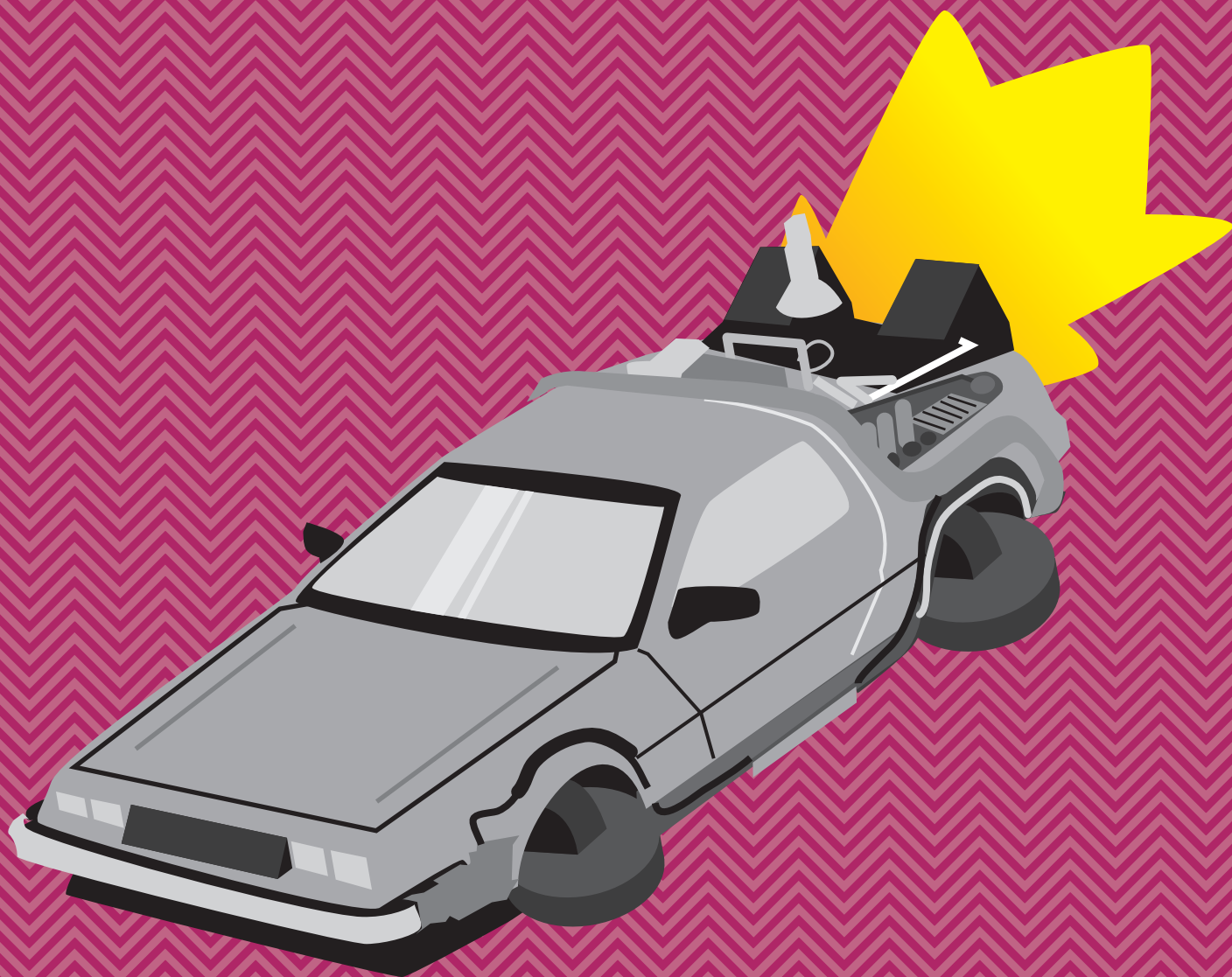


I, SCIENCE

THE SCIENCE MAGAZINE OF IMPERIAL COLLEGE



THE FUTURE

I, SCIENCE

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I, SCIENCE



As we come to the end of another year at Imperial, it's hard to avoid thinking about the future. For some, that means deciding on next year's courses; for others, it means facing the big wide world beyond university. For many of us here at *I, Science*, it means our last issue. But whatever our situation, we can share in the excitement about the scientific and technological advancements that that future will bring.

In medicine, for example, we may be on the cusp of restoring sight to the blind, either through stem cell research ('Stem Cells Offer Cure for Blindness', p7) or through retinal prosthetics ('Eye Science', p22). Such developments – which have already been successful in clinical trials – make it easy to imagine a future that's better than the present. The same is true for other fields: soon, instant translation could break down the language barriers that divide us, asteroid mining could put an end to fighting over resources, and human outposts in space could offer us a fresh perspective on our

existence ('Top 6 Technologies on the Horizon', p12).

Yet the impact of innovation is not always clear-cut. As the furore surrounding Google Glass has shown, advances in technology can clash with our expectations of privacy. In the case of optional gadgets, the problem is relatively confined, but what about a technology that underpins almost everything we do? The internet has changed the way we live our lives, but it has offered companies (and intelligence services) unprecedented access to our personal data ('Big Data, Big Problem', p9). Can we 'opt out' of this future, or is it too late?

Perhaps we should remember what computer scientist Alan Kay said: "The best way to predict the future is to invent it." These articles can only ever guess at what is to come, but we hope they will inspire you to build the future you want. If something piques your interest, find out more about it – who knows, maybe one day you'll turn up in an issue of *I, Science*. ■

CONOR

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NEWS FROM

IMPERIAL COLLEGE



JOHNNY DEPP FOSSIL FOUND



n Imperial College researcher has named an extinct creature after the actor Johnny Depp. The 505-million-year-old fossil,

Kooteninchela deppi, was found in the valley of the Stanley Glacier, in Kootenay National Park, British Columbia. The fossil, which is a distant ancestor of lobsters and scorpions, has scissor-like claws. These reminded the researchers of Johnny Depp's eponymous role in the film *Edward Scissorhands* – a movie about an artificial man who had blades instead of fingers.

"When I first saw the pair of isolated claws in the fossil records of this species I could not help but think of Edward Scissorhands. Even the genus name, *Kootenichela*, includes the reference to this film as 'chela' is Latin for claws or scissors. In truth, I am also a bit of a Depp fan and so what better way to honour the

man than to immortalise him as an ancient creature that once roamed the sea?" said David Legg, who carried out the research as part of his PhD in the Department of Earth Science and Engineering at Imperial College London.

Published in the *Journal of Palaeontology*, the discovery was part of a larger research project where scientists tried to piece together more information about life on Earth during the Cambrian period, when nearly all modern animal types emerged. Legg believes that *Kooteninchela deppi* was a hunter or scavenger, living in very shallow waters, that used its Edward Scissorhands-like claws to catch prey or probe the seabed. The creature was around four centimetres in length and had large compound eyes on top of its head, similar to those of a fly. *K. deppi* belonged to a group called the "great-appendage" arthropods – early relatives of modern arthropods. ■

ALICE HAZELTON

OBESITY CAUSES IRREVERSIBLE DAMAGE



Years of being overweight might lead to damage that cannot be undone, Imperial College scientists have warned. The accumulation of body fat causes arteries to stiffen, leading to a permanently increased risk of cardiovascular disease.

"The effects of having more fat seem to be different depending on your age. It looks like young people may be able to adapt to excess body fat, but by middle age the cumulative exposure to years of obesity may start to cause permanent damage to the arteries," said Dr. Declan O'Regan, who led the study at the Medical Research Council Clinical Sciences Centre.

The researchers determined the hardness of the blood vessels by using MRI to measure the speed of blood flow: in healthy, flexible vessels, blood travels slower than in stiff vessels. The study showed that young adults with more body fat still had flexible arteries, but that in people over 50, excess fat was associated with hardened blood vessels. Indeed, body fat percentage was a far better predictor of artery stiffness than body weight alone.

Although obesity is well known to be associated with risk of cardiovascular disease, scientists are still uncertain how excess fat hardens the blood vessels. Dr O'Regan said: "We don't know for sure how body fat makes arteries stiffer, but we do know that certain metabolic products in the blood may progressively damage the elastic fibres in our blood vessels."

Worryingly, the research suggests that the potential benefits of weight loss may be mitigated by age. But O'Regan hopes further study may reveal an understanding of obesity that could lead to prevention of its harmful effects. ■

VICTORIA DRUCE

SATURDAY SURGERY? SOUNDS SCARY



You're 44% more likely to die if you have a pre-planned operation on a Friday, as compared with a Monday, according to a study from Imperial College. If you are admitted at a weekend your chances are even worse, with the likelihood of death increased by 86%.

Yet these headline figures – while true – need some context to be properly understood.

The study was very large. It looked at over 4 million patients who had operations between 2008 and 2011 in English NHS hospitals. Of these, 27,582 – less than 1% – died within a month of their operation. So while the risk of death increases significantly, the absolute risk is nonetheless still very low.

Dr Paul Aylin of Imperial's School of Public Health led the study. He suggested that a lower quality of care at weekends in hospitals might be the cause of the increased chance of dying. The care patients receive in the few days immediately following their operation is critically important, so this could explain why patients treated at the end of the week also fare worse.

Aylin noted that the mix of patients treated at the weekend could be different to those treated during the week. His figures did, however, take into account factors such as patient age and the complexity of the operation, indicating that these alone could not account for the difference in risk.

A similar study from Aylin's team has previously evaluated the risks associated with emergency surgery at different times of the week. There they found a smaller effect, with the risk of death increasing by about 10% at weekends. ■

JOSH HOWGEGO

IMPERIAL INTERNSHIPS NOT UP FOR AUCTION



Following public commotion, the Institute of Biomedical Engineering has withdrawn a one-week internship it had put on offer in a private school fundraising auction.

The auction was set up by Westminster School, which charges over £7000 a term. Parents could bid on the placement, which was advertised as "a wonderful addition to the CV of any budding scientist", and before being removed, the internship was going for £251.

The Imperial student body responded to the auction with dismay. After learning about it on 14 May, the Union condemned it in a public statement saying that "to restrict this transformational opportunity only to the wealthy is a betrayal of our academic principles and the work to widen access to which so many staff and students have given their time." The auctioning also drew attention outside of Imperial, with *Bad Science* columnist Ben Goldacre calling it "bizarre" and "vile" on Twitter.

