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*Federal of Small Businesses, referenced by Jeremy Hunt, Media keynote speech, 8 June 2010. **Getting up to speed: making superfast broadband a reality, NESTA policy briefing, January 2009. The speed to upload 30 photos is based on each photo being 2MB (60MB total file size). 8 times faster is based on BT Infinity for business Option 2 maximum speed and UK average broadband speed from Ofcom report, August 2012. Broadband speed can be affected by a number of things: how far your business is from the fibre cabinet as well as the wiring in your building. Not all lines in an Infinity-enabled area can support the service. BT Infinity for business may require a BT line or similar and a fibre compatible router such as the BT Business Hub provided with Infinity. Terms and conditions apply. The speeds provided by BT Infinity for business are more consistent than standard broadband, giving you prioritised traffic with 16Mb assured throughput at 90% of the internet busy period. You’ll need to be in range of a BT Wi-fi hotspot, have a wireless device and register for BT Wi-fi. Our Fair Use Policy and terms and conditions apply. £1.15 a day is based on BT Infinity for business Option 2 for £35 a month on a 24 month contract.
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The closing date is 23:59 GMT on 5 February 2013
A shot at the truth

Scientific evidence on gun violence has been suppressed for too long

LOVE it or loathe it, there is no denying that the US National Rifle Association (NRA) has been stunningly successful in its efforts to fight gun control. In the 1990s, it even managed to largely shut down US government research into gun violence as a public-health problem – an unbelievable situation that still stands today.

This is why President Obama’s clear instruction to the Centers for Disease Control and Prevention to initiate research into reducing gun violence is important and necessary (see page 6).

It is only the first step. Deciding whether to fund the research will be down to Congress, where the NRA’s influence still holds strong.

If the NRA succeeds in blocking this attempt to bring science to bear on America’s gun problem, it will be another demoralising example of the power of money over evidence-based politics.

The NRA presents itself as a civil rights group dedicated to upholding and defending the Second Amendment to the US Constitution – the one about the right to “keep and bear arms”. The gun lobby interprets this as an inalienable individual right to own guns.

“The National Rifle Association’s strangle of research is utterly reprehensible”

Although the NRA was founded on this platform, it is important to recognise that it has strong links to the firearms industry, which supplies it with millions of dollars in funding.

Viewed from this perspective, the NRA’s strangle of research is utterly reprehensible. Imagine if a group associated with food manufacturers were able to curtail research on obesity, or if tobacco interests had nixed the science that tied smoking to lung cancer.

Hopefully we will now get some fresh answers on the best approaches to preventing gun violence. But if this knowledge is to be acted on, politicians and the public on both sides will need to abandon entrenched positions.

Liberal opponents of the gun lobby often assume that the answer lies in tougher restrictions on ownership – but that isn’t necessarily where the biggest gains could be made.

Advocates for gun rights must accept that public-health researchers aren’t the stooges of a sinister bureaucracy intent on seizing their guns. They are professionals trying to use the scientific method to save lives. They should be set free to do this work, and then listened to.

DNA secrets? Don’t flatter yourself

Imagine donating your DNA to a project aimed at discovering links between genes and diseases. You consent to your genome sequence being released anonymously into the public domain, though you are warned there is a remote possibility that it might one day be possible to link it back to you.

A few years later, that remote possibility comes to pass. How should you feel? This is no longer a hypothetical scenario. About 50 people who participated in a project called 1000 Genomes have been traced (see page 8).

The researchers’ intentions were honourable. They have not revealed these identities, and the original data has been adjusted to make a repeat using the same technique impossible. All they wanted to do was expose privacy issues.

Consider them exposed. It is clear that genomics has entered a new phase, similar to that which social media went through a few years ago, when concerns were raised about people giving away too much personal information.

What happens when the same applies to our DNA? Having your genome open to public scrutiny obviously raises privacy issues. Employers and insurers may be interested. Embarrassing family secrets may be exposed.

But overall, personal genetic information is probably no more revealing than other sorts. In fact there are reasons to believe that it is less so: would an insurance company really go to the trouble of decoding a genome to discover a slightly elevated risk of cancer or Alzheimer’s disease?

The available evidence suggests not. In 2006, Harvard University set out to sequence the genomes of 100,000 volunteers and make them publicly available, along with personal information such as names and medical records. One of the goals was to see what happens when such data is open to all. The answer seems to be “not a lot”. So far this Personal Genome Project has published 148 people’s full genomes. Not one volunteer has reported a privacy issue.

This is not a reason for complacency, but it suggests that our genomic secrets are less interesting to other people than we might like to believe.
Next stop: climate action

AT LAST, the US looks set to tackle climate change head on, following promises this week by President Barack Obama to put it centre stage in his next term as president. “We will respond to the threat of climate change, knowing that the failure to do so would betray our children and future generations,” he said on Monday in his inaugural address to the nation.

With the horrors of superstorm Sandy a fresh reminder that extreme weather events are becoming more frequent - a trend predicted by climate models - Obama sniped at Americans who still deny that human activity is to blame. “Some may still deny the overwhelming judgement of science, but none can avoid the devastating impact of raging fires and crippling drought, and more powerful storms,” he said.

Obama flagged a transition to cleaner energy as an economic opportunity, one that would be lost to other nations unless the US stepped up. “The path towards sustainable energy sources will be long and sometimes difficult, but Americans cannot resist this transition, we must lead it. We cannot cede to other nations the technology that will power new jobs and new industries,” he said. “We must claim its promise.”

Environmental groups responded enthusiastically. “President Obama’s clarion call to action on the threat of climate change leaves no doubt this will be a priority in his second term,” says Alden Meyer of the Union of Concerned Scientists.

Higgs on Twitter

IT’S official: Higgsteria was real. That is the message from an analysis of Twitter traffic around the time the Higgs boson discovery was announced last July.

The analysis – of more than 1 million Higgs-related tweets – forms a neat reflection of mounting real-world excitement, starting with rumours and eventually erupting into a buzz of global Higgsteria. It might even help marketers predict how news about products will fly on Twitter.

The discovery of the boson, or at least something very much like it, was the biggest science story of 2012. Mirco Musolesi of the University of Birmingham, UK, and colleagues, who study the relationships between social and geographic networks, saw it as an opportunity to gather data.

On 1 July, when rumours were already emerging of a particle discovery, the researchers began collecting tweets containing the words “higgs”, “cern”, “boson” and “Higgs”. They continued beyond the announcement on 4 July at CERN, near Geneva, Switzerland, right up until 7 July. The rate of tweets per hour on 1 July was just 36. It peaked at about 36,000 an hour on 4 July.

Predictably, the CERN Twitter account got the most retweets. Second place, however, went to Colin Eberhardt, a software consultant who has relatively few followers. He struck a nerve with this, most retweeted, tweet: “Possibly the biggest scientific discovery of our time, the #Higgs boson, announced in glorious MS Comic Sans Font” – a nod to the odd choice of font used by one of the two experiments that discovered the particle. *New Scientist*’s Twitter account was narrowly beaten to third place by that of TV presenter and physicist Brian Cox.

Musolesi’s team also used the data to create a model that uses the number of new tweeters at a given time to predict future numbers, a pattern that could be very useful to marketers.

Asteroid race

ONCE a wacky idea, commercial asteroid exploration has become a race, with the launch of a second company focused on mining near-Earth space rocks.

As *New Scientist* went to press, Deep Space Industries of McLean, Virginia, was preparing to announce a “fleet of asteroid-prospecting spacecraft”. It said it was “pursuing an aggressive schedule and plans on prospecting, harvesting and processing asteroids for use in space and to benefit Earth”.

