New Scientist

WEEKLY May 21 - 27, 2016

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Star cluster unchanged for 13 billion years

WATER INTO WINE
A decent bottle of bubbly, no grapes required

WORLD WAR ZERO
Clash of civilizations at the dawn of history

INTERNAL INQUIRY Has the gut microbiome been overhyped?

BETTER THAN EARTH

The solar system more life-friendly than our own

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Science and technology news
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KING OF THE SWINGERS The search for the world's greatest ape


News
After handshakes, we sniff people's scent on our hand
After handshakes, we sniff our hand
YouTube
This suggests that handshakes might transmit chemical signals
You won't believe you do it, but you do. After shaking hands with someone, you'll lift your hands to your face and take a deep sniff. This newly discovered behaviour – revealed by covert filming – suggests that much like other mammals, humans use bodily smells to convey information.
We know that women's tears transmit chemosensory signals - their scent lowers
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Professor Dame Carol Robinson
2015 Laureate for United Kingdom
By Brigitte Lacombe

For Women in Science
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Science needs women

L'ORÉAL UNESCO AWARDS

Dame Carol Robinson, Professor of Chemistry at Oxford University, invented a ground-breaking method for studying how membrane proteins function, which play a critical role in the human body.

Throughout the world, exceptional women are at the heart of major scientific advances.

For 17 years, L'Oréal has been running the L'Oréal-UNESCO For Women In Science programme, honouring exceptional women from around the world. Over 2000 women from over 100 countries have received our support to continue to move science forward and inspire future generations.

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CONTENTS

Volume 230 No 3074

This issue online
newscientist.com/issue/3074

News

8

Grape-free wine made in lab

We try the synthetic tipple that aims to mimic fine vintage

AVALABS

On the cover

26

Better than Earth

The solar system more life-friendly than our own

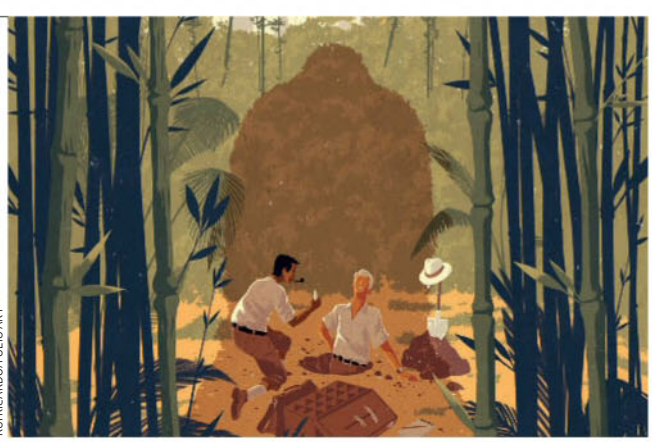
Cover image
Julien Pacaud

Features

34

King of the swingers

The search for the world's greatest ape



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PLAINPICTURE/APELÖGA

Dish the evidence

Health gurus should be held to much higher standards

BELLE GIBSON fell a very long way. A little over a year ago, the Australian self-styled health guru seemed to have it all. Built on a claim to have cured her own brain cancer through diet and alternative medicine, she had a huge social media following, a hit recipe app, a glowing reputation as a philanthropist and a glossy cookbook in the works.

Then it all came crashing down. Under scrutiny from reporters, she admitted that the whole thing was a fabrication. She hadn't had cancer and hadn't made the promised donations to charity. Earlier this month, Gibson fell even further when the consumer affairs regulator of her home state initiated legal action against her and her company for "misleading and deceptive conduct".

Lifestyle gurus whose claims don't stand up to scrutiny are nothing new. But Consumer Affairs Victoria also took action against her publisher, Penguin Australia, for failing to fact-check the book, ordering it to make a A$30,000 donation to the state's Consumer Law Fund and issuing a warning over its future conduct. From now on it will have to "substantiate" all health claims, train its staff better and publish "a prominent warning notice" in books about alternative therapies.

This development is intriguing – and promising. Lifestyle advice is big business, but it is unusual for those who cash in on it to get their comeuppance. This looks like a rare victory for evidence over charlatanry, even though it was Gibson's deception, not health claims, that led to her downfall.

These victories should be commonplace. Other areas of consumer advice are much more tightly regulated. In many jurisdictions, for example, financial advice comes with stringent warnings, and those who provide it must have professional qualifications and adhere to codes of conduct.

"Lifestyle advice is big business, but it is rare for those who cash in to get their comeuppance"

As a society, we seem less protective of our health than our wealth. While aspiring financial advisers are studying to gain proper accreditation, any wellness blogger can pick up a worthless nutritional qualification for a small fee. Pretty much anyone can declare themselves to be a diet expert. And when the only arbiter of authority is popularity, the word "recipe" can quickly be followed by "for disaster".

That is in part driven by an insatiable appetite for quick-fix health advice. The latest example is the Hemsley sisters, UK food bloggers who have been criticised for promoting pseudoscience – but nonetheless have a TV series about their own brand of healthy eating "free from grains, gluten and refined sugar" (see page 18). Would it have been given the green light if Channel 4 had been ordered to substantiate "all health claims"?

Suggestions of policing frequently draw allegations of censorship and conspiracy. And indeed, we must preserve people's freedom to shun grains, gluten and refined sugar – or conversely, to eat only doughnuts. It is not that you can't eat healthily without grains, but casting them as dietary demons is unscientific: the argument for going gluten-free, for example, is flimsy (*New Scientist*, 12 July 2014, page 28).

But standards could and should be much higher. That means targeting not just those who make unsupported claims, but also those who seem happy to promote and cash in on "clean eating" or "wellness" gurus with little or no due diligence. They, too, should carry the can for the damage – financial or otherwise – that results from their actions. ■

ANINDITO MUKHERJEE / REUTERS

It's that time of the weather cycle

Heat respite in sight

APRIL was the seventh month in a row to smash global temperature records, but a brief respite is on the cards with the present El Niño coming to an end.

Since October, each month has exceeded the 1951-1980 global temperature average for that month by more than 1 °C. The heatwave is fuelled by a double whammy of global warming and a strong El Niño cycle. The relative contributions of these two phenomena are hard to gauge, but clues can be found in previous El Niño cycles, says Blair Trewin of the Australian Bureau of Meteorology.

"If you compare the temperatures of the last 12 months with the same stages of the last strong El Niño event in 1997 and 1998, it's about 0.3 °C warmer this time round," says Trewin. "This is consistent with an overall warming trend."

However, the record run of high global temperatures may be interrupted towards the end of the year when La Niña kicks in, he says. La Niña has the opposite effect to El Niño, the cyclical weather pattern that warms the central and eastern tropical Pacific Ocean.

The present El Niño phase began in 2015. Last week, the US National Oceanic and Atmospheric Administration reported that there is a 75 per cent chance of it switching to La Niña as early as September.

"If records are still being broken [during La Niña], it will suggest that it is background warming that is playing the key role," says Agus Santoso of the University of New South Wales in Sydney, Australia.

Synthetic genome

WHAT'S the secret? Last week, more than 130 researchers, lawyers, ethicists and others met at Harvard Medical School to discuss making large genomes from scratch. But no journalists

"Should something so monumental be organised and launched in such a fashion?"

were allowed to attend.

It is rumoured that the meeting discussed plans for a 10-year research project aiming to build a complete human genome.

"This is a natural extension of the human genome sequencing project," says Paul Freemont of Imperial College London, who says he is "very familiar with the meeting". The Human Genome Project sequenced our genome in 2003 – this project would write the sequence by synthesising the code chemically.

Such a feat might prove useful in medical fields as diverse as drug screening, stem cell research and organ transplants. By designing genomes and developing them into cell cultures, it may be possible to tailor therapies to better match their recipient, or to function more effectively.

Synthetic biologist Drew Endy at Stanford University in California decided not to attend the meeting. "Should something so monumental be organised and launched in such a fashion?"

So why all the secrecy? It may be because the project is linked to a paper that will be published in a major journal, and those that authored it are bound to respect that journal's press embargo.

Lethal injections

THE end is nigh. On Friday, pharmaceutical firm Pfizer announced that its drugs could no longer be used for lethal injections.

The death penalty is legal in 31 US states. Executions have typically involved injecting prisoners with a "cocktail" of sodium thiopental, pancuronium bromide and potassium chloride.

But in recent years, some firms have refused to sell the drugs to US prisons, making it more difficult for states to execute people.

Now Pfizer says that when it sells drugs to government entities, it will ask them to certify that they will be used only for medical purposes and will not be resold to someone else.

Franklin Zimring, a professor of law at the University of California, Berkeley, says that lethal injections lend the death penalty an air of medical legitimacy.

"What you are witnessing now is the last gasp of that pretence," says Zimring.

If states want to keep the death penalty, they will have to find another way to do it.

FLIP NICKLIN/ MINDEN PICTURES/ NATIONAL GEOGRAPHIC CREATIVE

Smallest porpoise on the way out

Vaquita apocalypse

IT'S the smallest porpoise with the biggest problem. The vaquita, found only in the Gulf of California, now numbers just 60 or so individuals – a 92 per cent drop since 1997.

If Mexico doesn't widen its conservation strategy the species may be gone as soon as 2022, according to the International Committee for the Recovery of the Vaquita. The porpoises have few predators, but they often get

tangled in the gill nets favoured by poachers targeting another critically endangered animal: a fish of similar size called the totoaba. In China, Totoaba swim bladders fetch a lot of money as they are considered a delicacy.

Despite government efforts to crack down on poaching, vaquitas continue to decline. This is due partly to loopholes in regulation that allow the use of gill nets to catch other large fish. "If the vaquita disappears, it is entirely upon the government of Mexico for letting that happen," says Zak Smith of the Natural Resources Defense Council in California.

Microbe moonshot

THE White House is taking an interest in your gut. It has just launched its National Microbiome Initiative, a $500 million effort to understand the complex communities of bacteria, fungi and other microbes that live on or in everything.

Disruptions to our microbial mix have been implicated in a host of diseases, but the microbiome affects the environment too. Microbial imbalances can lead to zones of low oxygen in oceans – killing off fish – while agricultural depletion of bacteria can result in barren soils. The plan is to develop technology to optimise such communities (see page 16), says Jo Handelsman at the White House Office of Science and Technology Policy.

The government will provide $121 million for the initiative over the next two years, and more than 100 universities, charities, foundations and companies will chip in a further $400 million.

The funding and scope of the project is comparable with – and perhaps larger than – the controversial Human Brain Project, according to a White House spokesperson.

Statin snafu

IT HAS been branded a farce. A software error means an unknown number of people in the UK have been told to take cholesterol-lowering drugs when they didn't need to – or told they didn't need to consider the drugs when they should have done.

Statins are recommended for those who have not had a heart attack but are deemed to have at least a 10 per cent chance of having one in the next 10 years, because of risk factors like smoking and overweight, or a family history of these factors. There is an online calculator for this heart attack risk, but some doctors in the UK have been using software that may give the wrong result.

About a third of UK family doctors' practices use a program made by the IT company TPP. Last month, the firm told the UK government that there was a problem with the software, and that it has overstated the risk for some people while understating it for others. The government told doctors of this on Wednesday.

"Only a limited number of patients are potentially affected," a government spokesperson said, but admitted the company had not revealed what proportion of test results were wrong.

Magic away depression

SHROOM for improvement? The first clinical trial of magic mushrooms for depression has produced some encouraging results, but involved only 12 people and no control group.

The trial aimed to test whether psilocybin – the active ingredient in magic mushrooms – might be a safe treatment for depression. All the volunteers had previously tried at least two other treatments without success.

Each participant underwent two psychotherapy sessions, both conducted after doses of psilocybin. A week after the second session, all of them had reduced symptoms. After three months, five no longer met the clinical criteria for depression (*The Lancet Psychiatry*, DOI: 10.1016/S2215-0366(16)30065-7).

Although there was no placebo group, the results are promising, said Phil Cowen, a psychiatrist at the University of Oxford, who wasn't involved in the study.

Enthusiasts have long believed that the drug's ability to induce profound-feeling experiences could be therapeutically useful. Brain-imaging studies have shown that psilocybin targets areas of the brain overactive in depression.

Team member Robin Carhart-Harris of Imperial College London said that therapists are important for a positive outcome, and has discouraged people from self-medicating. "That kind of approach could be risky," he said.

JERRY LAMPEN / REUTERS

Hints of promise

60 SECONDS

Private present

The first man in the US to undergo a penis transplant, 64-year-old Thomas Manning, says he looks forward to returning to a normal life after his own penis was amputated as part of cancer treatment. Surgeons at Boston's Massachusetts General Hospital matched Manning's skin tone and blood type with a dead donor.

Floating wind farm

Scotland is to get the world's largest floating wind farm, with five 6 megawatt turbines generating electricity by the end of 2017. Norwegian energy company Statoil has been granted a seabed lease for the development, 24 kilometres off the coast of Peterhead.

Dinosaur drill

The Chicxulub crater, in Mexico's Yucatán peninsula, is about to yield its secrets. It was made by an asteroid that struck Earth 66 million years ago and is thought to have wiped out the dinosaurs. A drilling project has taken samples from the crater, which will be analysed in June.

Paint-on GMOs

A US company, AgGenetics, has developed a technique to custom-design animals' fur patterns through genetic engineering. It hopes to create a heat-tolerant version of Angus beef cattle whose coats are white instead of dark, so the animals can thrive in the hot tropics. The technique could also pave the way for custom-designed pets.

Space fluids

Bodily fluids created in space landed on Earth on 11 May, when Elon Musk's Dragon capsule splashed down in the Pacific Ocean. It was carrying almost 1700 kilograms of scientific material from the ISS, and included bodily waste and other samples from astronaut Scott Kelly, who spent a year on board the station. The material could tell us about the effects of long stints in space.

AVA LABS

A new kind of mixology

Welcome to the wine lab

A Californian start-up wants to bring the taste of fine vintages to the masses, by chemically mimicking classic wines – no grapes necessary

Chris Baraniuk

"WE can turn water into wine in 15 minutes." So claims the Ava Winery, a San Francisco start-up that is making synthetic wine without grapes – simply by combining flavour compounds, water and ethanol.

Mardonn Chua and Alec Lee came up with the idea while visiting a winery in California's Napa Valley in 2015. There, they

"I saw this iconic bottle of wine that I could never afford or enjoy. It got me thinking"

were shown the bottle of an iconic wine, Chateau Montelena, which is famous for being the first Californian Chardonnay to beat French contenders at the Paris Wine Tasting of 1976.

"I was transfixed by this bottle displayed on the wall," says Chua. "I could never afford a bottle like this, I could never enjoy it. That got me thinking."

Traditionally, wine is made by fermenting grapes – yeast turns sugars in the grape juice into ethanol. The process also develops many hundreds of flavour compounds, but takes time and produces variable results. Could there be a simpler way?

Within days, Chua began combining ethanol with fruity flavour compounds like ethyl hexanoate, which has a pineapple-like aroma. The initial concoction was monstrous, he says.

But six months later, Chua and Lee think they have produced an experimental synthetic wine that mimics the taste of the sparkling Italian white wine Moscato d'Asti (see "Notes of peach and plastic bag", right). They are now turning their hands to producing an imitation Dom Pérignon champagne.

The race is on to develop synthetic food and drink. The first in vitro beefburger – grown from meat cells cultured in laboratories – was eaten in London in 2013, but it cost $325,000 to make.

In vitro meat isn't the only attempt to make ethical alternatives to our favourite foods. Hampton Creek, a food firm in California, is attempting

FAKING A FLAVOUR

Wine wouldn't be the first tasty substance to be chemically mimicked.

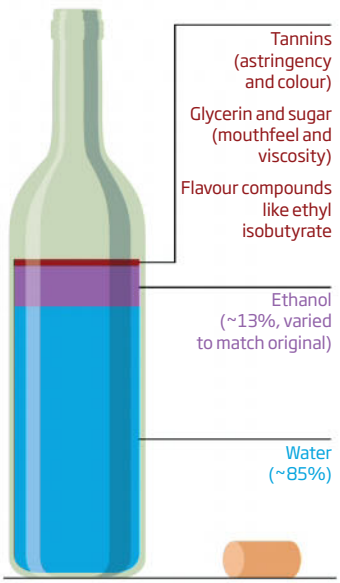
Vanilla is the world's second most expensive spice after saffron, and is facing a global shortage, with prices of Madagascan natural vanilla doubling to £158 per kilogram in the last 12 months. But home bakers need not fear - chemically synthesised vanillin , a phenolic aldehyde, has been used as a cheap but tasty substitute for over 100 years, costing only £10 per kg.

And you don't need life to give you lemons to be able to make lemonade. A basic version can be made simply by combining citric acid with sugar and carbonated water. Some argue this mixture doesn't taste as good, but it is easier to preserve.

The artificial sweetener xylitol is made by reacting xylose with hydrogen. Sugar substitutes are lower in calories than sugars like sucrose, and may be better for your teeth and blood sugar levels too.

What's in synthetic wine?

The Ava Winery is mimicking wine by adding chemical compounds to ethanol



to develop vegan eggs, made by mixing plant proteins.

We've been making synthetic lemonade for decades (see "Faking a flavour", left), and now a start-up in New York is turning its hand to luxury coffee. Highly prized kopi luwak is made from coffee beans found in the excrement of the Asian palm civet – Afineur is hoping it can copy the taste by

"The big secret is most of the hundreds of chemicals in wine have no perceptible impact on flavour"

fermenting carefully selected microbes instead.

But the Ava Winery is aiming to make artificial wines simply by mixing the right compounds together. For all the world's love of wine, our understanding of which components are most important for the taste and finish of a wine is patchy at best. A bottle usually contains around 1000 different compounds, so identifying those that are fundamental for flavour is a significant challenge.

The team decided to combine chemistry with the expert taste buds of a qualified sommelier. Using gas chromatography-mass spectrometry and other tools, the team analysed the composition of wines including Chardonnay, champagne and Pinot Noir, identifying key flavour molecules – like the esters ethyl isobutyrate and ethyl hexanoate – and their concentrations (see "What's in synthetic wine?", left). They then mixed these molecules and tinkered with the proportions, and had their sommelier test the resulting concoctions.

$50 Dom Pérignon

Tony Milanowski, a winemaking expert at Plumpton College in East Sussex, UK, has his doubts. Some flavour compounds like fatty acids and esters may be difficult to dissolve straight into a synthetic batch. These are usually produced as microbes ferment the grapes, gradually releasing the chemicals in forms that are able to mix with the other compounds present.

But Chua and Lee are not deterred. "The big secret here is that most compounds in wine have no perceptible impact on the flavour or the aroma," says Lee.

"It's absolutely going to be substantially cheaper," Lee says of their method, which cuts out the need to grow grapes and then ferment them over long periods.

They plan to sell an initial batch of 499 bottles of their Dom Pérignon mimic. At $50 a pop, they will begin shipping this summer to customers keen to experience the taste of a classic champagne that could otherwise cost upwards of several hundred dollars.

But the team is likely to meet with stiff resistance from classical winemakers and researchers.

"It's nonsense, to be honest with you," says Alain Deloire, director of the National Wine and Grape Industry Centre at Charles Sturt University, Australia, who has worked for champagne specialists Moët & Chandon.

Deloire argues that the natural origins of wine – the landscape and culture where the grapes grow, for example – have an indispensable impact on the drink that is produced, and consumers look for this in what they buy.

One thing that might put consumers off is that any synthetic wine is unlikely to have the word "wine" on its label. There are strict rules governing which products may use this term – in the EU, for example, it must apply only to the fermented juice of grapes, whereas in other jurisdictions like the US other fruits can be used.

But although losing some of the trappings of traditional wine may make synthetic ones less attractive, French winemaker Julien Miquel can foresee an interest in trying recreations of classic vintages. "There would be some curiosity on how close they could get," he says. ■

NOTES OF PEACH AND PLASTIC BAG

Lisa Grossman tried an early version of the Ava Winery's Moscato d'Asti mimic. Here are her tasting notes:

I had high hopes for the synthetic Moscato d'Asti. Unfortunately, I don't think it's ready to compete with the real thing.

We did a blind taste test between the synthetic wine and a Ruffino 2014 wine from Italy. The smell was the first thing that gave the synthetic stuff away: while the Ruffino smelled grapey and fruity, the synthetic wine smelled astringent, more like cleaning alcohol or plastic. A co-worker described it as the smell of those inflatable sharks you take to the pool. Not very appealing.

The two wines were very different in colour, too – the Ruffino was a deeper yellow, and the synthetic wine was clearer with smaller bubbles. The Ruffino was a bit thicker, and when you swirled it in the glass it left slight streaks running down the sides, a feature known as "legs". The synthetic wine didn't have much in the way of legs at all.

SWEET AND FRUITY

The synthetic wine tasted better than it smelled, though.

It was sweet, which I expected, but not overpoweringly sweet. It had some fruity notes like pear or peach, and maybe something artificially floral-scented, like a lavender soap.

But that essence of plastic bag was back on the aftertaste. Overall, I'm not sure I would drink a whole glass of this.

Ava Winery says it is now working on improving its synthetic Moscato d'Asti prototype.


AFP

Trojan war final act in world war zero

Colin Barras

THE Trojan war was perhaps grander than even Homer would have us believe. In fact, the epic conflict may have been a final act in what one archaeologist has dubbed "world war zero" – an event he claims brought the eastern Mediterranean world to its knees 3200 years ago.

And the catalyst? The Luwians – a mysterious and arguably powerful civilisation overlooked by archaeologists. So says Eberhard Zangger, head of the non-profit foundation, Luwian Studies, in Zurich, Switzerland.

The story goes like this. By the second millennium BC, civilisation had taken hold in the eastern Mediterranean. The Egyptian New Kingdom coexisted with the Hittites of central Anatolia and the Mycenaeans of Greece. Then in little more than a generation, all of them had collapsed. Was the culprit climate change? Earthquakes? Social unrest? Experts can't agree.

Zangger says that's because one crucial piece of the puzzle is missing: the Luwian civilisation in western Anatolia played a crucial role in the downfall. And he has built a case. The literature shows that western Anatolia was rich in mineral and metal ore deposits, making it an important region in antiquity, he thinks.

Through studies of satellite imagery, Zangger has found that the area was densely populated. Only a handful of the 340 large city-like sites he has identified have been excavated.

"Some of these sites are so large you can see them from space," says Zangger. "There's so much waiting to be found, it's really just mind-boggling."