Following this commotion, the university dealt swiftly with the issue, and on the same day published a statement pronouncing that "on reflection, the Institute of Biomedical Engineering has requested that the auction place be withdrawn and is considering the best and fairest approach to hosting work experience placements in the future".

Westminster School, which had numerous internships on offer, defended the auction by saying that school contacts had offered the in placements addition to, and not in place of, existing positions, and that each auctioned placement came with a second place to pass along to a pupil at one of their partner state schools.

In response to the ordeal, the Union decided to set up a campaign to get the college to offer bursaries to internship students and to increase its advertising for opportunities, so that equal access is further improved. ■

EMMA BORNEBROEK



Paulo Ordoveza

WORLD NEWS

PICK OF THE BEST



UK WILDLIFE IN TROUBLE

The *State of Nature* report, the most comprehensive stock take of UK species to date, was launched by Sir David Attenborough and UK conservation charities this May.

It suggests that 60% of all the 3148 species surveyed have declined over recent decades, with more than a tenth at risk of disappearing.

The hedgehog suffered one of the most significant declines, with its numbers reduced by around a third since 2000. The bumblebee's range has reduced drastically since the seventies and for a fellow insect, the V-moth, numbers are down to less than 1% of what they were in the sixties.

Beyond land animals, both plants and aquatic wildlife have been affected: European eel numbers have declined so much that the species is now considered Critically Endangered, while the bastard gumwood tree has only one adult tree left in the wild.

Authors suggest there are “many and varied” reasons for diminishing species numbers but more prominent reasons include rising temperatures and habitat degradation.

The report, an ambitious nature health check for the UK and its Overseas Territories, was compiled in association with over 25 wildlife organisations with recognised help from many volunteers.

Sir David Attenborough, who wrote the report's foreword, said that it was a “stark warning” but “also a sign of hope as it is heartening to see so many organisations coming together to provide a single voice, stating loud and clear what is happening to our wildlife.”

The report ends with a reminder that we really can each do our bit - whether that be volunteering with wildlife charities or even just providing space for nature to creep into our gardens. ■

LIN LIN GINZBERG

AN END TO FLU SHOTS?

Seasonal flu shots could be on their way out thanks to a new synthetic vaccine. Engineered by researchers at the National Institute of Allergy and Infectious Diseases in Maryland USA, it could provide stronger, longer-lasting protection against a broader range of flu strains compared to current vaccines.

Traditional vaccines contain an inactivated virus strain. However, the flu virus mutates at a rapid rate, which means the vaccine has to be updated nearly every year and its effectiveness can vary. Many of the viruses for vaccines are also grown in eggs, a process that can take several months and is susceptible to contamination.

The new vaccine, which is made of protein nanoparticles, is entirely synthetic and made in the lab. Researchers created the nanoparticles by fusing haemagglutinin (HA), a spiky protein found on the coat of many flu viruses, with ferritin, a bacterial transporter protein. The HA spikes cause an antibody response that is effective against many strains, so the vaccine will not need to be updated as regularly.

In animal tests the vaccine induced antibody production that was 34 times higher in mice, and 10 times higher in ferrets, than that caused by a traditional vaccine. While the experimentally-tested vaccine incorporated HA from a 1999 H1N1 flu strain, it also provided protection against other H1 strains of flu viruses, including one from 2007, suggesting that this new vaccine may be able to protect against future flu strains.

However, it cannot protect against other types of flu virus, such as bird flu strains H7N9 and H5N1, that have different HA proteins on their outer surface.

The research team hope to test the vaccine on humans within the next two years. They also hope to use the same technique to develop vaccines for other viruses such as HIV and herpes. ■

REBECCA KNOWLSON

KEPLER OFF THE RAILS



Kepler, NASA's exoplanet-hunting spacecraft, may well have bitten the dust after a breakdown of its stabilisation mechanism. Though the project has lasted longer than originally planned, the news comes as a devastating blow to NASA scientists.

Kepler depends on four reaction wheels to keep itself precisely oriented. Three control motion about each of its axes, whilst a fourth acts as a backup. One wheel stopped spinning in July 2012 and after a second failed in May this year, the future of the spacecraft looks uncertain.

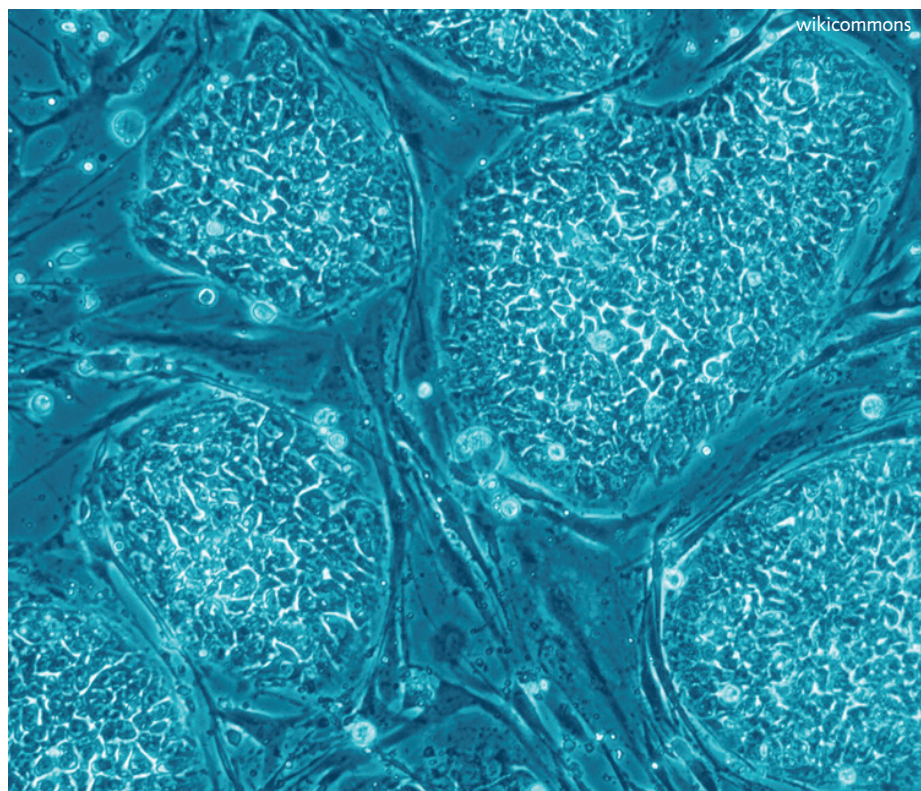
Kepler is tasked with searching for Earth-like planets potentially capable of sustaining life, and has so far identified 132 confirmed planets and over 2,700 potential ones. The spacecraft keeps its camera focused on 150,000 Sun-like stars in the constellation Cygnus, watching for dips in light output caused by planets passing in front. Due to the minute changes Kepler has to detect, maintaining long-term pixel-perfect focus is essential, hence the importance of the reaction wheels and the astronomical impact their failure has.

Replacing the broken equipment is out of the question: Kepler orbits the Sun at a distance of 40 million miles from Earth, approximately 160 times the distance between the Earth and Moon. Though engineers are trying to remotely restart one of the faulty wheels or develop a work-around, NASA doesn't seem hopeful: Kepler's planet-hunting days are likely numbered.

Yet while Kepler may be dead in the water it's not all doom and gloom. There is still two years' worth of data to analyse, which may reveal more hidden planets.

Kepler's successor will be TESS, the Transiting Exoplanet Survey Satellite. While TESS is not due for launch until 2017, its existence demonstrates Kepler was successful enough in its search that NASA wishes to continue its exoplanet-hunting work. ■

LAURENCE POPE



STEM CELLS OFFER CURE FOR BLINDNESS



A man once considered to be blind now has sufficient vision to hold a driver's licence, thanks to recent developments in stem cell research. Advanced Cell Technology (ACT), a Massachusetts-based biotechnology company, has confirmed that upon treatment with human embryonic stem cells, a clinical trial participant's sight improved from 20/400 (essentially blind) to 20/40 (short sighted).

The trial currently includes 22 sufferers of Stargardt's macular dystrophy and dry age-related macular degeneration. Both diseases result in the gradual loss of retinal pigment epithelial (RPE) cells: cells that supply energy and nutrients to photoreceptors, and recycle the debris that gathers on the retina.

The scientists used embryonic stem cells to create new RPEs, a task that many teams

before them had failed to achieve.

ACT is yet to release the trial results as they are awaiting a "sufficient aggregation of data," chairman and CEO Gary Rabin announced, so it remains unclear from which of the two diseases the participant suffered.

Stem cell research is often beset by technological difficulties and ethical debate, since the cells are usually collected from fertilised egg cells. This team side-stepped many of these ethical issues by using unfertilised human egg cells. Stem cell biologist George Daley, from Harvard Stem Cell Institute, who took part in one of the previous failed projects, called this an "unparalleled achievement".

Despite this, the research has faced staunch opposition from groups such as the Human Genetic Alert, who fear that such work will lead to human cloning. ■

BEN STOCKTON



BIG DATA, BIG PROBLEM

*The way companies and governments collect and use information about you is changing rapidly. **David Lawrence** takes a look at the burgeoning data-gathering industry.*



A new revolution is slowly rearing its head as an ever increasing barrage of personalised adverts begins to follow us around the web.

For some it may be 'single girls in your area'; for others, that unaffordable, lusted-after item that you simply must have. Either way, the advertisers are coming for you.

This targeting is conducted by a wide range of organisations that have begun to 'mine' our data, including the websites we have frequented and the places we have visited, and to use it to make predictions about our future. They then use these predictions to identify what we might be most tempted by and to target their adverts accordingly. Such vast amounts of data are now being collected that it cannot be processed by conventional database systems – complex new methods are required for its interpretation. This data and the processes used to comprehend it are both referred to as 'Big Data'.

The adverts may be a little annoying and a tad divisive, but the really intriguing aspect of Big Data is trying to predict where it's headed next. This is one question to which no one really knows the answer. Big Data may well change the landscape in fields as diverse as the search for aliens and finding a cure for cancer. But one thing is for certain: as we move in to the future, the privacy and ethical concerns surrounding the use of our data will grow.