Planetary Resources of Bellevue, Washington, launched last April with a similar mission: to send space telescopes to spot asteroids bearing precious metals, and to mine the best candidates. It took a step towards this goal on Monday, unveiling a prototype asteroid-hunting telescope, Arkyd 100.

“Having competition is generally good and it also validates the market,” says Alan Stern, a former NASA scientist now working with several commercial spaceflight firms.

Canada gets its maples mixed

IS THERE a botanist in the house? Canada’s new $20, $50 and $100 bills appear to have the wrong maple leaf on them.

Instead of a sugar maple leaf, one of the nation’s best known symbols, the bills feature the Norway maple, a native of Europe that is so invasive in North America that some US states have banned its sale and importation.

The leaf shown on the banknotes has five major lobes, unlike any maple tree native to Canada, while the sugar maple has just three lobes, says Julian Starr, a botanist at the University of Ottawa.

The Bank of Canada says there is no error. Since no maple is native to the whole of Canada, the designers chose a “stylised blend” of leaves to avoid regional bias, says Julie Girard, spokeswoman for the bank. “This way it’s representative of all of Canada,” she says, adding that the bank even consulted a tree specialist to avoid species bias.
**Planet and pension**

SAVE the planet, save your pension. A new report claims that environmental problems could bust pension funds by 2050.

Aled Jones of Anglia Ruskin University in Cambridge, UK, and his colleagues drew together evidence about a wide range of environmental problems, from water shortages to atmospheric pollution to climate change. They plugged these into models used to predict the values of pension funds.

Jones ran several scenarios, varying how quickly governments and industry responded to environmental problems. The results are published by the UK’s Institute and Faculty of Actuaries (IFA). In almost all cases the value of funds began to fall before 2100. In the worst-case scenario, where governments and markets did nothing, values dropped steeply from around 2020 and fell to zero by 2050.

“Despite strong evidence that there is a risk that resource constraints could have significant economic impacts, these risks are not being factored in by many actors in the global economy,” says Peter Tompkins of the IFA.

**So long, mercury?**

THIS crackdown has a few cracks in it. Environmentalists have criticised loopholes in a new global treaty to control mercury pollution.

The Minamata Convention says that products such as batteries containing mercury will be phased out by 2020 and major sources like coal-fired power stations will have to obey stricter rules.

Mercury causes developmental problems and death in humans, says Peter Tompkins of the IFA.

**“Mercury kills or causes developmental problems in humans, and affects animals’ reproduction”**

and affects animals’ reproduction. More than 1900 tonnes of it were released into the air in 2010, and at least another 1000 tonnes into water, according to the UN Environment Programme. The biggest sources are artisanal gold mining and coal burning.

But the treaty is weak on both, says Elena Lymberidi-Settimo of the European Environmental Bureau in Brussels, Belgium. For instance, while countries must draw up plans to cut mercury use in artisanal gold mining, no dates or targets are set. That is because much of this gold mining is illegal and difficult to track, says Tim Kasten, head of the chemicals branch of UNEP in Geneva, Switzerland. Instead, the treaty focuses on helping miners reduce the amount of mercury they release. “This is the most that can be done,” he says. He adds that coal power stations will have to reduce their mercury emissions.

Kasten says it will take decades for exposure rates to drop, “but we have to start now”.

**Squeaks in space**

THE wheels are no longer turning on NASA’s search for alien Earths. The agency’s exoplanet-hunting Kepler telescope is out of action because of a problem with one of the wheels that help control the telescope’s orientation.

Kepler launched with four reaction wheels: three to control its motion along its three axes, and one spare. Last July, one wheel stopped turning. If the spacecraft loses a second the mission is over, so when another wheel showed signs of elevated friction on 7 January, the team decided to play it safe. They are resting the craft in the hope that the lubricating oil which helps the wheel’s ball bearings run smoothly around a track will redistribute itself.

Regardless of the outcome, NASA is poised to pick a successor to Kepler in the months ahead. The winner will launch in 2017.

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**60 SECONDS**

**Smog rules for Beijing**

As thick smog once more chokes Beijing, China’s government is planning drastic measures to curb the pollution. A draft regulation circulated on 19 January proposes taking polluting vehicles off the road and temporarily shutting factories.

**Star smash 750 AD**

A blast of radiation that hit Earth in the 8th century may have been due to a neutron star crash. The blast is recorded as high levels of carbon-14 in two sets of Japanese tree rings. That can be a sign of a solar flare but there is no record of anyone seeing such an event. Now Valeri Hambaryan of the University of Jena, Germany, suggests the culprit was an invisible gamma ray burst, perhaps from colliding neutron stars.

**Building a star on Earth**

South Korea has started developing a prototype fusion power reactor with the help of the US Department of Energy. Nuclear fusion fuels the sun but no fusion reactor on Earth has ever created more power than it consumes. South Korea’s reactor, dubbed K-DEMO, will be in Daejon and aims to generate 1 billion watts for several weeks, more than other reactors in development.

**Smoking out asthma**

Hospital admissions for childhood asthma dropped by 12 per cent the year after England introduced smoke-free legislation in 2007. Before that, admissions were rising by 2.2 per cent a year, peaking at almost 27,000 in 2006 (Pediatrics, doi.org/j9n).

**Dinnerware hazard**

Melamine has been found in the urine of 12 volunteers who ate hot soup from melamine bowls, but at levels 200 times lower than that considered safe by the WHO. Further investigation into absorption of the potentially poisonous chemical is needed, say researchers (JAMA Internal Medicine, doi.org/j3p).
Gun violence in Obama’s sights

The US president turns to science to answer problem of gun crime

Peter Aldhous

“WE DON’T benefit from ignorance,” Barack Obama said last week after ending a de facto freeze on US government research into the public-health impact of guns.

With a stroke of his pen, the now re-inaugurated president directed the Centers for Disease Control and Prevention (CDC) in Atlanta, Georgia, to scientifically assess existing strategies to reduce gun violence and identify pressing questions that should be answered.

However, researchers are optimistic that the president’s move will revitalise efforts to find ways to reduce the number of homicides (currently around 11,000) and suicides (19,000) committed in the US each year using guns – work that has long been suppressed by the powerful gun lobby.

“I think it’s a bold step, for him and the country,” says Garen Wintemute, who heads the Violence Prevention Research Program at the University of California, Davis.

Obama’s executive order to the CDC is part of a package of measures drawn up in response to the killing of 20 children and six adults at Sandy Hook Elementary School in Newtown, Connecticut, last month.

Although the CDC should now be able to resume work on gun violence, its budget must be approved by Congress, which is why Obama has asked Congress to release $10 million for new research. This would be used to probe, for example, whether exposure to violent video games and movies makes people more likely to commit gun crime.

Given its huge death toll, gun violence ought to be near the top of the public health agenda, or so you might assume. So it was for a while, in the early

“There is no shortage of questions, such as the degree of risk in letting alcohol abusers own guns”
1990s, when CDC-backed research found, for instance, that people with guns in the home were more likely to become victims of homicide.

But in 1996, after lobbying by the National Rifle Association, Congress barred the CDC from using its funds to “advocate or promote gun control”. Simultaneously, it slashed $2.6 million from the agency’s budget – precisely the CDC’s annual funding for gun violence research.

CDC officials have since steered away from investigating the ramifications of gun ownership. “It’s incredible that the CDC has been so hampered in doing research on this terrible public health issue,” says David Hemenway of the Injury Control Research Center at Harvard University.

Noting that “research on gun violence is not advocacy”, Obama’s plan stresses that the rule Congress passed in the 1990s does not block the CDC from following his directions. It also specifies one initial priority: getting Congress to provide an additional $20 million to expand coverage of the CDC’s National Violent Death Reporting System (NVDRS) from 18 states to the entire nation. This will aid investigation of whether gun control laws are having the desired effect.