We know from Hittite texts that the Luwian cities sometimes formed coalitions powerful enough to attack the Hittite empire. Zangger thinks that 3200 years ago the Luwians did just that and destroyed the Hittites.

Shortly after, Egyptian texts document an attack force they termed the "Sea People". Zangger thinks these were also Luwians, continuing their campaign for wealth and power and, in the process, destabilising the Egyptian New Kingdom.

The Mycenaeans, perhaps anticipating an attack on their territory, formed a grand coalition of their own, says Zangger. They sailed across the Aegean and attacked the Luwians, destroying key cities like Troy – events immortalised in Homer's *Iliad*.

On returning to Greece, in the sudden absence of other threats, Zangger believes the Mycenaeans squabbled and fell into civil war.

Other archaeologists praise Zangger for bringing attention to this region, but question his grander conclusions.

"He's really getting the ball rolling to do larger holistic studies of the area," says Christoph Bachhuber at the University of Oxford. "Archaeologists will need to discover similar examples of monumental art and architecture across western Anatolia and ideally texts from the same sites to support Zangger's claim of a civilisation."

The textual evidence available is from after the Bronze Age and can be interpreted as supporting or undermining Zangger's theory, says Ilya Yakubovich, a historical linguist at the University of Marburg, Germany. ■

FINE ART IMAGES/HERITAGE IMAGES/GETTY

Gift horse – Bronze Age D-day?

Sun-skimming comet might be an asteroid

WHEN is a comet not a comet? It's a question astronomers are asking themselves more and more often. Now it seems one of these supposed ice balls might actually be an asteroid that gets within a cosmic hair's breadth of the sun – a mere 8 million kilometres from it.

The two kinds of space rocks are traditionally thought to be very different. Comets are loose piles of rock and ice on long, elliptical orbits that heat up and develop a tail of gases as they near the sun. Asteroids, on the other hand, are lumpy bodies of hard rock and metal that mostly orbit the sun at a distance that falls somewhere between Mars and Jupiter.

But an increasing number of objects are being discovered that blur the line between the two. The latest is comet 322P/SOHO 1, discovered in 1999 by NASA's Solar and Heliospheric Observatory. But SOHO's view is shaded to protect it from intense sunlight and its resolution is comparatively low, meaning it can't get a good look at 322P during the comet's closest approach to the sun.

Now, Matthew Knight at the University of Maryland in College Park and his colleagues have used ground-based telescopes and the Spitzer space telescope to take another look. They found there was no sign of a tail from 322P as it got close to the sun. They also found that its density is at least 1000 kilograms per cubic metre, double that of the famous comet 67P/Churyumov-Gerasimenko (*The Astrophysical Journal Letters*, doi.org/bhjj).

"A rising number of objects are being discovered that blur the line between comets and asteroids"

The readings are a big clue that 322P may actually be an asteroid, says Knight. If so, that would make it the asteroid that gets closest to the sun, coming to within about 5 per cent of the distance between Earth and the sun.

Knowing where the line falls between asteroid and comet is useful in helping us trace the history of the solar system. Jacob Aron ■

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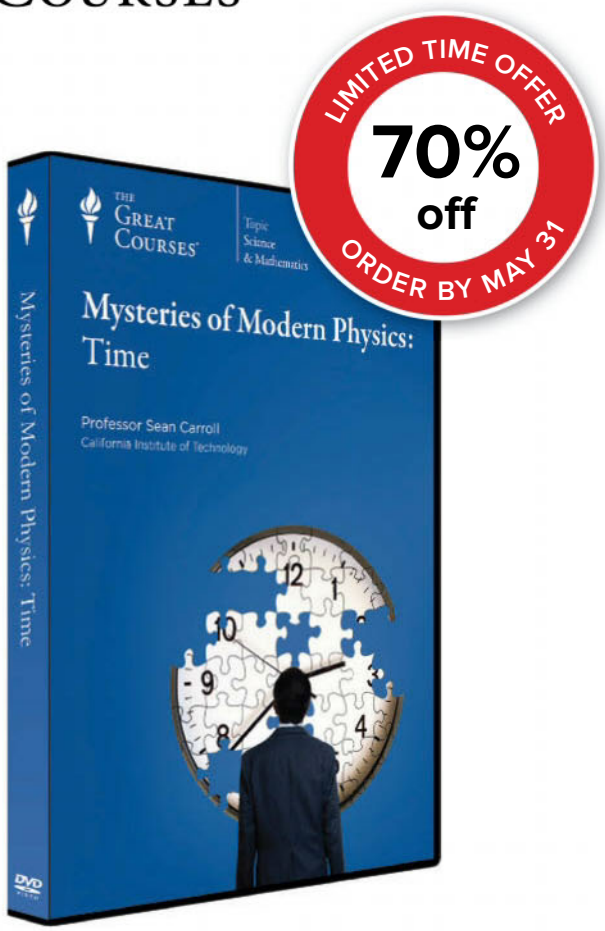

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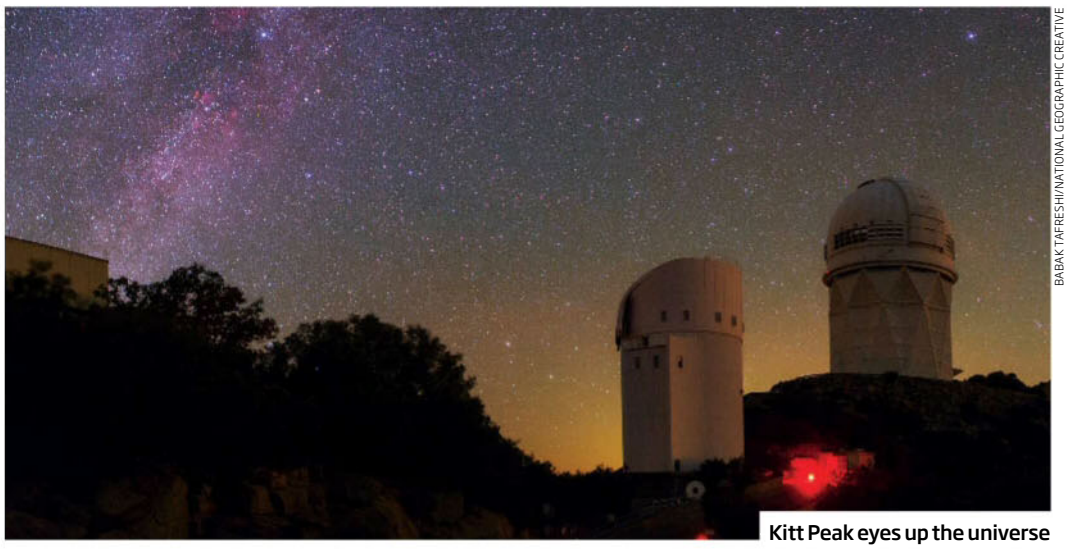


BABAK TAFRESHI/NATIONAL GEOGRAPHIC CREATIVE

Kitt Peak eyes up the universe

The galaxy that time forgot

Jacob Aron

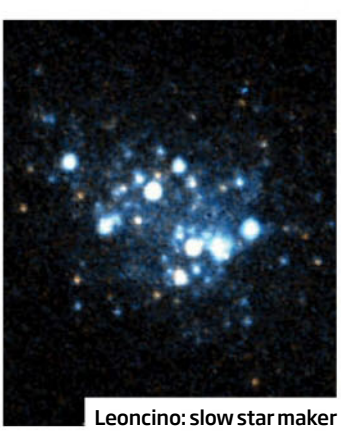
A GALAXY that seems to be relatively unchanged since it was born shortly after the big bang could help us understand the cosmos in the deep past – and learn how the earliest galaxies formed stars.

Shortly after the big bang, the only elements in the universe were hydrogen and helium, with a few traces of other light elements. Heavier elements, which astronomers refer to as "metals", were only created after the hydrogen and helium formed into stars, which forged new elements through nuclear fusion.

Because of this, astronomers measure the abundance of metals within stars and galaxies to track their evolution. Now Alec Hirschauer of Indiana University in Bloomington and his colleagues have measured a small galaxy called AGC 198691, around 30 million light years from Earth, with the lowest metallicity ever seen.

"This galaxy is a close analogue to what we expect galaxies were like shortly after they formed after the big bang, before they have had the time to chemically enrich to the levels we see in local, nearby systems," says Hirschauer. "It is a nearby laboratory we can use to approximate the conditions soon after the big bang."

The galaxy is near the constellation Leo Minor, so the team nicknamed it the Leoncino dwarf. They used telescopes in Arizona at the Kitt Peak National Observatory in Tucson, and the MMT Observatory in Mount Hopkins, to analyse the light from Leoncino and found that its ratio of oxygen to hydrogen – a proxy for overall metallicity – is the lowest ever seen, just 2 per cent of our sun's metallicity (*The Astrophysical Journal*, doi.org/10/bhjk).



NASA; A. HIRSCHAUER & J. SALZER, IU; J. CANNON, MACALESTER COLLEGE; AND K. MCQUINN, UT

Leoncino: slow star maker

Leoncino hosts bright, blue stars, which could only have formed relatively recently, as stars generally start their lives blue and hot and get redder and dimmer as they age. That means the galaxy probably forms stars very slowly, and is only starting to use up material hanging around since the big bang.

Astronomers don't yet understand why some galaxies form stars more slowly than others, though it seems to be related to their mass. "AGC 198691 is a small galaxy, and so has been inefficient at converting gas into stars over the length of time that it has existed," says Hirschauer.

Studying Leoncino further will help deepen our understanding of the differences between galaxies, and also give us a look back at how galaxies behaved in the early universe.

"By studying how the stars of AGC 198691 are forming, we have a glimpse into what very early galaxies were doing," says Hirschauer. ■

First Americans hunted big game in Florida

THE earliest Americans migrated quickly, but were less quick to wipe out their prey. That picture is painted by finds from the bottom of a watery Florida sinkhole 9 metres deep, including 14,500-year-old stone tools and the remains of a butchered mastodon, a type of prehistoric elephant.

Having arrived on the Pacific coast at least 15,500 years ago, these first settlers must have rapidly spread east and south to occupy vast swathes of North America, the discoveries suggest. They also show that humans lived alongside large mammals for at least two millennia before the animals went extinct – challenging the assumption that we speedily drove megafauna to extinction (*Science Advances*, doi.org/bhjg).

"These people knew where to find game, raw materials for tools and other critical resources for survival"

"We maybe need to reopen our lines of investigation into the interactions between these early people and mega mammals," says Jessi Halligan at Florida State University in Tallahassee. Her team donned scuba gear to recover the stone artefacts and bones at Page-Ladson, in north-west Florida.

For a long time, the first human culture in America was thought to be that of the Clovis people, who arrived from Siberia about 13,000 years ago. The new discovery adds to evidence that pre-Clovis people reached the Americas at least 2500 years earlier. "These people had successfully adapted to their environment; they knew where to find fresh water, game, plants, raw materials for making tools, and other critical resources for survival," the team's paper says.

"It is excellent proof of the pre-Clovis occupation of eastern North America," says Dennis Stanford at the Smithsonian Institution in Washington DC. Colin Barras ■

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JAN VAN DE KAM

Early Arctic melting famishes overwintering birds in Africa

WHAT happens in the Arctic doesn't stay in the Arctic. Climate change is affecting the high-Arctic breeding grounds of red knots. The youngsters among these small shorebirds don't grow as big as they did 30 years ago – and so struggle to feed and survive after reaching their wintering grounds in Africa.

Red knots make epic journeys from the Arctic Ocean to the tropics and back every year. For more than 30 years, Jan van Gils at NIOZ Royal Netherlands Institute for Sea Research and his colleagues have been measuring the birds each autumn at a migratory stopover in Poland.

They found that juvenile birds weighed less and had shorter bills in years when the Arctic snowpack melted early, probably because they hatched after the peak of insect abundance (*Science*, doi.org/bhgr).

Once the knots reach their wintering grounds on the coast of Mauritania in western Africa, shorter bills prove costly. The knots' preferred food is a small clam that lives 30 or 40 millimetres below the surface of the sand, and the birds' bill is normally almost exactly that length. Having a shorter bill means they can't reach as many of those clams, and have to resort to eating shallower clams – which are scarcer – or plant rhizomes, which are nutrient-poor. "Every millimetre counts," says van Gils.

Shorter-billed birds were much less likely to survive their first year, the researchers found.

How embryos get attached

IT'S a sticky business. Scientists have uncovered how embryos stick to the uterus in the first week of life. The discovery might one day help improve treatments for recurrent miscarriages and pre-eclampsia, a life-threatening elevation of maternal blood pressure.

After a human egg is fertilised, it tumbles down the mother's fallopian tubes and into her uterus. There, it sticks to the uterine wall and then buries itself under the wall's lining.

Now, Harry Moore and Bikem Soygur at the University of Sheffield, UK, have shown that a protein called syncytin-1 probably plays a vital role in this process.

Syncytin-1 is known to help embryos burrow into the uterus, as well as form a placenta – a process that begins about six days after fertilisation. But Moore and Soygur found that the protein is secreted earlier than this (*Human Reproduction*, doi.org/bhgt).

Moore thinks the protein is produced this early to help the embryo stick to the uterus, as previous research has shown that syncytin-1 makes different cell types stick together.

He says it may be possible to use the finding to develop blood tests that identify embryos that haven't implanted properly.

Cannibal stars explode violently

CALL it cosmic indigestion. In January 2015, observers witnessed a rare "red nova" in the nearby Andromeda galaxy that outshone ordinary stellar explosions.

Using Hubble Space Telescope observations from a decade earlier, Morgan MacLeod of the University of California at Santa Cruz and his colleagues have concluded that a large yellow star ate a little red one (arxiv.org/abs/1605.01493). "It's a star-eat-star universe," he says.

Normally, in a close binary, the gravitational pull of one star pins the other, so that one side of one star always faces the same side of the other star. But the lower mass of the red dwarf left it vulnerable to so-called Darwin instability, proposed by Charles's son George in 1879. As the giant star aged, it expanded and spun more slowly. The red star couldn't keep facing its partner and fell towards it, eventually skimming the surface and triggering the flare-up.

Dwarf planet deserves a name

WHAT'S a planet gotta do to get a moniker? A body beyond the orbit of Neptune, known only as 2007 OR10, may be the third largest dwarf planet in the solar system – yet it doesn't have a proper name.

It is one of a gaggle of trans-Neptunian objects discovered by a team led by Mike Brown at the California Institute of Technology in the 2000s. The team originally pegged its diameter at about 1200 kilometres, making it the second smallest dwarf planet.

But now a team led by András Pál of the Konkoly Observatory in Budapest, Hungary, has used data from the Kepler and Herschel space telescopes to revise that to 1535 km, bumping it up to third place (*The Astronomical Journal*, doi.org/bhhb).

Shooting stars' oxygen mystery

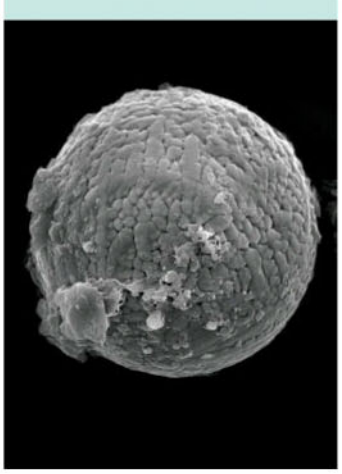
FEW things seem more ephemeral than shooting stars. Yet the scorched remains of 60 micrometeorites have survived 2.7 billion years in the limestone Tumbiana Formation of Western Australia. They are some of the oldest space rocks ever discovered on Earth.

The fact that the meteorites contain oxides of iron also shows that the upper atmosphere must have contained oxygen at least 300 million years earlier than ground-level air.

"We were very surprised to find micrometeorites at all, let alone those with iron oxides," says Matthew Genge of Imperial College London. "These tiny spherules had trapped ancient atmosphere, storing it away like little treasure chests."

The presence of oxygen in the meteorites means that levels of this gas in the upper atmosphere, 75 kilometres high, at the time must have been similar to levels found in the atmosphere today – roughly 20 per cent (*Nature*, doi.org/bhgs).

That oxygen might have come from the sun's ultraviolet radiation splitting molecules such as water and sulphur dioxide, thus freeing oxygen at high altitudes. The team thinks a methane-rich layer in the middle atmosphere would have separated the bulk of anoxic air below from the oxygen-rich upper atmosphere.



ANDREW TOMKINS

Life's origin not so tough if you can build bits of RNA in the lab

ONE of the hardest steps leading up to life on Earth might not be so hard after all.

RNA, or something very like it, has long been a strong candidate for the first self-replicating molecule necessary for life. It carries genetic information and can also catalyse many biochemical reactions.

But how could a large, complex molecule like RNA form spontaneously? The main sticking point was that no one knew of a plausible way to make two components of it, adenosine and guanosine – needed to represent A and G in the genetic code. Making these subunits separately and linking them together step by step generally led to a useless mess in which most of the molecules were the wrong shape.

Now a team led by Thomas Carell, an organic chemist at the Ludwig Maximilians University in Munich, Germany, may have cracked it. They started with simpler precursor chemicals and let the whole process unfold at once, under mildly acidic conditions that mimicked those of early Earth.

Their approach produced high yields of adenosine, and some guanosine (*Science*, DOI: doi.org/bhgv). Better yet, Carell's starting points – such as formic acid – or their precursors have been found on comets and thus were probably available at the origin of life.

"We now have a pathway that would allow us to use simple molecules that were likely present on the early Earth," says Carell. The next step is to link the components into a full-length RNA strand, he says.

Spiders' sticky silk has a dual identity

SPIDER silk acts as both a liquid and a solid, a feat that could inspire new types of robots.

Arnaud Antkowiak of the Pierre and Marie Curie University in Paris, France, and his colleagues studied the sticky "capture silk" that makes up the spiral of an orb-weaver spider's web. When stretched, the silk extends like a spring. But when compressed, it remains taut, rather than sagging in the middle as an ordinary thread might.

Most materials that act like this are liquids: a soap film is an example.

"It seems to adapt its length," says Antkowiak. The capture silk appears to be a liquid-solid hybrid that changes its size according to the space it needs to fill. "It's just weird," he says. This dual nature stems from the silk being made of a filament wrapped in glue droplets.

The team was able to mimic this behaviour with a range of plastic filaments coated in silicone oil, ethanol or other liquids, creating what they call "liquid wires" (*PNAS*, DOI: 10.1073/pnas.1602451113).

Antkowiak says this behaviour could make the materials useful in building soft robots.

STEFAN SOLLFORS / ALAMY STOCK PHOTO

Time for a new dandruff shampoo?

LOOKS like our knowledge was a little flaky. It seems bacteria, rather than fungi, could determine whether you get dandruff.

Since the 19th century, the prevailing wisdom has been that a fungus called *Malassezia* is to blame for dandruff. But now we have bacteria in the cross hairs.

Zhijue Xu of Shanghai Jiao Tong University in China and his team swabbed the scalps of 363 adults, and used DNA sequencing to compare their fungi and bacteria. They found that about 90 per cent of scalp fungus in all people, regardless of whether or not they had dandruff, was *Malassezia restricta*.

But bacteria revealed a different story. People with dandruff had more *Staphylococcus* bacteria and much less *Propionibacterium* than those who didn't have dandruff, suggesting that the bacterial balance on your head may determine whether you sport snowy flakes in your coiffure (*Scientific Reports*, doi.org/bhgq).

Xu says his team will now investigate methods for balancing the proportions of scalp bacteria, which they hope might be a way to reduce dandruff.

Moonshot or mania?

The White House has launched a huge project into the microbes that live on us. **Sally Adee** looks behind the hype

MARTIN OECGERLI/WWW.MICRONAUT.CH

ARE they for us, against us or just cohabiting? It's hard to know what to think about the microbes that live in and on us. In the same week that researchers announced that there is no evidence that probiotic supplements work, the White House launched the National Microbiome Initiative. This $500 million "moonshot" is intended to understand the vast colonies of bacteria, fungi and viruses that coevolved with our bodies, lands and oceans. The hope is that it will lead to breakthroughs in health and many other fields of science.

"We need the means to change dysfunctional microbiomes and make them functional," says Jo Handelsman, at the Obama administration's Office of Science and Technology Policy.

On the human health side, thousands of papers have been published over the last few years linking changes in gut flora composition to allergies, asthma, obesity, cancer, Parkinson's, Alzheimer's, anorexia, autism, depression and even ageing.

The studies hint that we may one day be able to affect these conditions by tweaking our gut bugs. But there's quite a gap between this promise and the current science. That vacuum has been filled with misconceptions, snake oil and hype. Jonathan Eisen, a biologist at the University of California, Davis, calls it "microbiomania".

The National Microbiome Initiative seeks to bridge that gap, but it could be decades before its scientists can unpick the complex interplay of microbe and human biology to develop treatments.

"It may take decades to unpick the complex interplay of microbes and human biology"

So in the meantime, what should we make of the dizzying array of touted medical links, the rise of DIY microbial transplants and the probiotic foods industry, which some estimates put at $96 billion by 2020? Not to mention the spectre of faeco-cosmetic treatments.

Let's start with that array of medical links. The intriguing associations we are seeing can be traced back to the trillion microbes in our guts producing chemicals that break down proteins and cell walls. This has downstream effects on aspects like chemical regulation, the immune system and the brain, the specific mechanisms of which are just starting to be decoded.

Although possible connections between bacterial products and medical conditions are multiplying fast, not everyone agrees that the bacteria are causing the observed effects, rather than the other way around. "No doubt microbes drastically influence many aspects of our biology," says Eisen, "but as with brain scans, finding a difference between two groups of people doesn't tell you a lot."

What's more, says Mick Watson of the University of Edinburgh, UK, "a lot of people do really bad microbiome research", without, for example, using control subjects.

And most of the good science is done in mice. Several experiments have suggested that autism-like behaviours and gastrointestinal ailments can be explained by microbiota, and in one case these behaviours were suspended by injecting microbes from neurotypical humans. But does that tell you much about autism? "None of that makes any sense!" says Eisen. "Mice don't have autism. This is not autism." Nonetheless, it has led to headlines suggesting autism was cured by probiotics.

Much like Eisen, many microbiologists are worried about the premature applications of these studies. Another bugbear of his is microbial forensics. People are saying we should consider having criminals' microbiomes typed for a database, he says. "Are you kidding me? People have been executed based on bad forensics in the past."

More immediately concerning is the rise of faecal transplants – taking faeces from someone healthy and giving them, via rectal insertion, to someone else.

In the US and Canada, the transplantation is regulated as an investigational drug, which means its use is restricted to clinical trials – the exception is treating *Clostridium difficile* infections, for which the transplants have a 90 per cent success rate. In the UK, however, the transplants aren't considered medical procedures, so can be done if a supervising physician agrees to it. The Taymount Clinic in Hitchin, UK, for example, offers them for ulcerative colitis, multiple sclerosis and Parkinson's disease, and its counterpart in the Bahamas is treating people with autism (see "Faecal tourism", right).

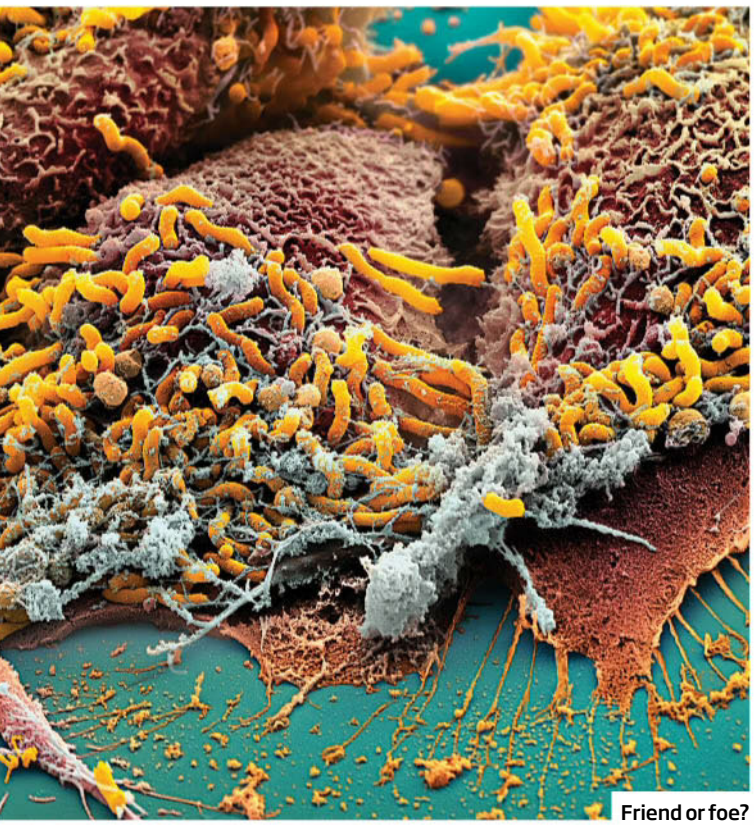
SWALLOWING A MYTH?

It's tempting to think that regular doses of "friendly" bacteria will keep your gut happy. This notion explains the wild success of probiotic drinks, yogurts and supplements.

But last week, the market got a black eye from a review of existing studies that found no evidence that taking probiotics benefits healthy people. In four of seven trials analysed, no effects were observed on the faecal microbiota composition when compared with a placebo (*Genome Medicine*, doi.org/bg82).

There are several reasons why this could be. Some suppliers may use bacteria that are dead. Others don't put in the right mix, says Jonathan Eisen of the University of California, Davis. Even a well-made probiotic is unlikely to survive the enzymes that kill microbes traversing our bodies.

Three other studies did find some changes to the abundance of certain bacteria, but because of their poor design, no conclusions can be drawn.



Friend or foe?

All the microbiologists *New Scientist* spoke to vehemently warned against seeking out a clinic for this until trials have found conclusive evidence that the procedure works for the relevant condition and is safe. They were alarmed by the growing trend of DIY transplants – people armed with a blender and an enema kit going it alone.

So if faecal transplants are an application too far, at least for now, and probiotics have little impact (see "Swallowing a myth?", left), what can microbes do for us in the next few years?

"Think beyond the gut microbiome," says Elisabeth Bik, a microbiologist at Stanford University in California. Researchers have long sought to manipulate oral microbiota for the treatment of bad breath or tooth decay. Osel, a company in California, is modifying the vaginal microbiome to treat bacterial vaginosis; and at Washington University, researchers are supplementing the skin with probiotic bacteria to treat wound infections or acne.

WH.GOV

Searching for answers

"Microbiome research is incomplete. We simply do not know what many microbial genes do"

Bik sees these as legitimate applications that aren't too far off.

The jury is still out on whether eye-catching disease cures will ever materialise. "It's like the post-genome blues," says Eisen. "We spent $2 billion on the human genome, and it was sold as being critical to developing cures for all sorts of human ailments." So far, it has led to more questions than answers.

Watson thinks the problem is that today's microbiome research is incomplete and focuses mainly on bacteria. "Most of it ignores fungi, protists, viruses and other parts of the microbiome," he says. Even if those were included, it wouldn't be enough – "for many [microbial] genes, we simply do not know what they do," he says. For microbiome research to develop, the field needs to become more focused, build standards and change from being a mostly observational science.

That's exactly what the National Microbiome Initiative aims to do. "We're looking for the principles that govern the response of the microbiome," says Handelsman.

In the meantime, scientists and press officers should take care to avoid hype. "You can't put out a press release that says you've solved autism – oh, footnote, it was in mice," says Eisen. It's naive to think this won't send people to clinics to get a faecal transplant for an autistic child, he says. While moonshot programmes unpick the impossible complexity of the microbiome, people will try to apply it by any means necessary. ■

FAECAL TOURISM

The Taymount Clinic in Hitchin, UK, is the UK's premier destination for those looking for a faecal transplant. It offers them for conditions such as ulcerative colitis, multiple sclerosis and Parkinson's disease. The faeces come from non-smoking, non-drinking, naturally slim donors.

Glenn Taylor, who runs Taymount, says rising demand has forced the clinic to build an extension that more than doubles its size.

Sixty per cent of its clients come from the US and Canada, so in July 2015, the clinic opened a branch in the Bahamas – "just a half-hour flight from Florida, in a beautiful environments", says the website. Taylor says the Caribbean outpost has carried out faecal transplants on people with autism. "They are changing the way that autistic patients present just by changing the microflora," he says. And it's the same with obesity: "We hear all the time from patients with transplants who suddenly have no trouble losing weight."

NOT-SO-CLEAN BREAK

The clinic is also developing a wellness treatment for healthy people as a kind of "spring cleaning" for the gut, a week-long retreat involving a series of colonics followed by a selection of faecal transplants. "It would freshen you up if you were feeling a little sluggish, or after a holiday", says Enid Taylor, a co-founder of the clinic.

However, so far, faecal transplants have been shown to work only for *Clostridium difficile* infections. The microbiologists *New Scientist* spoke to were uniform in their condemnation of faecal transplants whose safety and efficacy hasn't been shown in clinical trials. Melanie Thomson, a microbiologist at Deakin University in Geelong, Australia, is concerned by "hyped hopes" raised by practitioners. "But I understand the frustration and hope that drives people to engage with [unproven] science in the hope of a 'cure' for intractable conditions," she says.

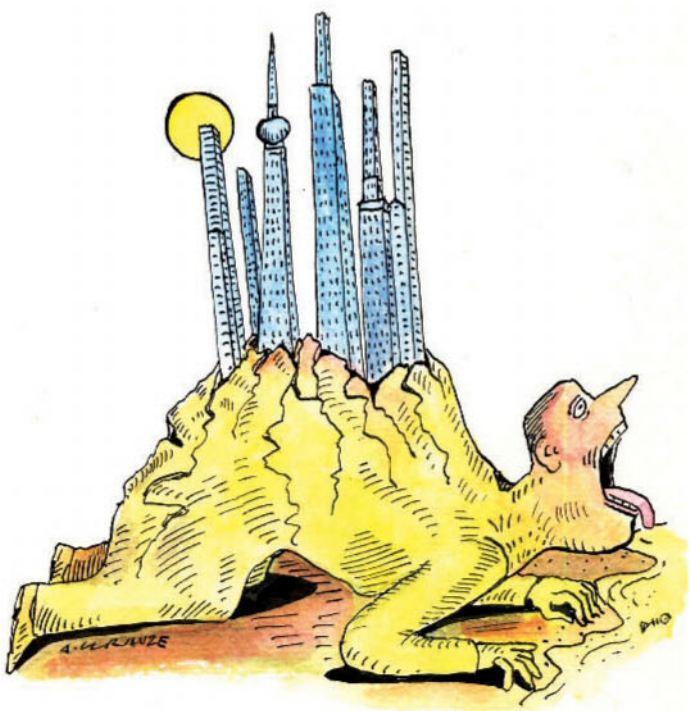
Last-gasp thinking

An artificial mountain to make rain in the desert? The idea alone may reflect a new thirst for risky geoengineering, says **Jamais Cascio**

RISING to nearly 830 metres, the Burj Khalifa in Dubai – part of the United Arab Emirates – is a marvel of engineering, and the world's tallest building, for now.

It may soon pale in comparison to a new megastructure in the desert nation. The UAE, with the help of the US National Center for Atmospheric Research, is considering building a mountain to increase rainfall. The study is only beginning, but researchers expect to have the first modelling results – showing necessary height and slope – this summer.

While an artificial mountain may sound outrageous, this isn't the first such suggestion. In 2011, a Dutch group looked into building a 2-kilometre peak for sport and recreation. While it did not get off the drawing board, research concluded it could be done.



A mountain in the UAE, one of the 10 driest nations on Earth, wouldn't be for skiing, however, but for triggering cloud formation and much-needed rainfall. Rising water demand in the country, combined with the effects of climate change, takes a toll on a total annual rainfall that averages just 75 millimetres. Hence the heavy use of expensive, energy-hungry desalination plants.

Talk of mega-scale projects to lessen impacts of global climate disruption is growing. That's no surprise, as anthropogenic global warming is so intense that we're nearing the point where even aggressive emissions-reduction plans may not avert disaster.

Seawalls may protect against rising tides, while reflective blankets and paint may slow glacial melting, and temperature rises may be slowed or stopped by seeding the upper stratosphere with megatonnes of tiny particles.

None of these are solutions to

Hard to swallow

Trendy clean-eating fads are best taken with a big pinch of salt, warns **Anthony Warner**

IT IS in the nature of science to be full of uncertainty. This is a result of its innate need to doubt, challenge and confront beliefs. Its conclusions are carefully weighed. This is its great strength, but can be a weakness when engaging a public hungry for clear answers.

This is particularly true in the world of food. Ask a dietitian or food scientist which foods are unhealthy and the likely answer will be along the lines of: "Well that's an interesting question, but it really depends what you mean by healthy – no food should really be classified as healthy or unhealthy as that is not really helpful – we think that you should try to achieve a balance."

Ask the latest internet healthy-eating guru and they will declare "white rice, sugar and anything with gluten".

Who do you think the human mind, with its instinctive bias for tuning in to simple messages, is most likely to believe? The balanced, cautious voice of science, or the clear-cut opinions of a self-appointed insta-guru?

Should we care? If clean-eating proponents the Hemsley sisters – whose prime-time TV show began in the UK last week – and others like them manage to get a few people to eat more vegetables, that's good, right? Perhaps, but at what cost? When you scratch the surface of such messages, bad science is often lurking beneath.

"When you scratch the surface of clean-eating messages, bad science is often lurking beneath"

The Hemsleys advocate excluding perfectly nutritious foods for no sound reason – cereal grains, for example. Worse, though, is that they have in the past endorsed the GAPS diet, a brutally restrictive, pseudo-scientific regime that makes an unsubstantiated claim that it can cure autism. A leading paediatric dietitian has said that a child made to eat the GAPS diet could

global warming – they are, at best, tourniquets while we try to decarbonise economies.

All would have unintended consequences. Generating clouds by blocking air flow with a mountain won't make water appear magically out of nowhere, but alter where moisture collects and falls. Rainfall patterns will shift. Somebody else may lose out.

This could affect other countries on the Arabian peninsula, the Middle East in general, even eastern Africa. Rainfall changes in already precarious environments wouldn't go unnoticed, and may spark conflict in an unstable area.

Even if the UAE builds a mountain, the larger climate problem remains. What's more, oil-rich nations in the region face a double-whammy: temperatures reaching levels beyond those human civilisation can handle, alongside the imminent end of the fossil-fuel economy.

This could be a last gasp attempt by the UAE to stave off unbearable heat by cashing in on the fact that oil is, for now, still in demand around the world. ■

Jamais Cascio is a distinguished fellow at the Institute for the Future, and writes about the impact of innovation at Open the Future

be seriously harmed or die.

A combination of likeability, photogenic appeal, a clear simple message and certainty in your beliefs is a powerful combination.

That brings us to Belle Gibson, the Australian health blogger who claimed diet and natural healing techniques cured her cancer before confessing she made it up. You would hope that no sensible person would reject conventional medicine's might in favour of the untested opinions of one person. Sadly many did, and to great cost. ■

Anthony Warner is a food industry development chef who blogs about pseudoscience as The Angry Chef

INSIGHT Green energy

ROLF SCHULTEN/BLOOMBERG VIA GETTY IMAGES

Too much of a good thing

The dangerous myth of cheap renewables

Michael Le Page

"Germany had so much renewable energy on Sunday that it had to pay people to use electricity." That was the striking headline on the Quartz news site last week. Excess electricity can overload a grid, so to even things out some big consumers were paid to up their energy use.

Wind and solar provided 22 per cent of Germany's electricity in 2015. That isn't typical but it's not the only place with too much energy at times. In Texas there is now so much wind energy that some firms give electricity away to households for free at night.

It sounds like wonderful news. The cost of wind and solar is falling so dramatically that they are finally becoming competitive with other electricity sources. The tempting conclusion is that the days of fossil fuels are numbered. Clean, green energy is going to deliver cheaper power for us all. Problem solved.

Except this is not how it works. To understand why, imagine you're a potential solar investor in a free market. The question you have to ask is will you be able to sell electricity for more than it costs you to produce it. If you're the first to install solar in an area, the answer could well be yes. But as more solar comes on line, there's going to be a surfeit of electricity on sunny summer days, meaning no one will want to buy yours. You will have to sell it cheap if you can sell it at all – whereas your fossil-fuelled competitors, who can adjust production to demand, will still be able to sell theirs for a decent price.

"It may look like we are close to the renewables dream but with our current tech this is an illusion"

In reality, the market is not free. To make renewables profitable, governments have had to subsidise them: most wind and solar firms get a guaranteed price for their electricity. This means they can sell power even when too much is produced – hence why Germany was paying customers to use electricity. Rather than being something to celebrate, this is a sign of a serious economic problem that could bring the renewables revolution grinding to a halt.

We can't keep subsidising forever. The UK is already slashing subsidies because they cost so much – and wind and solar only supply around 3 per cent of the country's energy. Globally, it's 1 per cent. It would be exorbitantly expensive to keep subsidising as that figure rises, says Varun Sivaram at the Council on Foreign Relations, a think tank based in Washington DC.

What's that, you say? Batteries? Well, very cheap batteries would help but they are still costly. And while they are ideal for smoothing out the daily variation in solar, batteries don't help much with the seasonal variation.

The solution is to keep reducing the cost of installing solar, so companies can still turn a profit even as the price of their electricity falls. The bad news is this might not be possible with the silicon solar panels currently used. But other, more efficient solar technologies in the pipeline might do this better.

So although it may look like some places are getting close to realising the renewable dream, with existing technologies this is an illusion. The only way forward, Sivaram and others argue, is to keep investing in new technologies that can deliver even cheaper power.

This is why it's worrying to see headlines like "Why the renewables revolution is now unstoppable". This is hubris. If left to market forces, the revolution is all too stoppable. The message politicians need to hear is, "The renewable revolution will only happen if you make it happen." ■

Hyperloop's first flight

The first tests of Elon Musk's ambitious high-speed transport system for California are already taking place, finds **Aviva Rutkin**

IS THE future of transport barrelling towards us? Over the past week, several groups in the US unveiled early models for the Hyperloop, Elon Musk's imagined "fifth mode" of travel – after planes, trains, cars and boats.

Musk, co-founder of SpaceX, first published his sketches for the Hyperloop in August 2013. In his vision, pods of people would shoot down low-pressure tubes at speeds up to 1220 kilometres per hour, propelled by linear induction motors similar to those used on roller coasters.

Musk claimed the commute from San Francisco to Los Angeles, which takes about 6 hours to drive or more than an hour to fly, could be cut to 35 minutes.

"The dream is a mode of transportation that is incredibly fast, convenient and carbon-free"

On 11 May, in the Nevada desert, an independent company named Hyperloop One held the first public demonstration of its technology. A metal sled shot along a 900-metre open-air track in 1.1 seconds – although without any of the complexities of low-pressure tubes that a real system would need.

"We whooped, high-fiving all around, and hugs. I had tears mixed with sand," Hyperloop One co-founder Shervin Pishevar wrote in a blog post. A larger-scale test is slated for later this year – on a longer track.

Meanwhile, SpaceX is holding an open competition to build the pods that will travel on the Hyperloop. On Friday, a student team from the Massachusetts Institute of Technology became the first to show off their pod, at an event in Cambridge, Massachusetts.

The MIT designs, which rely on magnetic levitation, won an interim prize from the competition in January. Later this year, they and other teams will have a chance to test their versions at a track outside the SpaceX headquarters in Hawthorne, California.

The Hyperloop is "once a concept, now very much in development", says MIT team captain Philippe Kirschen. "The dream is a mode of transportation that is incredibly fast, incredibly convenient and it's conceivably carbon-free."

In a 57-page document setting out his original Hyperloop vision, Musk estimated that the project would cost no more than $6 billion, but many have since suggested it could come to at least ten times that much. Musk also claimed that a one-way ticket would cost only $20. ■

JOHN GURZINSKI/AFP/GETTY IMAGES, DAVID BECKER/GETTY IMAGES, AP PA/JOHN LOCHER,MIT

Clockwise from top left: MIT's mock-up of its first pod; the test cart crashes into a sand bank after the first run; playing inside mock-ups of the tubes; shooting along the track; a test sled waits its turn; crowds gather at the site; preparing for launch

Match that doodle

AI can find the snap that inspired your scrawl, says **Aviva Rutkin**

DOODLERS, rejoice. A computer program can scan your sketches and search for a photograph that looks just like them.

It's an exciting step towards a search engine based on drawings, says James Hays, a computer scientist at the Georgia Institute of Technology in Atlanta.

"For some types of images you want to find, it would be very hard to express that thing with just language," he says. "What if you could just draw what you want?"

In the past few years, artificial intelligence has become adept at recognising photos of cats or faces. But sketches aren't as straightforward – few of us are good enough at drawing, for a start. We tend to exaggerate some features and skip over others, or simplify objects to stick figures, even adding bits that don't belong.

Hays and his team recruited 664 workers on crowdsourcing platform Amazon Mechanical Turk to make sketches. A photo was randomly selected from a stack of thousands and then shown to the worker for 2 seconds. Each snap fell into one of 125 categories of recognisable objects, such as beetle, sword, banana or rocket. Then, the worker drew what they had seen from memory. Altogether, the crew spent nearly 4000 hours sketching.

To match the sketches to the original photographs, two neural networks collaborated. One analysed the sketches, the other evaluated the photos, then they looked to see which pairs were the most similar. The work will be presented in July at the SIGGRAPH conference in Anaheim, California.

In a test, the AI correctly matched the sketch to the photo 37 per cent of the time. That might seem low, but the answer was only marked right if the program picked the exact photo that inspired the sketch – no half-marks for close guesses. Humans only got it right about 54 per cent of the time. For AI, that's not an insurmountable goal, says Hays. "Computationally, we might be able to beat the human baseline."

"Police could catch criminals by searching databases with drawings made by criminal sketch artists"

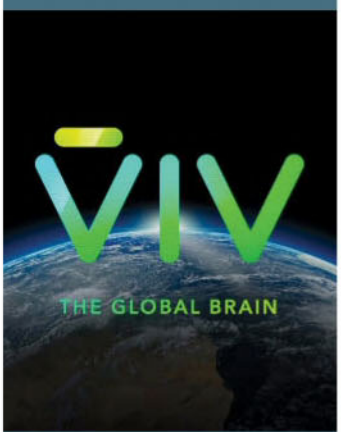
Work like this could open up exciting possibilities for sketch-based search, says Timothy Hospedales at Queen Mary University of London. In the far future, he envisions a program that helps catch criminals by searching police image databases using drawings made by criminal sketch artists.

A more immediate application might be e-commerce. Hospedales and his colleagues developed a program that can match sketches of shoes and chairs with similar photographs, which they will present next month at the Computer Vision Pattern Recognition conference in Las Vegas. "Maybe you want to express the style with a sketch and then retrieve photos in that style from your favourite online shopping site. It provides a different way to shop," he says. ■

VINCENT MIGEAT/AGENCE VU/CAMERA PRESS

Is it a bird? Is it a plane? Ask the AI

ONE PER CENT



VIV LABS

New AI in your pocket

Move over Siri. The creators of Apple's intelligent assistant have unveiled their latest AI project: Viv. Dag Kittlaus, co-founder of Viv Labs, demonstrated the assistant in New York last week. Viv can follow complicated verbal instructions – such as sending money to a friend, or telling you if the weather will be warmer tomorrow. It isn't tied to any operating system, so could work for any type of smartphone. Kittlaus said Viv should be available later this year.

70K

The number of users of dating site OKCupid who had usernames and answers to personal questions posted online by researchers last week

Robots you swallow

An origami bot made out of dried pig intestine could one day unfold in someone's stomach and hunt down foreign objects or patch wounds. The device, developed at MIT, folds up small enough to be encased in a swallowable capsule of ice that melts once ingested. Slits in the material – which is the same as that used in sausage casings – dictate how it unfolds and then moves.

NEW SCIENTIST G^MECHANGERS

INTRODUCING THE SECOND IN A NEW SERIES OF WHITE PAPERS FROM *NEW SCIENTIST*

What's the future of business?

We at *New Scientist* decided to take a look at how three of the key drivers of business – energy, money and automation – might change over the next decade. To do that, we've asked three writers with deep understanding of these areas to tell us how they think the future could unfold, and how it might confound our initial expectations.

The author of our second GameChangers report in the series is Steven Cherry, who for 15 years covered the work sector for *IEEE Spectrum*, and now directs TTI/Vanguard, a members-only forum that explores the impact and implications of future technologies for senior business leaders.

In his report, Cherry examines the arguments for and against the idea that automation will ultimately outsource every human job, and explores the paradoxes inherent in both. If cognitively complex jobs are the only ones that are safe, why is there still such high demand for cashiers? If automation generates new jobs, why is GDP slowing? And when can you expect the robots to take your job? To find out, register to download your free copy of *GameChangers: Automation and Artificial Intelligence* today.

Sally Adee
Editor, GameChangers

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NEWSCIENTIST.COM/GAMECHANGERS

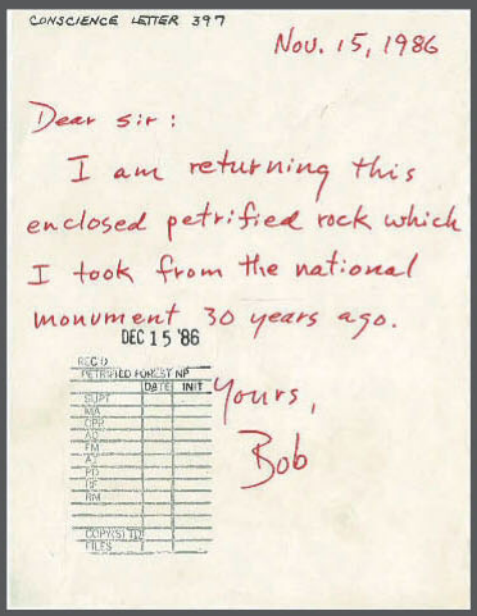
ABOUT THE AUTHOR

Steven Cherry is the Director of TTI/Vanguard, a membership forum based in New York that explores future technologies. Previously he was a journalist and editor at *IEEE Spectrum*, the magazine of the Institute of Electrical and Electronics Engineers. Prior to that he was an editor at the Association for Computing Machinery (ACM). He founded and co-hosts the award-winning podcast series, *Techwise Conversations*, which covers technology news, careers and education, and the engineering lifestyle.

GAME CHANGERS AUTOMATION AND ARTIFICIAL INTELLIGENCE

IN THIS EXCLUSIVE NEW REPORT FIND OUT:

- *Why every technological breakthrough takes twice as long as we expected, but we're still not prepared for its arrival*
- *Why GDP is an increasingly limited tool for measuring productivity, and what that means for jobs and automation*
- *Which jobs might be safe – and which won't*

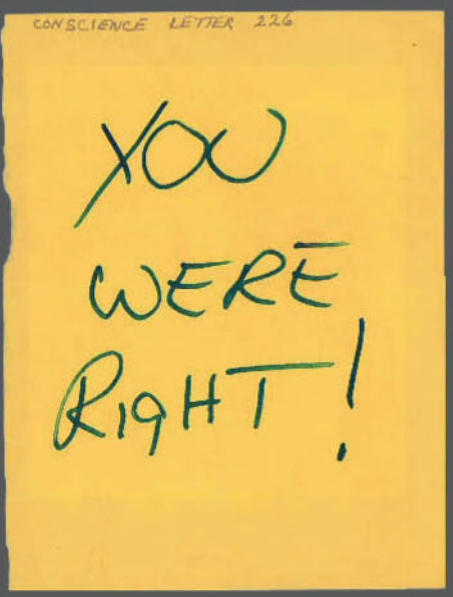

CONSCIENCE LETTER 397

Nov. 15, 1986

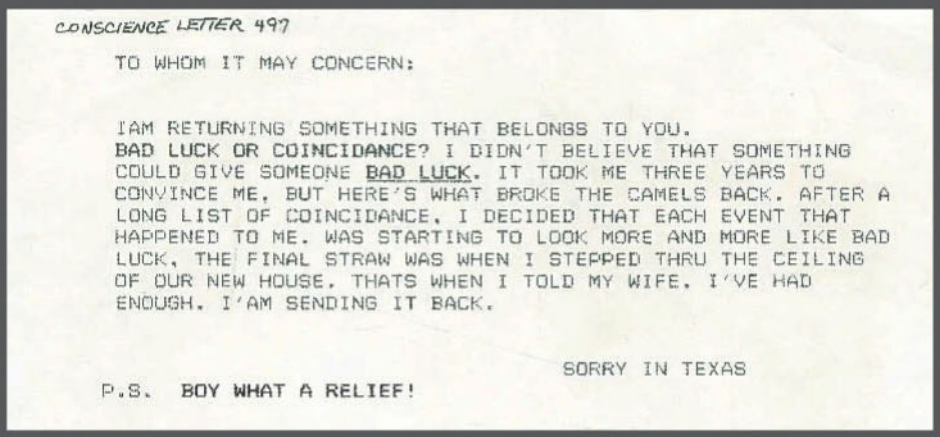
Dear Sir:

I am returning this enclosed petrified rock which I took from the national monument 30 years ago.

Yours,
Bob


CONSCIENCE LETTER 226

YOU WERE RIGHT!

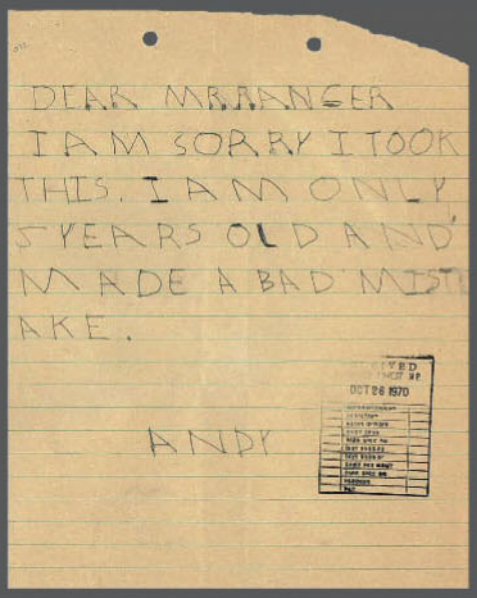

CONSCIENCE LETTER 497

TO WHOM IT MAY CONCERN:

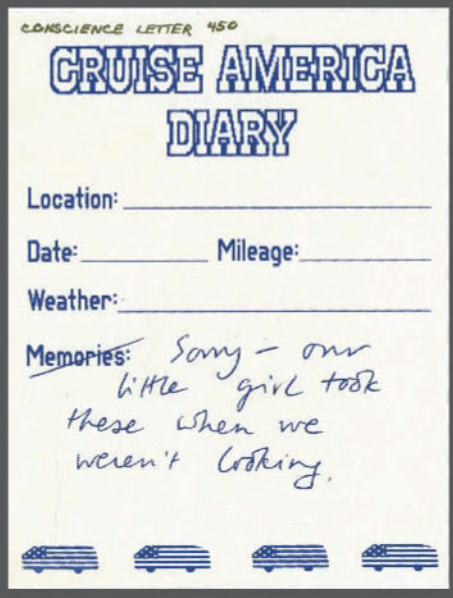
IAM RETURNING SOMETHING THAT BELONGS TO YOU. BAD LUCK OR COINCIDANCE? I DIDN'T BELIEVE THAT SOMETHING COULD GIVE SOMEONE BAD LUCK. IT TOOK ME THREE YEARS TO CONVINCE ME, BUT HERE'S WHAT BROKE THE CAMELS BACK. AFTER A LONG LIST OF COINCIDANCE, I DECIDED THAT EACH EVENT THAT HAPPENED TO ME. WAS STARTING TO LOOK MORE AND MORE LIKE BAD LUCK. THE FINAL STRAW WAS WHEN I STEPPED THRU THE CEILING OF OUR NEW HOUSE. THATS WHEN I TOLD MY WIFE. I'VE HAD ENOUGH. I'AM SENDING IT BACK.

SORRY IN TEXAS

P.S. BOY WHAT A RELIEF!


DEAR MR RANGER
I AM SORRY I TOOK
THIS. I AM ONLY
5 YEARS OLD AND
MADE A BAD MIST
AKE.

ANDY


CONSCIENCE LETTER 450

CRUISE AMERICA DIARY

Location: _____

Date: _____ Mileage: _____

Weather: _____

Memories: Sorry – our little girl took these when we weren't looking.

Petrified with guilt

GUILT can be a powerful thing. Over the years, these "rocks" – actually chunks of ancient petrified trees – have proved irresistible to many light-fingered visitors to the Petrified Forest National Park in Arizona. Eventually, often decades later, conscience prompts some to return their "souvenirs" anonymously, along with a little note of apology.

It's easy to see the temptation. These chunks of organic matter gain a rich, colourful beauty as minerals such as quartz, cobalt, iron and copper fill the pores of the original material over hundreds of millions of years.

So many pieces have been returned that park rangers have created a conscience pile to store them, as well as displaying some of the 1200-plus letters.

"The rocks were very appealing," writes one visitor, "and in a moment of exuberance we took the rock with us as a memento of our trip."

"I'm returning this rock that belongs in the forest," writes another. "My conscience has bothered me ever since I brought it home."

But it's not only guilt that prompts a change of heart. These rocks hold a secret: a curse said to plague anyone who steals them. From car troubles and cat attacks to financial losses and even a plane crash, all have been attributed to the prophecy of the rocks. "The final straw was when I stepped thru the ceiling of our new house," one letter reads.

Photographer Ryan Thompson, who stumbled upon the conscience pile during a trip in 2012, was interested by the "combination of humour and heartbreak in the letters".

"I was immediately curious about the attribution of power to an inert mineral," he says. "It's not difficult to imagine what possesses visitors to pick up a small souvenir, but it's a lot more interesting thinking about the reasons for their return."

And Thompson admits yearning for them too. "When I arrived home after my second trip," he says, "I purchased a few pieces of petrified wood on eBay in an attempt to satisfy the desire."

David Stock

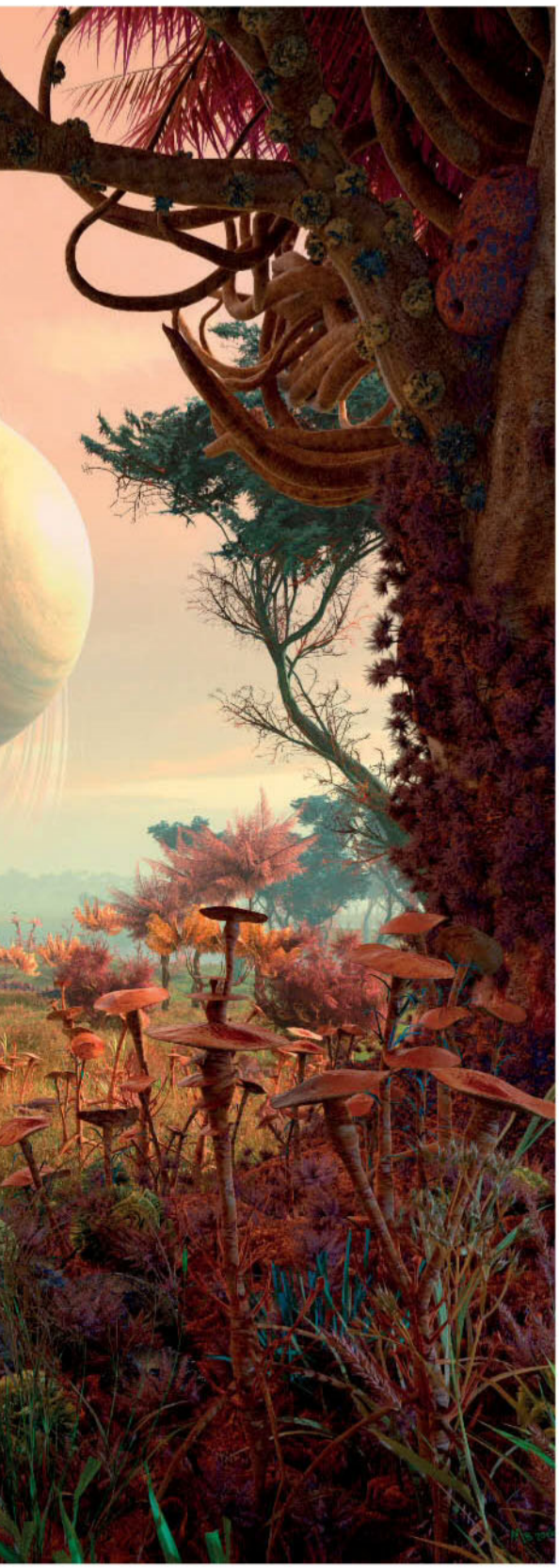
Photographer
Ryan Thompson
badluckhotrocks.com
Letters: Petrified Forest National Park Archives

THE BEST OF

ALL POSSIBLE WORLDS

Earth and the solar system have always been our benchmarks for life-friendly environments. No longer. The system next door might trump ours (page 27), while observations further afield are forcing a fundamental rethink of where life can flourish (page 29)

MATTHEW BORRET



Paradise next door

Planets even balmier than our own could be just a cosmic stone's throw away, finds MacGregor Campbell

"WHEN I was a kid, I was always looking at Alpha Centauri," says Eduardo Bendek. One of the things he discovered about it while growing up in Chile was that our closest neighbouring light had a secret: it is not one star, but two.

More than 30 years later, Bendek, now an astronomer at NASA'S Ames Research Center, suspects that his favourite celestial beacon might just be hiding another, more marvellous secret. There could be a planet orbiting one of the stars. And not just any old space rock. This could be a place so bursting with life that it makes Earth look post-apocalyptic.

And at a mere 4.4 light years away, we might feasibly develop a probe that could visit within decades. That's precisely what a project backed by Stephen Hawking and billions of dollars now plans to do. We could catch our first glimpse of this bucolic world within a generation.

We are used to thinking small when it comes to alien life. Our list of living worlds has a sole data point, Earth, and even our convivial planet seems to have been a tricky place for life to get started. How could we expect more than a self-replicating bag of biomolecules anywhere else?

That might be too lofty a view of Earth. After all, huge areas of our planet, including the poles and deserts, are rather barren. And whole epochs of time were inhospitable to life.

Time was perhaps the most important attribute identified by astrophysicist René Heller of the Max Planck Institute for Solar System Research in Gottingen, Germany, when in 2015 he was considering the factors that make a planet more habitable than Earth. Habitability isn't just about having the correct balance of temperature and chemicals. Life takes aeons to get started, so it's also about how long those persist.

One reason Earth might not top the charts in terms of its habitable lifetime is the size of the sun. The smaller a star, the more efficiently it uses its fuel and the longer it lasts before blowing up, taking any nearby planets with it. The sun is a G-type star, the third smallest variety. So planets orbiting diminutive K and M-type stars can expect longer lives.

But water is a factor here too. The presence of liquid water is thought to be a prerequisite for life. And to host this life-giving stuff, planets should ideally reside in a habitable zone: the band of space around a star with the appropriate temperature. The habitable zones of M-type stars must be far closer in than in those of warmer stars like our own. So snug, in fact, that the star's gravity is likely to wreak havoc on any planets. The difference between the gravitational tug on the front and back of the planets can deform them into an egg-shape, which eventually stops them spinning. Hardly ideal for life. A K-type star, on the other hand, would have just the right conditions. And that's exactly what Alpha Centauri B, the smaller star of the pair, is (see "Sweet spot", p 28).

A second thing that makes a planet more likely to be benign for longer is its size. Rocky planets like Earth can have liquid metal cores, a boon for life because it drives plate tectonics, which in turn refreshes atmospheric gases. The liquid metal also spins, creating a magnetic shield around the planet that deflects biomolecule-destroying radiation. Once the core cools and solidifies, those effects vanish. A planet bigger than Earth would take longer to cool because there is more bulk for the heat to dissipate through.

Could a large rocky planet be orbiting Alpha Centauri B? In 2012 Xavier Dumusque at the Harvard Smithsonian Center for Astrophysics and ›

colleagues turned their telescope on the star, looking for the characteristic wobble caused by a planet's gravitational tug. They found evidence for a planet about 10 per cent larger than Earth with an orbit of just over three days.

Cue serious excitement. These initial observations made the planet look a little hot, but here nonetheless was evidence for a planet with some traits that could make it superhabitable – and right in our cosmic back garden.

The excitement was short-lived. Last year, Suzanne Aigrain at the University of Oxford showed that the wobble Dumusque spotted was almost certainly a measurement error. Still, that is no reason to give up hope. NASA's Kepler telescope, which hunts for exoplanets in the Milky Way, has found so many that a star without one now seems unusual. Many are "super-Earths" – precisely the large rocky worlds that fit the bill for superhabitability.

Also encouraging are the measurements that rule out rocky planets more than three times the size of Earth. That's good because when planets reach such a size they become less likely to be hospitable to life. The increased pressures halt internal heat convection and the crushing gravity shuts down plate tectonics.

Plus, Christophe Lovis at the University of Geneva says measures of the star's wobbles rule out any gas giant planets orbiting close to it. Traditionally, such a planet would have been thought likely to destabilise the orbit of a rocky world or swallow it up, although that's now being questioned (see "Elephant in the room", right). "I think it's more likely than not that there is a potentially habitable planet around at least one of Alpha Centauri's stars," says Bendek's collaborator at Ames, Ruslan Belikov.

To know for sure we need pictures, so Bendek and Belikov have proposed a mission to get them. To snap an exoplanet, you need a telescope equipped with a coronagraph, a shade that blocks the blinding glare from the parent star. Alpha Centauri's two stars make things even more difficult.

Existing space telescopes such as Hubble were not designed to block the light from stars as close to one another as the Alpha Centauri pair. So Bendek and Belikov came up with an instrument they call ACESat. This would suppress both stars' light using a coronagraph in conjunction with a deformable mirror. Subtle ripples in the mirror deflect the light of each star separately, and simulations show it would be able to reveal Earth-sized planets in the habitable zone of either one. "I realised you could directly image an Earth around Alpha Centauri with a telescope as small as 25 centimetres," says Belikov. That is small enough to fly into orbit at what is, in space freight terms, rock bottom price.

Once it's there, Belikov knows exactly where to point it. Computer simulations show there's nothing further out from the stars than roughly 2.5 times the Earth-sun distance, since such an orbit will not be stable, he says.

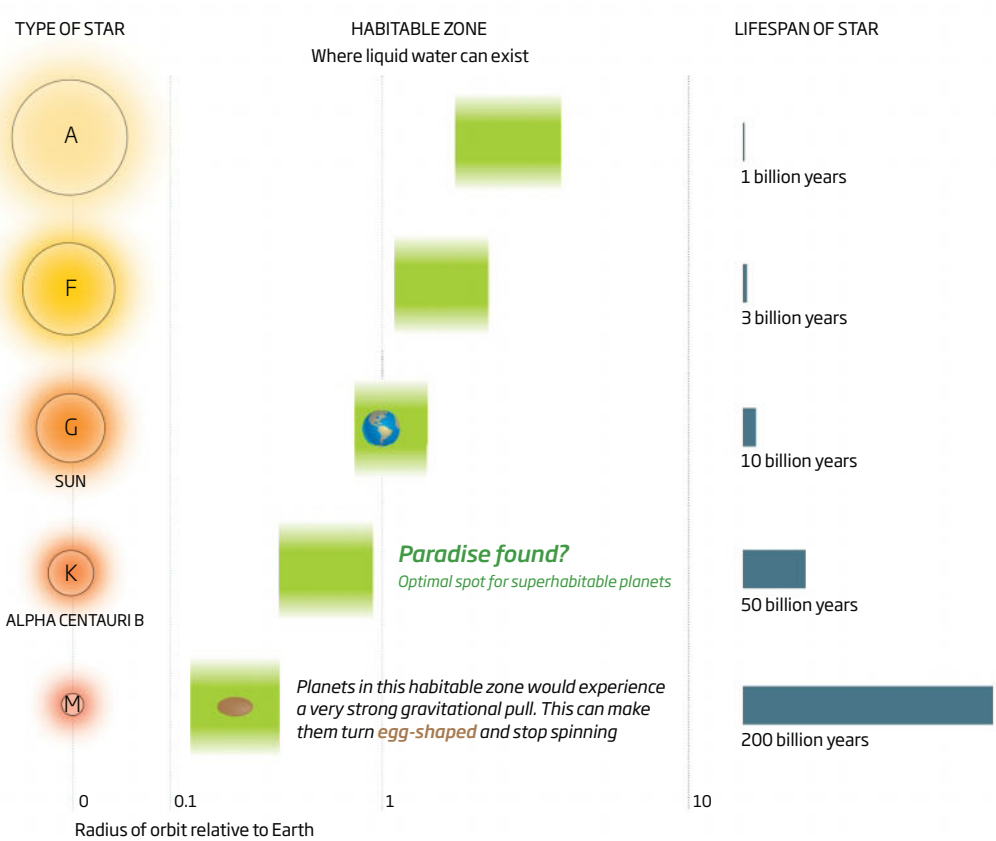
At the moment, however, NASA is not about to take up the Ames duo's plan.

Alpha Centauri is a star we could conceivably visit

ESO/DIGITIZED SKY SURVEY 2/DAVIDE DE MARTIN

Sweet spot

The lifetime of stars varies according to their size. Both M- and K-type stars live longer than our sun, which would give planets orbiting them longer to develop life. But which is the perfect place to hunt for a habitable world?



A mission focused on just two stars is simply too chancy for it, says Bendek. In contrast, the Kepler mission has surveyed more than 100,000 stars. In terms of funding, "when you start to look at single targets, exoplanet discovery gets a lot more difficult," he says.

Undeterred, Bendek and Belikov are exploring private financing. That may not be a bad move. After all, Russian billionaire and physicist Yuri Millner has already hatched a plan to visit Alpha Centauri. Announced last month, the Breakthrough Starshot initiative plans to send a tiny spacecraft there.

It doesn't seem beyond the pale, even if not all of the required technology exists yet. The plan involves accelerating the craft to 20 per cent the speed of light by equipping it with a solar sail and pushing it with a giant Earth-based laser.

It has been 37 years since Bendek first looked at Alpha Centauri through a telescope. It will be at least as many before we get a close-up look at the stars. But never before has the idea of visiting another star been within the realms of possibility. And we have a fantastic reason to make the trip. There could be a paradise next door. ■

MacGregor Campbell is a consultant for *New Scientist* based in Portland, Orgeon

Elephant in the room

A habitable solar system needs a distant giant such as Jupiter – or does it, asks **Stuart Clark**

IN THE search for habitable planets, we thought we knew what to look for: foreign solar systems resembling our own. We were wrong.

Our home system, it turns out, is a place of exceptional order, with its neat arrangement of small rocky worlds close to the sun, and far-flung gas giants. When we stare beyond its confines, we come across nothing else quite like it. Instead, we consistently find systems where gas giants and rocky planets are mixed together higgledy-piggledy. If we assume that such an arrangement is the upshot of a long history of instability, it severely limits the time that life would have had to get started in most of the cosmos.

But we are now beginning to question a number of long-held assumptions about what makes a planetary system amenable to life. In particular, the role of gas giants like our very own Jupiter are under scrutiny. Maybe life can find a foothold in systems where these giants are not quite so placid after all.

Jupiter, a vast gas ball less than a light hour from us, dominates the planets of our solar system with its sheer bulk: its mass is more than double that of all the other planets combined. We've long thought its whopping gravitational influence was a significant factor in enabling life to get started on Earth. Shortly after the planets formed, so the traditional story goes, Jupiter began tossing comets out into distant orbits – meaning they would only occasionally return to menace Earth. Now there is an alternative view, backed by computer simulations: that Jupiter fired comets into the inner solar system, where they delivered essential starter chemicals for life by crash-landing on Earth. Either way, Jupiter's presence seems to have been key to the habitability of our planet (see "Help from Jupiter", p 30).

Our standard picture of how solar systems form had convinced us that we should find enormous gas planets in roughly the same position as Jupiter everywhere we look. As a primeval cloud of gas and dust contracts to give birth to a star, the remaining material forms rocky planets in tight orbits. Gas giants form further out – where things get chilly enough for volatile compounds such as water, carbon monoxide, carbon dioxide and ammonia to condense into ices. This provides more bulk than simple rocks and metals, so the outer planets naturally grow large.

Unfortunately, nature hadn't read the script. In 1995, Michel Mayor and Didier Queloz, then at the Geneva Observatory, Switzerland, discovered 51 Pegasi b, a gas giant circling a sunlike star. Its orbit was not the gigantic one of Jupiter, but a mere 8 million kilometres in diameter, taking it once around its star every 4.2 Earth days.

> "Why didn't the gas behemoths swallow all the rocky planets as they glided inwards?"

It was the first example of what we now call a hot Jupiter, and the more we looked, the more of them we found. No one could explain their existence until computer models showed that under certain circumstances an ageing gas giant could spiral inwards towards its star.

But as one problem dissolved, another appeared. If these gas behemoths had glided inwards, wouldn't they have knocked the rocky planets in the way into their star, or ›

else ejected them from the system altogether? That conclusion seemed hard to avoid, and made planet-hunters wring their hands in despair of habitable worlds. In 2012, Jason Steffen of the Fermilab Center for Particle Astrophysics, Chicago, seemed to have the confirmation when he looked at 63 hot Jupiter systems and found no evidence of additional planets. Other discoveries over the last few years added to the pessimism (see "Beware, superflares", below right).

That conclusion may have been premature, however. When astronomers switched to looking at systems with gas giants in slightly larger orbits or with slightly less mass, there was evidence of other planets. In 2015, we found our poster child: the WASP-47 system. It contains a hot Jupiter, a rocky planet 1.8 times the diameter of Earth and a Neptune sized-planet all in tight orbits lasting less than 9 days. The rocky world would be far too hot to host life, but the discovery swung the mood back towards optimism. Maybe rocky planets could exist happily next to gas giants after all.

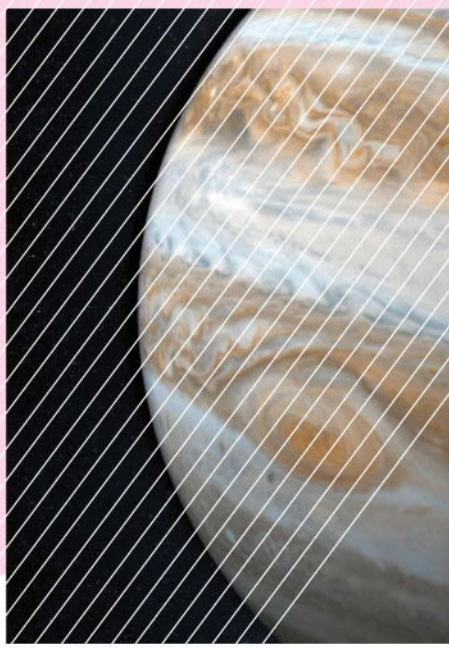
How, though, are rocky planets able to survive the attentions of nearby hot Jupiters? Clearly, the computer models were lacking something. "The trouble is that we do not yet have a coherent view of planetary formation," says Giovanna Tinetti of University College London.

Indeed we don't. Astronomers think that there are two ways gas giants might be created, depending on the density of the material they form from. In the first scenario, collisions between comet-like and asteroid-like fragments build up what will become the core of the gas giant. Once it reaches three to five times the mass of Earth, it pulls a dense cloak of gases around it, becoming a gas giant. This is known as core accretion, and it's a slow process, taking a million years or so to complete.

In the alternative scenario, known as the disc instability model, the planet-forming cloud is so dense that certain areas collapse into an almost fully formed gas giant without a well-defined solid core. This process takes perhaps a thousand years.

The problem is, we can't easily tell which way a gas giant formed, not even Jupiter and Saturn. Resolve this quandary, and it would help crack the conundrum of how the rocky planets and gas planets manage to coexist in systems like WASP-47.

We are finally about to have a shot at it. If all goes to plan, NASA's Juno mission will arrive at Jupiter on 4 July. "Juno is all about the formation and evolution of Jupiter. This is the key theme of our mission," says Jonathan Lunine of Cornell University in Ithaca, New York. The spacecraft will perform a number of close orbits to study the details of Jupiter's gravitational field and show whether the planet has a dense core. If it does, it would validate the core accretion model.



NASA's Juno probe will peer beneath Jupiter's clouds

But Juno has a second objective that will shed light on gas giants in distant planetary systems too. It will measure how much water there is in Jupiter by peering below the clouds using a microwave-sensing radiometer. With that information, planetary scientists can calculate its oxygen abundance and compare this with its carbon content, measured in 2003 when NASA's Gallileo probe made a kamikaze dive into Jupiter's atmosphere. Lunine calls these measurements the "key ingredient" in understanding where the planet formed: computer models indicate that the abundance of oxygen and carbon is set by the distance from its star at which the planet formed.

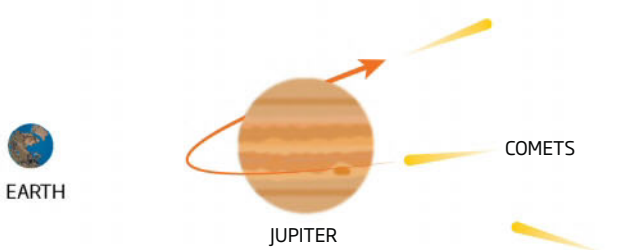
In the case of Jupiter, most astronomers believe that although it may have wandered a little as it formed, it has ended up pretty much back where it began. Once we know the water content of Jupiter, we can treat that value as being characteristic of a gas giant that formed roughly where Jupiter did. We can then measure the water in hot Jupiters, by sensing the

Help from Jupiter

The planet's huge gravity could have boosted the habitability of primeval Earth in one of two ways

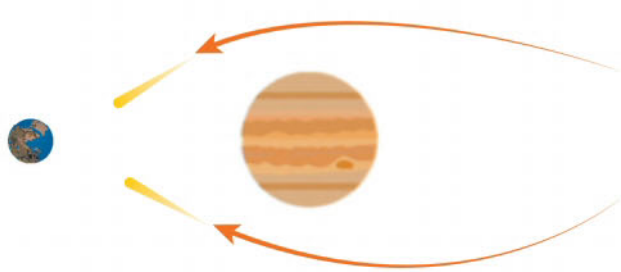
Either

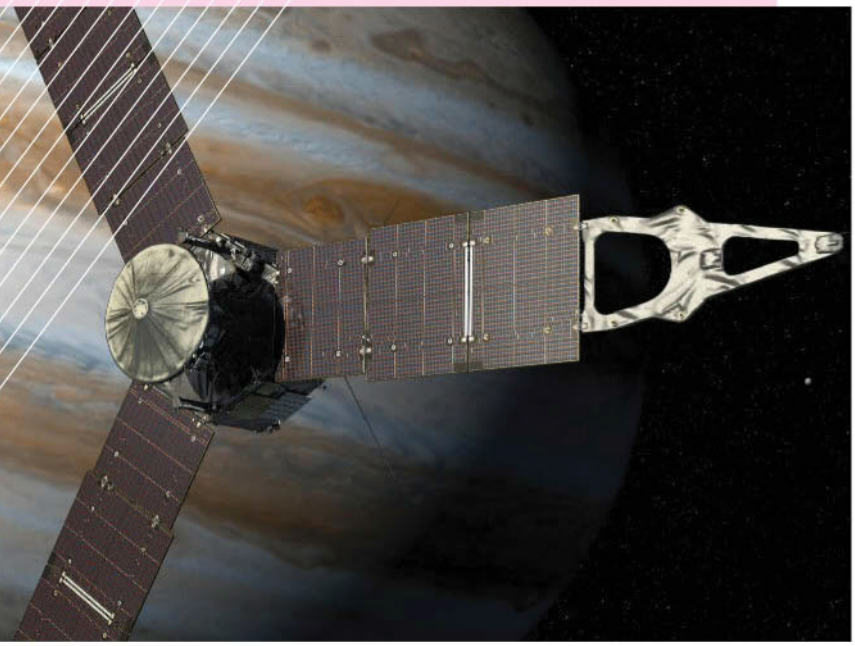
Jupiter flung comets to the outer reaches of the solar system, shielding Earth from destructive impacts



Or

Jupiter deflected more comets towards Earth, seeding our planet with ingredients for life such as water and amino acids

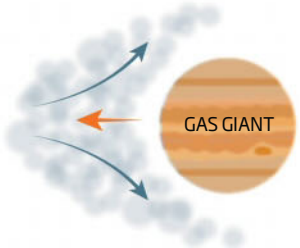




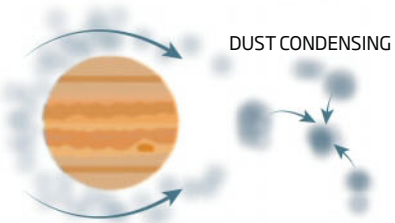
Friendly giants

Gas giants are born far from their stars, then appear to migrate inwards. We used to think that prevented rocky planets from forming, but recent evidence suggests it could happen

Gas giants fling the dust needed for planet formation out of their way as they migrate



But if the dust cloud is sufficiently dense, perhaps enough is left behind to form a planet



light that passes through the planets' clouds and seeing how much of the characteristic wavelengths absorbed by water are missing. Compare those measurements with those of Jupiter, and we'll know where the foreign gas giants must have formed. "Juno's measurements will be a nice ground truth to compare to exoplanets," says David Sing at the University of Exeter, UK. "We can use this to start to see the variety of where the exoplanets formed."

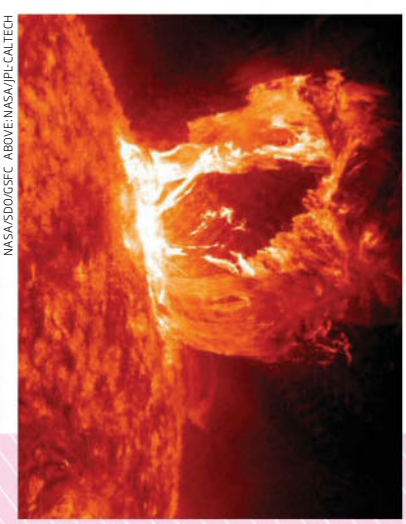
Sing has already made a start. Together with colleagues, he targeted 10 nearby hot Jupiters with NASA's Hubble and Spitzer space telescopes and calculated their oxygen concentrations. Armed with data from NASA's James Webb space telescope, set to launch in 2018, he will be able to make more accurate measurements. "Then we're going to really be able to ask those questions about where did the exoplanets form," says Sing. Observations from the new telescope should let us work out exactly how gas giants formed and migrated, if at all, in different systems. That should help solve the riddle of how rocky planets survived with gas giants apparently pinballing around nearby.

One plausible solution is that gas giants do indeed migrate, with rocky planets forming only after this shuffling has subsided. There are already hints that this is possible. Theorist Alessandro Morbidelli at the Côte d'Azur Observatory, France, helped develop the so-called Nice model of planetary formation, which involves gas giant migrations. Recent improvements he has made suggest that a sufficiently dense planet-forming disc could survive the passage of a migrating planet. Enough stuff would be left behind for rocky planets to form in its wake (see "Friendly giants", above).

One thing is already obvious. "Migration is a dramatic thing," says Tinetti. "But a migrating planet no longer seems to be a showstopper for having other planets in the system."

That can only be good news for those hunting habitable planets. It means we no longer need look for systems that match our own. Nature it seems, is far more egalitarian than that. Even in the most unusual cosmic neighbourhoods, there is potential for life. ■

Stuart Clark is a consultant for *New Scientist*. His latest book is *The Unknown Universe* (Head of Zeus)



NASA/SDO/GSFC ABOVE: NASA/JPL-CALTECH

BEWARE, SUPERFLARES

THERE are signs that all sorts of planetary systems can be just as amenable to life as our own (see main story). But that life could still be snuffed out at any moment.

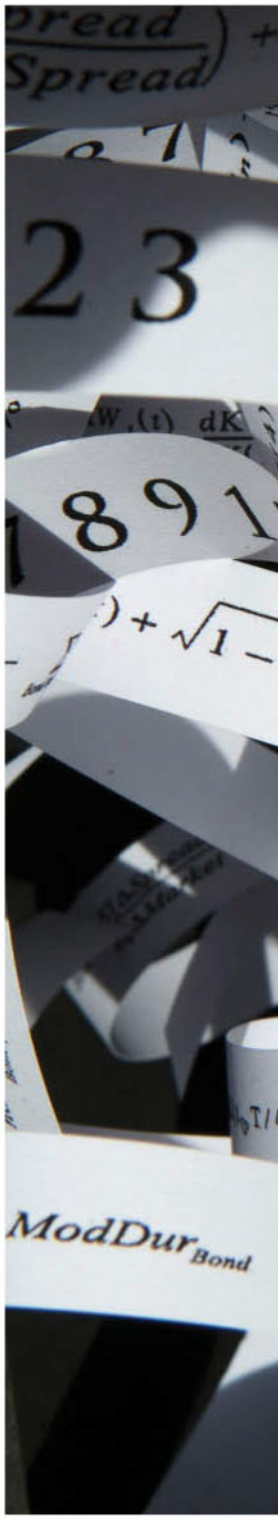
We have known that enormous ejections of material from stars are possible since at least the 1980s, but only recently have we begun to observe stars continuously and see how frequent they are. In 2012, Hiroyuki Maehara at Kyoto University in Japan looked at 120 days of observations of 83,000 sunlike stars and saw 148 of them produce whopping flares.

Superflares can be thousands of times more powerful than any flare our sun has produced in a century. The ensuing storm of radiation would be enough to fry our satellites and melt nuclear power stations.

If a superflare hit a habitable planet, it could eviscerate its atmosphere, allowing ultraviolet rays to rapidly scorch life from the surface.

For science to make sense, free will and a flowing time must both exist, argues physicist **Nicolas Gisin**

Time to decide



"I THINK, therefore I am." The 17th century French philosopher Descartes's words are a justly famous summation of what many of us feel to be the essence of the human condition.

But what does "I think" mean? Are we passive laundry machines through which thoughts happen to pass? Or are we active agents free to influence our thoughts and decisions?

The ability even to ask the question seems to require the second interpretation, yet modern science – in particular, modern physics – almost unanimously plumps for the first. In a deterministic universe, where one thing leads inevitably to the next, any conception we have of free will is an illusion.

I don't buy that. I think that we are missing something fundamental in our formulation of science. And the solution to the problem of free will is linked to another glaring deficiency of today's physics – its insistence that time as we know it does not exist.

A rather lesser known French philosopher of the 19th century, Jules Lequyer, wrote, "Without free will, the certainty of scientific truths would become illusory." We need free will to decide which arguments we find convincing, and which we dismiss – the essence of doing science.

"Are we really just passive laundry machines through which thoughts pass?"

What irony, then, that the search for scientific truth seemed to kill free will. That started with Newton and his universal law of gravitation. Derived from observations of the solar system bodies, it speaks of a cosmos that operates like clockwork and can be described by deterministic theories. Everything that happens today was set in motion yesterday, and indeed was determined in the initial conditions of the big bang; nothing truly new ever happens.

Things became even more inscrutable with Einstein's relativity, which showed that there was no unique definition of simultaneous events. To square that with a deterministic universe, a picture known as the "block universe" emerged. Here we dispense not just with free will, but also with a flowing time. Past, present and future are all frozen in one big icy block. The present in which we are free to think and be – in which we exercise free will – is just as illusory as free will itself.

And so philosophers of science bend over backwards to explain why we think we have free will. They argue we are programmed to always make choices that correspond to a predetermined, necessary future. So we might feel our choices are free – but this feeling is a phantom.

For me, such a construction is a game of words. Quoting Lequyer again, "Instead of asking whether free will is certain, let's realise certainty requires free will."

It took me a long time to identify what I believe is the key to the problem: a crucial detail of the mathematics we use to describe the world. Fittingly, it goes back again to Descartes. He gave the name "real" to the numbers commonly used in science: 1, 2, ¾, 1.797546… His point was to distinguish them from the imaginary numbers based on the square root of -1, numbers that intuitively cannot exist in the real world.

But are the mathematical real numbers physically real? Certainly not! Most real numbers are never-ending strings of digits. They can be thought of as containing an infinite amount of information – they could, for example, encode the answers to all possible questions that can be formulated in any human language. Yet a finite volume of space-time can only hold a finite amount of information. So the position of a particle, or the value of any field or quantum state in a finite volume, cannot be a real number. Real numbers are non-physical monsters.

Moreover, the digits of almost all real numbers appear at random, so you can't

PROFILE

Nicolas Gisin, a physicist at the University of Geneva, Switzerland, is a pioneer of quantum communication and cryptography. In 2003 his group was the first to demonstrate the long-distance "teleportation" of quantum states. Read more of his arguments about time and free will at arxiv.org/abs/1602.01497

QUITTERIE DE FOMMERVAULT/MILLENNIUM IMAGES, UK

compute what the next digit is. If you were told we live in a cosmos described by random numbers, you might be less inclined to believe the universe is deterministic.

Real numbers are extremely useful for deterministic models of nature. But a deterministic model does not imply that nature itself is deterministic. Consider, for example, a chaotic classical system that alternates between two states: a weather system where it is either sunny or raining, for example. A model might show that, after a while, the duration of phases of sun and rain depend on the thousandth decimal place of the numbers you used to define its starting point – a physically non-existent digit.

As the philosopher Elizabeth Anscombe noted in 1971, "The high success of Newton's astronomy was in one way an intellectual disaster: it produced an illusion… [it] gave the impression that we had here an ideal of scientific explanation; whereas the truth was, it was mere obligingness on the part of the solar system, by having had so peaceful a history in recorded time, to provide such a model." Seemingly deterministic systems such as solar systems, clocks and harmonic oscillators are the boring exceptions. Chaos, quantum measurements and indeed life, where new things happen, are the interesting rule.

Creative time

The fact that the universe is not so precisely determined as our infinitely precise numerical description would have us believe suggests that a degree of intrinsic randomness triggers its fate. Not everything is necessary or predetermined – and science does not have to contradict free will. Science does not explain free will either, but then my point is free will comes first: it is free will that allows us to put trust in science in the first place. Free will doesn't require explanations any more than mathematical axioms require justifications.

This free will does not mean we can invent the future. It does not create new possibilities: it merely lets us influence which pre-existing potentialities become actual. In that sense, it chimes with the dominant "Copenhagen" interpretation of quantum theory, made popular by Werner Heisenberg. Here, the act of making a measurement "collapses" the wave function describing a quantum system into one of a number of pre-ordained possibilities. Quantum theory is a random, non-deterministic theory, but creates a determined world – and seems in no way incompatible with a common-sense conception of free will.

This line of thought restores time to a more exalted status, too. It is more than just an evolution parameter by which we label the sequence of events that unfold by necessity. Instead, there is a time before a non-necessary event happens and there is a time after it happens, and these times are different. The happening of a non-necessary event, like the result of a quantum measurement, is a true creation that can't be captured by a mere evolution parameter.

I call the sort of flowing time this requires "creative time". It is extraordinarily poorly understood by today's science – but that could change with future physics, such as quantum theories of gravity that might replace Einstein's theories that spawned the block universe. Time passes, and free will exists – any other way, science makes no sense. ■

RUI RICARDO/FOLIO.ART

Millions of years ago, the jungles of Southeast Asia were home to a veritable King Kong. **Colin Barras** joins the search and finds a whole lot of teeth

HUNTING FOR THE GREATEST OF APES

Hong Kong, 1935: a young palaeontologist picks his way through the back streets, ducking in and out of apothecary's shops. He's looking for dragon teeth, the name the Chinese give to old animal teeth used in traditional medicines. In a dusty drawer of trinkets, his eyes fall on a large molar unlike that of any living animal, and he instantly knows his search is over. The tooth belongs not to a dragon but an ape, and if its teeth are anything to go by, it was huge.

So begins the story of the discovery of a truly fantastic beast, the greatest of all great apes. According to some estimates, it stood 3.5 metres tall, weighed over 500 kilograms, and stalked the nightmares of the earliest humans to reach China. Its name? Gigantopithecus.

Eighty years after Ralph von Koenigswald stood dumbstruck in a Hong Kong drugstore, fossils of the giant ape remain sparse. A jawbone fragment described earlier this year is just the fourth ever found. The four pieces and several thousand teeth are our only evidence it even existed. But from these scraps, we are slowly piecing together an image of this real-life King Kong*, how it lived and why it eventually vanished from the face of the planet.

Von Koenigswald was born in Berlin, Germany. From an early age, he yearned to hunt for evidence of humanity's ancestors. That meant one thing: a journey to Southeast Asia, home to the oldest and most primitive human fossils at the time. After a stint looking for *Homo erectus* in Indonesia, von Koenigswald's attentions turned to orangutans and their poorly studied ancestors. His particular stroke of luck was born of the realisation that he could take his search to Asian apothecary's shops, where ground-up teeth are an important part of many traditional medicines.

"I began to hunt for fossils in the Chinese drugstores in Java," he later wrote. "I discovered that I had made a grave mistake in simply inquiring about 'teeth'. I should have asked for 'dragon teeth', since that was the name of the 'drug' I sought. When I finally learned the correct name and obtained a prescription, I succeeded in finding these teeth in every Chinese drugstore in every Chinese community."

Subjected to von Koenigswald's expertise in extinct fauna, the so-called dragon teeth proved almost systematically to be fossils of ancient mammals, from horses to large giraffes.

A DRAGON'S TOOTH

In 1935, he headed for Hong Kong – a decision that would lead him to one enormous molar and change his career. "He took one look at that tooth," says Russell Ciochon, a palaeoanthropologist at the University of Iowa, "and knew it was ape. And it was huge." At roughly an inch across, its grinding surface was easily twice as big as a typical human molar.

For the next few years von Koenigswald scoured drugstores for more evidence of the extinct behemoth, with little success. "The rarity of this giant form is obvious," he wrote. By 1939, he had examined thousands of fossil teeth but discovered only three more belonging to Gigantopithecus.

Still, each new find added weight to the idea that he was dealing with a new species. He was categorical that the four molars had belonged to four different individuals. He also noticed a trend that gave him clues about when the apes had lived. The molars were always found in shopkeepers' trays, mixed in with other teeth in a similar state of preservation. Von Koenigswald knew the owners of these other teeth well: giant pandas, tapirs, bears and the extinct, elephant-like stegodon. The giant ape was systematically surrounded by middle Pleistocene animals. It was about a million years old.

Then came the war. Japan's imperial army rolled into Java in 1942 and von Koenigswald was interned in a prisoner-of-war camp. The teeth he had gone to such lengths to collect saw out the Japanese occupation in a milk bottle buried in a neighbour's garden on the island. For von Koenigswald's colleagues in the US, the wait was interminable. Franz Weidenreich at the American Museum of Natural History in New York was particularly exasperated. He had big ideas about Gigantopithecus and was itching to share them with the scientific world.

In 1945, with von Koenigswald still a prisoner, Weidenreich pushed ahead with the publication of his theory. He had noticed that smaller breeds of dog often have relatively large brains and small faces compared with ›

* …or – as portrayed in this year's remake of *The Jungle Book* – King Louie

Ancient porcupines, this guy's ancestors, are accused of eating the evidence for Gigantopithecus

JOEL SARTORE/NATIONAL GEOGRAPHIC/GETTY

larger ones. Humans also have much larger brains and relatively smaller faces than chimps, gorillas and orangutans, something that had puzzled researchers for years. Weidenreich believed it all made sense if our family tree included some unusually large ancestors. As the millennia passed, our bodies shrank but our brains remained large. In other words, we were descended from Asian giants, and Gigantopithecus was one of them.

"No one gives the idea much credibility now," says Ciochon. "If von Koenigswald had not been in prison, that episode probably would never have happened." But it's not the craziest theory ever concocted and for a brief time, Weidenreich's idea that humans evolved from an enormous Asian ape was in the scientific mainstream. Then the war ended, von Koenigswald was released, and he gently but firmly plucked Gigantopithecus out of the human evolutionary tree and plonked it back with the other apes.

The downgrading didn't diminish scientific interest. Far from it: Chinese authorities, determined to find fossils of the giant ape in their proper geological context, launched a series of field expeditions in the 1950s. The quest took them to southern China's fantastical karst landscapes, where limestone sugarloaf mountains loom over rice paddies. They met with farmers who had long collected Gigantopithecus teeth to sell on the lucrative medicinal market, and were directed to caves carved into the sheer cliff faces.

In Liucheng cave, no fewer than 1000 Gigantopithecus teeth were recovered, together with fragments of three giant jawbones. From the size of the jaw fragments, the Chinese researchers deduced that Gigantopithecus might have stood 3.5 metres tall. In truth, there's little to go on. Ciochon believes the ape was more like 2.5 metres tall.

So what was Gigantopithecus and how did it live? Von Koenigswald named the Chinese species *Gigantopithecus blacki*. Its oldest reliably dated remains are 2 million years old. Another, older and slightly smaller species has also been found in northern India: *G. giganteus*, known from an 8.6-million-year-old jawbone and teeth.

The idea that the enormous apes might have been part of our family history stuck around until quite recently. In the 1980s, Bruce Gelvin of California State University argued that if it wasn't a direct ancestor, it might have been a very early cousin species, much like African *Australopithecus* species. Around the same time, a team including Ciochon found more than a dozen Gigantopithecus teeth with a couple of stone tools in Longgupo cave in China. And two years ago, a Chinese team raised the possibility that Gigantopithecus was the toolmaker.

Ciochon rejects the idea. If they did make tools, he says, these would probably have been made of organic material like sticks, bamboo or leaves, and in any case tools are not necessarily evidence of an intelligent ancestor. There are at least three living species of non-human primate that use stone tools: chimpanzees, bearded capuchins and long-tailed macaques. Ciochon says the stone tools at Longgupo were probably left much later by early humans.

PRICKLY POST-MORTEM

There's another reason to doubt the image of Gigantopithecus as a cave-dwelling toolmaker. The caves its teeth were found in were not caves when the ape was alive. At the time, the deep valleys had not yet been carved into the karst landscape to produce the iconic limestone mountains. Ground level was much higher up, and what we now see as lofty caves dug out of cliff faces were small sinkholes and underground fissures. They were home to

We'll be piecing his story together for a long time yet

ZUMA PRESS, INC./ALAMY STOCK PHOTO

porcupines, not giant apes.

Those porcupines offer an answer to one of the enduring questions about Gigantopithecus: how come it left so many teeth and so few bones? Porcupines need calcium to make their quills, explains Ciochon. They are known to gather bones, drag them back into their underground lairs, and gnaw on them until there's nothing left. You could say that Pleistocene porcupines ate most of the evidence for the world's biggest ape.

It's lucky, then, that we can reconstruct a fair amount about an animal from its teeth and jaws alone. "Even from tiny pieces of dental tissue, we learn about the diet, ecology and life history," says Kornelius Kupczik at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany. What emerges is a picture of Gigantopithecus as a forest-dwelling herbivore. Analysis of carbon and other elements in the fossil teeth reveals no signs of a meat diet: the ape was vegetarian.

Gigantopithecus also suffered from unusually poor dental health. Something like 10 per cent of the teeth that have been found have caries, and the recently discovered fourth jawbone shows that some individuals lost a tooth or two during their lives. Both features suggest the ape ate lots of sugary fruit. Earlier this year, Hervé Bocherens of the University of Tübingen, Germany, published a study of Gigantopithecus teeth that argued we should think of the ape as an overgrown orangutan confined to the forest floor by its great size.

The shape of its dental roots suggests another possibility, say Kupczik and Christopher Dean at University College London. It had a bite powerful enough to chew through tough foods like bamboo. Other lines of evidence, including food residues on some teeth, also suggest bamboo was on its menu. In other words, perhaps Gigantopithecus was more like a giant panda than an oversized orangutan.

Either diet leaves a central puzzle unsolved. Both species that Gigantopithecus has been compared with – giant pandas and orangutans – lived alongside it in Asian forests. Why did they survive and the ape die out? "The extinction of *Gigantopithecus blacki* is still mysterious," says Yingqi Zhang at the Chinese Academy of Sciences in Beijing. On present evidence, it seems it may have vanished around 320,000 years ago. This is the age of the youngest teeth yet found, which Zhang and his colleagues described in 2013.

We now know that those last apes might well have been the grandest of the bunch. Last year, Zhang, Ciochon and their colleagues collaborated on a systematic study of teeth from a number of sites. They were able to confirm that the last Gigantopithecus had exceptionally large teeth, even by its own standards. The biting surfaces were 1.5 times larger than those of earlier members of the species. "This does not necessarily mean their body size increased accordingly, although I prefer to believe so," says Zhang. If he's right, then Gigantopithecus was larger than it had ever been just before vanishing.

Zhang and his colleagues recently noticed something else about those last teeth. The biting surfaces were not just larger, they were also distinctly more complex. The team hasn't yet worked out exactly what that means, but it might hint that the giant ape was facing a drastic change in its menu before its extinction, perhaps because the region's plants were changing.

Bocherens agrees with this assessment. His team's work suggests that while Gigantopithecus ate any leaves, shoots and fruits it could lay its hands on, it drew the line at grasses and other vegetation from the savannah. That doomed the species, says Bocherens, because climate change during the Pleistocene meant grasslands got bigger at the expense of forests, where the apes lived.

"Maybe Gigantopithecus was more like a giant panda than an oversized orangutan"

That might not be the full picture, though. *Homo erectus* arrived in Southeast Asia about 1.7 million years ago and could have rubbed shoulders with Gigantopithecus for a million years. If *Homo erectus* hunted the apes, or competed with them for resources, this might have added to their problems. Gigantopithecus may even have been one of the first species that humans pushed towards extinction. Then again, maybe not – for here too, the Gigantopithecus story is plagued by open questions.

In the mid-1990s, Ciochon and others found Gigantopithecus and *H. erectus* teeth together in Chinese and Vietnamese caves, and declared that the two apes had had a "long coexistence". But Ciochon now thinks the "*H. erectus*" teeth belonged to another ape, and there were no hominins in the cave. "I think today most people agree humans and Gigantopithecus were not living side by side," he says. "They were certainly both present in China 1 million years ago, but I don't think they were inhabiting the same areas."

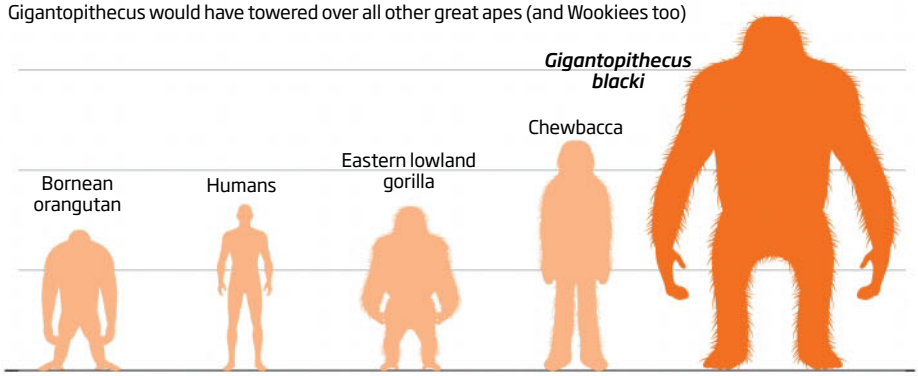
Gigantopithecus, he says, was confined to dense forests, whereas early humans were far more likely to live and hunt in open grasslands. That's not to say they never, ever met. "Let's not forget that humans may kill for other purposes than feeding," says Bocherens. "We cannot rule out that humans hunted Gigantopithecus even if they did not feed on the same resources." Proof would come with the discovery of Gigantopithecus bones with butchery marks. "This is probably a bit too much to ask," he concedes.

We've learned more about Gigantopithecus in recent years than von Koenigswald could have hoped as he stood in that Hong Kong drugstore 80 years ago. Yet still the story of our largest fellow ape eludes us. "We need to find its face," says Zhang. Such a momentous discovery would at last tell us what Gigantopithecus really looked like. ■

Colin Barras is a freelance writer based in Ann Arbor, Michigan

A truly great ape

Gigantopithecus would have towered over all other great apes (and Wookiees too)



SOURCE: DOI: 10.1186/1471-2458-12-439/WWF/WOOKIEEPEDIA

Londinium calling

Before developers lay foundations for new buildings, they make way for the likes of **Sadie Watson** and her team. Meet the archaeologist unearthing London's past

THE thought of archaeology rarely evokes the smell of exhaust fumes, the sound of smashing concrete or the spark and screech of steel cables being sawn to pieces. But this is the reality of a dig in the heart of the city. "Sometimes we're digging while a building is being demolished directly above our heads," says Sadie Watson, a project director for Museum of London Archaeology (MOLA). "Safely, I should add."

Thankfully, Landmark Place – the site on the bank of the River Thames where I meet Watson – is open to the air. As her black hard hat indicates, she is the senior archaeologist on site, responsible for the entire dig and the safety of the team. The people in red hats, dotted throughout trenches and pits reinforced with steel piles, are archaeologists digging into London's past. The white hats, far outnumbered by reds, belong to construction workers, there to facilitate the dig by removing excavated earth or clearing modern debris before excavation by hand begins.

Since 1990, developers in the UK have been obliged to fund archaeological exploration before they start building, so in London the process of demolishing an old structure to build a shiny new one offers a window on the city's nearly 2000-year history.

Watson's team has about five months to find, record and remove the artefacts and remains that would otherwise be obliterated. "Archaeology is destructive, too, but we're preserving it by recording it," she says.

From the scaffold walkway that runs around the site's perimeter, she points down at a section of ancient stone wall, 3 metres thick. "This wall is a major monument of Roman London," she says. It was built along the Thames around AD 270. "It must be preserved in situ." Structures too important

to remove stay in the ground. That can mean, as it has here, that foundations need to be redesigned around them.

London's past leaves its mark in a host of different ways. "We see huge deposits from the Great Fire of London in 1666," Watson says. Long before that, in AD 60-61, the queen of the Iceni people of East Anglia led a rebellion that razed the city. "As you dig down past AD 100, towards Boudica, there's a frisson," says Watson. "Will we find evidence of her?"

Each dig has the potential to reveal new insights about our history. Here, the team has found thick oak timbers that once formed a dockside. By analysing the rings on these timbers, they can pinpoint the year the trees were felled. To Watson's delight, some timbers also have stamps burned into them, showing they are Roman in origin. "It's incredibly rare to find Roman, branded stamps. There are parallels on bricks in Ostia, the harbour city of ancient Rome. Discoveries like this help us connect what we're doing with the wider picture of the empire."

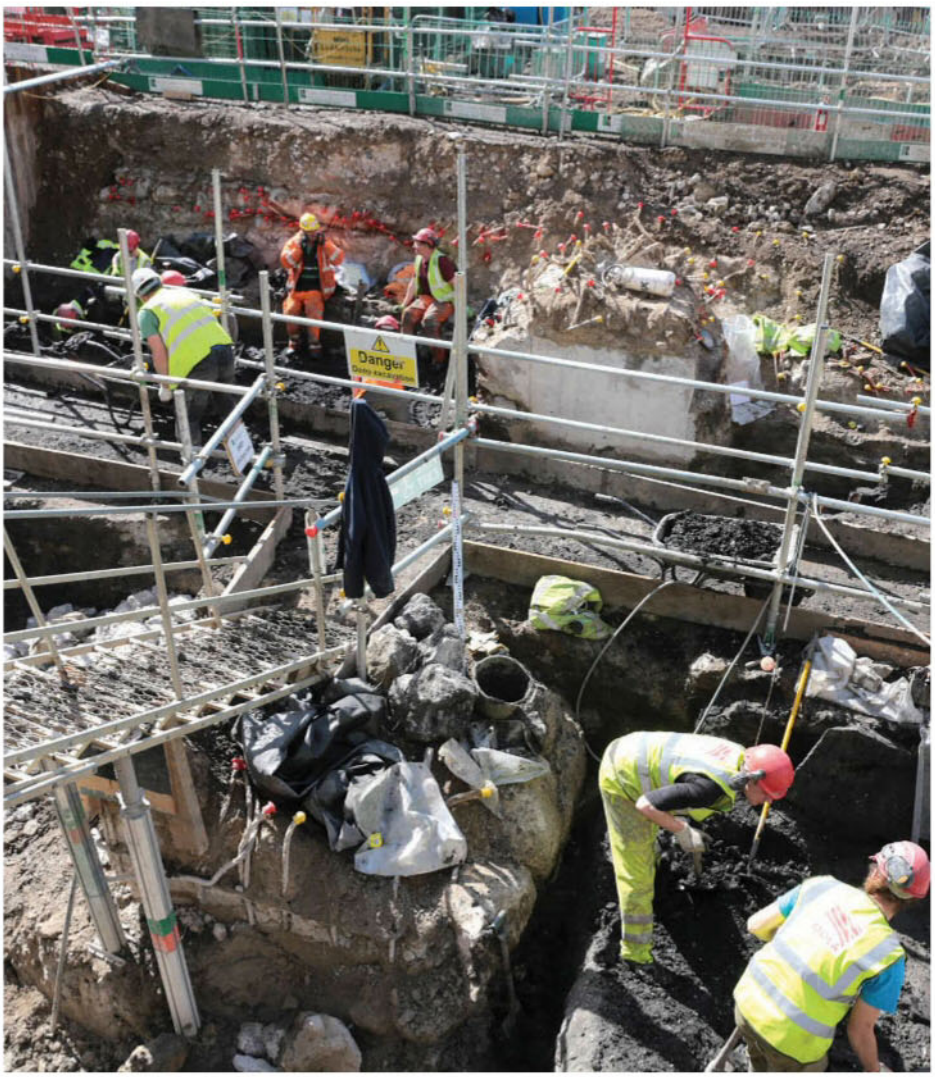
The largest assemblage of Roman remains ever found in London was unearthed in the financial district a few years ago. Watson and her colleagues found items from right across the Roman period – remnants of temples, industry, domestic life, and possible armour production. "It was the most spectacular archaeology I've ever seen," she says.

For Watson, the most memorable finds are those that highlight something unexpected – like intimate details about how people lived or even what amused them. In a dig near St Paul's Cathedral, beneath the remains of 17th-century inns, she found a porcelain drinking vessel, beautifully hand-painted, in the shape of a phallus. "Ever tried to Google 'porcelain penis'?" she asks. "Don't, because it doesn't end well." The cup was probably used for a drinking game in a high-end Reformation-style boozer. "From that one object, you can conjure the entire London of Charles II and his mistress Nell Gwyn."

Every feature Watson's team finds is given a unique number, drawn to scale, photographed, written up and digitally scanned. "We know exactly what was there, the date, its pinpoint GPS location, how it relates to the other things on the site and in the city… This context is the most important thing for archaeology." That is especially true in urban settings, where everything is built over what came before.

When the construction workers go on their lunch break, peace suddenly descends and we can actually hear trowels scraping. "Oh, that's nice," says Watson. "We only get one peaceful hour a day, but such is life – that's London." ■

By Sean O'Neill



Clockwise from top left:
MOLA archaeologists measure timbers that will be sent for tree-ring dating

The dig at Landmark Place. MOLA archaeologists wear red hard hats

Items from active digs may be cleaned to remove burial deposits and soil

Roman coins are often found on London digs – and counterfeits from that era are common too

MOLA's warehouse archives many of the finds for later study

Once objects have been washed and cleaned, they are left in MOLA's warm drying room. These remains are dry and ready to be catalogued

Being lead archaeologist doesn't stop Sadie Watson from getting hands-on whenever she can

DAVE STOCK

Spring-clean your mind

From nerve dictators to pointy eggs, tune into some of the most interesting ideas around

QUENTIN BERTOUX/AGENCE VU

Be your own search engine: a good book can inspire as well as inform

Governing Behavior: How nerve cell dictatorships and democracies control everything we do by Ari Berkowitz, Harvard University Press, $29.95/£19.95

TOWARDS the end of his chummy yet dizzying state-of-the-art tour of behavioural neurobiology, Ari Berkowitz makes an important claim. Unlike, say, the pacemaker cells and synaptic complexes that together regulate the beating of the heart, we humans "simply aren't very good at creating automatic mechanisms that take into account all the possible consequences". He's not kidding. Financially savvy readers may recall 2013, when the S&P 500 stock index took a $136 billion dive as trading algorithms responded instantly to a malicious tweet claiming bombs had gone off in the White House. No self-respecting nervous system would have fallen for that. Nervous systems let animals respond creatively to novel situations while never exceeding vital parameters. A heart may beat faster: it does not explode.

Explaining how they do this may be summed up in a single word – redundancy. "If we can imagine multiple mechanisms for how the nervous system controls a behavior," Berkowitz writes, "it probably uses all of them." This is captured in a single notorious example: a crab's control over its digestive system. Though it involves the interplay of only 30 neurons, crab digestion varies individually, altering over time and in response to changes in water temperature. "Having a single mechanism operating would certainly improve clarity of government," Berkowitz concedes, "but nervous systems are not concerned with clarity, only with survival and reproduction." His metaphor of nervous system as government is a tempting stick with which to beat ideologues: what if the best government available is actually the messiest and most confusing imaginable? Simon Ings

Penguins, Pineapples and Pangolins: First encounters with the exotic by Claire Cock-Starkey, British Library, £12.99

Before now, I had never given even the slightest thought to how explorers would first have described that marvellous fruit, the pineapple. But thanks to this book, I now know that they compared it with the apricot for taste, and the artichoke for shape. Flip through this book before you head out to a summer party, and then impress your friends with first-ever descriptions of avocados, mangoes, orangutans, Aboriginal Australians and Indian acrobats. Or you could plunder the tales of some of the 17th and 18th-century European travellers, say Samuel Purchas or Captain William Dampier, whose stories make the pages so gripping.

You may already have learned how to make a love potion from Cock-Starkey's earlier book, *How to Skin a Lion: A treasury of outmoded advice*. And if you have, you're likely to be the sort of reader desperate to know who first explained the true nature of the chameleon's colour-changing ability. You won't be disappointed.

This book reminds us why we shouldn't always be googling it: the search engine may give you all the information in the world, but it can't inspire you the way this volume will. And if your child is around, read it out loud for her. You can only pep her up with the excitement of discovery – and, with luck, share your joy of discovery. Vijay Shankar

No Need For Geniuses: Revolutionary science in the age of the guillotine by Steve Jones, Little, Brown, £14.99

The French revolution brought new technologies and social reforms that modernised the whole world. It was fuelled in no small part by scientists, so what else could engineer Gustave Eiffel do but etch their names on his tower? A telling number lost their heads at the guillotine for doing science – and interfering in state politics. With typical wit and easy storytelling, biologist Steve Jones tells the stories of the guillotined and of those who escaped with their necks intact.

Against other accounts, such as *Science and Polity in France: The end of the old regime* by Charles Coulston Gillispie, Jones's book stands thankfully light. Yet it still amply popularises physicists, biologists, astronomers, chemists and mathematicians, while not failing to show the human vanity behind so many of their actions. The story of how guillotine-enthusiast-cum-scientist Jean-Paul Marat falsely accused the chemist Antoine Lavoisier over the latter's tobacco tax reforms, and led him to the guillotine, is as gripping as a Hollywood thriller. This was a time when sci-tech began to look closely into people's lives and needs, while glossing over its own sociopolitical and economic impacts.

After retelling the Bible as science (*The Serpent's Promise*) and guiding us through Darwin's backyard (*Darwin's Island*), Jones now makes his mark as a popular science historian. Vijay Shankar

The Most Perfect Thing: Inside (and outside) a bird's egg by Tim Birkhead, Bloomsbury Publishing, £16.99

Author and zoologist Tim Birkhead is probably most famous for successfully crowdfunding his guillemot research after the Welsh government pulled the plug on 25 years of study, or for filling York Minster with floor-to-ceiling paintings of seabird colonies. But he is also clearly passionate about eggs.

And yes, it being Birkhead, guillemots do crop up a lot in this book, but there's so much more as well – from the reasons for hydrophobic micro-nodules on the shell of a megapode's egg, via the purulence of hoopoe preen gland ejaculate, to the vitalness of albumin and the deep secrets of the yolk.

All this is revealed in a text that bubbles with enthusiasm. Add in the secrets of a goldcrest's red-hot legs and, of course, why guillemot eggs are so pointy and vastly variable in pattern, and you have a book that will keep you enthralled from your morning egg to your evening quiche. A delight. Adrian Barnett ■

Doing it for ourselves?

A new take on the mind-body connection poses big questions

Cure: A journey into the science of mind over body by Jo Marchant, Crown, $26

Michael Le Page

BANG! You're startled by a loud noise. Instantly you're fully alert and looking round for danger, heart racing. Or you see something erotic, and your body optimistically readies itself for intercourse. These simple observations are incontrovertible proof that our state of mind has a powerful effect on our bodies – a basic truth that we have ignored for too long, says science writer Jo Marchant.

Her book on this began as an article that appeared in *New Scientist* in August 2011. Marchant, a former colleague, had emailed me a few months earlier. Would I be interested in running a story about how our minds influence our health, and how we can harness these effects to help ourselves. "These areas have always been seen as a bit too close to pseudoscience," she wrote, "but studies are now starting to show clear physical effects and pin down mechanisms." It was one of those rare proposals that pretty much had me at hello.

Even if you read that piece, you will find *Cure: A journey into the science of mind over body* fascinating and thought-provoking. Marchant has travelled extensively around Europe and the US, talking to health workers and ordinary folk, to produce this meticulously researched book. Her bold aim: to rescue the idea that our minds influence our health from the clutches of pseudoscience and restore it to its proper place at the heart of conventional medicine.

"A lot of alternative therapies failed to show benefit in trials... some can be harmful, even deadly"

The first section covers how doctors can exploit the power of our minds to make us feel better, lower drug doses and in a few cases, such as irritable bowel syndrome and chronic fatigue syndrome, actually make us better. The evidence that methods such as hypnosis and virtual reality can greatly reduce pain and provide an alternative to addictive drugs is particularly compelling. There's a very clear message for doctors: how patients feel really matters.

The second part of the book looks at things we can do ourselves, such as mindfulness, biofeedback and even – gasp – spirituality. These techniques cannot magically cure serious disorders and diseases, but there is evidence that they can help us feel better and reduce our chances of developing stress-related ills such as heart disorders.

What's missing for me are the negative studies. A lot of "feel-good" alternative therapies have failed to show any benefit in scientific trials and some can be harmful, even deadly. There are also hordes of quacks out to exploit sick people. Marchant does touch on this briefly in the final pages, but she's far too polite, and perhaps too reluctant to introduce any discord into this positive book.

That said, *Cure* is a much-needed counter to a reductionist medical culture that ignores anything that doesn't show up in a scan. "Taking account of the mind in health is actually a more scientific and evidence-based approach than relying ever more heavily on physical interventions and drugs," Marchant concludes.

Cure should be compulsory reading for all young doctors. And reading it might just turn out to be good for your body as well as for your mind. ■

Spiritual input won't cure major diseases but we may feel better

JULIAN KUMAR/GODONG/PANOS

Seven of the best

Caged or wild, animals have us in thrall, finds **Simon Ings**

1. *Wattana: An orangutan in Paris* by Chris Herzfeld, *University of Chicago Press, $26*

"IF YOU do not leave a zoo confused and conflicted… it has not done its job," wrote zoologist Matthew Cobb recently. By that light, the story of 11-year-old orangutan Wattana, living in Paris's Jardin des Plantes, is a resounding success. Philosopher Chris Herzfeld wants us to note how primates adapt to captivity. Adopting human habits does not make them "less ape"; on the contrary, she says, "they exhibit a fundamental trait of hominoids: plasticity". Even so, it is a melancholy read, full of the loss, loneliness and make-do-and-mend (Wattana is an inveterate knot-tier) of a captive life.

2. *One Wild Bird at a Time: Portraits of individual lives* by Bernd Heinrich, Houghton Mifflin Harcourt, $28

Many discomforted by zoos argue that an animal is first and foremost an organism of its own world. What it does there is what matters. From the woods of Maine, New England, Bernd Heinrich's unselfconscious approach to animal behaviour reaps huge rewards. It is written to a challenging format: chapter by chapter, he spots and solves a puzzle of bird behaviour, one species at a time. But the whole book is a delight, written in an unforced style rare these days.

3. *The Genius of Birds* by Jennifer Ackerman, Penguin Random House, $28.00

No observer of Heinrich's stripe will be surprised by the contents of Jennifer Ackerman's new book; but for the unobservant rest of us, there is much of interest in this defence of bird cognition. Ackerman's winning conceit is to sidestep all that agonising malarkey over consciousness and talk about genius – broadly, defined as the ability to do well what everyone else does badly. Under Ackerman's pen, this behaviourist approach proves both fertile and fascinating.

4. *What a Fish Knows: The inner lives of our underwater cousins* by Jonathan Balcombe, Scientific American, $27

The intelligence of birds is generally acknowledged, if underestimated. Fish, however, have a harder time. Ethologist Jonathan Balcombe is their passionate advocate, assembling a gobsmacking case for intelligence, awareness, memory, emotion and complex social organisation. He reckons our prejudice stems from a presumption that the fish that stayed in the water stopped evolving when a few went ashore, a notion "completely at odds with the tireless process of evolution".

5. *Following the Wild Bees: The craft and science of bee hunting* by Thomas D. Seeley, Princeton University Press, $22.95/£17.95

The rather febrile fashion in natural history writing may occasionally be down to paucity of material. As we start to run out of bees, for example, they boom in popularity, and indefatigable enthusiasts like Thomas Seeley pop up, trying to turn us all into bee hunters. He has lists of equipment. He has advice on what to wear. He is a vigorous, chivvying nuisance and you want to hit him.

Seeley is also a world-renowned animal behaviourist, an experienced guide to a hidden world, so anyone deeply interested in natural history will ignore this mad little volume at their peril.

6. *What is a Dog?* by Raymond Coppinger and Lorna Coppinger, University of Chicago Press, $30

Some alien worlds hide in plain sight. There are five times as many feral dogs on Earth as there are pet hounds. People assume ferals are what results when pure-bred dogs interbreed. The authors lay into this idea with aplomb – and evidence. Far from being cast-offs, feral dogs contain the "essence of dog", evolving to live off human waste and domesticating only to secure an even more reliable food supply. Any owner of a pure-bred will feel silly after reading this.

ANNIE-MARIE MUSSELMAN/REDUX/EYEVINE

Ticket to ride: coyotes have been travelling on buses in the US

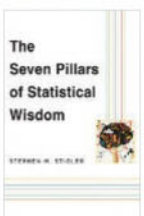
7. *Coyote America: A natural and supernatural history* by Dan Flores, Basic Books, $27.50

It is often impossible to separate how animals behave "wild" from how they behave around humans. Coyotes are a startling example. Once limited to a small range in the south-west US, they responded to eradication campaigns by expanding across all of North America and adopting their would-be nemesis's habits to an almost ludicrous degree: coyotes have even been seen catching buses. Historian Dan Flores has fun describing how coyotes make a mockery of our attempts to put nature in order: "It turns out, the coyote really is The Dude, and The Dude *absolutely* abides." ■

Of monarchs and measurement

In a world awash with data, let's look to our statistical roots, says **Jonathon Keats**

The Seven Pillars of Statistical Wisdom by Stephen M. Stigler, Harvard University Press, $22.95



NEVER entrust measurement to a monarch. With the arrival of a smaller sovereign, you might see your property literally shrink in line with their shoe size. To avoid this injustice, medieval surveyors came up with an ingenious idea. They would line up 16 citizens, measure the combined length of their feet, and then divide the total into 16 equal foot-long segments. While they didn't formalise the mathematics, it was an early example of a powerful technique for analysing data that statisticians now call aggregation.

According to Stephen M. Stigler, aggregation is one of the "seven pillars of statistical wisdom", principles such as probability and information measurement he characterises as the "disciplinary foundation" of statistics. His engaging book incisively (albeit rather technically) explores their history, in search of "a unity at the core of Statistics both across time and between areas of application".

The historical development of aggregation exemplifies the tortuous path to unification. In ancient times, the Athenian general and historian Thucydides described an attempt by soldiers to estimate the height of a wall before a siege. The calculation was made by counting rows of bricks. Though "some [soldiers] might miss the right calculation," he wrote, "most would hit upon it". Making siege ladders based on the most often-arrived-at number, the soldiers showed an intuitive grasp of the statistical average now known as the mode.

THE ART ARCHIVE/BIBLIOTHÈQUE INGUIMBERTINE CARPENTRAS/GIANNI DAGLI ORTI

A 15th-century manuscript shows surveyors measuring boundaries

Mode and mean averages may have been in everyday use, but they were erratically applied by scholars until at least the 1600s. Researchers each used their own recipe for aggregation. Inconsistency and ambiguity were rampant, and serious impediments to the accumulation of knowledge.

One reason for this lack of consensus was surely the paucity of communication between scholars working in relative isolation. But there may also have been some hesitation due to the counter-intuitive nature of aggregation. After all, as Stigler observes, averaging is a radical idea: "you can actually gain information by throwing information away". Observers' identities are discarded, which means no observation holds more weight, even if the observer has higher credibility. In order to embrace this simplest principle of statistics, scientists had to overcome social conventions and common sense.

"Averaging is a radical idea: you can actually gain information by throwing information away"

Other "pillars" have different histories, but they have this quality of radicalism in common. Information measurement, for example, is also counter-intuitive because the information gained doesn't increase linearly with the number of observations made; to double your accuracy, you need to quadruple your effort.

Even Isaac Newton seems not to have appreciated this. While he was Warden of the London Mint, coins were weighed in batches to assess them for consistency: the weight deviation permitted per coin was multiplied by the quantity in the lot. As a result, quality control was an order of magnitude looser than intended. A shrewder (and less scrupulous) warden could have made a fortune playing the statistics.

Stigler is emphatic that the failings of the past shouldn't make us smug. On the contrary, he argues convincingly that we still need to apply statistical methods with care, especially when negotiating big data: "With ever larger data sets come more questions... and more worry that the flexibility inherent in modern computation will exceed our capacity to calibrate, to judge the certainty of our answers."

Stigler doesn't elaborate on this – except to allude to the need for an "eighth pillar" – and his book is too modular to articulate the promised unity that might lead us beyond his traditional seven. That said, this lively account of a radically counter-intuitive past at least encourages us to question big data's reputation. Never entrust measurement to a monarch – or judgement to a computer. ■

Jonathon Keats's latest book is *You Belong to the Universe: Buckminster Fuller and the future*

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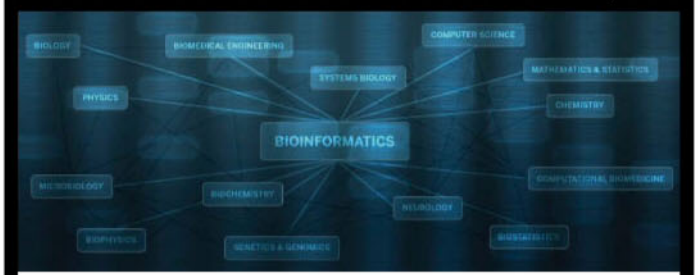

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The Schulich School of Medicine and Dentistry fosters an interdisciplinary approach to biomedical research that is enabled by state-of-the-art imaging facilities, technologically advanced core laboratories, and a common mission to innovate, integrate and translate breakthrough medical imaging technology in fields including neurological disorders, cardiac disease, musculoskeletal disease, pulmonary disease, and cancer for the betterment of Canadians. The Tier 1 CRC will be expected to pursue an independent, externally-funded, research program situated at the Robarts Research Institute and establish strong links to clinical departments. The position will provide excellent opportunities to collaborate with distinguished researchers at Western and its affiliated research institutes including the Lawson Heath Research Institute, Robarts Research Institute, and London Regional Cancer Program, as well as the Department of Medical Biophysics, the Department of Physics & Astronomy, the Department of Medical Imaging, and the Biomedical Engineering Graduate Program.

Candidates with a collaborative translational research program complementing the existing research strengths of the Medical Biophysics department and Robarts Research Institute including image-guided interventions are particularly encouraged to apply. Our research programs benefit from close collaborations between clinical and basic science faculty, and offer unique training programs in diverse fields.

Applicants must hold a Ph.D., M.D. /Ph.D. or equivalent. The successful candidate will be appointed at the rank of Associate Professor or higher with tenure if qualifications and experience warrant in the Department of Medical Biophysics with the possibility of a joint appointment in another Department at Western University depending on qualifications and discipline.
The candidate will also be appointed as a Scientist at the Robarts Research Institute. Anticipated start date is **September 1, 2016** or as negotiated.

With full time enrollment of 32,000, Western graduates students from a range of academic and professional programs. Further information about the Schulich School of Medicine & Dentistry can be found at **www.schulich.uwo.ca**, the Faculty of Science at **www.uwo.ca/sci** and/or at **www.uwo.ca**. Western's Recruitment & Retention Office is available to assist in the transition of successful applicants and their families.

The application should include a detailed curriculum vitae, brief description of the current research program, accomplishments, at least five representative publications in the last five years, and the names of three references.
Please send the complete application to:

Dr. Robert Bartha
Committee Chair, Tier 1 CRC in Medical Imaging
Schulich School of Medicine & Dentistry, Western University
selection.committee@schulich.uwo.ca

Please ensure that the form available at: **http://www.uwo.ca/facultyrelations/faculty/Application-FullTime-Faculty-Position-Form.pdf** is completed and included in your application. Applications will be accepted until the position is filled. Review of applications will begin after **June 15, 2016.**

This position is subject to budget approval and conditional upon a successful CRC application. Applicants should have fluent written and oral communication skills in English. The University invites applications from all qualified individuals. Western is committed to employment equity and diversity in the workplace and welcomes applications from women, members of racialized groups/visible minorities, Aboriginal persons, persons with disabilities, persons of any sexual orientation, and persons of any gender identity or gender expression. In accordance with Canadian Immigration requirements, priority will be given to Canadian citizens and permanent residents.

Accommodations are available for applicants with disabilities throughout the recruitment process. If you require accommodations for interviews or other meetings, please contact Brigitte Neale, **brigitte.neale@schulich.uwo.ca**, **519-661-2111 ext. 82698.**

University of Missouri School of Medicine

The University of Missouri (MU) School of Medicine in Columbia invites applications and nominations for the position of

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This position reports directly to the Dean of the School of Medicine.

MU has an outstanding research infrastructure in life sciences. MU has numerous distinctions including the largest and most powerful university-owned research reactor in the country; the only NIH-funded national swine resource and research center; one of 13 regional biocontainment laboratories in the nation; one of only four Mutant Mouse Regional Resource Centers; a Rat Resource and Research Center. Thus, MU is the only university in the nation to hold three major NIH national centers.

The Senior Associate Dean for Research will work with the Dean of the School of Medicine and campus research leaders to develop strategies that identify areas of research significance which will enable the School of Medicine to grow its research enterprise. The candidate will be expected to coordinate and lead extramural applications for research infrastructure and other large institutional awards; represent the School of Medicine to local, regional and national constituencies; and provide leadership in the area of clinical and translational research. The Senior Associate Dean will also oversee the graduate program in biomedical sciences, the research compliance programs, laboratory safety and the fiscal integrity of the research enterprise.

This individual will have an MD or PhD or equivalent degree, broad progressive administrative leadership experience in an academic health center environment; working knowledge of current national biomedical research interests with a history of sponsored funding; national recognition for achievement in research pursuits that would warrant appointment as a Full Professor. There should be a demonstrated record of promoting collaboration and cultivating both internal and external relations. The candidate must demonstrate the highest integrity and personal ethics and have a strong commitment to diversity.

Interested individuals should submit a letter of interest and a current CV to:
Barbara Montgomery,
staff for the search committee,
montgomeryb@health.missouri.edu or
MU School of Medicine, DC018.00
Columbia, MO 65212
telephone (573) 882-0003

For additional information, visit the following web sites:
http://medicine.missouri.edu/ and
http://missouri.edu/

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- Competitive stipends, paid health insurance, reimbursement for moving expenses, and a travel allowance to attend scholarly meetings or training.

The typical duration in the CPFP is 4 years (year 1: master's degree; years 2-4: NCI Summer Curriculum in Cancer Prevention and mentored research).

Applicants should meet the following eligibility criteria:

- Possess an M.D., Ph.D., J.D., or other doctoral degree in a related discipline or must be enrolled in an accredited doctoral degree program and fulfill all degree requirements by June 2017.
- Be a citizen or permanent resident of the United States at the time of application.
- Have no more than five years relevant postdoctoral experience.

The application deadline is **August 25, 2016**.
To be considered fellows must submit application via the CPFP website (**https://cpfp.cancer.gov/**).
To learn more about eligibility requirements and to apply, please visit our website **https://cpfp.cancer.gov/** or contact **cpfpcoordinator@mail.nih.gov.**

Contact:

Program Coordinator
Cancer Prevention Fellowship Program
National Cancer Institute, NIH
9609 Medical Center Drive
Room 2W-136 MSC 9712
Bethesda, MD 20892-9712
Phone: **240-276-5626**
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Role Accountabilities

The role will be based in Shell's Projects & Technology Group, located in the Shell Technology Center, Houston, Texas. The successful candidate will work within Shell's in-house Microbial Biofuels team, working with transformable host organisms to efficiently produce different biofuel components at both lab and pilot scale. The challenges range from working with both yeast and bacteria, mesophiles and thermophiles, solid and liquid phase fermentation, to molecular microbiological transformations that generate robust and high carbon flux microbes for efficient fuel component production.

Potential candidates will be engaged in a range of activities such as: molecular transformation, microbial pathway evolution, novel fermentation and organism research.

Responsibilities will include: include the evaluation of different metabolic routes, the transformation of specific hosts and the evolution of organisms taking into account a wide range of contributory factors, identifying opportunities and engaging with the development of commercial plans.

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Experimental Quality

What is research?

In his book on experimental design, David Glass of the Novartis Institutes for Biomedical Research in Cambridge, Massachusetts, puts it this way: Scientific research is the process of determining some property Y about some thing X, to a degree of accuracy sufficient for another person to confirm this property Y.

In other words: If it needs to be accurate enough for someone else to confirm it, it needs to be reproducible. Therefore, what distinguishes research from playful observation is reproducibility.

But reproducibility seems to be in a crisis. The oncology research team at Amgen failed to reproduce 47 of 53 published preclinical cancer studies; none of the effects of more than 100 compounds initially reported to lengthen life span in a mouse model of Amyotrophic Lateral Sclerosis (ALS) could be reproduced, and none were successful in human trials, and the number of retracted studies has been increasing.

While most were retracted because of misconduct, 21% of the retractions are related to sloppy science—contamination of reagents, mistakes in statistical analyses, or the authors' inability to reproduce their own data, according to a 2014 study.

And these retractions are likely only the tip of the iceberg. Case in point: Only 1.4% are due to contaminated cell lines, even though studies have shown that about 15% of cell lines are contaminated with other cells, and 10-15% of cell cultures are contaminated with mycoplasma, a tiny bacterium.

This suggests that erroneous studies are often not retracted. One reason is that researchers who can't reproduce someone else's data have almost no place to publish their negative findings, because most journals have little interest in publishing them.

Meanwhile, biological experiments are becoming ever more complex. One high throughput experiment can involve processing thousands or millions of data points. This means that experimental design and statistical knowledge are more important than ever, while training in these areas is often inadequate.

The Burroughs Wellcome Fund has published a handbook to try and address some of these gaps. The handbook, Experimental Quality, discusses the major traps researchers can fall into and how to avoid them. These include confirmation bias; unreliable reagents; small sample sizes; lack of blinding and randomization; the importance of standards; multiple testing and false positives; and recording and reporting experimental procedures and results.

BURROUGHS WELLCOME FUND

To read the complete article provided to New Scientist by Burroughs Wellcome Fund visit:
http://www.bwfund.org/career-tools/experimental-quality

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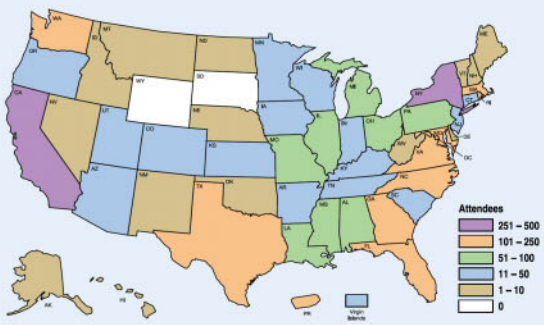
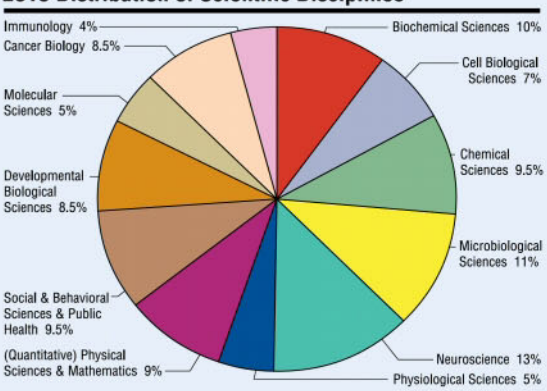
2015 ABRCMS Attendees by Location



2015 Distribution of Scientific Disciplines



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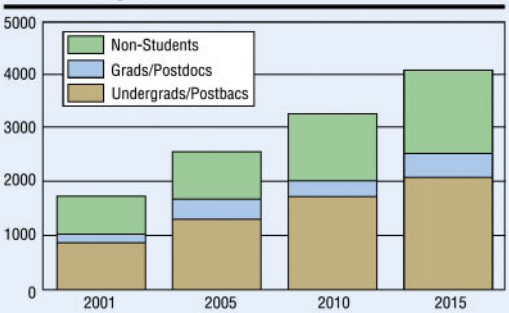
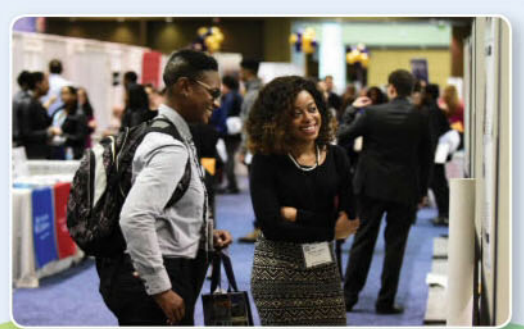


"It was a great opportunity to see the extraordinary research being conducted in the country and also to encourage and offer thoughtful advice to the future scientists."
FACULTY/JUDGE



"I love ABRCMS because of the vast amount of opportunities it has to offer. I meet so many new people who broaden my perspective of different areas of research. It's great to see people from all walks of life who possess the desire to be involved in science."
STUDENT ATTENDEE

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EDITOR'S PICK

How is health info protected?

From Keith Appleyard

You report Google's artificial intelligence company DeepMind having access to a "huge haul" of NHS patient data (7 May, p 22). I have read its agreement with London's Royal Free Hospital (bit.ly/NS_RFH) and I am concerned.

The document insists that identifiable personal information, such as name, address, NHS number, date of birth, telephone number and email address, must be encrypted while in transit to a facility in the European Economic Area for Google's use. But it does not prohibit that data being held unencrypted there.

To mask patients' identities it is usual to pseudonymise such data. But this agreement explicitly states: "as this data is being held for direct patient care purposes, pseudonymisation is not required". As a result, there is a risk that personal data could be accessed at the non-NHS location.

If the researchers do not intend to contact patients themselves, why can't they just use a unique number for each – plus, say, gender, date of birth and postal region? That would comply with the "data protection principle", stated in the agreement, that the data processor will "use the minimum that is required".

London, UK

Morality in history, life and religion

From Jack Burns

Nicolas Baumard says that the elite were the ones promoting new religions to protect their interests (30 April, p 35). In Christianity, the elite were the ones who wanted Jesus dead. The Pharaoh tried to stop Moses from spreading Judaism. In Islam it was the rich traders and leaders who wanted to stop the Prophet.

Throughout history the poor have been the early adopters of moralising religions and the rich have tried to stop them.

Leicester, UK

From Valerie Moyses

Pre-Christian religions did concern themselves with morality. Egyptians believed over 4000 years ago that the soul would be judged. Prehistoric hunter-gatherer religions did not concern themselves with sexual morality, since for them the paternity of a child did not matter.

When people settled, men amassed goods and assets – which they wanted to benefit their true offspring, not a potential cuckoo in the nest. Women then had to be forced into monogamy. Hence honour killings, child marriage, female genital mutilation… all in the name of religion. Morality-based religions were invented by men to control women. If it ever happens, true male-female equality, not evolution, will cause moralising religions to vanish.

Bloxham, Oxfordshire, UK

From Roderick Ramage

The philosopher Montesquieu addressed Baumard's subject in his 1716 essay on Roman politics in religion. He wrote that "when the Roman legislators established religion, they were not thinking at all of the reformation of customs, nor of laying down moral principles; they had no wish to inconvenience a people whom they hardly knew any more. They had from the very first but one general aim, which was to inspire in a people who feared nothing, fear of the gods, and to make use of this fear…"

Coppenhall, Staffordshire, UK

From John Atack

Over 17 centuries before Jesus, the Babylonian king Hammurabi placed high value on morality: "Anum and Enlil named me… to cause justice to prevail in the land, to destroy the wicked and the evil, that the strong might not oppress the weak."

Radcliffe-on-Trent, Nottinghamshire, UK

From Sigrid Rausing

Baumard's "life history theory", like sociobiology before it, seems to fail to distinguish between cause and effect – the two merge into "strategy". Distressed starlings lose weight – an effect of distress, not a "fast life strategy". Affluent women have fewer babies not because they have "switched" to "slow life", but because they usually have careers.

The claim that disapproving of behaviour that threatens your interest is a "general principle of human moral cognition" does not take seriously the idea of holding principles. These may benefit us in the long term, but quite often disadvantage us in the short term.

You could build a plausible evolutionary theory on that. But to argue that morality is only a means by which elites hold down the masses, to deny them sexual opportunity, revenge, and having "fun" sounds like the old stories about what the poor would get up to if "we" don't stop them.

London, UK

Politics must migrate to reason

From Roger Taylor

Your comments on migration were excellent but your plea for an intergovernmental agency to "promote research" and "make and defend evidence-based decisions", while eminently sensible, flies in the face of long-established political reality (9 April, p 5). It is not just an immigration agency that is "long overdue": it is the use of reason by politicians generally, on any topic you care to mention.

I suggest that you focus your efforts on determining how we might coax our representatives into rational problem-solving – most of us "plain folk" manage it most of the time. Given reasoning politicians, many of the problems we face, from immigration to real horrors like climate change and antibiotic resistance, will be in with a chance of being solved, and setting an example to other governments can only do good.

Meols, Wirral, UK

From Kerry Willis

Deborah MacKenzie gives us many new ways to understand migration and to review our often stereotyped responses to immigrants and refugees (9 April, p 29). I would like to see a follow-up article examining the effects, both positive and negative, of migration on countries and regions from which people have migrated or fled, particularly in recent times.

Monbulk, Victoria, Australia

Mother Earth, father comet

From John Watson

Current theories on the origin of life on Earth are based either on life developing in isolation here, or on it arriving from comets. I suggest that the answer may be both. Earth provides the bulk of the ingredients – relatively heavy elements such as sulphur, chlorine, phosphorous and metals – as well as sustained energy sources and a stable environment. Comets provide the strongly reactive but volatile substances such as alcohols,

"A platform simply for the collection and analysis of data is being instantly written off as biased"

Rohan Talbot regrets knee-jerk denunciation of the Forensic Architecture project on Facebook (7 May, p 42)

aldehydes, amines, organic acids and simple esters. For example, Joshua Sokol reports successful efforts to create ribose, a key ingredient of RNA, on simulated interstellar ice grains (16 April, p 12). There is plenty of supporting evidence about comet chemistry as found on comets 67P, Lovejoy, and Hale-Bopp.

Life doesn't work without both components. Bizarrely, this idea seems analogous to mammalian fertilisation…
Culcheth, Cheshire, UK

Turning nightmares off and on again

From Bryn Glover
I cannot resist the urge to report how Michelle Carr's article on nightmares speaks to my experience (30 April, p 36). I had a recurring nightmare throughout my childhood that both terrified and fascinated me.

The details are unimportant, but imagine an endless rubber sheet, flat and motionless, slowly beginning to undulate. It accelerates until it consists of crashing waves and shattering eggshells and then suddenly all is still and in a while the process begins again. It is associated with a taste or smell, undescribable because it relates to nothing else.

It woke me frequently during childhood, but as adolescence proceeded, lucid dreaming enabled me to end it before it became terrifying. One night I decided not to end the experience but, in full awareness, to allow it to play out. The undulations became especially violent but then bright lights pervaded the scene and everything became calm and peaceful. The dream has never returned.

I suppose if I were a religious person I might be claiming all kinds of spiritual significances.
Kirkby Malzeard, North Yorkshire, UK

From Annemieke Wigmore
I miss one side of dreaming here: what effect does food have on our nightly imaginings? I know several people, apart from myself, who report exceedingly vivid dreams whenever they eat cheese before bedtime. How common is this? This should be part of any research worth its name.
Cudworth, Somerset, UK

The editor writes:
■ We had extra information online reporting that food may have an effect (newscientist.com/article/2086358), though in a very small experiment in this office those of us who ate cheese before sleeping had less-vivid dreams (19/26 December 2015, p 69).

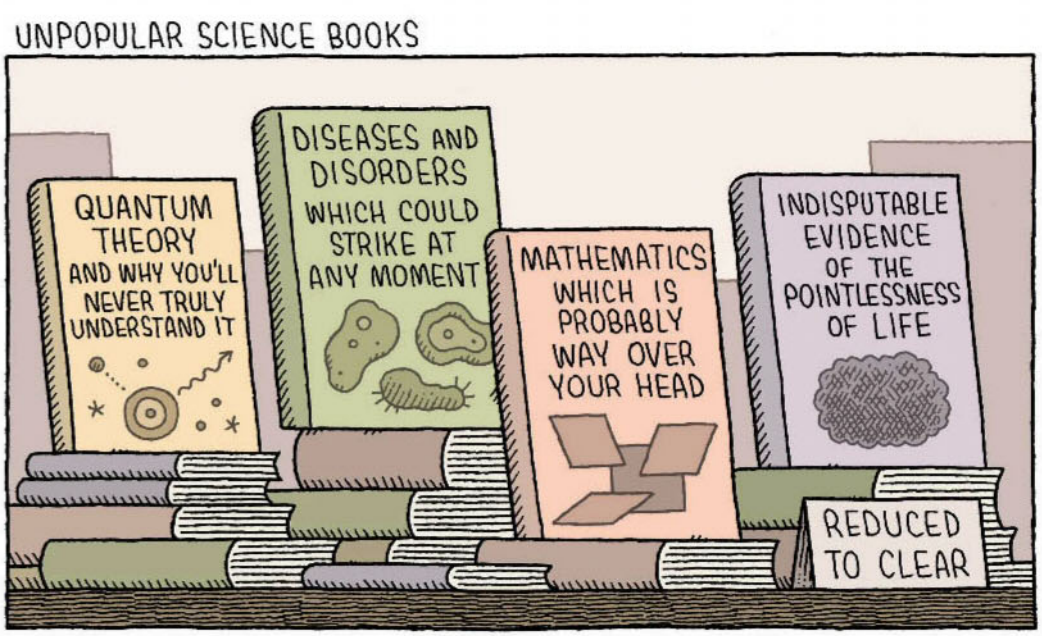
What really affects raccoons' fear?

From Chris Warman
William Handley suggests that bold urban raccoons represent a behavioural subculture that differs from the more cautious animals of British Colombia's Gulf Islands (Letters, 23 April). Subcultures are more likely to develop in long-lived, highly intelligent animals with strong social structures: there are other explanations for why island raccoons appear more afraid when they hear a recording of dogs barking. They may not have had time to get used to what is, after all, an empty threat. Or urban raccoons may have evolved bold behaviour. They breed annually with litters of up to five, and live on average less than four years. Natural selection can work rapidly on short-lived prolific animals.
Hinderwell, Tyneside, UK

Probably fewer wild pigs than that

From Jim Hone
Stephen Ornes highlighted many aspects of the impacts and control of wild pigs (2 April, p 40). But there are probably not "23 million feral pigs in Australia". The paper "How many are there? The use and misuse of continental-scale wildlife abundance estimates" in *Wildlife Research* reports with 95 per cent confidence that the number is between 3.5 million and 23.5 million, around an estimate of 13.5 million (doi.org/bgr3).
Canberra, Australia

TOM GAULD



For the record

- War in heaven. Titan is a moon of Saturn (7 May, p 31).
- Not that axis of evil: the Planck satellite is a European Space Agency project (30 April, p 30).
- Julie Carpenter, who suggested throwing AIs at role-playing games, is at the California Polytechnic State University in San Luis Obispo (19 March, p 5).
- The acidity of seawater fell by the desired amount when adding olivine: the pH rose (14 May, p 10).

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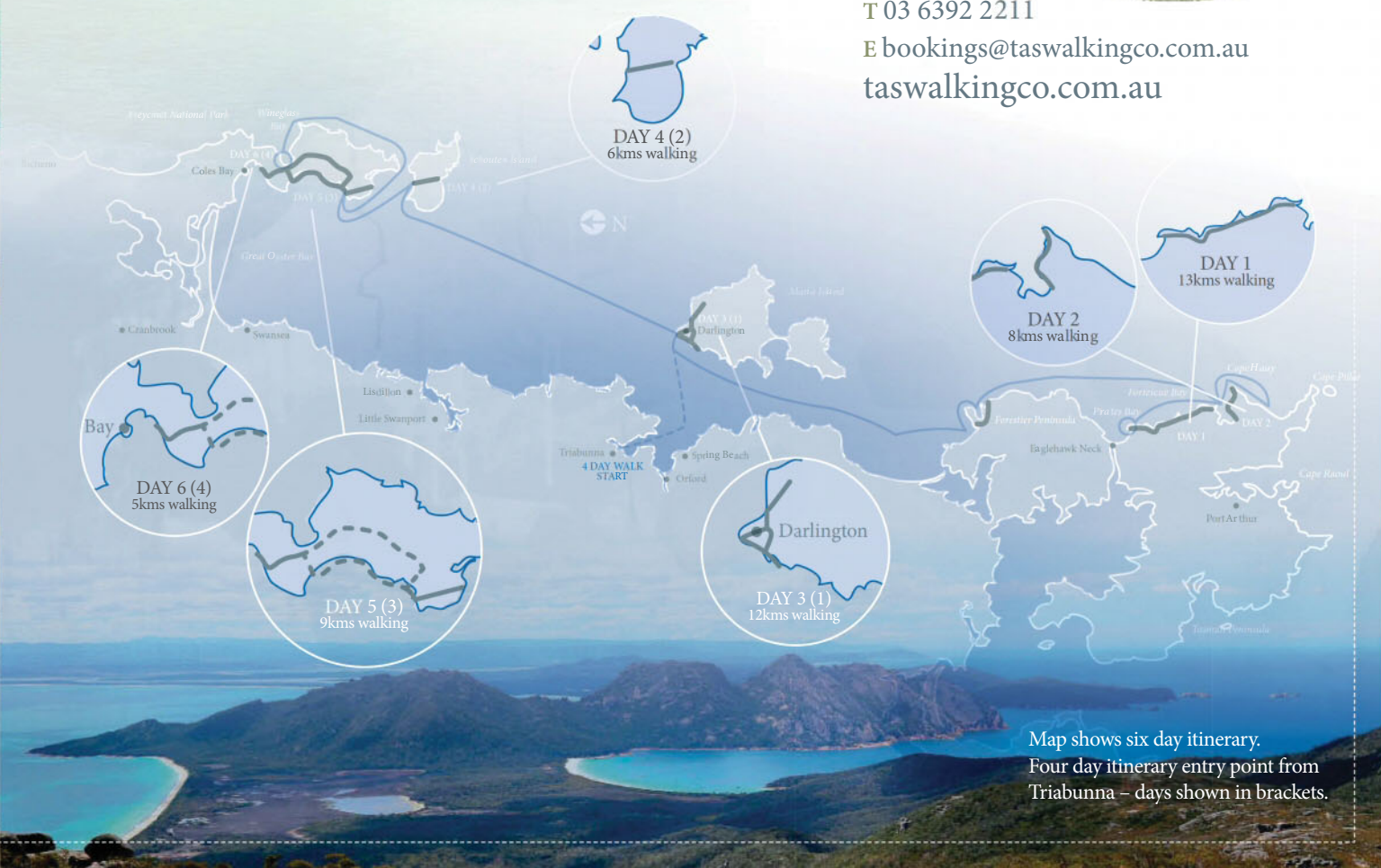

Map shows six day itinerary.
Four day itinerary entry point from Triabunna – days shown in brackets.

PAUL MCDEVITT

FEEDBACK previously caught wind of the fact that a certain type of Asian civet smelled, incredibly, of hot buttered popcorn (7 May), prompting us to ask readers for other incongruous smells found in nature.

Frank Hollis writes that it is "a recognised phenomenon amongst greyhound owners that the pads of their hounds' feet also smell of popcorn". Could this be true? Paul R. Bowden tells us that his dog's feet do indeed smell like popcorn, and further enquiries suggest this is a trait shared by all breeds. Sadly, Feedback doesn't have any pups to test the theory, nor do we find ourselves in the habit of going around sniffing dogs' feet, so we cannot confirm at this time.

CONTINUING the theme, Matthew Bastin offers "an animal I read about, but have not actually had the chance to smell first hand". That would be the kakapo, a small flightless bird also known as the owl parrot. Matthew recalls that William Stolzenburg, in his book *Rat Island*, reports that the bird has been described as giving off a musty, sweet scent reminiscent of freesias, honey or clarinet cases. "Yet it eats none of these things," ponders Matthew.

AND it's not just animals that exhibit these unusual qualities. Steve Swift has a large katsura tree growing in his back garden, with "leaves that emit the smell of candy floss when they've fallen to the ground in the autumn".

Because the smell comes from the leaves on the ground, Steve says, "you often smell it when you're some way off, but the smell fades as you approach the tree, as the aroma travels along the ground until something stirs it to nose level".

As an additional autumnal treat, the leaves sometimes turn a beautiful pink before falling to emit their confectionery scent. Willy Wonka, eat your heart out.

TELEVISION naturalist Steve Backshall writes in with some animals he has known and sniffed: otter spraint (that is to say, droppings) has a distinctly sweet odour that some people claim smells of violets, although it's not something Feedback is inclined to put to the test.

"Giant salamander and hellbender skin secretions smell like rhubarb," writes Steve, "while elephants in musth leave behind a honeyed garlic smell."

We're also reliably informed that African stink ants evoke freshly laid tarmac. "As a side note, CK One *eau de cologne* is used to attract a range of wild cats (including puma) to camera traps," says Steve.

WHILE visiting Australia, Clement Le Lievre noticed that children there are making the most of the days by gradually weaning themselves off sleep. "*The Advertiser* reports that Australian children's sleep 'has been declining by around half an hour a night since the mid-1980s'. Assuming they were getting the recommended 12 hours of sleep per night to begin with," writes Clement, "they must now be sleeping around -5530 hours per night." Strewth!

FURTHER to previous examples of pre-science prescience (16 April), Ken May tells us that we've not yet exhausted George Eliot's powers of premonition. In *Felix Holt, the Radical*, she references the speedy if dull journey provided by pneumatic railways:

"Posterity may be shot, like a bullet through a tube, by atmospheric pressure, from Winchester to Newcastle: that is a fine result to have among our hopes; but the slow, old fashioned way of getting from one end of the country to the other is the better thing to have in the memory."

A criticism that could be equally levelled at California's much-hyped Hyperloop?

A STRIKING example appears in Jonathan Swift's 1726 novel *Gulliver's Travels*. As Jim Cable reveals, "the hero reports from Laputa, a flying island where he met various crazy scientists". The book records that these astronomers had "discovered two lesser stars, or satellites, which revolve about Mars; whereof the innermost is distant from the centre of the primary planet exactly three of his diameters, and the outermost, five; the former revolves in the space of ten hours, and the latter in twenty-one and a half."

The real moons of Mars – Phobos and Deimos – "were only discovered in 1877, with somewhat similar characteristics," says Jim.

FROM worlds without to worlds within: Xavier Duran recounts that Thomas Mann's *The Magic Mountain*, published in 1924, is full of scientific references. "In one passage, a Dr Krokowski hypothesises a substance 'that exists everywhere in the body and sets free the soluble toxins that act like a narcotic on the nervous system '." Xavier says this sounds a lot like endorphins, which were only discovered in 1975.

DESPITE the UK's Psychoactive Substances bill being widely viewed as "unenforceable", the government has announced that its blanket ban on drugs will go into effect on 26 May.

Any consumable that provokes a mental effect is covered, including aromatics, and Feedback can't help but wonder how many of the interestingly scented plants and animals above will be proscribed. Repeat after us: "Yes, I've sniffed a kakapo, but I swear I didn't inhale."

"In his recent cartoon on pubs for scientists," says Martin Grell, "Tom Gauld missed out the chemist's favourite watering hole: the Red Ox."

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Divide and rule

I saw this tree in Austria over the summer (see photos). The trunk seemed to divide near the base and became almost three separate trees as it climbed higher. What species is this, and is it a normal occurrence? If so, what purpose does this division serve?

■ The photographs do not reveal the finer details of the foliage – in particular, flowers or cones – that would enable anyone to be sure of the species. It is a conifer in the broad sense, and most probably a cypress. In contrast with deciduous trees, such as the oak, lopping a young conifer off at the base is likely to kill it. Unlike an oak, it will not regrow with multiple trunks. The only reasonable conclusion is therefore that three seeds have germinated close to each other. In other words, it is three trees together rather than just one.
Terence Hollingworth
Blagnac, France

Twisted tips

Many aircraft wings have their tips turned up to reduce turbulence. I have not observed the same on wind-turbine blades – do they not experience the same problem? (Continued)

Thanks to those who noticed that when answering this question in a previous issue, we used a hoary old chestnut about how lift is generated by an aircraft. Here's a better explanation – Ed

■ An earlier answer about how winglets – the upturned tips on aircraft wings – work perpetuates an unfortunate misunderstanding about the way wings generate lift. It states, almost as an aside, that the pressure difference between the top and bottom of the wings causes lift.

There is indeed a pressure difference there, which answers the winglet question nicely – as the response explained very well. But the assumption that this difference also causes lift misses the mark.

The better and simpler explanation draws mainly on Newtonian physics: in basic terms, a wing or aerofoil tilted slightly upwards at the front deflects air downwards. This flow produces an equal and opposite reaction: lift.
Paul Hargreaves
Private pilot
Windsor, Ontario, Canada

Above board

Does wood from the upper part of a horizontal tree branch, which is under tension, have different characteristics to that from the lower part, which is under compression? Is wood ever selected for a purpose on the basis of such differences? (Continued)

■ A good example of something that takes advantage of the tension and compression properties of wood is the traditional longbow – although that wood comes from the trunk. The living sapwood stretches, so forms the outside or back of the bow stave, whereas the dead heartwood goes on the inside, or belly, of the stave, and resists compression.

The English longbow was traditionally made from Spanish or Italian yew, which carried less water than English yew. This possibly gave us the posh word for archery – toxophily – because the yew (*Taxus baccata*) that bows are made of is poisonous.
Dave Hulme
Stockport, Greater Manchester, UK

This week's question

MEMORY TEST
Do goldfish really have a memory span of three seconds, as per the urban myth? If not, how long is their memory span? Do we actually know?
Cristina Sanchez
Sintra, Portugal

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