Take for example, crime fighting. You may have seen in a recent Horizon documentary,

Age of Big Data, how a police department in America is using Big Data to predict where on their patch the next crime will happen, by accumulating all the data about crimes in the area over the past several years. This by itself doesn't sound particularly concerning ethically, but combine this with the ability to generate a pool of potential suspects and to predict each of their movements for the next 24 hours (a feat that is already possible thanks to research from the University of Birmingham), and criminals of the future may be identified in advance of a crime that they have not yet committed, on the say-so of a computer. Sound familiar? That's because the plot of the 2002 box office hit *Minority Report* concerned just this eventuality (although psychic 'precogs' take the place of huge police databases). Thanks to Big Data, it looks as if 'PreCrime' could beat hoverboards in the race to reality.

You may think you are safe from the perils of Big Data as a law-abiding citizen, but think how Big Data could affect hospital treatments in the future. As medicine moves into a personalised era, where decisions are made on the basis of our unique genetic code, what if the 'computer says no' when asked if you are a good candidate for life-saving surgery? Surgeons are reputed to be fiercely protective of their procedure success rates, so if the data warns them that you may be a risky candidate, would they take the chance? No one really knows what the future holds for Big Data. It will surely provide us with a multitude of benefits we can't even conceive of yet, but nonetheless, the potential ethical implications may be just as great. ■

Jeroen Bennink

FIRE AND FLOOD

With climate change an unavoidable part of our future, Christopher Yates considers the consequences of an unchecked rise in temperatures.

In the absence of any policy changes, the global temperature in 2100 will be 4 °C higher than in pre-industrial times. That may not sound like much, but according to climate scientists and recent reports from the IPCC and the World Bank, there will be dramatic consequences. World Bank president Jim Yong Kim has said that “[I]ack of action on climate change threatens to make the world our children inherit a completely different world.” So just how will the world change?

While the average global temperature increase will be around 4 °C, this temperature change won't be distributed evenly across the world. Among the most impacted regions will be the polar ice caps. The temperature in the Arctic is rising at approximately double the global average

rate, which has led to a 40% decrease in sea ice over the past 30 years. As the ice caps melt, they release water into the oceans, diluting the oceans and leading to rising sea levels.

The surface of the sea is not level around the globe. The polar ice sheets, mountains and deep sea vents all perturb the pull of gravity, leading to 'mountains' and 'valleys,' which are further shaped by the effects of wind and ocean currents. The Gulf Stream, for example, pulls water away from the north-eastern USA, leading to a lower sea level. These currents are driven by 'thermohaline gradients' – differences in temperature and salt levels. As the polar ice caps melt, cold water will be added to the oceans, disrupting these gradients. If the Gulf Stream is disrupted, the local sea rise will be higher around the north-eastern USA than elsewhere.

There will also be large rises around Asia and Africa.

Sea levels could rise by as much as two metres by 2100, meaning flooding will increase and many coastal cities and small island nations could be lost. Bangladesh is prone to floods, containing 230 rivers that swell during monsoons. With rising sea levels and increased rainfall, the country could find itself completely changed. If sea levels rise by 1 metre, a quarter of the coastline could be lost, with 30 million people losing their homes.

In addition to the Arctic getting warmer, hot regions will get even hotter, leading to droughts and water shortages in many parts of the world. Land temperatures will rise more than ocean temperatures, meaning a greater overall impact than the quoted 4°C rise suggests. It has even been suggested



shaunamey

that, just as wars in the 20th century were fought over oil, wars in the 21st and 22nd centuries could be fought over water.

As well as shifts in the average temperatures, there will also be changes to weather patterns. What we currently think of as extreme weather – the recent never-ending winter or the heat waves that affected much of Western Europe in 2003 and killed around 55,000 people in Russia in 2010 – will become more and more common. Heat waves in Australia in 2009 put power supplies and morgues under tremendous stress, while railway lines in Adelaide buckled under the heat. As well as increased heat waves, tropical cyclones are likely to increase in both frequency and intensity thanks to the changes in ocean temperature.

Droughts, increased temperature and changes to weather patterns are likely to have huge impacts on agriculture, ecology and biodiversity. During the 2010 Russian heat wave, approximately 25% of crops failed, leading to \$15 billion in economic losses. Crop failures due to droughts in the USA in 2012 led to food price increases on a global scale.

Sea life will be affected both by changes to the ocean temperature and to its chemistry. As more carbon dioxide is produced, the ocean will become more acidic. Its pH is predicted to decrease by approximately 0.3 compared to pre-industrial levels (a lower pH means greater acidity); this is a bigger drop than it sounds, since pH is a logarithmic scale. As pH drops, the calcium carbonate that makes up shells is more easily dissolved.

“THE AMAZON COULD SWITCH FROM SINK TO SOURCE, PRODUCING CARBON DIOXIDE AND EXACERBATING CLIMATE CHANGE”

Populations of many corals, molluscs and other marine wildlife have already been hit by climate change, and this situation will only get worse as ocean acidification continues.

Other ecosystems such as the Amazon rainforest will also be affected by forest fires, death of plants, extreme rainfall and droughts. The Amazon is one of the largest ‘carbon sinks’ on Earth, containing a whopping 100 billion tonnes of carbon. However with deforestation and forest fires, the Amazon could switch from sink to source, producing carbon dioxide and exacerbating climate change.

The World Bank and the IPCC currently have a target of cutting the temperature rise to 2 °C by 2100. With current policies and pledges we are on course for a 4 °C rise. Reaching the target will require dramatic cuts in greenhouse gas emissions, something which most governments seem reluctant to do.

Although most scientists and politicians are in agreement that man-made climate change is a major problem, there is a reluctance to act for fear of inhibiting economic growth, particularly in the current economic climate. However, while there will be short-term savings to be made by maintaining the *status quo*, failure to act on climate change could lead to far greater economic damage in the future. According to a 2005 study, acting to prevent climate change will cost the USA approximately \$12 trillion by 2100, but inaction will lead to damage costing around \$20 trillion by 2100 and over \$70 trillion by 2200.

Politicians may be worried about the fragile economic climate, but there is another climate to worry about – one which seems in an even more perilous position and will change irrevocably unless action is taken. ■

TOP 6



SPACE ELEVATOR

If humans are to become a space-faring species, we must find a more efficient method of lifting our luggage into space. One idea, a 'space elevator', may sound like sci-fi, but many scientists and engineers have proposed how to build one.

At around 100,000 km tall, the tower would be too heavy to support itself. Instead, scientists have proposed 'tethering' an orbiting asteroid to the Earth – a lift could then move up and down this tether.

Yet this method is not without difficulty; we currently lack a material strong enough and light enough to build the tether, and while some suggest carbon nanotubes could fill this role, there is debate that even these are too weak. Unless these problems can be solved, it looks like we will be relying on rockets for some time yet.

ANDY ROAST

MOON BASE

Colonies in space are a mainstay of science fiction, but now they may be on the verge of becoming a reality. Concerns about the long-term future of life on Earth are driving humans to venture into space, and the Moon's proximity makes it the most obvious place for our first non-Earth inhabitancy. While the USA leads the way, both Russia and Japan plan to establish their own moon bases by 2030. NASA's discovery of large amounts of water on the moon in 2009 has made the prospect of moon colonisation much more viable. It seems highly likely by the end of this century we will finally live on the moon.

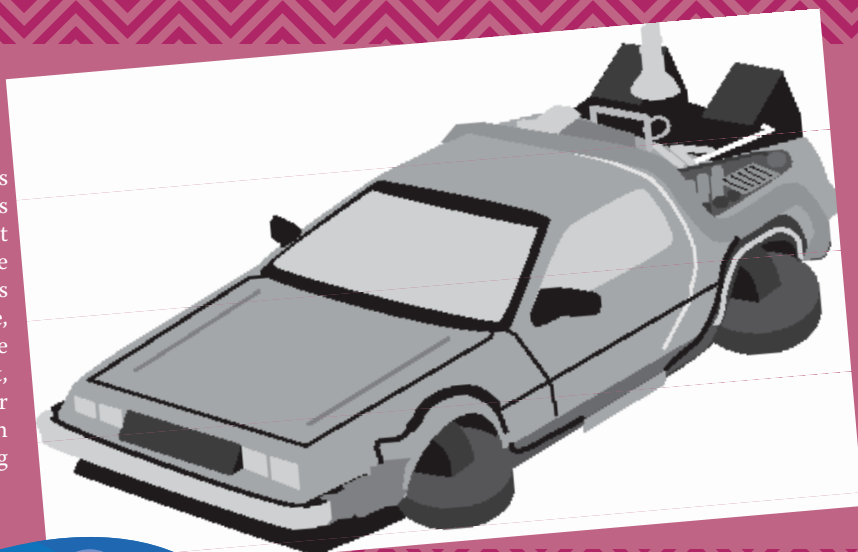
JAMES KEEN



FLYING CARS

Back to the Future, *Blade Runner*, *The Jetsons*... flying cars are at the core of futuristic fiction. But are these dreams soon to become a reality? Nearly a century after the first (unsuccessful) attempt at a flying car, 'roadable aircraft' are going mainstream. The latest models include Terrifugia's Transition, which has foldable wings, and Pal-V's One, which has a single rotor and propeller. While both are predominantly aircraft, requiring a runway for flight, Terrifugia has recently released plans for the TF-X, a car that can take off vertically from the road, set to be ready in 8-12 years. It's not quite *The Jetsons*, but for the time being it's pretty impressive!

REBECCA KNOWLSON



ASTEROID MINING

In the next 100 years, Earth may run out of many of the elements, such as platinum and indium, that keep our gadgets working. But since many of these elements originally came from asteroids hitting the Earth, could we mine asteroids to acquire more? Two companies, *Planetary Resources* and *Deep Space Industries*, seem to think so – they plan to start mining asteroids within the next 20 years. Sceptics of the missions point out that the cost of the mining equipment and the value of the ore can only be speculated, but given NASA's own plans to capture an asteroid, maybe this idea isn't so far-fetched.

JAMES KEEN

INSTANT TRANSLATION

True translation, accurately conveying the full meaning and nuances of other languages, is an art form machines have yet to trump humans at. Basic translation software can only provide the gist of texts, translating word for word in a crude rule-based approach.

But that process may be about to change.

Microsoft is currently working on software to translate one spoken language into another with an error rate of approximately 1 in 8 words. Other text-based software such as Google Translate uses pre- and post-translated documents to 'teach' itself grammatical rules and other nuances of grammar and syntax.

Slowly but surely software is getting smarter. It doesn't seem far-fetched to imagine high fidelity instant translation software being available within the next 50 years.

LAURENCE POPE

SEE-THROUGH SCREENS

In the film *Minority Report*, Tom Cruise's character accesses information by touching hyper-technological, see-through screens. These could soon become a reality as organic light emitting diode (OLED) technology advances. In contrast with normal LEDs, OLEDs are very thin and can be built into layers that are invisible to the human eye. Samsung have recently shown off a see-through window that at the swipe of a finger becomes a television set. This is all very exciting, but will your neighbours be able to watch your TV from the other side of the window? Probably best to avoid those TV guilty pleasures!

ANDY ROAST

MAN/MACHINE

Will we soon be able to merge our minds with computers? Rosemary Peters takes a look at the claims of the 'singularitarians'.

Imagine connecting your brain to the World Wide Web using Wi-Fi. You could shoot off an email, update your Facebook status or check out new posts on Reddit just by thinking about it. Though it may sound like science fiction, this melding of mind and computer has a name: the singularity.

At the heart of the singularity is the idea that computers will suddenly become unimaginably more powerful and more capable than they are now. And according to the enthusiasts known as 'singularitarians', if humanity goes far enough down this road, eventually people will be able to pour their consciousness into a computer and live forever.

In 1993 Vernor Vinge, a computer scientist, science fiction writer and retired Professor of Mathematics, popularised the idea in his paper "The Coming Technological Singularity".

"Within thirty years, we will have the technological means to create superhuman intelligence," he claimed.

Raymond Kurzweil, Director of Engineering at Google and author of best-selling books on the subject, also believes the unification of man and machine is at hand. According to Kurzweil, humans will soon be able to combine their minds with super-intelligent machines and achieve cybernetic immortality. He even thinks it will happen in his lifetime.

Many scientists are making strides in areas that make Kurzweil's predictions of a singularity look possible. Take Kevin Warwick, Professor of Cybernetics at the

University of Reading, who has become famous in the science world for his work in artificial intelligence, control, robotics and biomedical engineering. In fact, Warwick has been dubbed the first 'cyborg'.

In August 1998, Warwick had a doctor surgically implant a silicon chip transponder in his forearm that enabled him to operate doors, lights, heaters and other computers without lifting a finger. In 2002, he took his research one step further and had an electrode array, which he calls a brain gate, implanted into his median nerve fibres. The array could send signals back and forth between Warwick's nervous system and a computer. It also enabled him to move a robotic hand via the Internet.

"I went to New York, and we plugged my nervous system into the Internet and linked to the robot hand that we had in England," Warwick said. "My brain signals went across

the internet, moved the robot hand and when the robot hand gripped an object, signals were sent back from the fingertips, so I could feel how much force it was applying. It was fantastic realising that your body doesn't have to be in the same place as your brain as a cyborg."

Warwick's wife, Irena, also had an array implanted. Warwick describes this part of the experiment as "profound" because he and Irena could communicate via their nervous systems.

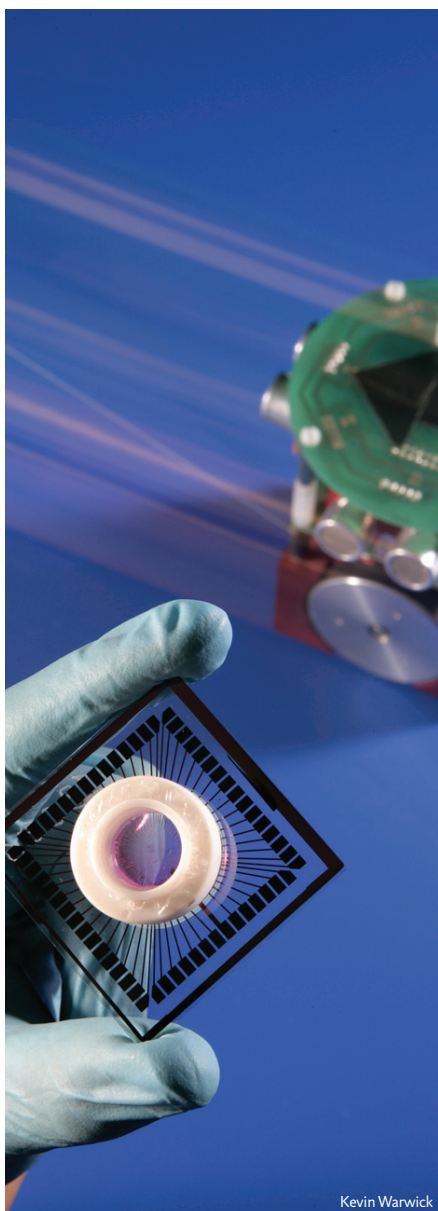
"Every time she moved her hand, my brain received a pulse," Warwick said. "It was a very basic form of communication. But when it's brain to brain instead of nervous system to nervous system, then it will be the basis of communicating by thought."

However, many scientists think Kurzweil's and Vinge's timetables for the breakdown of the boundary between man and machine are overly optimistic.

"I don't object to the possibility of us reaching at some point in the future vastly more capable computers," said Andrew Nuxoll, an Associate Professor of Computer Science at the University of Portland. "It's just that I object to the idea that it is going to happen in the next 20 years."

According to Nuxoll, it's not so much that artificial intelligence techniques have improved – though there is modest improvement there – it's that we're putting them on computers that have greater horsepower. "Singularitarians are seeing that we're getting the computing power to the point where the artificial intelligence

**“WITHIN THIRTY YEARS,
WE WILL HAVE THE
TECHNOLOGICAL
MEANS TO CREATE
SUPERHUMAN
INTELLIGENCE”**



Kevin Warwick

algorithms that we already have are going to be successful.”

An example of such advances in computing power can be seen in Watson, IBM’s Jeopardy-playing artificial intelligence. Watson is based on learning algorithms that have been around for decades, but it has only been in the last decade that the hardware was able to catch up with software capabilities. In 2011, Watson took on long-reigning Jeopardy champions Brad Rutter and Ken Jennings and beat them in a \$1 million battle of the “brains.” However, Watson did have access to 200 million pages of content including the full text of Wikipedia.

John Horgan, a science journalist and Director of the Center for Science Writings at Stevens Institute of Technology, points out several issues with the idea of the singularity. The first is that the singularity ideology comes off more like a religious belief than a scientific notion, especially in the idea of humans living forever through machine interfaces.

Moreover, Horgan says, there simply is not enough science behind the idea. While scientific fields have much room for development, Horgan doesn’t believe these developments will necessarily bring about a singularity.

“The fields that singularitarians think will bring about the singularity, such as artificial intelligence, nanotechnology, neuroscience and genetic engineering, have lots of room for progress. I find the idea that they’re going to create some kind of superhuman intelligence that’s going to change everything, change the world in some kind

of radical evolutionary way within the next few decades completely preposterous.”

He also highlights the fact that neuroscientists have only begun to scratch the surface of understanding the brain. There are many intricacies within the system that scientists haven’t even begun to plot.

“Most singularitarians seem to have no grasp of the complexity of the brain and how far science is from having any real understanding of how neuroprocesses produce memory, perception, emotion and consciousness itself,” Horgan says. “We don’t even have a paradigm.”

However, even if neuroscientists can create a paradigm by mapping out the brain’s complexity in its complete form, there is still a part of the brain that is seemingly as mysterious as it was when René Descartes wrote *Discourse on the Method* in 1637: consciousness.

“Consciousness isn’t easy to define, let alone create in a machine,” Horgan says. “Just having some really detailed 3D map of the brain won’t necessarily lead to the theoretical breakthroughs that you really need to understand how brains work.”

In fact, having all of the workings of the brain may do as little for scientists studying how the brain forms consciousness as having a complete mapping of the human genome has done for genetic therapy. This is because the map may do little to help scientists discover where the action is when it comes to the processing of information in the brain. As Horgan points out, “knowing all the circuitry isn’t necessarily going to accomplish anything.” ■





SCIENCE BEHIND THE PHOTO

Camel racing has been the Arabian Peninsula's prided (and lucrative) pastime for thousands of years. It's been called 'the sport of sheikhs'; there are few spectators and no cameras – simply an arena where wealthy men gather to pit one camel against another.

Traditionally, the jockeys were four year old boys, trained and employed to race the camels in the 45 °C heat. But after increased pressure from human rights activists, the use of child jockeys was abolished.

Now, the tall, gangly mammals hurtle gracefully along the track egged on by robots.

The Qatari government was first to produce camel-racing robots. They contacted K-Team, a Swiss robotics company, who sent two zoologists, ten engineers and a designer to the Arabian Peninsula. There were three main problems to solve: the shock the robots had to withstand as the camels raced at over 60 km/h, the unforgiving desert conditions and the camel's reaction to the robots.

Initial test runs were less than ideal. Unused to robots, the camels became scared and often ran in the wrong direction. Thus later designs were made more human. The jockeys now possess a 'head' and a 'thorax', and have two 'arms' to bear the whip and control the reins. The thorax contains a processor, four microcontrollers and a sound board, all sitting on top of shock absorbers.

During the race, trainers speed alongside their camels in Land Rovers, armed with a joystick and buttons. These are used to manoeuvre the camel, control the force of the whip and observe the camel's speed and heart rate. Trainers can also communicate to their camel through a microphone; their commands are amplified through a speaker hooked to the camel's ear.

With the robot's weight whittled down to 3kg, camels have never raced faster. So for now it looks like they are here to stay. ■

PHOTO AND TEXT BY NATASCHA MEHRABI

BITCOIN\$

As the financial crisis in Europe continues, Julie Gould asks if Bitcoin could be the solution to our economic woes.



Mike Cauldwell (Casascius)

Before pounds and dollars, you could use solid gold in exchange for goods. There was a limited supply of gold, so its value was inflexible. When we started using the currencies we know today, their value was compared to that of gold; this was the Gold Standard.

But measuring currencies against the value of gold meant countries could not alter their own exchange rates – to make exports cheaper, for example. So, using political means, money became flexible. Fiat currencies now relied on a country's creditworthiness, meaning centralised banks could control national economies and fund the state, by yielding power over money, exports and people. And it's been that way ever since the start of the 20th century.

So for a currency that is still a speck on the global monetary landscape, it is amazing how Bitcoin shook things up in April 2013. The value of an individual bitcoin, which was at just over \$20 in February, rose to record highs of about \$250, before plummeting to below \$100 on 11 April. With all this excitement, *what exactly is a bitcoin?*

Bitcoin is an experimental digital currency that is only available on the internet. Like gold, it is finite (supply is capped at 21 million bitcoins) and decentralised meaning that, in theory, it should be free from meddling governments.

You can generate them yourself using a piece of software called a Bitcoin Miner (building on the gold metaphor), which works to solve an algorithm; if you're

successful, it pays you 25 bitcoins. But as more algorithms are solved, and more bitcoins are mined, how is this supply ever going to stay capped? As the number of mined bitcoins increases, the algorithm becomes more difficult to solve, thus levelling out the supply. You can also get some using regular currency: exchanges such as Mt.Gox allow you to buy bitcoins from people who already have some.

What can we use them for? Well, like any regular currency, you use them to buy things. For example, Bitmit is the eBay of the Bitcoin world, while Silk Road is popular for more illicit trades. There are even some brick and mortar places that accept them, such as the Kreuzberg area of Berlin.

So why use Bitcoin instead of traditional currencies? One of the advantages is that there is no middle man handling the transactions, ultimately making them cheaper. If you want to send someone bitcoins, you just send them. Transactions should also be more secure, since when you make a transfer, an electronic signature is added. After a few minutes, the transaction is verified by a miner, and permanently stored in a public network.

But for the governments, none of this is good news; they will start losing control of money, transactions, and people. As politicians are entirely removed from the Bitcoin monetary loop, it makes the currency all the more attractive.

But Bitcoin, unlike the fiat currencies, is not legal tender for paying debts. So why do we need it? It will have been difficult to miss that we're in a financial crisis; the banks in

Cyprus froze all accounts; no one is allowed to access their cash, and if the banks in Cyprus go bust, only €100,000 is guaranteed. With the current economic climate, this could potentially happen elsewhere in Europe. So what could become the norm is for people to convert their pounds or euros into Bitcoins, and then sell them for dollars, therefore escaping a financial crisis.

So could Bitcoin be the new gold? Without banks, middlemen and fees, it looks pretty good. If Bitcoin were to take off, could it potentially re-stabilise the international financial markets?

Right now, the only people using bitcoins are the hardcore miners, those who are fascinated by the technology, and those that detest the banking systems. Will more people become involved, or is it just gold for geeks?

If the demand does go up beyond its supply, it will force up the value of each bitcoin too. This will force the price of goods down over time. Could this inevitable destructive

deflation cause economic disaster? Economic disasters have been known to be associated with deflation, but so have benefits. Falling prices could encourage people to save instead of spend, and lend instead of borrow. And all the benefits listed above make it all rather attractive.

But there are still problems with this “virtual gold”. Your transactions are entirely irreversible, and uninsured. So if your bitcoins get lost in the digital ether, that’s it.

When playing the stock market, there is a technique called selling short, which enables someone to turn a stable market into a volatile one by selling a commodity before you own it. Bitcoin value can also be influenced using distributed denial-of-service (DDOS) attacks during a Bitcoin exchange. This is when a server that is receiving bitcoins is flooded with more junk-data than it can handle. The server is then not able to distinguish between the good data (your bitcoins) and the bad, junk data. Someone else can then come in, hack the system, and steal your bitcoins right from under your nose.

The changing value of any fiat currency, including digital ones, is speculative, and subjective. Even the price of gold, which (in theory) is in finite supply, could change overnight if a giant comet, made entirely of gold, came floating by.

But how much value would you put on a bunch of numbers that only exist where you can’t really see them? The only thing giving these bitcoins any value is people believing that they have value, which is exactly the same for fiat currencies. So in reality, all currencies have value because people have faith in them. In other words, people have faith in the government that they won’t keep printing dollars so that they become worthless. And sure, the same is true for gold, but with gold, you can make jewellery, which has its uses.

So should we all start mining and buying bitcoins? As it’s still an experiment for those who understand the Bitcoin system, I would only put in what you can afford to lose. If only the investors would follow this advice with fiat currencies! ■



THE FUTURE: A HISTORY

Flying machines, lasers and genetic engineering were once fictional fantasies. James Keen asks, will today's science fiction become tomorrow's science?

Hankind has wondered about its future for thousands of years. What will our planet, our societies and our species look like in years to come? Many visions of our future have either foreseen a utopia – an ideal society we can look forward to embracing – or a dystopia – an undesirable future that in its extreme will harm our lives and threaten our existence. These visions of the future may seem farfetched at the time, and many remain that way, but some predictions have come eerily close to realisation.

H.G. Wells, a renowned science fiction writer from around the turn of the 20th century, was one of the most prolific predictors of the future. In 1896 he wrote about a doctor who creates human and animal hybrids, thus envisaging genetic engineering over half a century before scientists showed that the concept was possible. In 1901 he predicted a future moon landing, an event that was not realised until 1969 with the Apollo 11 mission.

Wells's most famous science fiction novel, *The War of the Worlds*, was published in 1898 and featured many things which later became reality. The Martian 'Heat-Ray' weapon is a type of laser. While the scientific principles behind a laser were theoretically discussed by Einstein, it was not until 1960 that the first laser was produced. In the story, the Martians are defeated as the result of biological warfare, something that wasn't seen in real combat until the First World War.

Many past visions of the future expected that automation would eventually replace human beings with robots. This plays on both the ideal of not having to work to make a living and the fears of artificial intelligence becoming a risk to mankind. Contrary to these predictions, many people are still employed to undertake manual labour. Automation is playing an ever-increasing role, yet in an advantageous way, with no

“**WELLS'S MOST FAMOUS SCIENCE FICTION NOVEL, *THE WAR OF THE WORLDS*, WAS PUBLISHED IN 1898 AND FEATURED MANY THINGS WHICH LATER BECAME REALITY**”

signs yet of artificial intelligence posing any real threat to us.

Over half a millennium ago, Leonardo da Vinci sketched a design for a basic helicopter, which he called the 'Aerial Screw', and explained how he thought the flying machine would work. It was never built, but it promised a future where mankind could traverse the skies rather than stay on land. The term 'helicopter' was coined in 1861 and the first operational helicopter was developed in the 1930s, some 450 years after da Vinci thought up the idea. Nowadays, helicopters are much more developed and are a major part of air travel.

Time travel has always featured heavily in our predictions of the future. Wells first wrote about a time machine in 1895, and we continue to be fascinated by time travel to this day, as evidenced by the popularity of *Doctor Who* and films such as *Back to the Future*. While the scientific community has largely dismissed the possibility of time travel, there are scientists who are devoted to researching it. Time travel as portrayed in science fiction may seem unlikely, but modern day predictions of the future still include it as a possibility.

Space travel and exploration are also common themes in futuristic predictions, usually spurred on by one of two things: the search for extra-terrestrial life, and the feeling that humans should branch out from Earth in order to ensure our prolonged survival.

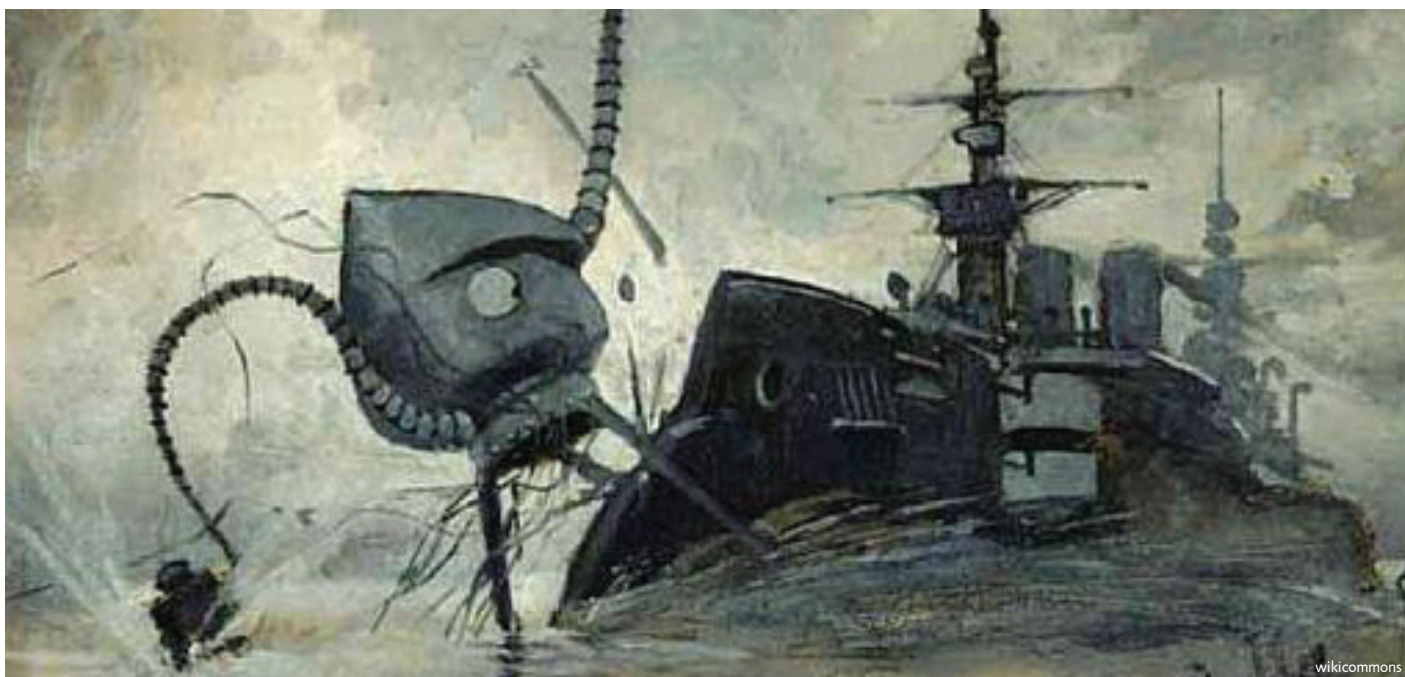
Yet here at the start of the 21st Century, space travel is still relatively primitive and very costly. Mankind has journeyed to the

moon and inhabited orbiting satellites such as the International Space Station, but we've yet to venture further. Missions to Mars are underway, and missions to other planets in our solar system are planned for the near future, but these are far from the visions of accessible space travel for all. Our current technology is simply unable to transport us vast distances in reasonable times, making space travel impractical. There is a ray of hope, however: NASA and other space agencies are researching ways to make everyday space travel possible, so it is not inconceivable that we may head for the stars in the near future.

Of course, visions of our future are not always positive. Many foresee the cataclysmic decline of society or even the downfall of the human race itself. These bleak views play on our fears, yet are compelling and often promote a change to our attitudes and our ways of living. George Orwell's famous novel *Nineteen Eighty-Four* depicts a state that constantly monitors and controls its citizens' lives. With the invention and widespread use of CCTV, it's easy to see how some people think this prophecy might become a reality.

So what of our modern-day predictions for the future? The UN has predicted that

the worldwide population will increase, partly due to increased life expectancy, to an estimated peak of 10 billion people. This will worsen the problems of food shortages and strains on resources. Fossil fuels, such as coal and gas, will have been used up. Nuclear fusion will likely have been developed, providing us with a new energy source. Improved travel will enable us to commute anywhere around the world in just a few hours. We may have visited Mars, colonised the moon and have begun to venture deeper into space. Our world, once thought vast by our ancestors, continues to become a much smaller place to be. ■



EYE SCIENCE

The first wave of retinal prosthetics can return some sensation to the eyes of blind people. But in future could we restore realistic vision? Josh Howgego takes a look.



Heikki Tetho sits in a darkened room with a camera observing his every move. The table in front of him is covered in black felt and on it are two objects. “The one on the left looks kind of round,” says his voice from behind a pair of large, heavy-looking goggles.

“Don’t touch it yet,” says a voice from off screen. “What about the one on the right?”

“That one looks a bit like it’s curving, like this,” says Tetho, gesturing with his hand. “Actually I think it’s a banana.”

The sound of applause erupts. “Well, that’s what it looks like,” announces Tetho. He has just seen and picked up a piece of fruit – yet only a month ago he was blind.

Tetho, 46, from Finland, was wearing a retinal prosthesis constructed by German company Retina Implant AG. His results were some of the best the trial saw. Since then these bionic eyes have been gaining popularity: the ‘Argus II’, a similar implant manufactured by US company SecondSight, was given the stamp of approval by the US Food and Drug Administration earlier this year.

These implants work by mimicking the photoreceptor cells found in our retinas. In many cases of blindness these light-sensitive cells have stopped working, but the nerves in the retina that communicate with the brain remain intact. The implants effectively take over this role by sensing light and stimulating the nerve cells.

The implant is most often positioned on the back of the eyeball rather than inside it, which means the surgery required is less risky. A camera worn on the patient’s head then beams visual information to the implant and each pixel of the array responds by stimulating the nearby nerve cells. Patients fitted with the devices end up ‘seeing’ in white dots and flashes – essentially what sighted people experience when they rub their eyes. These flashes are grouped into shapes and that’s what Tetho could see when he identified the curve of the banana.

“It’s not really fair to call this ‘seeing’ though,” says Konstantin Nikolić, a researcher at Imperial’s Department of Electronic and Electrical Engineering who studies retinal prosthetics. “What they’ve achieved so far is fantastic, but we have to be honest and say: ‘that’s not proper vision.’”

Nikolić cites an example of a clinical trial conducted in 2012 where patients were fitted with implants and tested on their ability to point out a white square on a black background. 96% were better at locating the square when their implant was switched on, compared to when it was switched off. Yet when the same patients were asked to say which way a white line moved across the black background, only 57% showed any measurable improvement with the prosthesis. This sensitivity is enough to enable blind people to write their name and make out the kerb as they’re walking along a street. But Nikolić says he’s not satisfied with stopping there. He is part of a small group of scientists who want to

“IF THE PROMISE OF OPTOGENETICS COMES TRUE, A SINGLE INJECTION COULD BE A PERMANENT END TO MANY TYPES OF BLINDNESS.”

build prosthetics that can restore more life-like vision. The situation is finally starting to look hopeful, but there have been many hurdles in their path.

For one thing, when light hits the eyes' light-sensitive cells, the process that transforms that light into a signal is complicated. The eye is not like a digital camera where pixels simply record the light that hits them: at least three types of cell modify the signals before they are sent to the brain to be constructed into a picture. These cells don't have linear connections to one another, but fan out in intricate patterns that aren't easy to understand or predict.

In addition, the photoreceptor cells in the central part of the retina are so tightly-packed, that even the most advanced artificial retinas cannot match their resolution. One pixel on the electrical implant could cover hundreds of nerve cells. That means a single pixel would activate many neural pathways, resulting in a blurred picture.

There's another reason why pictures aren't as crisp as real life. Because most systems are situated behind the eyeball, the visual data has to be sent to the implant

using wireless signals. But at the same time electrical power has to be beamed to the array. These two electrical fields can interfere with each other leading to confused information transfer.

As an engineer, Nikolić has been focusing on solutions to these practical problems, but lately he has become excited about a completely new approach to repairing vision.

The idea began in 2003, when Georg Nagel of the Max Planck Institute for Biophysics, Germany, discovered a new protein in a species of green alga. This protein, called channelrhodopsin-2 (ChR2), allows charged particles to enter the algal cells, but only if exposed to light. This discovery created huge excitement as it resembles the way that light triggers photoreceptors to send chemical signals to our nerve cells.

“In our eyes we have photoreceptor cells – which are light sensitive – and then we have ion channels, which are separate,” explains Nikolić. “But with the ChR2 you have a sensor and an ion channel all in one.”

In 2005, Nagel teamed up with colleagues from Stanford University and showed it was

possible to splice ChR2 into nerve cells. When light was shone on the cells they would emit neural signals – and the response was accurate to within thousandths of a second. Now scientists are hoping that this technology, known as optogenetics, could bypass all the complex machinery of the eye and confer realistic vision. The idea would be to transfer the genes into retinal nerve cells with an injection and make the nerve themselves responsive to light.

A start-up company in Paris called GenSight, fronted by Nikolić's colleague Botand Roska, is now experimenting with this very process. The difficulty is ensuring that the gene is transferred only to the cells where it's needed – and making sure it stays there. It wouldn't do for patients to end up with teeth or thumbs that fire signals to the brain in response to sunlight.

For blind people like Miikka Tetho this will be an exciting prospect. The current prosthesis models offer blind people the chance to make out the silhouette of the kerbside. But if the promise of optogenetics comes true, a single injection could be a permanent end to many types of blindness. This would be no world of white flashes; in the future blind people might see in colour. ■

THE DNA TREASURE TROVE

The challenge of studying long-dead species could have a surprisingly simple solution. Alex Gwyther looks at the emerging field of museomics.

“THE TEAM
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Consisting of over 60 different species, guenon monkeys are one of the most diverse groups of primates. Most are medium-sized with long tails, and many sport distinctive beards and whiskers. Their colourful facial patterns have prompted some to refer to guenons as birds among the primates.

Guenons belong to the tribe Cercopithecini and include vervet monkeys, red-tail monkeys and lesser spot-nosed monkeys. They split from the tribe Papionini – another primate group that includes baboons, macaques and mandrills – about 12 million years ago.

Previous studies into the guenon family tree have been hampered because it is hard to collect DNA samples from living monkeys. Some guenon species are kept in captivity, but many are endangered in their natural African forest habitat, making them hard to find and difficult to acquire permission to work with.

Now a team of researchers has overcome these obstacles by analysing DNA collected from monkey specimens held in museums.

The team was led by Professor Vincent Savolainen, from the Department of Life Sciences at Imperial College London. In a new study, published in *Systematic Biology*, they described how they used an advanced DNA sequencing technology to evaluate the evolutionary relationships within the guenon group.

Rather than collecting samples from live animals, Dr Katerina Guschanski, the main author of the paper, extracted DNA from 120 museum specimens from four different museums: the Natural History Museum in London, Berlin's Museum für Naturkunde, Belgium's Royal Museum for Central Africa and the Royal Belgian Institute of Natural Sciences.

Professor Savolainen's team was able to untangle a previously unsolved puzzle of when different guenon species evolved and how closely related they are to each other. They concluded that many new species of the monkeys evolved following changes in the African forest cover over the last 10 million years. They also provided the first evidence that some of the species could be the result of separate species interbreeding to produce hybrid species.

“These changes in forest cover isolated small groups of guenons in pockets of forest, where they eventually developed into separate species. In other cases, expansion of forests meant different species would be brought together and interbreed to create a new hybrid species,” he explained.

Dr Guschanski also used the data to identify when and where new species evolved and compared this to a timeline of climate changes in Africa. Professor Savolainen believes the research might help future conservation efforts.

“We learn from the past what might happen in the future to guenons and other monkeys as the size and shape of the planet's forests change,” added Professor Savolainen. “It will certainly allow us to refine models of how animals disperse and potentially move into pockets of conserved forests, and possibly how they are going to respond to climate change.”

The ability to analyse DNA collected from museum specimens is relatively new science, known as ‘museomics’. The term was first coined in 2007, when Dr Stephan Schuster, a molecular biologist at Pennsylvania State University, reconstructed most of the woolly mammoth genome using hair samples that had been kept in a Russian museum for 200 years.



Jason Coleman

Since then, the genomes of a number of animals have been sequenced using museomics, including woolly rhinos, polar bears and Tasmanian devils.

Museomics owes much of its success to “next – generation” sequencing – the name given to a range of new DNA sequencing technology, able to analyse thousands of DNA sequences at once. According to Dr Schuster, the technology’s rate of development is actually outpacing Moore’s Law: the prediction that computing power doubles every two years.

As a result sequencing costs are dropping rapidly. Dr Schuster explains that sequencing the guenon monkeys might have cost around \$36,000 a few years ago.

Now it costs only a few hundred dollars.

“I think this study really demonstrates the power of museomics in mainstream genetic research,” said Dr Schuster.

Professor Savolainen’s team found that any part of the specimen could be used – whether skin, skeleton, skull or teeth – and that DNA sequences could be successfully collected from samples as small as 10 milligrams and from specimens up to 117 years old.

And Professor Savolainen believes museomics’ application goes much further. “We made the point that it will unlock museum collections so people could now sequence the whole of the tree of life just

using the collection at the Natural History Museum,” he said.

A major advantage of sampling museum specimens is its ability to offer a snapshot through time of a species’ genetic diversity. Dr Schuster says that museomics enables the analysis of diversity either side of population bottlenecks, or just before species go extinct.

He also explains that breeding genetically diverse individuals is essential for conserving species. Museomics can help perform broad scans across species. In this way we can identify especially diverse populations and bring them together to improve the chances of species survival. ■

FEARLESS

*What would it be like to live your entire life without feeling fear? It's not all plain sailing, says **Laurence Pope**.*



“You asked me once, what was in Room 101. I told you that you knew the answer already. Everyone knows it. The thing that is in Room 101 is the worst thing in the world.”

Room 101, from Orwell's *Nineteen Eighty-Four*, contained everyone's worst fear. For the protagonist Winston Smith it was rats. For others it might be as sensible as snakes, or as bizarre as flowers. Say what you will, but everyone has some sort of fear.

Or do they? In the United States a woman, known only as S.M., has Urbach-Wiethe (UW) disease, an incredibly rare genetic disorder with only 300 or so cases recorded in medical literature. One of the symptoms in UW disease is the destruction of the amygdalae, almond-shaped groups of nuclei embedded within the brain.

The main impact of this destruction is the complete absence of fear within patient S.M. A group of scientists attempted to scare her with, amongst other things, poisonous snakes and arachnids, horror films and haunted houses. But they couldn't perturb S.M. Only recently have researchers found something that does trigger a fear response in UW sufferers: high concentrations of carbon dioxide in the blood. The fear of suffocation, simulated by breathing in high quantities of carbon dioxide, prompted the patients to feel fear for the first time in their lives. This suggests that the amygdalae, whilst important, are not exclusively the domain of the fear response.

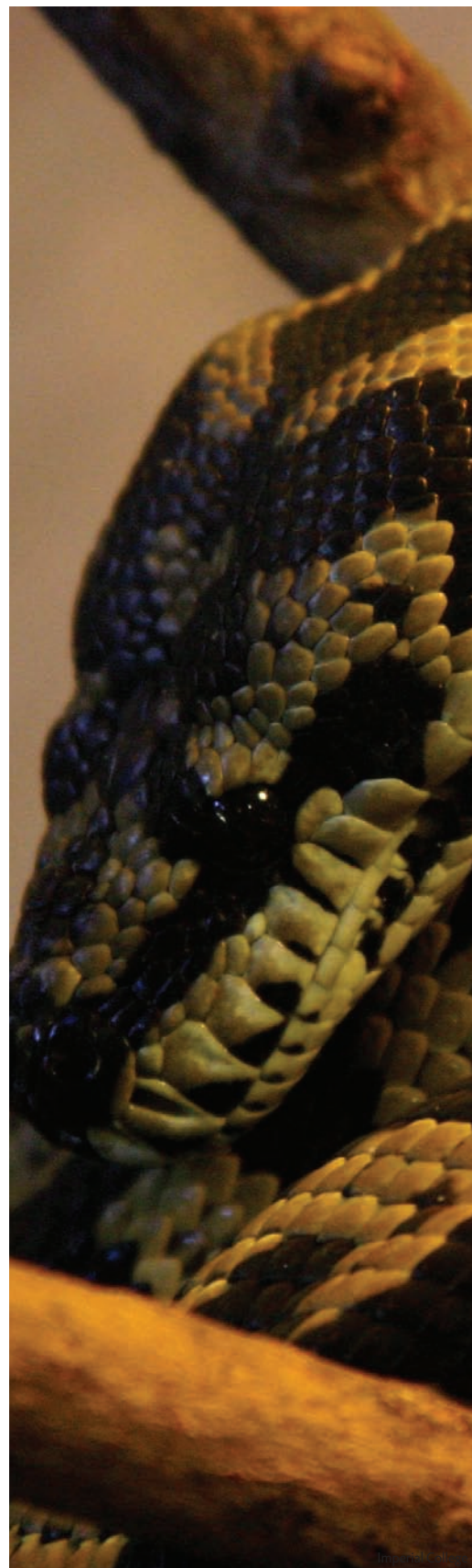
However unpleasant fear may be, S.M.'s case highlights the role it has to play in human evolution: S.M.'s

lack of fear has led her to handle dangerous animals that most sane people would seek to avoid. Just as pain is a protective mechanism to stop us from inflicting further damage upon ourselves, fear probably prevented early humans from running headlong into danger. Fears of snakes, spiders and other such creatures is likely a throwback from those times, and partly explains why people still display seemingly irrational fear responses towards harmless European animals.

But what if, using knowledge from S.M. and other UW sufferers, we could 'shut off' fear? Could we create super soldiers capable of fearlessly charging into battle? Or fire fighters who run headlong into burning buildings? Despite the damage to her amygdala S.M., is otherwise normal, so selectively dampening or even eliminating fear in this manner could prove extraordinarily useful.

Such an on/off switch would have to be carefully controlled. As handy it might be, a complete lack of fear also means no longer fearing death. Already servicemen, fire fighters, and those in other high-risk occupations put their lives on the line. Hypothetical users of a fear switch would have to accept that their lives would be placed at even higher risk.

But controlling fear is still some way off. As the case of S.M. shows the amygdala plays a large role in controlling fear, but its function would need to be clearly understood before it could be efficiently turned on and off 'as needed'. In the meantime you'll just have to man up and ignore that innocent garden spider in the corner of your room. The little guy isn't going to hurt you. ■



TECHNOLOGY: THE VOICE OF DOOM?

Nick Kennedy shares his thoughts on the darker side of modern technology.



um reveals clever £5 wrinkle trick that is making Botox Doctors furious!" This message, along with two mug shots (haggard mum, nubile mum), leapt out of an online dictionary. Later, I was listening to a You Tube mix when, straight out of the cyber blue, a clipped voice began: "The best way to overcome chemo..." I got back to deleting emails because someone out there thinks I need Viagra – and to transform my penis into a Neanderthal's club. I emailed back assuring them that I didn't need (couldn't afford) their wares.

That evening, at Kilburn station I noticed a poster: a stickman showing how feasibly you could slip under an oncoming train. This was sandwiched between two photographs of "dead" children. Their glazed eyes locked into mine. Never look at your phone when crossing the road. On the train I read that playing the trumpet could give you a stroke. And that Andrew Marr blamed a rowing machine for his.

As I alighted, an elderly man pointed at me from the safety of an NHS billboard. "Hey you. Looking at this poster remember to check your poo." OK, thanks. Now? And check your grammar.

Ceaselessly, we get bombarded with messages of risk. Technology is used to boost the assault. It has created a soil pipe through which alarmist flux can pass. Life has its gristly underbelly, we all know that. For every good there's a bad, life's a sort of yin-yang dualism. But we are repeatedly made aware of the bad, the shadow, the yang. And learn little about the light.

Consider Japanese loos. Researchers in Japan have created a toilet sensor that measures the user's blood pressure and sugar levels and even chemicals that indicate cancer risk. The data is automatically sent to the local GP. This is incredible, but unnerving. The toilet is a point of refuge, a plop-plopping hiatus from the external pressures of life. I don't want to keep craning round to see if there's some beacon flashing its death signal.

I am not advocating a world devoid of medical and safety advice. Of course it's in our best interest not to smoke or do acrobatics on the escalator at Waterloo. But it's becoming a plague. Technology is running rampantly ahead. Some of us cannot adjust in time. Anxiety channels have opened that we don't know how to shut. I mean, take this sugared espresso steaming before me. It's is no mild pick-me-up. It's a cornucopia of ills: missed heart beats and migraines, diabetes and farts.

Do these negative thoughts build up in the subconscious? Could they bubble up in paranoiac urges? Probably not. A study from University College London has shown that the brain is better at processing positive news than bad. Apparently some of us – particularly the 14 people involved in the study – simply shun negative thoughts.

But reminders that we will all perish are certainly not conducive to buoyant spirits or fun.■



BrainWashers

ALMA: THE SOUL OF ASTRONOMY

After 18 years of hard work, the world's largest observatory has finally been inaugurated. Eliette Angel talked to Paulina Bocaz, ALMA's Executive Officer.

Con 13 March 2013, ALMA (Atacama Large Millimeter/submillimeter Array) was formally inaugurated. Located 5,000 metres above sea level and in the middle of one of the driest places in the world, ALMA – which in Spanish means ‘soul’ – will study the cold and distant Universe.

Multiple radio antennas – whose dishes measure either 12 or 7 metres in diameter – behave as a single telescope with a total diameter of 16 kilometres. In fact, ALMA is more powerful than the orbiting Hubble telescope, allowing it to perform delicate interferometry experiments. In such experiments several antennas work in perfect synchrony, observing the cosmos to a precision of one millionth of a millionth of a second.

The size of this project – and its £660 million price tag – required many partners to work together: Europe (the European Southern Observatory, including the UK), North America

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(Canada and the USA), and East Asia (Japan and Taiwan), in co-operation with the Republic of Chile. The antennas, each weighing around 100 tonnes, can ‘walk’ thanks to two custom-built transporters, Otto and Lore. These allow astronomers to arrange the antennas in different configurations, effectively changing the zoom level of the resultant image.

Although ALMA released its first images in October 2011, the official inauguration ceremony was celebrated in March 2013 at ALMA's Operations Support Facility (located ‘only’ 2,900 metres above sea level). Here, authorities and scientists from around the world greeted this new astronomical tool.

“This is an example of the great achievements that become possible when institutions and nations pool their efforts... Applying this on a global scale by partnering up in such a great project, we are giving the astronomers the possibility of doing the unique research that is only possible with ALMA,” commented Tim de Zeeuw, ALMA's former director. ■



Raul European Southern Observatory

INTERVIEW WITH PAULINA BOCAZ

Why is ALMA located in Chile?

"The sky in the Atacama Desert is so clean, because of the lack of moisture and light pollution, that when you see the sky you are able to distinguish [it] as a relief and not simply in two dimensions as in other places."

What does this observatory aim to discover?

"ALMA will try to better understand star and planet formation and will be able to get close to the Big Bang as well. But also we are expecting to make unforeseen discoveries and that is really exciting. This is a powerful instrument pointing upwards."

“ALMA HAS ALREADY OBSERVED ANCIENT STAR FACTORIES, FOUND STARS FORMING CLOSE TO A SUPERMASSIVE BLACK HOLE, AND DISCOVERED SUGAR MOLECULES AROUND A YOUNG, SUN-LIKE STAR”

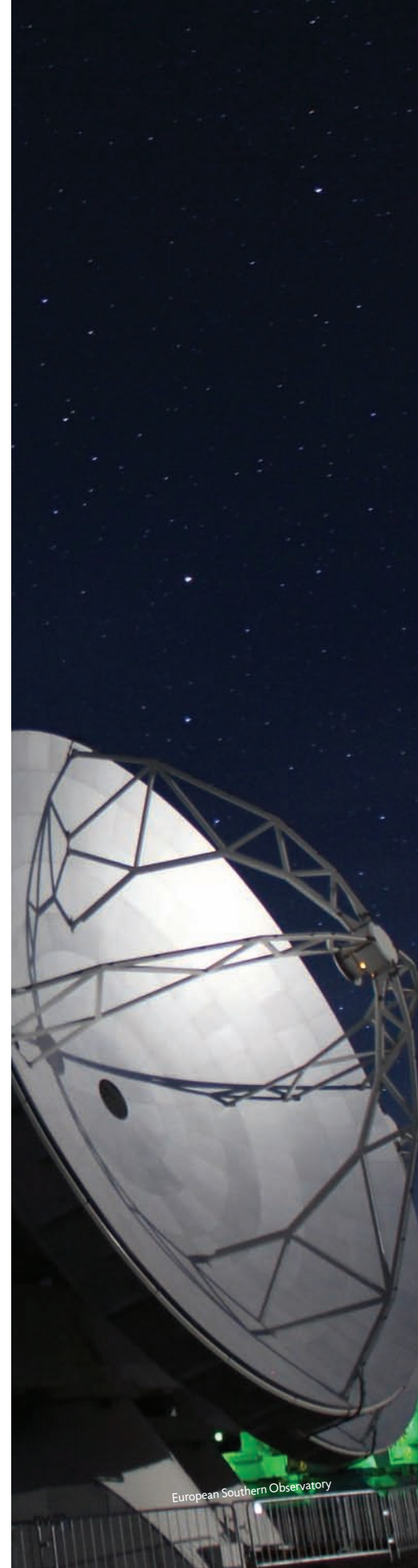
Indeed, ALMA has already made important discoveries such as the observation of fertile star factories in the infant universe, 12.8 billion years ago; the first detection of star formation close to the supermassive black hole at the centre of the Milky Way; and the presence of sugar molecules (glycolaldehyde) in the gas surrounding a young, Sun-like star. One-tenth of ALMA's time is reserved for astronomers working in Chilean institutions with the remaining 90% available to the rest of the world.

ALMA is located on the Chajnantor plateau, very close to the San Pedro de Atacama and Toconao indigenous communities. Some days before ALMA's inauguration, the observatory held an activity with these local communities – how was that?

"We went to make a payment [an offering of coca leaves, among other symbols] at 5,000 metres above sea level. Members of the community thank the Mother Earth and ask both for the community welfare and for the observatory's success. That was a great honour for us and a signal of respect [to the indigenous community]."

And what about the UK's participation in ALMA? The 'Front End' is the first element in a complex chain of signal receiving, conversion, processing and recording of this observatory. This system is designed to receive signals from ten different frequency bands, from 0.3 mm (band 10) to 9.6 mm (band 1). To coordinate this massive task, ALMA created three Front End Integration Centres: one in the USA, another in Taiwan and the third in the UK, located at the Rutherford Appleton Laboratory.

Bocaz explained that this latter laboratory delivered the last 26 units to Chile at the beginning of this year, completing the 70 receivers that ALMA needs to work, just in time for the inauguration.



BIOTECH BEASTS

*Frankenstein's Cat: Cuddling Up to
Biotech's Brave New Beasts*
Emily Anthes
Oneworld Publications (2013)

Dolphins with prosthetic tails, spy beetles armed with robots, resurrected pets from frozen DNA... You name it, they're doing it. Scientists from all over the world have been creating animals that fit our whimsical needs. But should we have the power to play god and invent the fauna of the future? And where do we draw the line? What if a mouse could be engineered to prevent it from feeling pain – would this mean animal testing was no longer an issue?

Travelling around the world, Emily Anthes, a journalist and popular science writer, takes the reader on a journey to find out just how humans are inventing biotechs: new beasts from Dolly the sheep, to clones of an endangered mountain lion, to a 'pharm' where chickens are modified to lay eggs laced with cancer-fighting drugs. *Frankenstein's Cat* is truly an eye-opening exploration of weird science.

On her journey from petri dish to pet store, Anthes catalogues the wide variety of science's funny and furry beasts that might one day become commonplace in society. That is if governments, animal activists and the public can decide what should and shouldn't be allowed in the world of genetic engineering, and what these animals can be used for.

Indeed, throughout the book Anthes explores the ethical and philosophical dilemmas that accompany such research. "There are no easy answers to the ethical dilemmas that biotechnology can pose," she writes. Not only that, but she makes us question our reasons for doing so: what does this tell us about human nature?

It is a compelling read full of strange surprises, with great personal insight and a very touching sense of humour. ■

JULIE GOULD

FOOD FOR THOUGHT

*Gulp: Adventures on the Alimentary
Canal*
Mary Roach
Oneworld Publications (2013)

Only a lucky few have had their arms squeezed by the stomach of a cow. Mary Roach is one of them. She didn't just put her hands "up" the cow; she went straight into its stomach through a fistula – a small hole – straight into its side.

This experiment is just one of the ways that Roach explores the ins-and-outs of our ins-and-outs. She also introduces us to some of the more colourful characters in digestive science, such as the "archbishop of roughage", John Harvey Kellogg, who maintained that a "healthy colon" should empty itself four times a day, assisted by platefuls of Kellogg's Corn Flakes.

Roach also looks at our reactions to our own bodies: how as consumers, we are happy to spend hours preparing our meals, but to speak of what happens to them once they start their trip down the alimentary canal, is "as much taboo as mating and death."

Amongst all the humour, it is sometimes easy to forget that the alimentary research can help thousands, if not millions of people with diseases every day. So even if fecal transplants may not sound all that great, they have been able to restore people back to normal toilet habits.

With insatiable curiosity, Mary Roach has managed to take the reader on an incredible journey that she herself has taken; meeting the researchers, patients and animals that all helped in the discovery of how our gut, the mystery that lies between our mouths and ... our butts, works. This is one book that will make you laugh out loud and cry out in disgust in one sentence. ■

JULIE GOULD



STELLAR PHOTOS

The Cosmic Gallery: The Most Beautiful Images of the Universe
Giles Sparrow
Quercus (2013)

Some stories can't be told with words. When it comes to the story of the universe, Giles Sparrow trusts the only thing that truly seems fitting for such a cosmic story: photographs.

Space-lovers will fawn over the intricacies of the universe that each picture showcases. From photos of the rainbow layers of a ring nebula, to the yellow rays of sunlight that lick the outline of Venus during its transit of the Sun, Sparrow shows readers the majesty of our celestial backyard in extreme detail.

Beyond being intricate, the 100 images printed in the book are visually intoxicating. Photographers will be stunned by the clarity and dignity with which Sparrow provides snapshots of our cosmos. They will also garner details about how the photo was taken and who took it.

Though the book is mostly made up of photographs, this is not to say there isn't text amongst the quixotic beauty displayed in the book. Science nuts will delight in the details provided by the text that accompanies each image. In addition to providing a fact box that succinctly breaks down what is being shown in the photo, along with a few quick numerical details about the celestial object, the text splits the book up into six thematically organized chapters. Each chapter expands on an aspect of our galaxy while providing interesting galactic, historical and social information to set the backdrop for each exotic image.

Whether you want to peruse the book while sitting in an armchair on a rainy day or use it to learn about the majesties in our universe, *The Cosmic Gallery* is a book that should adorn every bookshelf or coffee table. ■

ROSEMARY PETERS

MONSTER MYTHS

The Science of Monsters
Matt Kaplan
Constable (2013)

Matt Kaplan's debut book takes his audience on a magical but educational voyage, taking in the Minotaur, werewolves and giant squid (to name but a few). If you spent your whole childhood speculating as to whether these fantastical creatures were myths or whether they really did walk the Earth, Kaplan is here to scientifically speculate. By using explanations drawn from ancient history, folklore and popular culture he examines how these tales have developed over time.

Kaplan begins his chapters with concise and thoroughly researched explanations of the status of the myths today before delving into all potential possibilities as to how they became components of bed-time stories and Hollywood films.

Although slightly stretching to make theories connect at times, Kaplan links the various theories together through what appears to be extensive research. He explains our fears of giant lions through psychology, and points to catastrophic floods as the cause of 'two-headed beast' fossils that seemed beyond biological explanation. Geology even comes into it when Kaplan explains how the tales of the Minotaur roaring in the Labyrinth arose at a time when Crete was renowned for its earthquakes.

A personal favourite: Kaplan's chapter on vampires, zombies and werewolves supplies a scientifically magical and biomedical possibility for the popular and chilling fable of zombies, which opens up the reader to explanations they may never have even considered.

He uses clear enjoyable language throughout, using footnotes both to add light humour and to confirm that he has definitely done his background reading.

This is a fascinating and engaging book that exceeds its expectations, and can be read and enjoyed by even novice 'monster experts'. ■

CHRISTINA CLARK