There is no shortage of questions that the CDC could now investigate. Wintemute, for example, wants to examine the value of California’s efforts to recover firearms from people who bought them legally, but subsequently became ineligible to own a gun because they were convicted of a serious crime. “We need to know whether that intervention – which is expensive and potentially risky – actually works,” he says.

Another important question surrounds the degree of risk posed by allowing people with a history of alcohol abuse to own guns. That could be studied if the CDC restored questions about gun ownership to its Behavioral Risk Factor Surveillance System, the main survey the agency uses to investigate how certain behaviours may lead to disease, injury or death.

Philip Cook, a leading gun violence researcher at Duke University in Durham, North Carolina, hopes the new work will also include projects on suicide prevention.

At present, he notes, there is very little information on where guns used in suicides were obtained – limiting our ability to suggest controls that might help keep firearms out of the hands of vulnerable people.

ARE SMART GUNS THE CLEVER OPTION?

The US government appears to be keeping an eye on emerging technologies that could have a big impact on the future landscape of gun control. Last week, US attorney general Eric Holder met with Robert McNamara, co-founder of a firm called TriggerSmart, to discuss gun violence policy. The company, based in Limerick, Ireland, has developed guns that can only be fired by authorised users.

The guns have radio frequency ID tags embedded in their grips. The gun owner is issued with a transponder that can be located in a ring or wristband. When transponder and tag signal each other, the gun can be fired.

The technology identifies a gun owner much faster than biometric measures that recognise fingerprints or the way someone grips a weapon. TriggerSmart also has a system that allows guns to be wirelessly disabled within certain areas, like schools.

Matthew Lang of Xavier University in Cincinnati, Ohio, says there should be new research (see main story) into the impact that smart guns could have on crime rates, especially since a remote deactivation system could prevent mass shootings like the one at Sandy Hook school. “It would be a question worth asking right now,” Lang says. Pro-gun lobby groups like the National Rifle Association are against the use of smart guns, believing such regulation is aimed at hampering public access to weapons.

Another technology entering the debate is 3D printing. Obama proposes banning the sale of magazines that hold more than 10 rounds. However, online campaign group Defence Distributed recently created a 3D-printed magazine that holds 30 rounds, successfully using it in an automatic weapon.

Even though 3D printing is some way from allowing people to easily get hold of firearms components, Lang thinks its potential must come under scrutiny. “If 3D printing takes off and if it becomes a household norm, then we’ve got a problem.” Hal Hodson

The new research, the White House plan says, should include “investigating the relationship between video games, media images and violence”.

It is well established that playing violent video games causes a short-term rise in aggression – measured, for example, by testing volunteers’ willingness to subject others to unpleasant blasts of sound.

What is unclear is whether prolonged exposure to violent games translates into an increased risk of real-world violence. Getting a definitive answer would mean following the behaviour of thousands of children into adulthood so that any link between gaming and crime can be identified, says Craig Anderson, who heads the Center for the Study of Violence at Iowa State University in Ames.

Given the gun lobby’s powerful influence in Congress, it is unclear whether the CDC will get additional funds for gun studies, or whether the work will have to compete with existing priorities.

Obama’s main proposals on gun control similarly hang in the balance, requiring congressional approval. The president wants to impose bans on assault weapons and large-capacity ammunition magazines (see “Are smart guns the clever option?”, above), and to close a loophole that allows individuals to sell guns privately without background checks on the buyer.

Bringing in those measures will require new legislation, which will be debated by Congress in the coming weeks and months.

Are guns too easy to get hold of?
Genome detectives change the donation game

ARE we being too free with our genetic information? As increasing amounts of genetic information is placed online, many researchers believe that guaranteeing donors' privacy has become an impossible task.

The first major genetic data collection began in 2002 with the international HapMap Project – a collaborative effort to sequence genomes from families around the world. While its consent form assured participants that their data would remain confidential, it had the foresight to mention that future attempts to match a genome with its donor might succeed.

“The risk was felt to be very remote,” says Laura Lyman Rodriguez of the US National Institutes of Health's National Human Genome Research Institute in Bethesda, Maryland.

Remote but not impossible: in a paper published in Science last week, a team led by Yaniv Erlich of the Whitehead Institute in Cambridge, Massachusetts, used publicly available genetic databases to put likely surnames to the anonymous DNA data in HapMap's successor, the 1000 Genomes project. Then, using online phonebooks and the donor age and location information provided by the project, Erlich's team managed to identify about 50 of the donors (doi.org/j9c).

To prevent Erlich's method from being used successfully again, age data has been removed from the project's website. But the genie is out of the bottle, says Jeffrey Kahn of Florida State University in Tallahassee. While someone is bound to find another way to identify genetic donors, says Rodriguez, the National Institutes of Health (NIH) believe it would be wrong to remove their genome data from the public domain. She says that full accessibility is "very beneficial to science", but acknowledges that a careful balance between confidentiality and open access is required.

It is especially pertinent, says Kahn, because genetic data carries information about family members as well as the donor. A relative's genome "Anonymous" genome donors can't always hide in the crowd

"Anonymous" genome donors can't always hide in the crowd, he says. Imagine, for example, which you might want to keep secret from an employer. An individual's relatives could not prevent that individual from donating their genome, says Rodriguez, but would-be donors should discuss the risks and benefits with their families.

David Craig of the Translational Genomics Research Institute in Phoenix, Arizona, whose method of picking a person's genome out of a mix of DNA samples also led to NIH removing some data from the public domain, praises the work of Erlich's team. But he is not overly concerned about the implications at this point. While Erlich was able to put names to a few genomes in the database, doing the reverse – finding the genome of a certain person – is still very difficult and has little payoff. But he acknowledges that as more people donate their genetic information, the greater the risk of someone being identified.

"We can't guarantee privacy anymore," says Erlich. He does not expect this to deter people from donating their genetic information: the fact that credit cards are frequently stolen does not stop people from using them. That is because we trust that the legal system will protect our money; similar protections could help reassure people that their DNA will be safe. "It's not about how to protect privacy anymore, it's how to not misuse data," he says. Sara Reardon

Your molar roots are stuck in the past

TALK about exploring your roots. Longer lifespans mean our adult teeth erupt later than they did in our early ancestors, but the memo didn't make it to the roots of our molars. They develop at the same pace as they did in Homo erectus.

Christopher Dean and Tim Cole at University College London studied the microscopic structure of adult molars to reconstruct the pace of their development, much like tree rings can be used to build a picture of tree growth. They found that the roots of chimpanzee molars go through a growth spurt as the teeth erupt through the gum – probably to provide more stability for biting and chewing. The same thing happened in early hominins, but not in modern humans: by the time our molars arrive, their roots have been fully developed for at least a year.

Dean and Cole found an explanation in Homo erectus, a species who lived between 1.8 million and 300,000 years ago. H. erectus gained its molars at exactly the same age as our molar roots have their growth spurts. Or as Dean puts it: "Our roots are stuck in the past."

In humans, he says, root growth spurts are merely a hangover from an early stage of evolution. We retain molar roots like H. erectus because the growth spurts use too little energy for natural selection to weed them out (PLoS One, doi.org/j8w).

H. erectus had a bigger brain and smaller teeth than its ancestors. Some believe, controversially, that these features reflected big dietary changes, including eating the first cooked food, which would have been easier to chew while supplying more energy.

The new study may find favour with critics of the controversial “cooked food hypothesis”. It shows that H. erectus still required an early molar root growth spurt – presumably to prepare its teeth for heavy-duty chewing. Colin Barras
EVEN the darkest cloud may have a silver lining. The sharp drop in air pollution that accompanied Greece’s economic crisis could be a boon to the nation’s health.

Mihalis Vrekoussis of the Cyprus Institute in Nicosia and colleagues used three satellites and a network of ground-based instruments to measure air pollution over Greece between 2007 and 2011. Levels of nitrogen dioxide fell over the whole country, with a particularly steep drop of 30 to 40 per cent over Athens. Nitrogen monoxide, carbon monoxide and sulphur dioxide also fell (Geophysical Research Letters, DOI: 10.1002/grl.50118).

Pollution levels have been falling since 2002, but the rate accelerated after 2008 by a factor of 3.5, says Vrekoussis. He found that the drop in pollution correlated with a decline in oil consumption, industrial activity and the size of the economy. “This suggests that the additional reported reduction in gas pollutant levels is due to the economic recession,” he says.

In Athens, a combination of heavy car use and lots of sunshine have created serious health problems, so city dwellers should see real benefits. Sunlight triggers chemical reactions that make the car exhaust pollution more harmful, for instance by forming small particulates that cause respiratory diseases. “Hospital admissions for asthma should decline,” says Dwayne Heard of the University of Leeds in the UK.

“Hospital admissions for asthma should decline,” says Dwayne Heard of the University of Leeds in the UK.

It’s not all good news: despite the drop in pollutants, levels of ground-level ozone – another cause of respiratory disease – have risen. Ozone would normally be suppressed by nitrogen oxides, but those have declined. That will take the edge off the benefit, says Heard.

Greece isn’t the only country where air pollution has dropped. Nitrogen oxide levels fell across Europe after the 2008 financial crisis (Scientific Reports, doi.org/j74). In the US, nitrogen dioxide levels fell between 2005 and 2011, with the sharpest fall at the height of the recession (Atmospheric Chemistry and Physics, doi.org/j75).

Such declines can be one-offs, or governments can help make them permanent, says Ronald Cohen of the University of California, Berkeley, who led the US study. “A time of crisis is a real opportunity to initiate change.” After the 2008 financial downturn, for instance, the US and Europe committed to pollution cuts. “In 10 years, there will be an end to air pollution in the US and Europe,” says Cohen. “It’s an incredible success story.”

Greece, however, is not seizing the current opportunity, says Vrekoussis. “Investments in clean technologies and low-carbon green strategies have been abandoned,” he says. “I’m afraid that in the long run the negative effects will override the positives.”

Global greenhouse gas emissions initially fell in the wake of the financial crisis, but not by much. Emerging economies like China and India continued their economic growth, so a small emissions drop in 2009 was followed by a huge rise in 2010 which continued in 2011.

Michael Marshall

“The drop in air pollution in Greece is linked to a decline in industrial activity and the size of the economy”
Four-stranded DNA found in cancer cells

Andy Coghlan

SIXTY years after James Watson and Francis Crick established that DNA forms a double helix, a quadruple-stranded DNA helix has turned up, and it could strengthen the fight against cancer.

Quadruple helices that intertwine four, rather than two, DNA strands have been researched for decades. They have been made synthetically in the lab, but were seen only as curiosities as there was no evidence that they formed naturally. Now they have been identified in human cancer cells.

The four-stranded packages of DNA, called G-quadruplexes, are formed by the interaction of four guanine bases that together make a square. They appear to be transitory structures, and are most abundant when cells are poised to divide. They form in chromosomes and in telomeres, the caps on the tips of chromosomes that protect them from damage.

Because cancer cells divide so rapidly, and often have defects in their telomeres, the quadruple helix might be a feature unique to cancer cells. If so, any treatments that target them will not harm healthy cells.

“I hope our discovery challenges the dogma that we really understand DNA structure because Watson and Crick solved it in 1953,” says lead researcher Shankar Balasubramanian of the University of Cambridge. “We need to be open about what its structure is, because it’s dynamic.”

Balasubramanian’s team identified the four-stranded structures in cancer cells with the help of an antibody that attaches exclusively to G-quadruplexes. To stop them from unravelling into ordinary DNA, they exposed the cells to pyridostatin, a molecule that traps quadruple helices wherever they form.

This enabled the researchers to count how many formed at each stage of cell division. The G-quadruplexes were most abundant in the “S-phase” – when cells replicate their DNA just before dividing (Nature Chemistry, doi.org/j9b).

“I expect they will also exist in normal cells, but I predict that there will be differences with cancer cells,” says Balasubramanian. His hunch is that the formation of G-quadruplexes is triggered by the chaotic genomic mutations and reorganisations typical of cancerous or precancerous cells.

“This research further highlights the potential for exploiting these unusual DNA structures to beat cancer, and the next part of this is to figure out how to target them in tumour cells,” says Julie Sharp of Cancer Research UK, which funded the study.

Previous work carried out by the group found that the addition of pyridostatin to human breast cancer cells stopped them from replicating and from migrating across a gel in a process that mimics the spread of cancer cells in the body (Nature Chemical Biology, doi.org/j9f).

The results reinforce the possibility that blocking G-quadruplexes could combat cancers. “If you block them with pyridostatin, it’s bad news for the cell,” says Balasubramanian.

As well as determining whether quadruple helices exist in healthy cells, another important question is whether G-quadruplexes play a role in embryo development, and whether such a role is mistakenly reactivated in cancer cells. “We plan to find out whether the quadruplexes are a natural nuisance, or there by design,” Balasubramanian says.
Go Inside the Forensics Lab

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Dwarf planet feels quantum gravity

Ker Than

KILLING Pluto was only the beginning. The dwarf planet Eris, named for the Greek goddess of strife, could also bring down the most popular explanations for dark matter and dark energy.

Many galaxies appear to have stronger gravity – and thus more mass – than can be explained by their visible matter alone. Overly massive galaxies are most often attributed to dark matter, an invisible substance that interacts with matter through gravity. To date, though, no one has directly detected dark matter particles.

But a well-established notion in physics could hold another explanation for their size. This says that empty space is really a frothy, turbulent sea full of virtual particles – matter and antimatter that spring in and out of existence so fast that we can’t see them. Though they are tiny, quantum objects, Dragan Hajdukovic, a physicist at CERN near Geneva, Switzerland, thinks these bubbling particles may have opposing gravitational charges, similar to electrical charges.

In the presence of a gravitational field, the particles would generate a secondary field, which, in the case of galaxies, could explain the mass discrepancy.

Hajdukovic’s theory could also explain dark energy, the baffling force thought to be driving the universe apart at an accelerated pace. If virtual particles have gravitational charges, then space-time itself is imbued with a small charge that could be causing objects in the universe to speed away from each other.

To test whether quantum-scale gravity is at work, Hajdukovic plans to borrow a trick from Einstein (see diagram). Due to gravitational effects in the solar system, such as the tug of other planets, Mercury’s oval-shaped path around the sun slowly turns, or precesses. In the 1800s astronomers noticed that this happens at a different rate than predicted by Newtonian physics. Einstein showed that the sun’s mass creates a curvature in space-time that affects Mercury enough to explain the difference, lending credence to his theory of general relativity.

Hajdukovic’s quantum gravity might create a similar discrepancy with more distant orbiting bodies, he says – which is where Eris and its moon Dysnomia come in.

Best known for depriving Pluto of planethood by showing that there are many similar bodies in orbit beyond Neptune, Eris’s great distance from the sun means the effects of general relativity become negligible. Newtonian physics should dominate, putting Dysnomia’s precession rate around Eris at 13 arc seconds per century. But if quantum gravity exists, the rate should be -190 arc seconds per century, Hajdukovic calculates (Astrophysics and Space Science, doi.org/j6r).

He thinks the required measurements could be made from Earth using existing observatories. “Einstein was lucky that there is a planet so close to the sun as Mercury,” he says. “My theory might be lucky that there are trans-Neptunian objects allowing astronomical tests.”

Gary Page of Longwood University in Farmville, Virginia, is sceptical that Earth-based tests would be sensitive enough to pick up the effect. Still, he praises Hajdukovic for going beyond the party line. “It’s always good when people are willing to go a little bit out on a limb.”

Is Earth bashing through walls of dark matter?

THE knives are out for dark matter (see left), but our search for the cryptic stuff that may make up about 86 per cent of all matter could be set for a breakthrough – literally. Earth may be smashing through huge walls of dark matter that we could detect.

According to a leading theory, dark matter is made of weakly interacting massive particles, but the hunt for WIMPs keeps coming up empty. “I feel like it’s time to broaden the scope of our search,” says Maxim Pospelov of the University of Victoria in Vancouver, Canada. He is focusing on the idea that some dark matter might be tied up in domain walls – structures separating areas of the universe where an exotic force field exists, the rate should be -190 arc seconds per century. But if quantum gravity

Observation:
5600 arc seconds per century
(one arc-second = 1/3600 degrees)

Newtonian prediction:
5557 arc seconds per century

“Is Earth bashing through walls of dark matter?”

in the early cosmos settled down with different values.

To maintain these distinct values, the domain walls must be rich in energy. As the theory of relativity says that mass and energy are interchangeable, on a large scale the domain walls look like concentrations of mass – that is, like dark matter.

Earth may pass through a domain wall every few years as it drifts through space. We wouldn’t feel it, says Pospelov, but if a worldwide network of magnetometers simultaneously saw an unusual signal, it could signify that Earth has pierced a dark matter wall (Physical Review Letters, doi.org/j9h).

Douglas Finkbeiner of the Harvard-Smithsonian Center for Astrophysics is not convinced that dark matter walls exist. But he is glad that physicists are keeping an open mind about alternatives to WIMPs. “We’ve looked for WIMP dark matter in so many ways,” he says. “At some point you have to ask, are we totally on the wrong track?” Lisa Grossman
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Preterm babies not short of grey matter

Douglas Heaven

PREMATURE birth need not lead to learning difficulties. That’s the exciting conclusion of two independent but complementary studies.

Together, the studies suggest that the relatively small cerebral cortex seen in many preterm babies contains a normal number of neurons that can be nurtured back to health with the right care.

A small cerebral cortex was widely assumed to reflect a lack of neurons, perhaps because some of the cells die following the ischemia – reduced blood flow to brain tissue – often experienced by premature babies.

To study the effects of ischemia in more detail, Stephen Back at the Oregon Health & Science University in Portland and colleagues turned to fetal sheep brains, a good animal model of the brain of human fetuses.

Back’s team compared neuron numbers in sheep brains that had experienced ischemic injury and those that had not: the numbers matched. “We counted the money and it was all there,” says Back. “But the cells were all squished together.” The cells from the injured brain did differ in shape, though, lacking the branches – dendrites – that radiate from healthy neurons. “Instead of oak trees, we saw saplings,” says Back.

The team used an MRI technique that measures how water diffuses through brain tissue, called diffusion tensor imaging, to explore the effect this has. In tissue with fully branching neurons, water diffuses randomly in all directions. In the damaged neurons, however, water diffused towards the surface of the brain – an indication of neuron immaturity (Science Translational Medicine, doi.org/j8s).

In a sister study, Steven Miller at the Hospital for Sick Children in Toronto, Canada, and colleagues studied the links between neonatal care and brain development in 95 preterm babies. “The surprising detail was that it was mostly the cerebral cortex that is influenced, not the whole brain,” says Miller.

MRI scans of the premature babies when they were 32 and 40 weeks old showed the same pattern of underdeveloped – but not dead – neurons that Back’s team found in the animal tissue (Science Translational Medicine, doi.org/j8t).

“There’s a remarkable agreement between the two studies,” says Back. “The data is spot on.” Miller agrees: “We think we’re seeing the same thing.”

The findings could change the way we think about brain damage. “The injury is not as bleak as we used to think,” says Back. “It’s a disorder of maturation, not loss.”

Miller’s study suggests that better nutrition or cognitive stimulation might promote brain growth. “You could jump-start the cells and get them developing again,” says Back.

Zoltán Molnár at the University of Oxford describes the work as groundbreaking, although he thinks Back’s team could have studied other brain regions too for a more complete picture.

The findings are genuinely illuminating, says David Edwards at University College London, but he adds that we shouldn’t be too quick to settle on underdeveloped neurons as the only explanation for reduced cortical volume. “They have room to grow, but by how much?” he says.

Get cirrus in the fight against climate change

FEATHERY cirrus clouds are beautiful, but when it comes to climate change, they are the enemy. Found at high-altitude and made of small ice crystals, they trap heat – so more cirrus means a warmer world. Now it seems that, by destroying cirrus, we could reverse all the warming Earth has experienced so far.

In 2009, David Mitchell of the Desert Research Institute in Reno, Nevada, proposed a radical way to stop climate change: get rid of some cirrus. Now Trude Storelvmo of Yale University and colleagues have used a climate model to test the idea.

Storelvmo added powdered bismuth triiodide into the model’s troposphere, the layer of the atmosphere in which these clouds form. Ice crystals grew around these particles and expanded, eventually falling out of the sky, reducing cirrus coverage. Without the particles, the ice crystals remained small and stayed up high for longer.

The technique, done on a global scale, created a powerful cooling effect, enough to counteract the 0.8°C of warming caused by all the greenhouse gases released by humans (Geophysical Research Letters, DOI: 10.1002/grl.50122).

But too much bismuth triiodide made the ice crystals shrink, so cirrus clouds lasted longer. “If you get the concentrations wrong, you could get the opposite of what you want,” says Storelvmo. And, like other schemes for geoengineering, side effects are likely – changes in the jet stream, say.

Different model assumptions give different “safe” amounts of bismuth triiodide, says Tim Lenton of the University of Exeter, UK. “Do we really know the system well enough to be confident of being in the safe zone?” he asks. “You wouldn’t want to touch this until you knew.”

Mitchell says seeding would take 140 tonnes of bismuth triiodide every year, which by itself would cost $19 million. Michael Marshall
Liquid lightning

The solution to storing large amounts of energy may lie in cheap, abundant metals. But first you have to melt them...
FLU is an insidious virus. It infiltrates your cells, replicates and escapes before your immune system even knows it is there. Now we know how: flu uses a clock to abscond before it is caught.

It all comes down to a viral gene that usually makes one main protein, but will sometimes make another, called a nuclear export protein (NEP). Using microRNA molecules that inhibit specific bits of the gene, Benjamin ten Oever and colleagues at the Mount Sinai Hospital in New York City were able to slow down or speed up the production of NEP. They then watched as the virus failed to infect cultured lung cells or take hold in mice.

When NEP is made too slowly, says ten Oever, the immune response is able to catch up with the virus before it spreads to more cells. When it is made faster, the virus abandons the cell before it multiplies sufficiently to infect others (Cell Reports, doi.org/j86).

So NEP accumulates at just the right rate to act as flu’s alarm clock, and once a certain amount is present, the virus jumps ship. Ten Oever hopes a flu virus with a defective clock could make a new type of live flu vaccine. Such a virus might be weak enough to be safe for those most susceptible to flu, the very young and old.

Did Mars hide life in its pockets?

SIGNS of life on Mars may have sprung up from underground. Because they would have been protected from harsh conditions on the surface, such as radiation, pockets of underground water may be where Martian life existed most recently. Sulphates, made through interaction with briny water, lie all over Mars. As water underground is also briny, this suggested frequent upwellings.

But Joseph Michalski of the Planetary Science Institute in Tucson, Arizona, and colleagues found that most basins, where groundwater would have pooled, are free of sulphates. The deep McLaughlin crater is instead rich in clays and carbonates (Nature Geoscience, doi.org/j88).

As water bearing these minerals is more life-friendly than sulphate-rich water, which is more acidic, future Mars missions could search such basins for habitability signs, such as organic molecules.

Moths can’t see the wood for the trees

A MISTY forest conjured up in the lab has revealed how moths navigate while flying. Yonatan Munk of the University of Washington in Seattle dangled a hawkmoth (Manduca sexta) from a tiny “joystick” in front of a screen displaying virtual trees. The device read the moth’s turns, allowing the display to update to match the insect’s expectations.

By varying the fogginess of the scene, Munk found that the moth only focuses on nearby trees, ignoring the rest of the forest even when visible. The discovery could improve software that helps moth-sized drones navigate.

Munk presented the work at the Society for Integrative and Comparative Biology meeting in San Francisco earlier this month.

Pucker up to capture my genetic code

SO ROMANTIC... when you kiss your partner passionately, not only do you exchange bacteria and mucus, you also impart some of your genetic code. No matter how fleeting the encounter, the DNA will hang around in their mouth for at least an hour. This means that women’s saliva could contain evidence of unwanted attention in cases of assault, or even telltale signs of infidelity.

Natália Kamodyová and her colleagues at Comenius University in Bratislava, Slovakia, recruited 12 couples who agreed to kiss each other passionately for at least 2 minutes. Afterwards, saliva samples were collected from the women at 5, 10, 30 and 60-minute intervals. Because Kamodyová’s method relies on detection of the Y chromosome, it can only be used to identify a man’s DNA in a woman’s saliva.

The results show that the man’s DNA was still present and could be detected through amplification after at least an hour, and possibly longer. “We’ve shown it’s possible to get a full profile, which could be useful in crime investigation to pinpoint the possible perpetrator among suspects or exclude those innocent,” says Kamodyová. Her team is investigating whether the DNA survives longer than an hour and whether it’s obtainable from the mouths of women who have died (Forensic Science International: Genetics, DOI: 10.1016/j.fsigen.2012.07.007).
Look at my blingy fractal necklace

How do you spot a fit partridge? Check out the fractals round its neck.

Fractal geometry is used when a pattern is too complex to be described by Euclidean geometry. It has been applied to coastlines, plant structures and animals’ foraging patterns. Lorenzo Pérez-Rodriguez at the National Museum of Natural Sciences in Madrid, Spain, and colleagues wanted to see if it could also be helpful when analysing the complex plumage patterns of birds.

Using images fed into software, the team found that red-legged partridges (see picture) with a more gradual transition between the plain and spotted areas of their bib have a higher fractal dimension (FD) – a measure of a pattern’s complexity.

To see if this was linked to the bird’s fitness, they compared the bibs of 68 birds of both sexes, half of which were on a restricted diet. After six months, the bibs of undernourished birds had a lower FD than before their food was reduced. Low FD also predicted poorer immune responsiveness.

Pérez-Rodriguez thinks that a fractal-rich bib could be used to advertise the health of the bird to potential mates. “Birds have quite a different visual system to ours,” says Thanh-Lan Gluckman at the University of Cambridge, so the work could also help us understand what one bird sees in another.

Solar-powered salamander hooks up with green algae

ANIMALS are weird. They ignore the abundant source of energy above their heads – the sun – and instead invest in cumbersome kit for eating and digesting food.

Not so the spotted salamander (Ambystoma maculatum): its embryos use algae as batteries.

We have long known that the embryos live in symbiosis with single-celled algae, Ophilia amblystomatis. The algae colonise the eggs, receiving organic waste as food in exchange for oxygen, which they generate by photosynthesis. Then, in 2011, researchers found the algae not just inside the eggs, but also inside the embryos’ cells.

To see if the embryos get more than oxygen from the algae, Erin Graham of Temple University in Philadelphia, Pennsylvania, and colleagues incubated eggs in water containing radioactive carbon-14. The algae take up carbon in the form of carbon dioxide, producing oxygen and radioactive glucose.

The team found that the embryos became mildly radioactive unless kept in dark conditions, something that could only be explained if the embryos were using the glucose.

In other words, the algae were acting as internal power stations, generating fuel for the embryos (Journal of Experimental Biology, doi.org/8q).

Salamander embryos deprived of algae struggle. “Their survival rate is much lower and their growth is slowed,” says Graham. Other vertebrates may well have a similar relationship with algae, she says: “Anything that lays its eggs in water would be a good candidate.”

Brightest light from black hole’s spit

GLOBS of plasma spat out by black holes can trigger the brightest flashes of light in the universe.

Gamma-ray bursts are high-energy flares that mostly originate billions of light years away, making it hard to see how they are created. In November 2011, NASA’s Fermi satellite saw a gamma-ray burst coming from the galaxy 4C+71.07, which sits about 10.5 billion light years away. The galaxy was also being watched by the Very Long Baseline Array, a radio telescope network that can see small features at a distance.

The supermassive black hole at the galaxy’s centre is feeding on surrounding matter, causing it to fire high-speed jets of particles. The radio array showed that, around the same time as the flare, the black hole spat out a knot of plasma that travelled up the jet at near the speed of light.

Electrons in the knot probably collided with and energised light from a slower-moving part of the jet, producing the gamma rays, says Alan Marscher of Boston University, who presented the work at a recent astronomy meeting in California. It’s still a mystery, though, what made the black hole erupt.

Back off my cake, it defines me

DOGS famously love a bone, but a taste for starch may have helped to turn their ancestors from wolves into pochos.

The first comparison of the full genomes of wolves and dogs has found 36 segments that clearly differ. Besides differences in genes linked to brain development, Erik Axelsson of Uppsala University in Sweden and colleagues found three genes in dogs that are vital for digestion and extend their ancestral carnivorous diet to include starch (Nature, DOI: 10.1038/nature11837).

A gene for the enzyme that splits starch into simpler sugars has replicated itself in the dog genome, and become more efficient – a sure sign that it is in demand.

Although the team has yet to date the emergence of these genes, Axelsson suggests one possibility is that it coincided with the dawn of agriculture, as settlements filled with heaps of starch waste. “Wolves were probably attracted, but only the ones that evolved the ability to digest the starch waste kept coming back,” he says.
Degrees of difficulty.

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Auto-appification

In-car apps should give drivers far more control over the performance and efficiency of their vehicle

Douglas Heaven

MIRROR, signal, manoeuvre – now set your engine to “supercar”. Car maker Ford has just released OpenXC – an open-source hardware and software toolkit that will let the hacker community play around with the computer systems that run modern cars. While the first apps may add nothing more exciting than internet radio, the open nature of the system should eventually lead to custom apps that give drivers far more control over their car’s performance.

Most cars are now run by computers that control everything from the engine to the incline of the seats but, until now, the driver has used only the data on speed, engine revs and fuel level. OpenXC will “demystify the details” of a car’s software, says K. Venkatesh Prasad of Ford Research and Innovation in Dearborn, Michigan. A driver will be able to download approved apps from a Ford store onto their smartphone that can then communicate with a car’s computer system.

Such apps may harness some underused parts of a car. For example, if a car with a weather app told the vehicles behind them when its wipers were on, drivers further down the road would have advance warning of rain. No weather satellite can give precise details about the specific road you’re on, says Prasad. “All of a sudden you’ve given new life to wiper blades.”

If you want to know how your engine is running, apps could display fuel pressure or the boost pressure of a turbo injection. With access to such parameters, apps could let drivers tweak their car’s performance. While manufacturers tend to balance their cars between economy and performance, software could push it to one extreme or the other, giving the car owner a more efficient or faster vehicle than the one they bought.

It is unlikely that Ford would approve these kinds of apps – they might not be safe – and so car hackers might try to get around security measures. There are ways to do this that open up a car like a jailbroken iPhone. “Gone are the days when you have to connect wires together, you’re now just talking to a computer,” says Jay Abbott of Advanced Security Consulting in Peterborough, UK.

“Auto-appification”

A carjacker’s dream come true?

Ford’s decision to open up car software to third party developers with OpenXC will give drivers more information about their vehicle – but it also raises security issues. An app that controls a car’s locking system, for example, might give thieves a new way to break in. It might also be possible to hijack sensor readings and give drivers false information about their speed. Ultimately, it will come down to a trade-off, says security specialist Ben Laurie at Google. “There are things you can do to increase security of the platform, but it is fundamentally impossible to make it both safe and maximally useful,” he says. Ford agrees security issues exist, but says OpenXC doesn’t introduce a new threat.

Abbott is a cybersecurity expert and car-modding enthusiast who enjoys tweaking a car’s performance by customising its software. Most microcontrollers in modern cars use a protocol known as a CAN bus to communicate. Since this protocol is well understood, encryption can be bypassed with off-the-shelf tools such as a CAN bus analyser, commonly used to check your car’s software for bugs.

In theory, OpenXC can work with any make of car that supports those standards – Toyota, Nissan and Honda have already expressed an interest. It will be up to individual manufacturers to provide access to the bespoke parts of their system. General Motors also announced a similar initiative at the Consumer Electronics Show in Las Vegas earlier this month, which will open up their cars to third-party app developers.

Sharing diagnostic data would also let manufacturers keep tabs on how their vehicles run once they are out of the showroom. “No question, we can learn from that,” says Prasad.

Hobbyists have been tinkering with car software for a number of years, says Abbott, but customised apps should take off with the release of these platforms. “Ford stepping in and opening up to a mass market is great,” he says. “It will promote a new generation of innovation.”
This floor’s in step with you

A pressure-sensitive video-screen floor could bring strange new possibilities and sights into your home

Paul Marks

GLANCE down at the interactive floor in Patrick Baudisch’s lab and you will not see your reflection in the glass. Instead, you will find your computer-generated doppelgänger, wearing a facsimile of your clothes, which walks and moves just like you do. It seems to be stuck to your feet (see picture).

This mirror world is one of the applications Baudisch and his colleagues at the Hasso Plattner Institute in Potsdam, Germany, developed after building an 8-square-metre pressure-sensing floor that can recognise people by their weight, track their movements and display video for them to interact with. The idea is that the pressure-sensing technology could lead to a raft of ways to control objects in your home, play games, or assist older or disabled people.

For instance, to play a version of indoor soccer, the floor generates a CGI football that can be kicked about by the people in the room. Or if someone sits on the floor, the system recognises who they are by their precise weight and flips a TV on to their favourite channel. Similarly, an elderly person’s activity levels could be monitored.

Developed with funding from Microsoft Research in Cambridge, UK, Baudisch envisions the device as a forerunner to pressure-sensing floors in people’s homes. His team will present the invention, dubbed GravitySpace, at the Conference on Human Factors in Computing Systems in Paris, France, in April.

The team’s prototype consists of a slab of 6.4-centimetre-thick glass installed in a hole cut into a standard floor, and an infrared camera and high-resolution video projector in the room below that tracks footprints and beams video up onto the glass.

Infrared LEDs surround the flooring, which is also coated with a rubbery, pressure-sensitive film. A footstep on the surface makes the film interfere with the infrared light, creating an image of the footprint that is captured by the camera below. “This pressure sensor is of such high resolution that the floor can recognise anything from shoe prints to fabric textures to someone’s knees,” says Baudisch.

Software running on a linked computer recognises what those objects are doing and generates relevant video in response. In the football app, for example, the floor measures the rate of change of pressure on the non-kicking foot to determine when you are kicking – the floor cannot “see” the foot that is in the air – and the ball is moved in response.

“It’s an extremely exciting research result,” says Ken Perlin, at New York University. “The future of computer interfaces is to become more sensitive to people’s needs. A floor that understands where you are and what you are doing is a logical step in that direction.”

Sharing app helps you connect, wherever you are

MAXED out on your phone’s data plan? Stuck in a dead zone? Your neighbour can help. A new app lets users share mobile internet connections with anyone around them, helping the data-starved avoid roaming charges and steep overage fees.

Called AirMobs, the app shares a phone’s data plan with others through the phone’s Wi-Fi signal. For every kilobyte shared, AirMobs awards a data credit that can be used later.

“The idea is to extend the principle of ‘give and you shall receive’ to create an incentive for people to share their data plan,” says Eyal Toledano at the Massachusetts Institute of Technology, who developed the app.

AirMobs aims to help users avoid high charges by connecting to the internet via the phones around them. In places where perhaps only one carrier has coverage, it can provide connectivity for all.

“You can use your credit in an area where you don’t have a connection,” Toledano says. “Maybe the guy next to you has great coverage.”

Users can choose how much of their data plan they share. AirMobs runs in the background, regularly checking the phone’s battery life and the strength of the cellular connection. It also detects movement, as the signal is more stable when the phone is stationary. When conditions are right, the Wi-Fi transmitter switches on automatically, and others can then connect.

Toledano says he has successfully tested the system within MIT, but he is hesitant to release it to the Google Play Store for fear that cellular carriers will object.

Bill Menezes, an analyst at Gartner in Denver, Colorado, agrees that’s a danger. “Verizon Wireless, for example, specifically prohibits resale of its services to a third party,” he says. “The question is how they would enforce it against an app like this.”

“If networks decided to collaborate and let all devices roam freely, AirMobs would be less needed,” Toledano says. “But where operators aren’t collaborating, user-to-user collaboration can fix the situation.”

Hal Hodson
Body armour to scale up by mimicking flexible fish

IN DAYS of old, knights protected themselves in armour made up of tough, interlocking “scales”. This idea might one day be revisited, with future soldiers decked out in scales inspired by the almost impenetrable skin of the “dragon fish”.

This fish, Polypterus senegalus, is a tough beast whose strong bite and sturdy exoskeleton has kept its species going for 96 million years. Each of the scales that cover its long body is made up of multiple layers; when the fish is bitten, each layer cracks in a different pattern so that the scale stays intact as a whole (Nature Materials, doi.org/frkx9r).

Now we know how the different types of scales work – as a series of joints between “pegs” and “sockets”, allowing the fish to bend as it swims. This combination of flexibility and strength is perfect for human armour, says Swati Varshney of the Massachusetts Institute of Technology, speaking at the Society for Integrative and Comparative Biology meeting in San Francisco earlier this month. She and colleagues performed X-ray scans of scales, reconstructed the shapes and then worked out how they slotted together.

Scales near the flexible parts of the fish, such as the tail, are small and allow the fish to bend. Those on the side, protecting the internal organs, are larger and more rigid. Their joints fit together tightly so that each peg reinforces the next scale rather than allowing it to flex.

The researchers created computer models of the different scale types and blew them up to 10 times their original size. Using a 3D printer, they printed a sheet of 144 interlocking scales out of a rigid material (an early prototype is pictured, below). The group hopes to eventually develop a full suit of fish-scale body armour for the US military that could replace the heavy Kevlar armour currently used, but Varshney says this is still some way off. Such a suit would mimic the fish: rigid and strong across the torso and more flexible towards the joints.

These fish are promising models for human armour because they have already tested designs on themselves, says Dominique Adriaens of Ghent University in Belgium. Once the design is pinned down, researchers could use different materials to make suits. Ceramic, for instance, would provide heat protection; metal could prevent punctures. Sara Reardon

Powerful prose stored in DNA

It is one of the most iconic speeches of all time, and now it has been immortalised in a very unusual way. A snippet of Martin Luther King’s “I Have a Dream” has been stored in the ACTG alphabet of DNA. Nick Goldman at the European Bioinformatics Institute in Hinxton, UK, and colleagues synthesised DNA to encode an eclectic mix of information, including an MP3 file of 26 seconds of King’s speech, and all 154 of Shakespeare’s sonnets. The team built on previous DNA-encoding techniques by adding error correction, allowing content to be retrieved with 100 per cent accuracy.

Bad grammar good, good grammar bad

Birthdays and the names of pets aren’t the only things that are password no-nos. Good grammar is now joining the list. Ashwini Rao and colleagues at Carnegie Mellon University in Pittsburgh, Pennsylvania, developed an algorithm that makes light work of cracking long passwords that are grammatically correct, even if they are mixed with numbers and symbols. The algorithm makes guesses by combining words into phrases, like “ihave3cats”, for instance. The team’s paper on the technique is due to be presented at a privacy conference in San Antonio, Texas, next month.

Belting up helps cyclists find their way

Think of it as satnav for your waist. A vibrating belt for cyclists, which guides you to your destination, has proven successful in early tests. Wearing a “vibrobelt”, you simply choose a destination on your smartphone and set off. The belt then gives you directional nudges just before each turn. Developed by Haska Steltenpohl of the Intelligent Systems Lab at the University of Amsterdam, the Netherlands, the system is designed to help cyclists keep their attention trained on the road. In tests, cyclists who used the vibrobelt were much more aware of their surroundings than those who had to glance at the screen of a GPS device.

For breaking tech news go to: newscientist.com/onepercent
Not cleared for take-off

The cutting-edge Dreamliner has been grounded with battery problems

WHEN it went into service a little over a year ago, Boeing’s 787 Dreamliner was hailed as a miracle of cutting-edge innovation. The Chicago-based company used lithium-ion batteries and a carbon-fibre fuselage to cut down on fuel consumption, and computer networks that provide passengers with far better in-flight entertainment, including internet access.

But a series of mishaps – including a battery fire aboard a 787 at Boston’s Logan International Airport on 7 January – has grounded all 50 planes in the global fleet. The US National Transportation Safety Board (NTSB) is investigating the plane’s electrical systems. And the US Federal Aviation Administration (FAA), which declared the plane airworthy in 2011, is questioning its own certification process.

A battery fire also forced an All Nippon Airways 787 to make an emergency landing at Takamatsu airport in western Japan on 16 January. The batteries store twice the power of nickel-cadmium cells, which saves on weight. But in 2007 the FAA warned Boeing that the company could only use lithium-ion batteries if the 787’s battery charging, power management and failure alarm systems could cope. Overcharging the batteries can cause prolonged increases in temperature and pressure that lead to “formation of highly unstable metallic lithium, which can ignite, resulting in a self-sustaining fire or explosion”, the FAA warned.

No one yet knows if the fault lies with the batteries – built by GS Yuasa of Japan and packaged by Thales of France – or if it was an issue with the attached wiring or electronics.

Because the NTSB is investigating the Boston battery fire, Boeing spokeswoman Lori Gunter cannot yet comment on what happened. But she says the 787 is built to cope with any problem the batteries throw at it. “It is designed to be able to handle any faults that we would expect to see from the battery,” she says.

Boeing’s rival, Airbus of Toulouse, France, uses smaller lithium batteries in its A380 jet to power emergency lighting, but plans to increase its reliance on them in the forthcoming A350. “Lithium-ion batteries can be designed in very different ways, with different chemistries, electronic protections, capacities and number of cells,” says an Airbus spokesman. “The way a battery is integrated in the aircraft is important.”

Smart in-battery sensors could be an answer too, say Gi-Heon Kim and colleagues at the National Renewable Energy Center in Golden, Colorado. They are developing a “fail-safe” lithium-ion battery that incorporates a passive early warning system (Journal of Power Sources, doi.org/j87) that senses the structural defects in a lithium-ion battery cell that can lead to drastic overheating. When it does so, it isolates the problem cell from the rest of the cells long before trouble occurs.

The outcome of the 787 investigations will also resonate off-planet, as the International Space Station is in line for an upgrade to more powerful lithium-ion cells made by GS Yuasa. “NASA is in close communication with Boeing, the FAA and the cell manufacturer on the ongoing failure analysis, and will apply any relevant lessons learned as appropriate,” says NASA spokesman Josh Byerly.

Discovery of a dynamic atmosphere at one of Saturn’s moons, Enceladus

Public lecture by Professor Michele Dougherty FRS, Imperial College London

Monday 4 February 2013, 6.30pm – 7.30pm
The Royal Society, 6 – 9 Carlton House Terrace, London, SW1Y 5AG

After passing close by to one of Saturn’s moons, Enceladus, NASA’s Cassini spacecraft detected plumes of water vapour coming from the south pole of the moon. Michele Dougherty will discuss the significance of these discoveries and the impact on future space exploration.

Free admission – no ticket or advance booking required. Doors open at 6pm.

For more information visit royalsociety.org/events

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TRIPLE CHANCE

Boeing’s 787 Dreamliner is based on a raft of emerging technologies

**Fuselage**
For the first time the pressurised cabin is made from carbon-fibre-reinforced plastic

**Computer networks**
Advanced networks for flight control and entertainment raise fears over passengers hacking the aircraft

**Lithium-ion batteries**
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Benign bird art

MILDLY distressed and hopelessly tangled, these birds look like the poster children for some environmental tragedy of our own making. In reality, they are the face of modern ornithology.

Todd Forsgren, a photographer based in Baltimore, Maryland, is fascinated by the long and intertwined history of birds and art. The two meet in the mist nets researchers use to trap wild birds, which cause a short-lived, slight shock but no injury. The Montezuma Oropendola (left) and Boat-billed Flycatcher (right) caught in Costa Rica are moments from being freed. “I hope as people learn more about the moderately traumatic process of mist net trapping, they will see the images as beautiful,” says Forsgren.

Earlier generations of birds have paid a higher price in the name of art. Forsgren draws inspiration from the lifelike paintings that feature in John James Audubon’s famous 19th-century monograph *The Birds of America*, which is among the most valuable of all printed books. But their lifelike poses are deceiving: Audubon shot and mounted his birds before painting them.

A century later, bird art was at the forefront of the new environmental movement. Artist and ornithologist Roger Tory Peterson used photographs to paint an early field guide to the birds of North America. Because of people like him, binoculars, not shotguns, became the ornithologist’s primary tool.

Today, through advances in technology, it is radio transmitters that are cracking the remaining mysteries of bird ecology. That’s where the mist nets come in, offering an easy and safe way to catch birds so that the transmitters can be fitted. “My photographs are about our world progressing, and moving forwards in some direction,” says Forsgren.

Colin Barras
Photographer
Todd Forsgren
toddforsgren.com
FACED with rising anger from environmentalists last year over his plans for a transcontinental pipeline to deliver treacle Canadian tar sands to Texas oil refineries on the Gulf of Mexico, the CEO of TransCanada, Russ Girling, expressed surprise. After all, his company had laid 300,000 kilometres of such pipes across North America. “The pipeline is routine. Something we do every day,” he told Canadian journalists.

But that’s the point. It is routine. The oil industry does it every day. And if it carries on, it will wreck the world.

We need not rely on climate-changing fossil fuels. Alternative energy technologies are available. But fossil fuels, and the pipelines and other 20th-century infrastructure that underpin them, have created what John Schellnhuber, director of Germany’s Potsdam Institute for Climate Impact Research, describes in a new paper as “lock-in dominance” (PNAS, DOI: 10.1073/pnas.1219791110). