you are benefiting and by how much."

But as Lewis found when assessing his medical career,

PAVED WITH GOOD INTENTIONS

It seemed like the perfect idea: using children's playing power to pump clean water.

The PlayPump was devised to solve a problem common in many villages in developing countries: acquiring clean water without having to pump deep wells by hand, an onerous task usually left to women.

What if you could get water as a freebie? This is what the PlayPump was designed to do: it was a roundabout which, as it spun, pumped clean water from a deep storage tank.

Donors from Bill Clinton to rapper Jay Z fell in love with the concept. In 2006, First Lady Laura Bush campaigned to raise $60 million to put them into villages across Africa. Three years later, almost 1800 PlayPumps were installed in South Africa, Zambia and other countries.

There was just one issue: they didn't work. Two reports, one by UNICEF, found that children playing on the roundabouts quickly tired, as they weren't free-spinning. In one village, children were paid to "play", but most of the time women ended up pushing it themselves. They were also inefficient, pumping about five times less water than the old hand pumps. And when they broke down – frequently – they were almost impossible to fix.

Proper trials – or even just asking recipients if these were wanted – might have found problems earlier.

PAUL HACKETT/GETTY

PETER DAZELEY/GETTY

Time for a rethink?

effective altruism can go far beyond donating money – its proponents also want you to fundamentally rethink your capacity to make a difference. "The idea is to take some of our existing notions of what it is to do good and really hold it up to scrutiny," says Sam Deere of effective altruism organisation Giving What We Can, which gets people to pledge at least 10 per cent of their income to charity, for life.

Rethink your life

The career you choose can have a big impact on your ability to change the world. The group 80,000 Hours – the name comes from the average amount of time you can expect to spend working – provides career advice for would-be effective altruists. "It's about finding a niche that fits your skill set but also gives you the ability to give something back," says Deere.

You don't have to work for a charity – in fact, maybe you shouldn't. For those with the right skills, the better bet might be a high-paying job. This is known as "earning to give" and lets you give a larger amount to the best causes. One offshoot of this idea, Founders Pledge, recruits super-wealthy entrepreneurs and tech CEOs to pledge at least 10 per cent of their income for life.

Figuring out how your chosen profession stacks up isn't always straightforward. To quantify how much good he would do as a doctor, Lewis used a statistical tool known as Quality Adjusted Life Years (QALYs), devised by health economists. One QALY is defined as one person living at full health for one year, and providing 36.5 QALYs is roughly as beneficial as saving one life. Lewis calculated each high-quality year he would be likely to add to his patients' lifespans over the course of his career, and found that in the UK, with its good nutrition and infrastructure, he could expect to "save" the equivalent of four lives.

According to the same maths, he would have saved the equivalent of 300 lives by working in a country like Ethiopia, where far less is spent on medical care per citizen.

Lewis chose to stay in the UK, but he moved into public health, where he can potentially direct policy that helps far more people than he could as a doctor catering to individuals. He now also gives 30 per cent of his salary to charity, a combination he thinks has maximised his ability to do good. "In my first year working [in public health] I probably did more good than I would have in my entire medical career," he says.

The approach hasn't been without its critics. One question centres on how comprehensive all this evidence really is. "Effective altruism is easier to understand in cases where you can use numbers in a more precise way," says MacAskill. Could the shortcomings lead to good charities being overlooked?

"Most of us don't donate to charity to improve the world. We donate to feel connected to community"

Some causes are trickier to evaluate than bed nets. How do you weigh up the overall impact of charities that campaign for equal rights for gay people or environmental action, for example? The way evidence is evaluated naturally directs attention towards systemic public health interventions, and away from more intangible political advocacy, which might do more to address the root causes of many problems, instead of just alleviating the symptoms.

Oversimplified

Others think privileging cold hard stats over the warm fuzzy feeling of doing good might even be counterproductive. Elizabeth Dunn at the University of British Columbia in Canada has looked at what motivates people to do good. For her, effective altruism relies heavily on the people involved being motivated by the movement's rational approach. If it catches on, she fears that a lack of tangible benefit – the feeling of community when you donate to a local cause, for example – might put people off donating altogether. It could also discourage people from donating to local causes.

But perhaps over-reliance on the feeling of community to motivate philanthropy is the exact problem effective altruism is trying to address. "People have this view that you should look out for one's community and pay attention to those closest to us," says Lewis. "Those people further away, we don't care about them as much." Everyone is susceptible to this bias, says MacAskill. The idea is to try and use rationality to "overcome these very human limitations".

"We are trying to create the equivalent of the scientific revolution," he says, "but not in the pursuit of truth but rather for the pursuit of good." ■

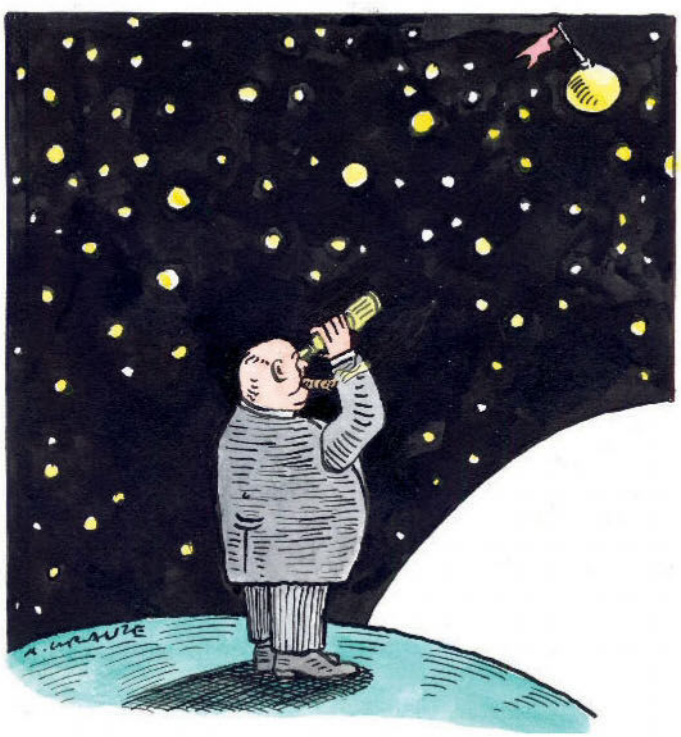
Visionary leader

In 1939 Winston Churchill mused about the possibility of exoplanets and life beyond Earth. His words still resonate, says **Rebecca Boyle**

A NEWLY unearthed essay has opened a fresh window on Winston Churchill's inquisitive mind. Even as the second world war loomed, the man poised to lead Britain in the fight against Nazi Germany, found time to consider the possibility of planets and life beyond our solar system.

"Are We Alone in Space?" written in 1939 and revised in the 1950s, was found by Timothy Riley of the National Churchill Museum in Fulton, Missouri, where the cigar-smoking leader made a famous speech about the "Iron Curtain" in 1946. Riley passed it on to astrophysicist Mario Livio to review (*Nature*, doi.org/bzsh).

In the essay, Churchill wonders about other worlds and other intelligent life elsewhere in the cosmos. "I am not sufficiently conceited to think that my sun is the only one with a family of planets," he writes. Today, we know most stars do have planets and have spotted thousands.



But why put pen to paper on this in 1939? Excitement about the possibility of alien life was at fever pitch after the 1938 US radio broadcast of *The War of the Worlds*. But, as Riley points out, the winds of war in Europe were surely on his mind, too, as he speculates about peaceful civilisations elsewhere.

"I, for one, am not so immensely impressed by the success we are making of our civilization here that I am prepared to think we are the only spot in this immense universe which contains living, thinking creatures," Churchill writes, "or that we are the highest type of mental and physical development which has ever appeared in the vast compass of space and time."

This is the essay's last line, and is a favourite of Riley's, and mine.

Armchair misdiagnosis

Donald Trump may be flawed, but so too are claims he is mentally ill, says **Dr Allen Frances**

DONALD Trump is unlike any other president in US history.

The country has had its share of stupid, lying, impulsive, ignorant, narcissistic, bellicose or unpredictable presidents. But never before has one embodied all of these traits.

Not surprisingly, Trump's radical policies, behaviour and unusual leadership style have sparked fierce political opposition. What is a surprise is that they have also provoked a lot of armchair psychiatric diagnosis, focused on the erroneous claim he has narcissistic personality disorder (NPD).

This started with political commentators and comedians, but spread to mental health professionals, who felt compelled to disregard ethical constraints against plying their trade in this way with public figures. Their letters and petitions in this vein call for his removal from office.

I strongly oppose these as the diagnosis is inaccurate: Trump may be a narcissist, but this doesn't make him mentally ill.

I wrote the criteria for NPD for the *Diagnostic and Statistical Manual of Mental Disorders*.

"Trying to impeach Trump or remove him from office on medical grounds is a terrible idea"

These state that the associated personality features must result in clinically significant distress and impairment. Trump appears to cause severe distress in others, rather than experiencing it himself, and has been richly rewarded, rather than punished, for his self-promoting and self-absorbed behaviours.

Such diagnosis also unfairly stigmatises people with mental illness (who are mostly well behaved and well meaning) by lumping them with Trump (who is neither). And it insults their suffering by comparing it with his tantrums. We must avoid the common error of confusing bad

"He is hopeful that there are perhaps others that are living, thinking creatures that might set better examples, perhaps," Riley says. Beyond this, the essay discusses the importance of water, which still guides the hunt for extraterrestrial life. Churchill points out that liquid water can only survive in what scientists now call a habitable zone. He also muses on interstellar travel and solar system exploration.

That he was interested in all this reflects his curiosity about the natural world and technology. This was seen in his order to convert the Royal Navy from coal-burning to oil-powered ships, the funding of research, and becoming the first prime minister to employ a science adviser.

The 20th century saw the fastest expansion of knowledge in history; it is only fitting that one of its most iconic leaders foresaw the issues at the forefront of planetary science in the 21st.

For today's leaders on both sides of the Atlantic, his words are a reminder of the importance of intellectual curiosity, the ability to contemplate the future, and the significance of these to human values. ■

Rebecca Boyle is a science writer based in Missouri

behaviour with mental illness.

Psychiatric diagnosis is already done too casually and inaccurately in health practice. Armchair diagnosis further cheapens its currency.

In any case, trying to impeach Trump or remove him from office on medical grounds is a bad idea. Those next in line support the same dangerous, science-denying irrationality, but in a more palatable form likely to stimulate less-effective opposition. ■

Allen Frances is professor emeritus of psychiatry and behavioural sciences at Duke University School of Medicine, North Carolina

INSIGHT Antarctic sea ice

NASA

We shouldn't jump to conclusions

Don't panic (yet) about record low sea ice

Michael Le Page

"SEA ice around Antarctica has shrunk to the smallest annual extent on record after years of resisting a trend of man-made global warming," is how Reuters put it on 14 February in a story reproduced around the world.

It might seem obvious that this record low is due to global warming – but we don't yet know if it is.

Since satellite observations of Antarctica began in 1979, the maximum and minimum area of sea ice has varied each year, but the average area has grown slightly. Climate change deniers have seized on this increase as evidence that the world is not warming. They're wrong. However, to suggest that this year's trend-bucking low is certainly a sign of climate change would also be wrong.

"There is little chance this is a signal of global warming," says Mark Brandon of the Open University in the UK, who studies the oceans around Antarctica.

How does this tally with the effect of climate change in the Arctic? Look at the differences between the two poles. The Arctic is an ocean surrounded by land. Much of the sea ice that forms in winter used to survive for several summers, getting thicker each year. Over the past 30 years, not only has the area of summer sea ice in the Arctic Ocean shrunk dramatically, its age and thickness has plummeted too. There is no question that this long-term change is due to global warming.

Antarctica, by contrast, consists of land surrounded by oceans. Most of the land is covered by ice sheets several kilometres thick. Where this ice slides into the sea, it forms floating ice shelves hundreds of metres thick. Some are hundreds of kilometres wide. Sea ice can only form in the waters

"In these 'post-truth' times, sticking to the evidence about climate change is more important than ever"

north of the land and ice shelves, far from the pole. So hardly any sea ice survives the summer in the Antarctic.

That means the extent of Antarctic sea ice can vary greatly from year to year depending on many weather conditions – not just the temperature. Winds blowing offshore can spread sea ice over a vast area, while onshore winds compact it.

The salinity of the water also matters. Sea water usually freezes at around –2 °C, but if it is diluted by fresh water from melting ice, it can freeze at higher temperatures. This would explain sea ice staying in Antarctica, even with increased sea temperatures.

Exactly why the average area of seasonal sea ice around Antarctica has risen over the decades isn't clear, but it could be due to changing winds around the continent. The reason researchers can't say for sure is that there are few observations of what's happening. For instance, we have no idea how thick the sea ice is.

What is clear is that this past year bucked the trend: the sea ice started melting earlier than usual in the spring and kept melting. It's not yet official, though the US National Snow and Ice Data Center is expected to confirm within days that the extent of sea ice has shrunk to its lowest minimum since satellite observations began.

However, because Antarctic sea ice is so variable, it is possible that the extent of summer sea ice was even lower before records began 38 years ago. By contrast, we are sure there is less Arctic sea ice now than there has been for thousands of years.

There are innumerable effects globally due to climate change. But the record Antarctic sea ice low does not seem to be one of them – and in "post-truth" times, sticking to the evidence is more important than ever. ■

Bears in the wood

WHAT do you mean: "They're not real pandas"? That get-up isn't meant to fool you – it's for the bears in China's Wolong Nature Reserve, which must not get used to human contact.

Dressing up like this is designed to keep the pandas wary of people, so they steer clear of the villages and farms that dot their territory. No one knows if it works – but for added authenticity, the costumes are doused with panda pee.

Photographer Ami Vitale wore the same outfit – urine included – to take this image, part of a set that won the second prize for nature stories at this year's World Press Photo contest. The panda keepers are trying to find a bear with a radio tracking collar that is in training for release into the wild.

Pandas once ranged across China, Myanmar and Vietnam. Now they can be found in just a few mountainous parts of China, amounting to about one-hundredth of their former habitat, with a mere 1864 animals left in the wild. But that is up from a low of about 1000 in the 1970s.

China hopes that its captive breeding programme will help. While the bears are notoriously difficult to breed, 38 cubs were born across China in 2015. The newborns are fed, weighed, massaged and generally cosseted.

Cubs are chosen for freedom if they seem independent, wary of humans and other animals, and are able to find food and shelter. Appreciation of cosplay is optional. Clare Wilson

Photographer
Ami Vitale
National Geographic

The coming plague

A killer pandemic is now more likely than ever. Where will it come from and how can we beat it, asks **Debora MacKenzie**

IN 1347, an epidemic of unimaginable ferocity struck Europe. People first experienced flu-like symptoms, but within days painful swellings developed, which turned black, split open and oozed pus and blood. The Great Pestilence, later dubbed the Black Death, swept across the continent within four years, killing up to half the population. The disease persisted in Europe until the 1700s, always circulating somewhere, killing people off.

We speak of it nowadays as history. In fact, it is more like natural history: infectious disease is part of the ecology of our species. Until 1900, and despite considerable competition from violence and starvation, it was our biggest killer, causing half of all human deaths. Now, it accounts for fewer than a quarter of all deaths worldwide, most of them in poor, tropical regions. In rich countries it is only a few per cent. And the toll is falling.

But we shouldn't be complacent: plagues will return. The 1960s notion that infectious disease was on the way out ended when HIV appeared in the 1980s. Since then, many infections like bird flu, SARS and Zika have caused alarm. But it took a near-disaster – the worst ever outbreak of Ebola – to scare the inertia out of governments. As a result, we are at last preparing for the inevitable. A clutch of programmes being launched this year will improve our grip on microbial killers. And the world now has an emergency medical response team – which, astonishingly, it never had before. But we aren't there yet. If a novel virus struck now, we would still be in trouble.

BRIAN LAROSSA

For all our high-tech modernity, and in many ways, because of it, the risk that new infectious diseases will evolve is actually getting worse. Pathogens began circulating regularly among humans only after we started farming and settled in towns. One reason was that we caught infections from our livestock: flu from ducks, tuberculosis from cows. But crucially, there were enough of us in close proximity that a germ could always find a new host and keep spreading, persisting among people and adapting to us.

Now we are crowding into cities and travelling more, especially within the tropics where pathogen diversity is highest. That plus globalised trade, migration and climate change reshuffle wildlife, people and pathogens. Farms and towns invade the habitats of animals with viruses that can jump to us, or to our densely packed livestock, also booming as demand for animal protein soars.

Public health experts have been warning for years of "emerging" diseases, which can go from unknown to epidemic if the pathogen mutates or the ecology of its hosts changes to make its spread easier. And it is viruses that epidemiologists are most worried about. Bacteria can be deadly, and antibiotic resistance could mean diseases from gonorrhoea to ordinary bladder infections become incurable, but work has at least begun on new drugs. In contrast, viruses can evolve and spread faster, there are thousands we know nothing about, and we have few drugs against them. The worst emerging infections since 2000 have all been viruses.

None is more alarming than the 2014 outbreak of Ebola in West Africa. The virus infected 50 times more people than any previous outbreak, and reached big cities for the first time. As a bat virus still ›

unaccustomed to humans, it spread fairly slowly, but an even slower international response allowed it to kill more than 11,000 people before old-fashioned methods, like isolating cases and quarantining their contacts, snuffed the outbreak out.

There was no other option. We were unable to produce a vaccine in time even though we already had experimental Ebola drugs and vaccines, and their deployment was accelerated, with regulation and manufacture taking months instead of the usual years. Researchers have since discovered that as it spread the Ebola virus was adapting to people, and getting better at transmitting. It almost spiralled out of control in Nigeria. "The world was close to an abyss," says Tom Frieden, outgoing head of the US Centers for Disease Control and Prevention.

To combat the next plague, we will need vaccines, drugs and diagnostic tools – and just as importantly, some way to deploy them effectively. "We do not have that," says Jeremy Farrar, head of UK medical research agency the Wellcome Trust. But we might if, in the wake of Ebola, we can build on momentum in three key areas: working out what the enemy is, arming ourselves against it and being ready to act forcefully and fast.

1 KNOW YOUR ENEMY

First, what should we prepare for? "Spotting the next HIV or SARS before it strikes is virtually impossible," says Ab Osterhaus, head of the new Research Center for Emerging Infections and Zoonoses in Hannover, Germany. "There are too many viruses in too many species, interacting with humans and evolving in unpredictable ways." To narrow the field, he says, we need "a detailed understanding of when, where and how viruses are moving from wildlife to people". Because, like the historical plagues, the next big disease is likely to be one that has made the leap from other animals to us.

In December, Mark Woolhouse and his colleagues at the University of Edinburgh, UK, reviewed what we know about such viruses. They identified 37 already able to spread from human to human, though poorly, that could become more contagious. These range from virtual unknowns like o'nyong-nyong, an African virus that causes debilitating joint pain, to Rift Valley fever, a common livestock illness.

That's just the viruses we know. A project called PREDICT, funded by the US Agency for International Development, is looking for others. In places, mostly tropical, where humans and wild mammals interact, the project screens people, their food and their rodent, bat and primate neighbours, looking for genetic sequences of viruses in families known to spawn human pathogens. They have found 984 viruses, 815 of them new to science. In the process, they have mapped hotspots of viral diversity and trained and equipped local labs to test for viruses and watch for disease.

Predicting risk

But which of these viruses should we focus on? Some are obvious, such as a Chinese virus closely related to SARS but different enough that prototype SARS vaccines won't work against it. Others might be identified using a clue discovered by Kevin Olival of the EcoHealth Alliance, who works with PREDICT.

He has statistically analysed all the available data on the flavivirus family, a troublesome lot carried by mosquitoes and ticks that includes yellow fever, Zika, dengue and West Nile. Last November, he reported that the more species a flavivirus regularly infects, the more likely it is to infect humans as well. That makes the riskiest flaviviruses a clutch of virtual unknowns: Usutu – a bird-borne virus invading Europe – Ilheus, louping ill, Wesselsbron and Tyuleniy.

The Global Virome Project wants to go further in learning about the enemy, genetically sequencing and mapping most of the estimated half-million so-far undiscovered viruses in families we know can infect humans. It reckons it will need $3.4 billion to do that over the next decade, and this year it will start canvassing for funds. The hope is that knowing what viral diversity exists and where could provide unexpected insights and spur investment in disease control.

2 ARM YOURSELF

Once we know what we are fighting, we have to arm ourselves. Finding weapons won't be easy, though. The vaccines that defeated so many infectious diseases in the 20th century were mostly made by government-owned firms that didn't have to turn a profit and produced what was needed as a "public good". In the 1980s, everything was privatised. That was good for spurring profitable medicines for chronic conditions. But much medical innovation is now done by small, start-up biotech firms, which can't afford to shepherd their products through the "valley of death" – the long, expensive process of testing for safety and efficacy, and establishing manufacturing processes and formulations for licensing. Only big pharma companies have the know-how and the $1 billion or so needed to bring a new vaccine to market. But vaccines for common diseases offer little profit; those against a virus that might or might not go epidemic are a commercial non-starter.

There have been efforts to bring public good back in. Since the 1990s, new treatments for diseases of poverty, like the meningococcal vaccine for Africa, were developed by public-private partnerships between big pharma, governments and large philanthropies like the Bill & Melinda Gates Foundation. "But the momentum fell," says Farrar. In 2013, government and private research on "neglected" emerging diseases amounted to only 1.6 per cent of the $195 billion spent on health R&D. Of that, only a fifth was private.

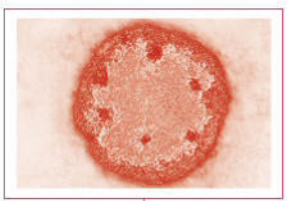
Now, because of Ebola, the momentum may be back. Last May, the World Health Organization set out an "R&D blueprint for action to prevent epidemics", which aims to bring all parties together to develop responses before the next plague strikes. Committees are being set up to look for solutions to problems that emerged during the Ebola outbreak, from agreed protocols for quickly testing and licensing experimental drugs and vaccines, to liability insurance for using experimental products, to contracts ensuring information and biological samples are shared.

But the most important goal is to accelerate R&D on nine priority pathogens (see "The nine viruses of the apocalypse", right). Using an approach pioneered for malaria vaccines, the WHO will find out what research is being done, get participants talking and push progress towards vaccines, drugs and diagnostic ›

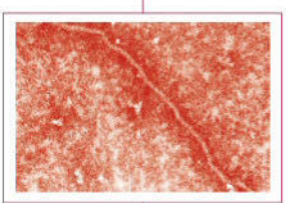
RIGHT: IMAGES ALL SPL

THE NINE VIRUSES OF THE APOCALYPSE

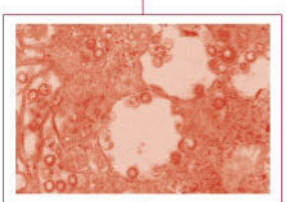
These are the diseases the World Health Organization thinks we should find remedies for, fast. The first six are its highest priority.



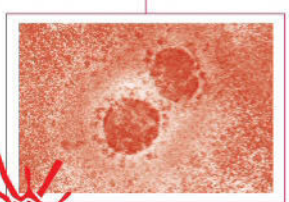
Lassa fever
This West African virus, carried by the common Natal multimammate rat, infects 300,000 people a year. Most have no symptoms, but it can cause diarrhoea and vomiting, then internal fluid accumulation, bleeding from orifices, shock, seizure and coma. It kills some 5000 people annually. Initial symptoms resemble other local diseases, making diagnosis tricky – one reason West Africa was slow to spot Ebola.



Nipah
This bat virus started killing people in 1999 in Malaysia after pig farms were built near fruit bats, which dropped half-eaten fruit into pigsties. People get it from pigs and bats, but it can also spread between humans. Nipah breaks out sporadically in and around densely populated Bangladesh, causes inflammation of the brain and has a high fatality rate.



Rift Valley fever
Widespread across Africa, this virus invaded the Arabian Peninsula in 2000, and could go further. It mainly infects cattle and is spread by mosquitoes; people can get it from mosquito bites or by eating infected beef. Symptoms are usually mild but it can cause haemorrhagic fever, which kills in half of cases.



SARS, MERS and emerging coronaviruses
These related bat viruses infect a range of mammals and have already emerged in humans twice, resulting in severe pneumonia: SARS in 2003 and MERS in 2014. Both spread from human to human.

Crimean-Congo haemorrhagic fever
Found across Africa, Asia and south-east Europe, the virus is invading new territory as its tick hosts capitalise on global warming. It appeared in western Europe in 2010. Infected people generally have a mild fever but some strains cause severe haemorrhagic disease, with bleeding internally and from orifices, from which 30 per cent of people die.

Chikungunya
A virus spread by *Aedes* mosquitoes between monkeys and small mammals in East Africa, Chikungunya started causing large epidemics around 2000 and exploded into Asia in 2005, after mutations made it better adapted to a new mosquito host. In 2014, it invaded the Americas and has occurred in Europe. It rarely kills but causes debilitating joint pains, which can persist for months.

Zika
A monkey virus that has infected humans in Africa and Asia for decades, Zika suddenly entered the Americas in 2013. In 2015, it was linked to a wave of severe birth defects including microcephaly. Companies are already working on vaccines but the WHO wants extra research into the virus's effects on fetal brains.

Severe fever with thrombocytopenia syndrome
Flies under the radar – possibly because of its name. The virus, discovered in 2011, can cause fever and multi-organ failure, killing 12 per cent of people it infects. It has been found in east Asia, seems to be carried by farm animals, and is spread by ticks. A nearly identical virus, called heartland, has turned up in the US.

Novel agent
Given the rate at which previously unknown or obscure infections have suddenly emerged in humans and other animals, the WHO is leaving a slot on its list for a germ we don't yet know. Research here may include looking for agents that might explode.

tests. Any products must be affordable. That means their prices will be "delinked" from the cost of developing them, by making sure companies are recompensed in other ways. So far no one knows how that will work, but it is already being discussed for new antibiotics.

The WHO is not alone in trying to encourage the forging of weapons. In January, the Coalition for Epidemic Preparedness Innovations (CEPI) was launched at the World Economic Forum in Davos, Switzerland, to help get experimental vaccines through the "valley of death". CEPI, which is backed by Norway, India, the Gates Foundation and the Wellcome Trust, has commitments of $540 million and, say organisers, is "on track" to get $1 billion for the next five years. By then it hopes to have vaccines against Nipah, MERS and Lassa viruses tested for safety and effectiveness in phase II trials. It even wants to have small stockpiles of the promising vaccines for fast response to outbreaks.

However, no one can afford phase III trials on larger numbers of people. And no one can test whether a vaccine works until there is an outbreak. Those tests may have to be done in a hurry once an epidemic starts.

MONEY MATTERS

As global economies become more interconnected, contagious diseases and their knock-on effects spread more rapidly. "Nowadays the biggest risk from epidemics is economic," says Ramanan Laxminarayan of Princeton University. The 2003 SARS epidemic killed 800 people, for example, but cost the world $54 billion in quarantine measures and lost trade and travel. The World Bank estimates that a flu pandemic as bad as the one in 1918 would lop 5 per cent off world GDP and cause an $8 trillion recession. The faster we respond to an epidemic, the less expensive it will be. So we must be prepared – and that costs. Who will pay?

One answer may be novel funding mechanisms. Last May, the World Bank launched something new: plague insurance. Rich countries are at risk from epidemics that start in poor countries. So under the Pandemic Emergency Financing Facility they can buy insurance against severe flu, coronaviruses like SARS or MERS, filoviruses like Ebola, and diseases that pass between animals and humans like Lassa. Premiums are based on risk, calculated for the bank by the epidemiological modelling company Metabiota. If one of these diseases strikes a poor country, money to contain it can be released quickly from the insurance pot. The bank also sells "catastrophe" bonds to fund response to a wider range of epidemics.

3 BE READY TO ACT – FAST

With potential mass killers identified, and drugs in hand, we will be on the right track. But we must also be ready to act fast on a large scale. Paradoxically, that means getting more familiar with what is normal, so we can spot ominous changes.

One problem is that contagion is exponential: case numbers rise very slowly at first, then sky-rocket. "First people complain that you are putting too much effort into a small problem. Later they say you were too slow," says Sylvie Briand, head of the pandemics department at the WHO. To better predict which outbreaks might take off, the WHO now has teams looking at the use of "big data", such as combining existing data sets on climate, vaccination and population immunity. It is also setting up networks of social scientists and anthropologists to explore ways to improve communications among people swept up in plagues – a major roadblock to rapid response during the Ebola outbreak. The first and fundamental problem there, however, was surveillance: no one spotted the first few cases of Ebola before it spread widely.

"To get ready for the big one, we need health workers close to the entire population, everywhere, who know where to go if something funny is going on – then labs to test samples, and response teams," says Seth Berkley, head of GAVI, a global alliance that helps poor countries get routine vaccines. Under a 2005 treaty called the International Health Regulations, all 192 WHO member states must set up enough surveillance to tell the WHO about any outbreak that is serious, unusual or could trigger international travel or trade restrictions. However, not one world region, even Europe, has done everything the treaty requires. Africa, home of many worrying viruses, has done least.

An international collaboration called the Global Health Security Agenda is trying to help countries fill the gaps – and Ebola has scared many into listening. "There has been a change of mindset," says Briand: watching existing health risks more closely will help countries spot new ones.

OGNEN TEOFILOVSKI / REUTERS

Going global: international flights spread pathogens

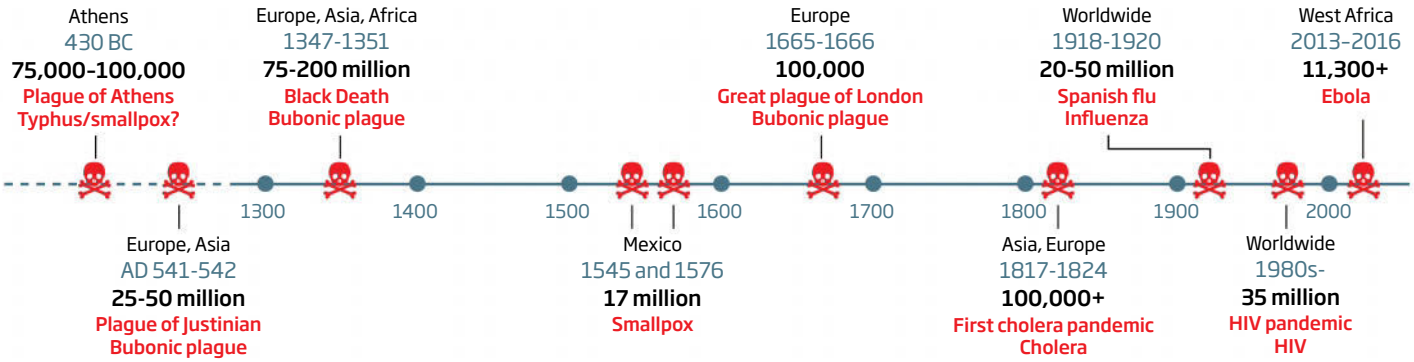
Emergency responders

In addition, the WHO, which has always been a technical agency, setting policies by slow consensus, has reinvented itself to respond faster in an emergency. Instead of independent offices in different countries spotting emergencies – or not – according to their own criteria, the WHO now has dedicated staff worldwide who can do standardised assessments of unusual events, deploy emergency teams within 72 hours and scale up quickly. To aid coordination, they are answerable to the head office in Geneva, a first for the WHO.

The agency is also working with the World Food Programme to set up global supply chains for equipment such as masks and syringes. This year it will launch an online course to train emergency responders. And it is working with the Inter-Agency Standing Committee, a Geneva-based body

Plagued by plagues

Infectious disease used to account for half of all human deaths before the rise of modern medicine, now globalisation is renewing that threat



that coordinates the world's emergency responses to war and natural disasters, which last year expanded its remit to epidemics.

But, no matter how fast you detect outbreaks, or how many drugs or vaccines you invent, you still face the problem of producing and deploying enough of them to make a difference. "You can't build a vaccine factory and only switch it on in an emergency," says Martin Friede at the WHO. Like standing armies, production lines and staff need honing and updating.

A possible solution for limited manufacturing capacity comes from ongoing efforts to control flu – one pandemic we know for sure will come. The flu vaccine is made of a standard, benign flu virus with two new proteins from whatever strain is circulating that year stuck onto it to induce immunity to that strain. The vaccine changes every year, but doesn't need new plants or regulatory approval as the package is well tested. "We can produce safety-tested vectors at scale, then drop in antigens of interest if a new disease emerges," says Berkley. "That way, you can build vaccine capacity for a pathogen you don't even know."

That isn't happening yet. Nor is it clear if the WHO will get enough funds to continue any of this work, especially with a new US president who has opposed UN funding. "The really big problem is appreciating what is at stake," says Berkley. He says a pandemic is an "evolutionary certainty". "If people understood the risk, they would want to be sure systems are in place to deal with it. The costs of doing that are trivial compared to the cost of ignoring it."

We have been jolted out of our complacency, but there's still a lot to be done. "With Ebola the world recognised that the largest unmanaged risk to the global economy and security is infectious hazards," says Bruce Aylward, assistant director-general at the WHO. "Are we prepared for pandemics? Definitely not! Are we more prepared? Definitely." ■

ROBERTO CACCURI/CONTRASTO/EYEVINE

Even supplying equipment in a crisis will be a challenge

Debora MacKenzie is a consultant for *New Scientist* based in Brussels

HOW YOU CAN REDUCE THE RISK OF A PANDEMIC

In our increasingly crowded, urban, globalised world, a virus will eventually get out of control. There are things we can all do to reduce the risks.

Bear witness: **Inform yourself and do what you can to spread awareness of the risks, and of the responses being devised that desperately need support. Politicians control purses, so get tweeting.**

Stand up to denialists: **Some will say warnings about pandemics are a hoax, because SARS/bird flu/swine flu was supposed to kill us all and didn't. Here's your riposte: a lot of people worked hard to keep SARS contained; bird flu hasn't gone rogue yet but it's a few mutations away; swine flu did kill and the next flu could kill far more.**

Prepare**: You needn't be a survivalist to prepare for the panic and disorder likely to attend a pandemic. Most countries have guidelines that recommend stocking a few weeks' worth of water, food, medicines, flashlight batteries and such. Learn about the best ways to avoid people who might be contagious. If you run a business, have a continuity plan. If you are a public official, check whether your administration has a pandemic plan. If not, check out the WHO's guidelines. If you speak for a health body or organisation, learn about communications in a pandemic because mistakes can be deadly. Hint: trust people with the truth.**

Keep watch**: Countries don't like to admit they have infectious diseases: it's bad for business. The ProMed global reporting site revealed SARS and MERS before the governments involved did. Now it has helped launch Epicore. Medical and veterinary workers sign up to it, then when ProMed gets wind of something it asks them what's happening. Replies appear on a web platform that can be set to partial or total confidentiality. Wherever you are, if you meet the criteria, sign up to Epicore. You could be the first to spot something amiss.**

Hushed up

Quiet supersonic airliners are finally a possibility, says **Devin Powell**

MATT CARDY / ALAMY STOCK PHOTO

WELCOME to the most unpleasant room at NASA. The sonic boom simulator at Langley Research Center in Virginia may have a comfortable sofa and a soft rug, but the sound system is vicious. A hundred speakers and subwoofers hidden in the walls can shake the floor and rattle your eardrums as they blast out the thunderous noise of a plane breaking the sound barrier.

NASA uses the room to understand how annoying sonic booms are. Life is full of irritating noise, from the drilling of roadworks to your partner's snoring. Where do the bangs and rumbles produced by a supersonic aircraft rank?

You might think we already know the answer. After all, fighter jets have been zipping around faster than sound for decades, making a noise like two quick-fire rifle shots. The same goes for Concorde: the famously graceful supersonic airliner produced booms powerful enough to crack windows.

But it has been more than 40 years since Concorde's first flight, and engineers at NASA and elsewhere now have some nifty ideas for making booms less shocking. If they can do enough to muffle the din – and prove it doesn't annoy anyone – then perhaps supersonic air travel can be reborn. "Airliners have been stuck at the same speeds since the 1960s," says Peter Coen, head of the NASA research team on the case. His goal is to quietly speed things up.

Concorde was a technological marvel. Aerodynamicists still drool over the curves of its wings and engine inlets. It didn't just break the sound barrier; it smashed it, with a cruising speed of 2100 kilometres per hour, nearly double the speed of sound at its cruising height. This meant it could carry you from London to New York in under 3 hours – if you were well heeled enough to afford a ticket. It remains the only faster-than-sound airliner, apart from Russia's short-lived Tupolev Tu-144.

In other ways, the plane was a nightmare. It guzzled fuel, leading one environmentalist to describe it as a "vulture, spewing black smoke" in 1977. The environmental issues – together with the fatal Paris crash in 2000 – dented the plane's image. But the real damage had been done years earlier. "What killed Concorde was mainly not being able to fly supersonically over land because of the sonic boom," says John Anderson, a curator at the National Air and Space Museum in Washington DC. This reduced its utility, and all airlines except British Airways and Air France cancelled their orders. Concorde was eventually mothballed in 2003, taking the dream of mass supersonic air travel with it.

Well, almost. A few companies, such as Aerion Corporation, have been developing small supersonic passenger jets for years. Recently, a new player called Boom Technology has emerged, pledging to offer supersonic flights across the north Atlantic for the price of a business class ticket from a standard airline. Joe Wilding, co-founder of Boom, says the firm's research suggests there is a ripe market. But Boom is aptly named: its planes won't be significantly quieter than Concorde.

In the 1970s, there was a serious effort to dial supersonic flight noise down. "For five years, pretty much all the top aerodynamicists in the world were working on this problem," says Albert George, a pioneer in sonic boom design at Cornell University in New York.

George and his colleagues came to realise that they were up against a serious physical limitation. Planes create shock waves as they move through air and drag it forward. These shock waves can't travel faster than the speed of sound, called Mach 1. It is the speed at which particles vibrate and pass energy from one to another, and it varies depending on air temperature and pressure. When a plane flies faster than this, the shock waves begin to bunch together, ›

Sons of Concorde

The sonic boom created by a proposed NASA aircraft would be 40 per cent quieter than Concorde's

A. Separate shock waves are created by the aircraft's wings, engines and tail

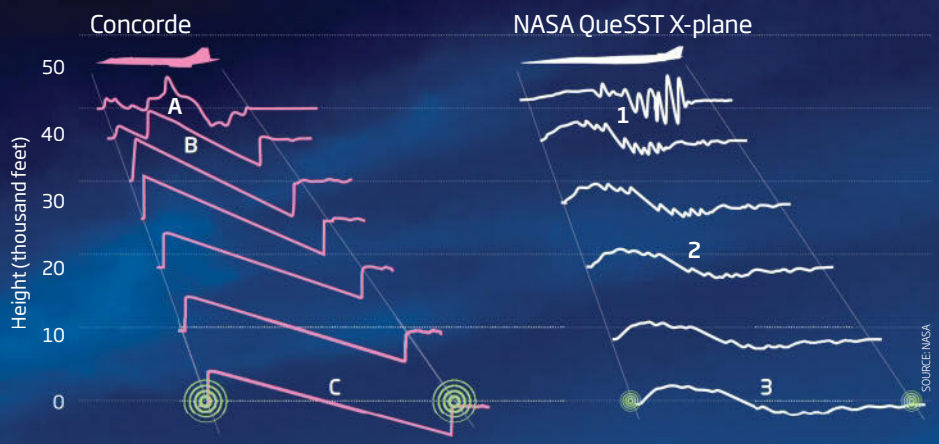
B. These waves quickly coalesce as they descend, creating an "N-wave"

C. The result is a sharp pressure increase at ground level that sounds like a pair of rifle shots

1. The NASA plane would produce smaller, more evenly spaced shock waves

2. This means they never coalesce into a single, sharp pressure spike

3. The boom is a quieter and more drawn-out, low rumble – which may be less annoying



105dB
Concorde's sonic boom sounded about as loud as a chainsaw

65dB
NASA's X-plane would sound about as loud as a dishwasher

Once they are quiet enough to fly over land, supersonic planes could get us around much faster than **conventional jets**

Concorde

Top speed:
2180kph
Fuel efficiency:
7km per litre per passenger

Airbus A320

Top speed:
860kph
Fuel efficiency:
32km per litre per passenger

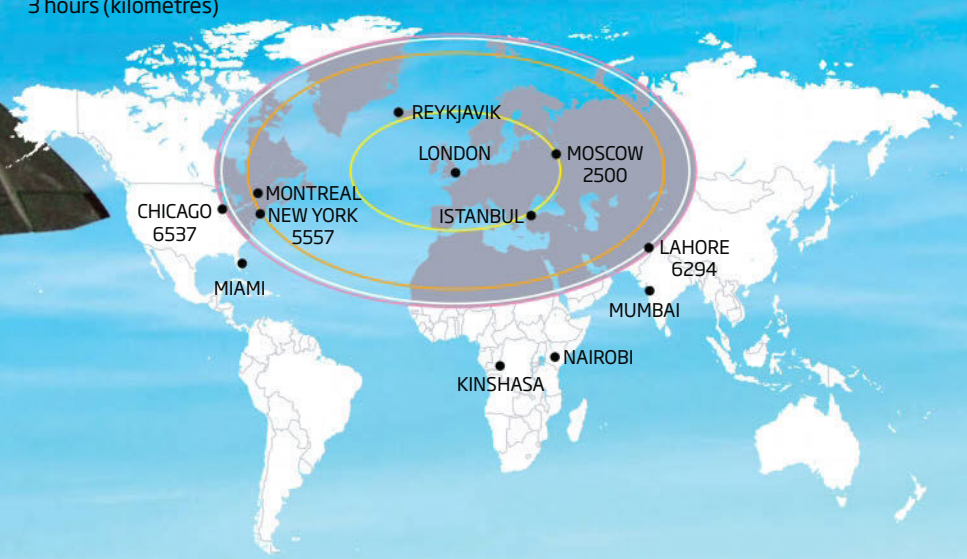
NASA QueSST X-plane *(proposed)*

Top estimated speed:
2100kph
Estimated fuel efficiency:
10km per litre per passenger

Aerion AS2 *(proposed)*

Top estimated speed:
1850kph
Fuel efficiency:
unknown

Approximate distance aircraft can travel in 3 hours (kilometres)



like water piling up in front of a boat.

It turns out that these shock waves typically coalesce as they propagate outwards into an "N-wave" sonic boom: two sharp changes in pressure, one upwards, as the plane shoves air out of the way, and one downwards, as air rushes back. Our ears perceive these pressure changes as sound.

All sorts of weird and wonderful designs to dampen the boom were tried in the 1970s. Imaginative new wing shapes were popular. They could be tiny or huge, stacked on top of each other or dramatically swept back. Some designers even proposed firing a laser off the front of planes, to see if ionising the air might help. "There were all these exotic configurations," says George. "But they just didn't work."

To do better, engineers needed a finer-grained understanding of how air flows. That is governed by what would become the Navier-Stokes equations, first written down by Claude-Louis Navier in 1822. Trouble is, these are sensitive to minuscule changes: even a tiny puff can change the overall picture. And accounting for the movements of air one particle at a time takes a lot of computing, so aerodynamicists are forced into approximations.

Concorde's designers were using slide rules, so they had to make a lot of approximations. But now we have supercomputers, and over the past decade engineers have developed a much more detailed picture of what happens to shock waves rippling off the hull of a supersonic plane.

Based on those insights, NASA thought it could design a plane that spreads the shock waves out so that they don't coalesce into such a sharp boom (see diagram, page 35). The agency used computers to precisely model the airflow across hundreds of designs – moving the engines and sculpting the wings to create eddies that cancel out other eddies from the nose. They still can't follow the shock waves all the way to the ground or account for the subtle effects of turbulence, which can increase the severity of booms. But NASA now has a design called the QueSST (Quiet Supersonic Technology) X-plane, which it reckons will produce a boom that sounds about 40 per cent quieter than Concorde's.

The proof of the plane will be in the flying, but already there is cause for optimism. The Japanese Aerospace Exploration Agency (JAXA) has been pursuing a similar boom-muffling project, and in 2011 it used a balloon to lift a proof-of-concept glider from Esrange Space Center in Sweden into the stratosphere. When dropped, the glider accelerated past the sound barrier. A low-hovering blimp bearing a microphone measured the noise as about half as loud as a typical N-wave boom. Buoyed by this success, JAXA strapped an experimental, unpiloted low-boom aircraft to a rocket in 2013. It malfunctioned and crashed (with an exceptionally large boom), but a second attempt, in 2015, flew successfully – and as quietly as expected.

However, quiet does not necessarily mean less annoying. Just think of someone snoring again: not loud, but not pleasant either. The real question is how we perceive sonic booms.

We already had a rough idea for N-wave booms. In 1968, a survey of 3000 people in Oklahoma City found that 56 per cent were "seriously annoyed" after six months of exposure to booms produced by planes at a nearby air force base .

JAXA

Not so big bang: Japan's supersonic test gliders are much quieter than Concorde

NASA's sonic boom simulator – that room with the concealed speakers at Langley – can help estimate whether muffled booms will irritate people. By subjecting people to different volumes of sonic boom, accurately reconstructed as they would be heard in a home, Coen's research team have established a basic threshold for annoyance, and shown that the X-plane's boom should be below it. But only with real test flights can NASA hope to get a true picture. "We have done everything we can with computer models," says Kevin Shepherd, the recently retired head of NASA's structural acoustics branch.

A real test flight of the X-plane is now being planned for. NASA agreed a contract with Lockheed Martin last year to produce a detailed design by the middle of this year. The next step, building and test-flying a small-scale aircraft, will require more than $200 million from Congress, NASA estimates.

These real-life tests are doubly important because of a potential sting in the X-plane's tail. In softening the boom at frequencies we can hear, it will shift more shock waves to inaudible frequencies. Neat, you might think, except those frequencies are just the right kind to shake buildings. No one yet knows if that might be enough to make rooms vibrate, creating a noise or jiggling objects off shelves.

Anyway, dampening down the boom might prove to be the easy part, says Stephen Trimble at news and data services firm FlightGlobal: supersonic planes also have an engine problem.

Engine failure

Jet engines used to work by sucking in air, mixing it with fuel and burning the result to generate thrust from the stream of hot exhaust. More modern engines split the air into two streams, with the majority bypassing the combustor and providing almost free lift.

These high-bypass-ratio engines are efficient, but supersonic jets can't use them – they must be rather wide to accommodate the two streams of air, which doesn't befit a fast, sleek aircraft. That means the X-plane will have to use the old-style engines, which is one important reason why it will end up using lots of fuel, even if it is made from advanced, lightweight materials (see diagram, page 35).

Worse, those engines make a terrible racket because most engine noise comes from the exhaust mixing with cooler air. This is the crucial problem that supersonic planes face, says Trimble. "A supersonic aircraft's engines must be a lot noisier, particularly on take-off when you need maximum thrust," he says. International regulations that cap noise levels at take-off are becoming more stringent. So even if the descendants of Concorde make a softer boom, their engines might be too loud to take off legally.

Yet we are too in love with the idea of supersonic flight to stop trying. Just look at the planes the European Space Agency has had on the drawing board for years, some of which are meant to transport passengers at eight times the speed of sound. When it comes to supersonic flight, we will always dream. ■

Devin Powell is a freelance science journalist based in New York City

With biotech on the brink of resurrecting extinct species, is this a new age for conservation, wonders **Sandrine Ceurstemont**

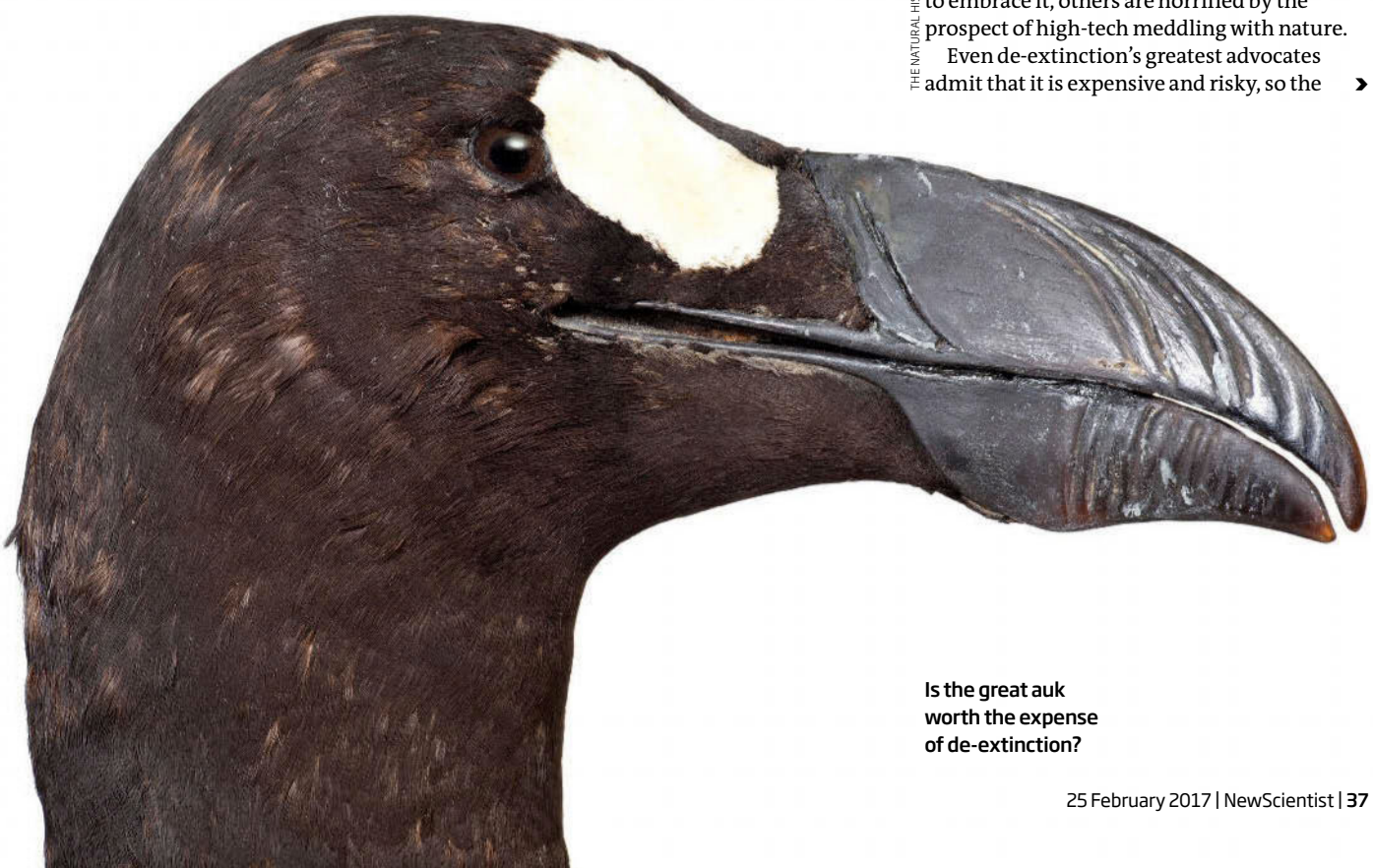
Extinct is not forever

KATSUHIKO HAYASHI is playing God. In his lab at Kyushu University in Fukuoka, Japan, he recently created eight baby mice using eggs made from reprogrammed mouse skin cells. Now he's working his magic on the northern white rhino, a species so endangered there are just three individuals left, all with reproductive problems. And he has even bigger plans: he wants to use the technique to resurrect extinct animals.

De-extinction isn't a new idea. But where early attempts owed more to *Jurassic Park* than to science, Hayashi and others are taking a more high-minded approach. They look at the fast-moving field of biotechnology and see its conservation potential. "Many animals are gone because of human error, so we need to use technology to recover them," he says.

He has a point. With 100 or so species disappearing from the planet every day, we are living through one of the biggest mass extinctions ever. And the causes – from poaching to pollution to climate change – are down to us. At the same time, cutting-edge biotechnology, including genome sequencing, cloning and gene-editing tools like CRISPR, is allowing us to manipulate life. We are now on the verge of being able to undo extinctions, and researchers are racing to get there first. But while some foresee a thrilling new age of conservation and are urging conservationists to embrace it, others are horrified by the prospect of high-tech meddling with nature.

Even de-extinction's greatest advocates admit that it is expensive and risky, so the ›



THE NATURAL HISTORY MUSEUM / ALAMY STOCK PHOTO

Is the great auk worth the expense of de-extinction?

"De-extinction technologies won't so much resurrect species as create new life forms"

VINCENT J. MUSI/NATIONAL GEOGRAPHIC CREATIVE

GOOD BREEDING

The aurochs, a large ancestor of domestic cattle, died out because of habitat loss and overhunting. Its last known sighting was in 1627, but Ronald Goderie from the Tauros project in Nijmegen, the Netherlands, and his team are bringing it back, at least in spirit. Rather than using genetic engineering, they are cross-breeding existing primitive bovine breeds with the same key traits as the aurochs, such as a slender build and forward-pointing horns. Goderie thinks this will spawn an animal better suited to modern times. "Living breeds have adaptations and genetic diversity that you might miss with the genetic engineering approach," he says.

Small herds of mock aurochs, dubbed tauroses, have already been released into the wild in a few European countries. Now Goderie and his team are refining their prototype by comparing its genome with that of the aurochs, which was published in 2015. They also plan to identify which genes in the aurochs are responsible for its distinct features, and selectively breed tauroses with the same ones.

reasons for pursuing it need to be well thought out. The biggest problem may be deciding which species to bring back. One approach is to focus on charismatic species. For example, geneticist George Church at Harvard University thinks he is just two years away from creating a hybrid mammoth-elephant embryo. But if conservation is the rationale, then charisma is less important than usefulness. "What I am most concerned about is functional loss," says ecologist Douglas McCauley at the University of California, Santa Barbara. "If a species with an irreplaceable role disappears, it can have a cascading effect and drive other species to extinction too."

Worthy candidates

By this yardstick, the moa is a good candidate for resurrection. A massive flightless bird once abundant in New Zealand, it became extinct about 600 years ago, largely as a result of hunting and deforestation. That has had a knock-on effect, with plants that relied on the bird to disperse their seeds still struggling to survive. So the moa performed an irreplaceable ecological role. But there are two further criteria to heed when deciding which de-extinctions to prioritise, according to McCauley and his colleagues. They argue that species that died out in the past 50 years should take precedence because, in most cases, an ancient animal would no longer fit in as the environment would have changed too much. In addition, they say, we should focus on species that can be restored to levels that can boost the functioning of the ecosystem.

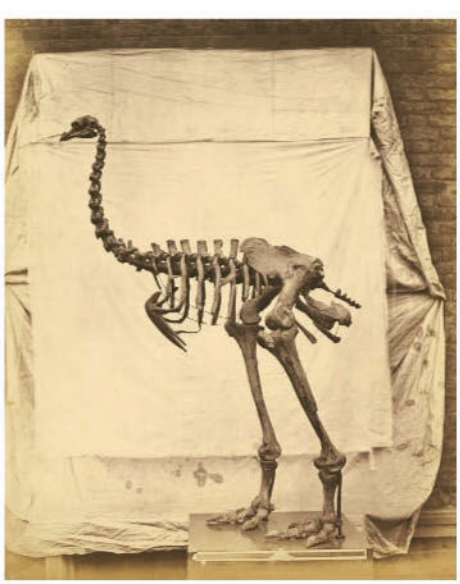
Although the moa became extinct centuries ago, it could tick one of these boxes. David Iorns, founder of the Genetic Rescue Foundation in Palo Alto, California, and his colleagues are currently working on sequencing its genome as a first step to de-extinction, and they think there is still suitable habitat for a reintroduction. "Its native environment remains sparsely populated," he says. However, the prospect of creating a good-sized population of moas is slim, not least because even if its genome can be recreated, the bird is so genetically distinctive that finding a surrogate animal to gestate the embryo would prove tricky.

Far more promising is the lesser stick-nest rat. Believed to have gone extinct in the past few decades, it played a crucial role in the Australian desert, where it used sticks to build impressive nests. Because the landscape is mostly flat, the structures – up to 3 metres long and a metre tall – became home to other animals too, from insects to reptiles. "They were like biodiversity high-rises," says McCauley. And the rat's rapid gestation and short lifespan make it a relatively easy target for resurrection. "With an aggressive breeding programme, an abundant population could be built up in five to 10 years," he says.

Nobody is working on the lesser stick-nest rat just yet, though. Indeed, de-extinction researchers keep identifying new risk factors that take candidate species out of the running. One is highlighted by plans to recreate the gastric brooding frog – the only known animal to turn its stomach into a womb, from where it spewed out its froglets by vomiting. Simon Clulow at the University of Newcastle in Australia aims to recreate the frog using DNA from cells found in a freezer. The idea is to transfer the DNA into another frog's egg that has had its nucleus removed – a method known as reproductive cloning. In 2009, the technique recreated an extinct subspecies of the Pyrenean ibex, a mountain goat. The animal had damaged lungs and only survived a few minutes, but the technology has improved since then. Nevertheless, if Clulow is successful he will not return his gastric brooding frog to the wild because it was probably wiped out by chytrid fungus, which continues to kill off amphibians worldwide. "We need to address the cause of its decline or it will just disappear again," he says.

And there are yet more challenges facing high-tech conservation. One of the biggest

Without moas to disperse their seeds, some of New Zealand's plants are struggling to survive



VCG WILSON/CORBIS VIA GETTY IMAGES

There are plans to re-engineer the black-footed ferret

unknowns is how faithfully we can recreate a species using genetic manipulation. With reproductive cloning, the embryo ends up with the surrogate's mitochondrial DNA, which is located outside the nucleus. Whether this will affect the offspring is still uncharted territory. As for gene editing, it holds the power to replace missing parts of the extinct species' genome with DNA from a living relative, but that could be even more risky.

What's more, de-extinction technologies won't so much resurrect species as create new life forms. "If you bring back a mammoth by editing an elephant genome, you'll get a mammoth that's part elephant," says Tom Gilbert at the University of Copenhagen in Denmark. Likewise, using guesswork to fill in gaps in the genetic code could result in species dramatically different from the original ones.

New and improved

To tackle this, Gilbert and his colleagues are tweaking their techniques to see whether it's possible to improve the proportion of the genome recovered from preserved tissue samples. They are also trying to identify the function of missing DNA in partial genomes from the recently extinct Christmas Island rat and great auk. Genes with the same functions from closely related living species could then be used to replace them.

Where some see a problem, others see an opportunity. Redesigning animals before bringing them back could improve their survival. That's the thinking behind plans for the black-footed ferret in the US. Thought to have been wiped out by the sylvatic plague, the wild population now numbers around 300, after a small group was discovered. But lack of genetic diversity leaves them vulnerable to disease, so Ben Novak at the University of California, Santa Cruz, and his colleagues are planning to reintroduce DNA from preserved specimens into the population using reproductive cloning. In the long term, the researchers want to tweak their genes to create black-footed ferrets that can survive the sylvatic plague. "Domestic ferrets are resistant to the disease, so we will be comparing their genome to that of the black-footed ferret to find immune genes that may aid in establishing resistance," says Novak.

In a similar vein, we could enhance existing species to perform the roles of extinct ones. By comparing the genomes of woolly mammoths and Asian elephants, Vincent Lynch at the University of Chicago in Illinois and his team identified genes responsible for many of the mammoth's adaptations to life in the Arctic, for example those controlling hair growth, cold tolerance and fat storage. Their discovery could one day lead to elephants that can survive in the cold. Although filling the ecological role of the mammoth isn't a conservation priority, a similar strategy may be deemed worthwhile in other cases.

With all the risks involved though, perhaps we should consign extinct animals to the history books. Even Gilbert isn't convinced there are good enough reasons to proceed. Ecosystems are complicated and he doesn't think that reintroducing vanished species is the best way to restore them. He is also sceptical about trying to increase genetic diversity to prevent a species' decline. "There is actually not much evidence that low genetic diversity is a problem," he says.

De-extinction also has outright opponents. Ecologist Stuart Pimm at Duke University in Durham, North Carolina, thinks it a complete waste of time. He sees a warning in failed experiments to reintroduce species into the wild through captive breeding. More importantly, people may start relying on high-tech band-aid solutions to undo environmental damage, diverting funds and efforts from preventing extinction in the first place. "De-extinction has no value and it can do much harm," says Pimm.

Nevertheless, with several projects in full swing, success may not be far off. Many expect Hayashi to be in the vanguard. However, he thinks he still has a decade of work ahead to create a white rhino by reprogramming preserved skin cells. "It's hard to adapt these techniques to wild animals," he says. "But I'm hoping that they can be used to save them." ■

We may have to use some guesswork to recreate the genome of the Christmas Island rat

P.J. SMIT (D. 1960) DEL. ET LITH. / CHARLES WILLIAM ANDREWS (1866-1924)

Sandrine Ceurstemont is a writer based in Morocco

NATURE PRODUCTION/NATUREPL.COM

The lady and the argonauts

In the 1830s, **Jeanne Villepreux-Power** solved a 2000-year-old mystery about an octopus with a shell

AS WAVES lapped at the boat, Jeanne Villepreux-Power adjusted her heavy dress. She'd been there for 3 hours, trying not to startle the small, shelled octopus in its underwater cage. She was about to give up, when the argonaut suddenly stretched out a tentacle. It picked up a piece of shell, placed it over the hole she had made in its own shell, then threw it away. Over the next few minutes it sifted through several pieces until it found a patch the right size, then bonded it in place.

Elated, Villepreux-Power knew she had witnessed something no one had seen before. She was on the verge of solving a 2000-year-old mystery: did the argonaut produce its own shell – or steal it, as a hermit crab does?

No one taught Villepreux-Power how to do experiments, or educated her in natural history. Born in 1794, she was the child of a shoemaker. Yet she became a noted marine biologist, her work celebrated by great men of the day. She invented what we now know as the aquarium and was an early pioneer of aquaculture – achievements that seem even more unlikely given that she grew up far from any coastline, in Juillac, France.

When she was old enough to work, she went to Paris and became a seamstress. There, after attracting attention for embroidering the dress for a royal wedding, she met the wealthy English merchant James Power. They married, and settled in the busy Sicilian port of Messina. It was a new world to Villepreux-Power and she was captivated. She decided to learn all she could about its flora and fauna.

She walked the length and breadth of the island, gathering what she could carry home and sketching what she could not. Fishers began to keep unusual animals for her to collect on her daily trips to the port. She even chartered a boat to catch marine life herself.

Word of Lady Power and her house of

curiosities began to spread. Scientists at the nearby Gioenia Academy in Catania came to see her impressive collection of insects, and jars of preserved fish and molluscs. They seemed alive thanks to the embalming fluid, made to her own recipe, that maintained the bright colours.

The scientists admired her paintings, while behind them two tame beech martens ran up and down a tree she had brought inside. Most entrancing of all were the sea creatures swimming around in glass containers. She had devised the containers for her laboratory so she could more easily study marine life – they were the first recognisable aquariums.

Villepreux-Power watched starfish and mussels, sea snails and seahorses. She was one of the first to record an octopus using a stone tool to open a fan mussel. She proposed raising fish in underwater cages to restock overfished rivers – the first hint of aquaculture. But it was the argonaut that really fired her curiosity.

The argonaut is a strange animal. Like all octopuses, it is a mollusc – but it is the only genus with a shell. And the only mollusc that can leave its shell: it can come and go as it pleases – just like hermit crabs. That suggests argonauts acquire shells abandoned by other animals. But Villepreux-Power wasn't so sure.

Membranes on two of an argonaut's arms stretch neatly over the shell, and suckers correspond exactly with shell ridges, making animal and shell seem of a piece. Reading through the latest scientific papers, she found that argument raged over the shell's source. "It occurred to me that the absence of experiments alone was the cause of such conflicting opinions," she wrote. What's more, she was in the perfect position to investigate – the Strait of Messina teemed with argonauts.

Villepreux-Power collected argonaut eggs and watched through a microscope as they grew, preserving each stage in her embalming fluid. Her work paid off: she found that a few days after they hatched, tiny shells appeared.

The experiment in the boat clinched the argument. She saw that the argonaut could patch its shell by secreting a liquid from the arm membranes, and realised that these membranes were how it made its shell in the first place. Aristotle had written about the membranes 2000 years earlier, taking them for sails. This gave the argonaut its evocative name, but Villepreux-Power was the first to spot their true use.

Her work was published by the Gioenia Academy in 1837, its members heaping praise on the "genius, patience and perseverance" of the "most beautiful ornament of Messina". She became the first female member of the academy, and had a deep-water fish named after her: *Vinciguerria poweriae*.

RMN GRAND PALAIS (MUSEE D'ORSAY)

Jeanne Villepreux-Power: seamstress, travel writer and self-taught octopus expert

She corresponded with scientists across Europe, including the famed naturalist Richard Owen, already known for his work on marine invertebrates. Convinced she had solved the argonaut question, Owen gave a presentation at the Zoological Society of London, which Villepreux-Power attended.

"Word began to spread around Sicily of Lady Power and her house of curiosities"

She was lucky that Owen, at least, was able to view her work impartially. She had brought with her 20 specimens showing the formation of the shell, and fractured shells in different stages of repair. She provided a wealth of other evidence based on 10 years of observation and experiment. But the conclusions of a woman – and a self-taught one at that – were not so easily believed: "Fortunately it happens that some of the more important facts bearing upon the question… do not rest upon her individual testimony as the sole authority for their existence," ran an editorial in the *Magazine of Natural History*.

The men of the Zoological Society were no fools, however. After the meeting, Villepreux-Power excitedly wrote to the Gioenia Academy describing the "unanimous" applause her work had received and the proposal to make her a correspondent member. In total, she became a rare female member of 16 scientific institutions across Europe.

Still, prejudice meant that another potential breakthrough was dismissed. Villepreux-Power had noticed that all argonauts appeared to be egg-producing females. Where were the males? She spotted that some shells contained what looked like a small arm, complete with suckers, and thought it might be related to the missing males. But the scientists knew better: it was a known parasitic worm, they said. Her observations were "evidently inaccurate" and a result of "her want of physiological knowledge". In fact, she was on the right track: we now know the male is far smaller than the female, and transfers sperm via a modified, detachable arm.

Villepreux-Power's experiments ended when she left Sicily for Paris in 1842. But she continued to produce important work, including a beautifully illustrated travel guide to Sicily that was celebrated by Sicilians as giving the island its rightful status in Europe. She even published a paper on meteorites when she was 73.

But widespread recognition of her invention never came. A craze for aquariums swept England after the opening of the first public aquarium in 1853, but their origin was credited elsewhere. Villepreux-Power appealed to Owen for help and he duly obliged, calling her the "mother of aquariophily" in an entry on molluscs for the *Encyclopedia Britannica*.

Villepreux-Power died in Juillac in 1871. She was quickly forgotten; though if the ship transporting her wonderful collection had not sunk in 1838 perhaps her work would be better known. But her greatest legacy can still be seen in the fish tanks and aquariums that bring the underwater world to the surface for all to see. ■

By Eleanor Parsons

Robots: who pulls the strings?

Despite the hype, an exhibition of robots reminds us how far AI has to go before we need to lose sleep at night, finds **Victoria Turk**

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Robots, Science Museum, London, to 3 September

ROBOTHESPIAN welcomes visitors to the opening of Robots at London's Science Museum with suitable drama. The life-sized humanoid blinks its pixelated eyes, moves its head and gestures theatrically as it introduces the exhibition with great enthusiasm. You might expect the robo-actor to give you a guided tour – if it wasn't bolted to the floor.

But move on a step and the illusion is shattered. Behind a wall sits engineer Joe Wollaston, with a computer and a headset. From here, he can see and hear people approaching RoboThespian through a camera and a mic on the robot. When he speaks, his voice booms out of the robot's mouth. Wollaston is RoboThespian's Wizard of Oz, and this is a peek behind the curtain. "What you just saw was an example of our telepresence application," he says after the robot's introductory speech. "So it's actually remotely operated."

"We worry robots will turn Terminator, but the real challenges are mundane. Stairs, for example"

RoboThespian can recognise people's movements and deliver programmed messages, but a human has to step in for anything more complex. It is, as Wollaston says, "artificial AI".

This illusion of intelligence is one of the underlying messages of the exhibition, which tracks 500 years of robots, from the earliest automatons to present-day research. Pinned to the next wall is an eerily realistic animatronics baby, commissioned from a special-effects company. The baby wriggles its arms and legs and even "breathes".

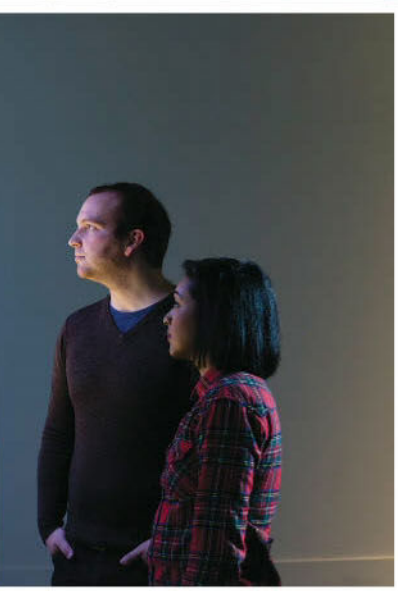
It is convincing, but its brain is still a long way off that of a newborn – all of the movements are pre-programmed. In this respect, there's not that much difference between the baby and much earlier robots such as the Silver Swan, an intricate automaton made in 1773 that twists its neck to preen its feathers, dips its head into a river of glass rods and catches a silver fish in its beak.

The baby uses modern programming, the swan runs on clockwork, but both impress by performing a physical display of an intellect they don't actually possess. They are just going through the motions – they don't have a brain.

Despite its age, the Silver Swan is a highlight of the show: even next to the most recent and impressive humanoid robots it is a wonderful thing. Perhaps it is because it is not trying to emulate a human that it continues to inspire awe.

If one thing becomes clear from the journey through attempts at building robots in our image, it is that we still haven't cracked it. A 16th-century automaton monk can walk across a tabletop, lift a crucifix and pray. Skip forward to the present day and we are still struggling to refine bipedal robot legs capable of naturalistic walking and dexterous hands with human-like precision.

While we worry about superintelligent robots turning Terminator, the challenges roboticists face are much more mundane. Stairs, for example. "Humans are pretty much the cutting edge of, well, human ability," says Anna Darron, one of the exhibition's curators. "To build



An automaton swan succeeds in looking lifelike (top), but (below, left to right) Komodoroid, iCub and RoboThespian have a harder task

a machine that can do everything that we do is a massive challenge."

The most painstaking attempts at mimicking human movement use human anatomy as a starting point. CRONOS ECCE1 and Rob's Open Source Android (ROSA) both take this approach, with articulated skeletons, motorised muscles and artificial tendons (made from string in ROSA) on display.

Why go to so much trouble? There's more than a hint of narcissism in our obsession with making humanoid robots – which, Darron points out, date back to Greek legends of mechanical people – but there are also pragmatic reasons to favour the human form.

"On a practical level, having a human-like machine or a machine with human-like abilities enables it to work in a human environment," she says. "We build the environment for ourselves – we don't want to have to adapt it for a machine."

To be fair to the humanoids and their makers, this is also a major reason why building a useful human-like robot is so much harder than building a swan that looks like it's swimming when you turn a handle. Our environments aren't predictable, so a robot that can walk around in a real-world setting would need to be able to cope with different terrain, navigate around furniture, and avoid bashing into humans that get in its way.

To do this, these robots need some of what we call AI – a level of agency beyond the automaton swan or animatronics baby. They use sensors to see and feel the world around them and calculate how to react. For example, ROSA, like RoboThespian, has face-tracking software that allows it to follow visitors with its head or eyes as they move.

The final room of the exhibition showcases robots that are already sharing our space. Some are designed purely to entertain, such as Honda's iconic ASIMO or Toyota's trumpet-playing Harry. Others are intended to serve, like Japanese roboticist Hiroshi Ishiguro's startlingly lifelike newsreader Kodomoroid or Toyota's robot nurse prototype Human Support Robot. And then there are those that are put to work, like Rethink Robotics's Baxter and ABB Robotics's YuMi, both designed for factory assembly lines.

These robots are a joy to watch. Some can make facial expressions or track the movements of the people around them. YuMi twists its arms in a manner that curator Ling Lee compares to a "yogic contortionist".

But each robot is only capable of doing the thing that it's designed to do. Give Baxter a trumpet and it won't make a sound; put Harry on a production line and it won't make a thing.

That is beginning to change, however. As AI advances, we are starting to develop robots that can learn. The last robot that visitors meet at the show is iCub, a humanoid the size of a young child that was developed at the Italian Institute of Technology.

"To make a robot that learns the way we do takes something that we don't yet have: general AI"

The iCub platform, which runs on a separate computer, uses artificial neural networks to learn about the world through observation, just like a child. Show it a box while saying "this is a box" and it will learn to recognise the object. Guide it to move on its feet and it will learn to walk.

However, the neural networks still have to be customised for each task, says research director Giorgio Metta. The robot may look like a five-year-old, but its mental ability is nowhere near. "The intelligence we manage to put into these machines is really very limited and domain-specific," he says. "Maybe we solve one problem, but transferring from one problem to another is very difficult – while a child will immediately learn something and the day after reuse that knowledge in a new domain."

To make a robot capable of learning the way we do requires something that we don't yet have: general artificial intelligence, AI that can perform a wide range of tasks. Only then will we have a robot that truly behaves like a human, with no wizard behind the curtain. ■

Tweet me, as I die in space

Space junk is giving us a timely reminder of its risks. **Julia Brown** listens in

@JustinJMcaulay | Your people predict I will burn up in Earths atmosphere early 2017. You'll get messages until then. i don't want to die.

FengyunAdrift @FengyunAdrift
11:40 PM - 16 Dec 2016

THIS may be the most unusual tweet in the world. It comes from Fengyun, a piece of space junk that has been orbiting Earth at around 28,000 kilometres per hour since 2007.

Now it and two other pieces of debris have a new purpose in life. They are part of Project Adrift, Cath Le Couteur and Nick Ryan's artistic exploration of the secret world of space junk – and the serious problem it poses.

Fengyun used to be part of Chinese weather satellite FY-1C, until it was blown to smithereens by an experimental anti-satellite missile. It might burn up soon, but many millions of other pieces, including Fengyun's estimated 2840 high-velocity siblings, will continue to circulate. Any one of them could hit a working satellite any second now, and blow that to smithereens too.

Through three Twitter streams, a short film and a soundscape created by an electromechanical instrument called Machine 9, Project Adrift captures the weirdness of this enormous graveyard of junk floating 1000 or so kilometres above the planet.

Vanguard is an abandoned weather satellite, the oldest of the estimated 100 million human artefacts in space. The satellite narrates an 11-minute documentary made by Le Couteur. "I had value," says the satellite, voiced by film director Sally Potter. "And now? I drift. Aimlessly. In perpetual orbit."

All kinds of stuff becomes space junk: batteries, old satellites, pieces of rocket – and once, even a spatula. Astronaut Piers Sellers, interviewed by Le Couteur for her film, caused a minor crisis in 2006 when the spatula he was using to make repairs to the outside of the space shuttle Discovery went missing. "She went off to become a satellite of her own," he says.

Nick Ryan, meanwhile, has given the junk a soundtrack. A composer and sound artist, he transformed data on the trajectories of 27,000 pieces into a score for Machine 9, a giant, specially built "space debris sound instrument", which was on show earlier this month at London's Science Museum. Every time a piece of debris flies silently overhead, the instrument generates one of 250 different recorded sounds made with earthly rubbish. The succession of knocks, clicks and other strange sounds eerily highlights the threat junk poses to our future in space.

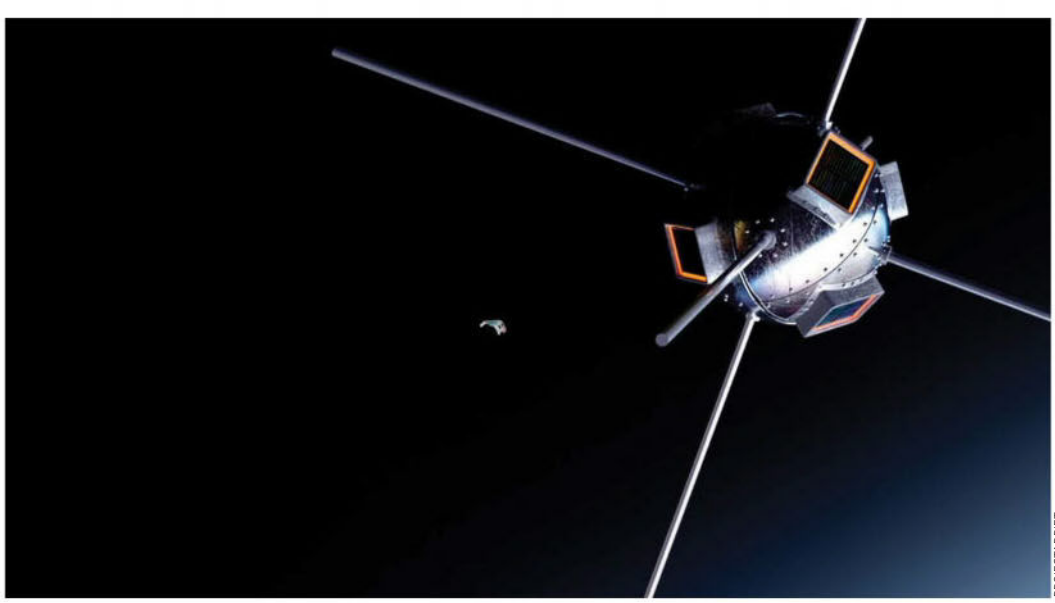
When a piece of debris hits a satellite, it creates thousands more pieces. They may hit other satellites, whose pieces will hit others, and on and on into a cascade of collisions. Never mind reaching Mars, one day there could be so much debris we won't even be able to leave Earth.

"Never mind Mars, one day there could be so much debris we won't even be able to leave Earth"

There are numerous efforts, of course, to find ways to clean up. "Janitor" satellites, laser tractor beams and soccer ball-resembling robots have been proposed, while Japan is developing an electromagnetic tether. Most of these projects are at an early stage, and all face enormous technical challenges. Sellers, who died shortly after Le Couteur's film was made, appears on screen to explain one of them. "Everything smaller than 10 centimetres across… we can't see it," he says. Being unable to detect small pieces means we have no way to remove them.

Sellers' spatula burned up a few years ago. But Fengyun, Vanguard and Suitsat, a floating spacesuit, remain in space limbo, and you can find out how they feel about it by following them on Twitter.

Soon, 4500 more satellites will be sent into low Earth orbit to enable global broadband coverage – providing even more targets for the junk. Project Adrift is a compelling and timely reminder that we need to stop just sending stuff up there and start thinking about what we are going to do about the problem. ■



PROJECTADRIFT

Vanguard, oldest of space's human artefacts, tells a poignant tale

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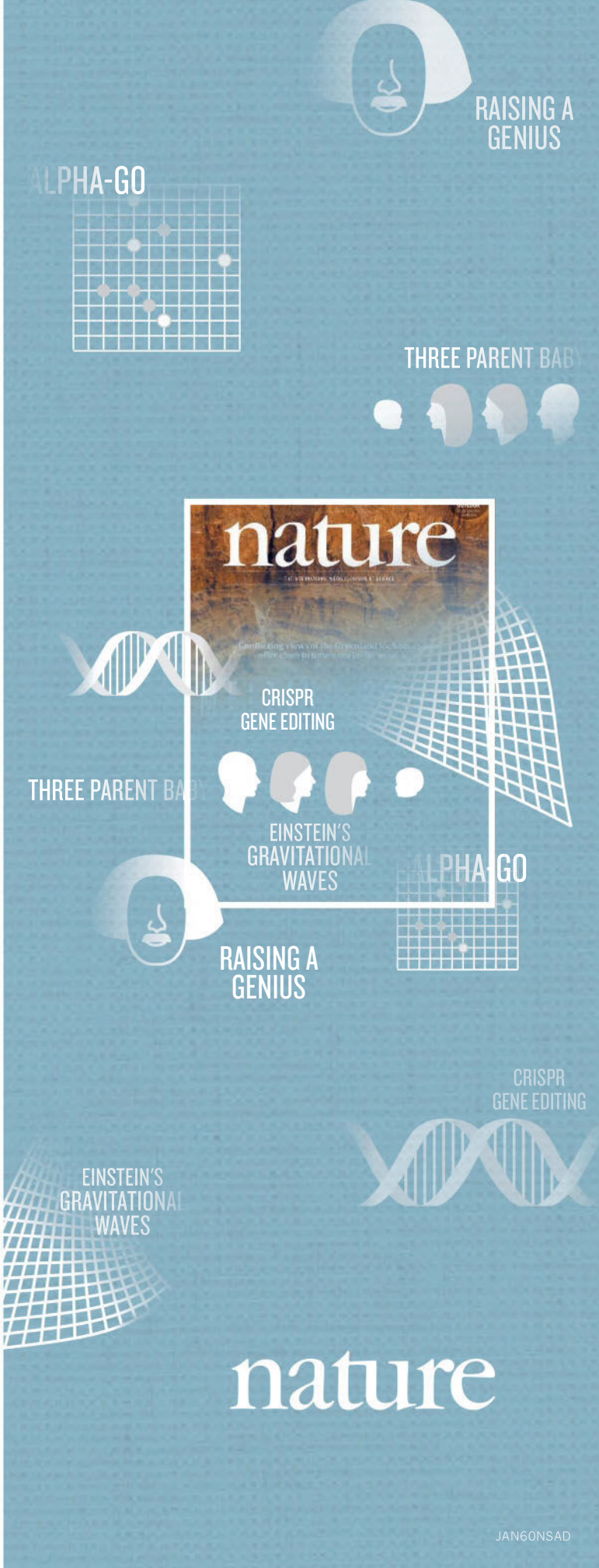

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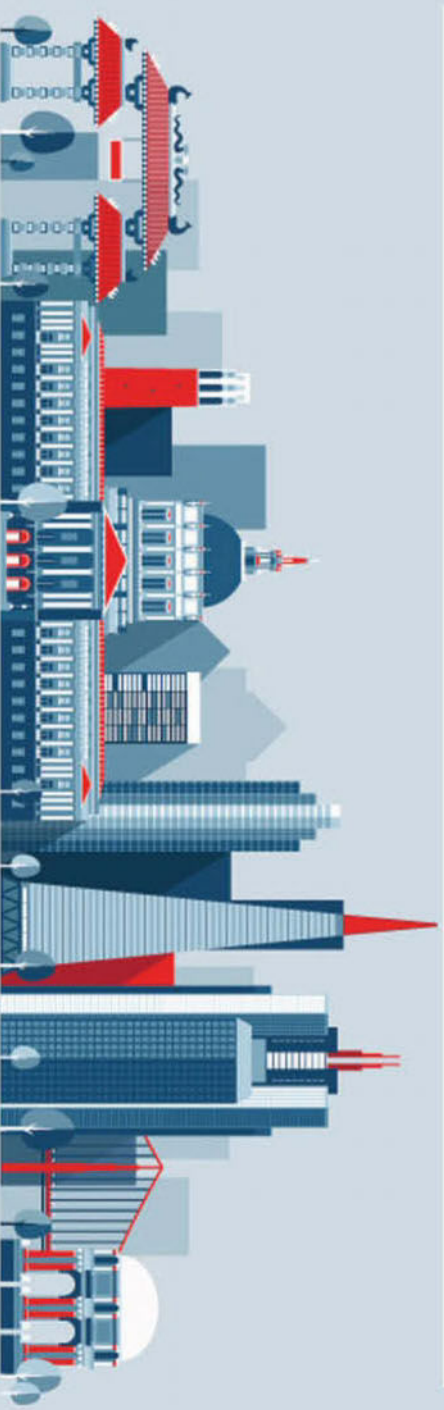

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EDITOR'S PICK

The meaning of life, artificial and observant

From Robert Cailliau, Prévessin-Moëns, France
Teal Burrell discusses human purposes and goals – which we clearly have from biological evolution (28 January, p 30). That raises the question: what purpose would an artificial intelligence have? If its software does not have a built-in set of goals, would an AI develop one at random from its observations of the world around it, or would it just pull the plug on itself?

From Guy Cox, St Albans, New South Wales, Australia
Burrell mentioning that those with a strong sense of purpose had a better chance of survival in concentration camps reminded me of an article on Arctic winter stays in the 16th and 17th centuries (3 April 1993, p 38). Those with a strong record of religious observance fared much better. The authors say: "Celebrations were something to look forward to; they gave a feeling of unity and the brief illusion of being at home… Perhaps this emphasis on religious observance was less a sign of innate piety than an intuitive psychological insight on the part of the more successful leaders."

An urgent need to grant inhuman rights, to what?

From Graham Meadows, Fitzroy North, Victoria, Australia
Recent commentary has raised the possibility that sapient AI, if developed, might be assigned the right to vote (17/24/31 December 2016, p 18) and might need to be freed from slavery as a form of suffering (Letters, 28 January). As we move towards the threshold where research might create an entity capable of suffering in a human-like way, we ought to establish safeguards to protect the rights of sapient AIs as research subjects from the very start.

Review mechanisms to safeguard such human rights are well established, ensuring adherence to the Declaration of Helsinki through research ethics boards and committees. Perhaps we need to consider what should trigger the involvement of these committees in advanced artificial intelligence research.

From Steve Dalton, Chipstead, Kent, UK
Robert Willis suggests artificial intelligences need rights (Letters, 28 January). I turn on a light bulb. Does it feel warm? I turn it off. Have I hurt it? Did I hurt it by turning it on? I turn my 1980s programmable calculator on and off, and ask the same questions.

In the future, I turn on my brain-embedded, internet-connected, super-smart AI chip that the law mandated all children must have to eliminate education inequality. Have I created a "me" with two votes? If it disagrees with me and I turn it off, have I killed it or committed election fraud by preventing it from voting?

Will the law mandate that it is always on and so visible to the

"Not poisoning bees would be so much better. Just saying"

Alix expresses scepticism about the worth of work on robot pollinators (18 February, p 14)

security services to keep us safe? If only this were science fiction.

We can share data only when rules are respected

From Michael Sharpe, Oxford, UK

Your leader article criticised the PACE trial of treatments for chronic fatigue syndrome, which I co-led, for not sharing data (11 February, p 3). On behalf of my colleagues, I need to point out that this part of your commentary is misleading. The PACE team has shared data many times with researchers who have agreed to respect its confidentiality, including with a Cochrane Collaboration group who have undertaken a meta-analysis of exercise therapy (which is in review) using individual patient data. We have not voluntarily released data to the general public as we do not have our participants' consent to do this. We suggest that the consent of trial participants must be considered in any discourse about sharing trial data.

The editor writes:

■ We do not criticise PACE, nor those controlling access to statins data. We do suggest that consent for future analyses should be considered during data collection, in the knowledge that such research is likely to need this.

Perhaps reality is a process in mind

From Bridget Carroll, Liverpool, UK

I was fascinated by your recent article on the essence of reality (4 February, p 29). I am trying to understand the origins of behavioural difficulties in young children, and I see a connection.

Alfred North Whitehead, who co-wrote *Principia Mathematica* with fellow philosopher Bertrand Russell, eschewed any material reality. In 1929, he wrote: "There persists… the fixed scientific cosmology which presupposes the ultimate fact of an irreducible brute matter, or material… senseless, valueless, purposeless… It is this assumption that I call 'scientific materialism'… which I shall challenge as being entirely unsuitable to the scientific situation." He held that reality is a dynamic process.

In the 17th century, philosopher Gottfried Leibniz similarly believed that reality is "activity".

Current systems theorists do not assume a bedrock material of "reality". Measurement is an intrusion and represents a temporary state – in which not everything can be measured.

I find "process philosophy" fascinating. For me it has required a complete suspension of traditional ways of thinking, and offered relief from the idea that behaviour has discrete, static causes, which leads to the blaming of children and families.

Is it time for a major rethink of the nature of "reality"?

From Julian Higman, Wantage, Oxfordshire, UK

Anil Ananthaswamy does not distinguish what is made (or thought) by humans from what is really out there. A few pages later, Frank Swain writes that it is impossible to "still believe we can take an objective view of nature, or that we are fundamentally separate from it" (4 February, p 42). Spot on. In the non-human universe there is no machinery, no writing – and there are no mental tools like dimensions, ›

and no time. There is energy and motion, and because energy exists in different forms, there is space. Both are "there" irrespective of humans' conception of them.

Ananthaswamy mentions time as something we might think of as reality, along with particles, energy and space. Time is not a part of "reality"; it is a generalised measuring device thought up, albeit inadvertently, to measure motion. Equally, the idea that "information" is a part of reality, never mind its true bedrock, needs to be challenged.

Information, however it is defined, is a truly human concept and only part of the universe in that it is in the human mind.

Very many mansions in the multiverse

From Chris deSilva, Dianella, Western Australia

Shannon Hall quotes Michael Hall as saying that the main problem with Hugh Everett's many-worlds interpretation of quantum mechanics comes from confusion over what constitutes a measurement (21 January, p 28). In the well-known thought experiment, the decay of a radioactive atom determines a cat's fate. In the many-worlds interpretation, when the atom decays the cat dies, and a parallel universe is created in which it lives. But it seems to me that at every moment in which the cat does not die a parallel universe must be created in which it does.

If we assume time is quantised at the "Planck time" (5.391×10^{-44} seconds), then for each second the cat remains alive in our universe, 2×10^{43} new universes are created. The quantum multiverse must be very crowded.

An infinitely puzzling speed limit question

From Martin Greenwood, Stirling, Western Australia

Michael Brooks tells us that "the ratio of the speeds of light and gravity rapidly went to infinity" after the big bang (26 November 2016, p 8). My dimly remembered high-school maths suggests that one of them must have gone to zero. That really would be strange.

The editor writes:

■ It would have been more precise to say that the ratio rapidly approached infinity.

Welcome to the Valles Marineris Wildlife Park!

From Charles Joynson, Rayleigh, Essex, UK

Sarah Moles notes that it is hard to decide which species to save with limited resources (Letters, 4 February). But if our longer term future includes terraforming other planets, then we will have to take other species with us as DNA, rather than as live and potentially dangerous fellow passengers. So the question for us now is: what to save that allows us to resurrect something in the future?

The options include saving a species in the wild, in a zoo, in frozen form or as a DNA sequence. The more of them we save, the more likely it is we could give each a place in future. But if we tried to resurrect an extinct mammal, would we be able to restore its genetic diversity, as well as its gut and skin microflora? And what about the rest of its ecosystem?

A way of seeing may help a diagnosis

From Martin Reynolds, Nantwich, Cheshire, UK

As a scientifically trained adult with autism, I was interested in your report of Michel Valstar's work on an algorithm that could help spot autism-like conditions from facial expressions (7 January, p 11). Many autistic individuals find our eyes drawn to the mouth rather than the eyes of others we're conversing with. Could this be used by the researchers?

Michel Valstar writes:

■ This thought resonates with our work with Alexander Foss, an ophthalmologist interested in the development of autism-like conditions. Gaze analysis is one cue we will include in future work.

For the record

■ Our piece on the work of Dora Colebrook and Leonard Colebrook on streptococcal infections appeared with a photo of someone else (4 February, p 40). See the online version (bit.ly/Colebrook).

■ Matthew Hodson of UK charity NAM told us that studies of couples in monogamous relationships, in which one partner is HIV-negative and the other positive and on treatment, mean: "When we are undetectable, we are uninfectious. This means that pretty much all the fear that HIV-negative people have of those of us living with HIV is just wasted energy" (11 February, p 22).

■ Oh caption! My caption! The first written language emerged some 5400 years ago, as the main text of the article stated (11 February, p 34).

TOM GAULD

The old 'Good Particle Physicist/Bad Particle Physicist' routine.

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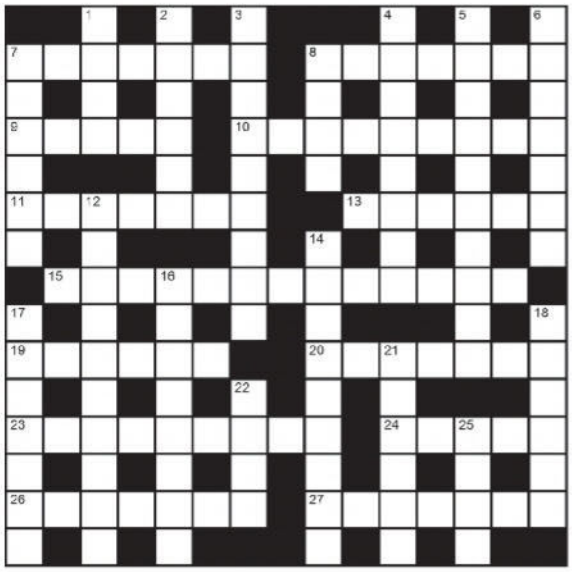
CROSSWORD

Compiled by Richard Smyth



Crossword No3

ACROSS

7 Colourless organic solvent, CH_3COCH_3 (7)
8 Programming language created by John Backus in 1957 (7)
9 Component whose failure led to the 1986 Challenger disaster (1-4)
10 Henry ___ (1731-1810), scientist who gave his name to a physics laboratory at the University of Cambridge (9)
11 Of flow, moving in parallel layers, with no disruption between the layers (7)
13 Tree species often known in Australia as a wattle (6)
15 Insect that secretes the toxic chemical cantharidin when alarmed (7,6)
19 Measuring less than 7 on the pH scale (6)
20 Sir J.J. ___ (1856-1940), discoverer of the electron (7)
23 Medical journal founded in London in 1823 (3,6)
24 Form of radiation that travels at approximately 3×10^8 metres per second (5)
26 Greek character used in physics to designate the mass-to-light ratio (7)
27 Whole number (7)

DOWN

1 The Search for Extraterrestrial Intelligence project (4)
2 Barbara ___ (b. 1951), the first teacher to travel into space (6)
3 Highly developed part of the human brain (9)
4 Stalactite-like structure that can form beneath sea ice (8)
5 Component parts of 3 Down, for instance (5,5)
6 Infection of animals and humans also known as wool-sorter's disease (7)
7 NASA human spaceflight programme, 1961-72 (6)
8 The third prime number (4)
12 Hypothetical set of possible universes (10)
14 Relating to midwifery or childbirth (9)
16 In animal anatomy, an opening that leads to the respiratory system (8)
17 Louis ___ (1822-95), French chemist and microbiologist (7)
18 A developmental stage in insects and other arthropods (6)
21 Sedimentary rock formed of roughly spherical grains (6)
22 Medical procedure that may be CT, PET or SPECT (4)
25 Prefix denoting a factor of 1,000,000,000 (4)

Answers to Crossword No2

ACROSS: 9 PROXIMA CENTAURI, **10** MEDULLA, **12** RIEMANN, **13** ADASAURUS, **14** AMINE, **15** OSMOSIS, **18** SHANNON, **21** MAUVE, **23** OXIDISING, **25** E-MAILED, **26** OPEN WEB, **29** ELECTROMAGNETIC. **DOWN: 1** SPAM, **2** BOND, **3** WILLIAMS, **4** LAMARR, **5** NECROSIS, **6** ATHENA, **7** MUTATION, **8** LINNAEAN, **11** ERDOS, **15** OHMMETER, **16** MAUNA KEA, **17** SNOWDROP, **19** AVICENNA, **20** OUNCE, **22** EOLITH, **24** ISOBAR, **27** WATT, **28** BUCK.

PAUL MCDEVITT

THE WHARF **is a free daily paper handed out in London's Docklands financial district, covering news, sports, lifestyle and more recently, witchcraft. Each week, the anonymous "Witch of the Wharf" conjures up a full page of mystical readings and celebrity gossip, proving she is well versed in all sorts of stargazing.**

The column includes practical advice for bankers, such as placing a lump of fire agate on your project proposal overnight to ensure it is successful, with the paradoxical promise that those who do will "be surprised by the result".

We wonder if there is a gemstone out there that will offer city slickers protection against the next financial crisis. Feedback thinks a fire agate paperweight worth about £100 billion might be adequate insurance.

Lastly, the column also offers cryptic advice to named readers, warning a certain "Dion" that "Someone is going to try to hawk you something. Steer well clear, it's not what it appears." Advice that we can all live by.

"SATAN, Lucifer, Baal, Moloch, Leviathan, Belfagor, Chernobog, Mammon…" It's not often that a scientific paper opens with the collected names of the beast, but "Mastering the devil: A sociological analysis of the practice of a Catholic exorcist" is hardly run-of-the-mill.

The journal *Current Sociology* has published an analysis of exorcisms, which it notes is presently a growth industry for the Catholic church, with half a million rituals performed annually worldwide.

One reason for that vast number could be that a single exorcism may not suffice. The study mentions that one particularly possessed individual required 26 exorcisms, while another received an incredible 354 over 10 years – surely entitling them to some kind of discount loyalty card, Feedback thinks.

The authors note that those affected often share a propensity to indulge in "suspicious experiences" – by seeking out seances, magicians, clairvoyants, and fortune tellers. Jones, put away that fire agate!

The devil finds work for downward dogs, reveals *Current Sociology*. A leading exorcist finds the practice so dangerous that: "… At the end of one of the rituals, he gives out a booklet titled *Beware of Yoga*"

FLORIDA newspaper *The Villages Daily Sun* informs readers that "Solar eclipses occur when the sun enters the Earth's shadow, NASA stated".

Andrew Doble is left puzzling over his orrery, trying to figure out where to move the sun so it is simultaneously in front of and behind the Earth.

AN INDIAN science textbook has been recalled after complaints that it gave details of how to kill kittens. The offending passage read: "Put a small kitten in each box. Close the boxes. After some time open the boxes. What do you see? The kitten inside the box without holes has died."

An important lesson on the proper storage of air-breathing mammals – but how very Newtonian! As any quantum physicist will tell you: the kitten can survive indefinitely, so long as you don't open the box.

WE ARE alerted by Tony Ware of a British school that banned triangular flapjacks after an "isolated incident" where a student was hit in the face by an airborne oatcake. Catering staff were told to cut the flapjacks into rectangles instead, but Feedback wonders: doesn't that increase the number of corners by 33 per cent? Gently curved edges would be ideal, if somewhat aerodynamic, but how round can these snacks be cut while still tessellating in a baking tray?

BIG matters are weighing on Ed Prior's mind, prompted by an article on Chile's Very Large Telescope (4 February, p 14).

"There are hopes that the 'Extremely Large Telescope' under construction there will examine many more planets," says Ed. "But now Chile faces the dire challenge of what adjectives to use for the next such telescope? The 'Very Extremely Large' Telescope? The 'Humongous Large' Telescope?" Feedback is scouring our very large dictionary for ideas.

IT'S just the thing if you're lacking direction on the field. Sportswear from Al1ve Magnetics offers "revolutionary compression" and performance-enhancing power, thanks to strategically placed magnets within the fabric.

Feedback is rather jaded by sportswear technology that promises to turn us into Olympians, but the idea of a shirt that will fold itself up after being washed is quite appealing.

DESK jockeys might prefer something from Seiichi Takamatsu and his colleagues, who announce in *Advanced Materials* that they have put a keyboard into a sweater. By working with conductive materials, they have created a stretchy, touch-sensitive garment that allows you to type on the trot. Just be careful hugging anyone dressed in Al1ve Magnetics sportswear unless you want your emails scrambled.

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Those veggie blues

Edible fruits and vegetables come in practically every shade of green, red and yellow. Why are so few of them convincingly blue in colour?

In the wild, the purpose of a fruit is to aid the dispersal and germination of seeds away from the parent plant. Hence, many fruits have evolved to be visually distinctive, as well as tasty, to aid recognition by animals that eat them and then deposit the undigested seeds in their faeces.

Blue, and its neighbour green, may be uncommon fruit colours because they barely stand out from the plant's foliage. The most effective colour in this respect is red – the complementary colour of green – so it is perhaps little wonder that so many fruits (and particularly berries) are red.

As for vegetables, the colour of leafy parts is dominated by the green of the light-absorbing pigment chlorophyll. Root or bulb parts usually grow below ground, where it would be pointless for them to have extra pigmentation. So subterranean parts of edible plants normally appear white, yellow or brown.

Even if blue were a beneficial colour for plants, it is produced via a complex chemical reaction involving the modification of anthocyanins, the pigments typically behind red or purple colouration. The fact that blue has so rarely evolved in nature suggests that the high energetic costs of making it usually outweigh any potential benefits.

Edible fruit and vegetables have been selectively bred by humans for millennia. However, because most people would consider blue an "unnatural" colour (probably because it is so rare in the wild to start with) and therefore unappetising, it tends to be avoided by horticulturalists.

Sam Buckton
Chipperfield, Hertfordshire, UK

Sleep tight

How do people in polar regions, where there can be up to 24 hours of daylight or night, cope physiologically?

In general, constant daylight need not be a problem because using blackout curtains plus a sensible bedtime will generate an effective light-dark cycle, which is the main cue keeping our internal clock in sync with the 24-hour day. If that is not possible, for example when you are sleeping in a light-penetrating tent, eye masks are an obvious solution.

The real problems arise with 24-hour darkness, or at least the lack of bright light when the sun does not rise above the horizon for lengthy periods. If the artificial light we are exposed to is too dim, our internal clock will drift out of sync, usually through a delay. So when we wish to sleep at our normal time (for example 11 pm), our body clock is not yet in "sleep mode". Sleep onset is then later and we are not ready to wake up at our normal time the following morning. If we do get up then, we experience sleep deprivation.

The best sleep coincides with our internal clock being in night mode, for instance when our core body temperature is lowest and the hormone melatonin is highest. If out-of-sync sleep is necessary, for example in night-shift workers, it is usually shorter and less efficient than desirable.

In polar regions in winter, the worst-case scenario can occur when the internal clock dissociates completely from the 24-hour day and runs at its own natural periodicity, which varies from person to person and is usually slightly longer than 24 hours. Many people who are blind have this problem, which means they regularly move in and out of sync, depending on their natural periodicity. They may experience good sleep alternating with poor sleep all their lives.

The solution in the polar winter is to increase the intensity of artificial light. At the British Antarctic Survey's Halley Research Station, where the sun does not rise for three months in winter, the internal clock delay was countered and sleep timing improved by boosting the average maximum daily light exposure from 500 to around 2000 lux. Sleep timing was directly related to light exposure: the brighter the light, the earlier the sleep.

"Night-shift workers find that sleeping out of sync is shorter and less efficient than they would desire"

For people who are blind, this is evidently not possible. Instead, the solution is "chronobiotic" treatment that shifts and synchronises the internal clock. Melatonin, when used as a carefully timed treatment, is the most successful approach. And there is also a relatively new drug, tasimelteon, developed to treat sleep-wake disorder by activating melatonin receptors.

Josephine Arendt
Faculty of health and medical sciences
University of Surrey, UK

This week's questions

GETTING SUCKED IN

How close would one have to be to the coalescing black holes recently detected by LIGO to actually feel the gravitational waves without the aid of instruments?

Robert Davies
Wellington, New Zealand

COLD COMFORT

Does getting more coughs and colds in my 20s toughen me up for when I'm elderly? By the time I'm 80, would the same pathogens I caught in my youth still be around or would they have mutated and not be recognised by my body's immune system? Is it better to avoid getting colds and flu now, or embrace the suffering as an investment for the future?

Robyn Vinter
London, UK

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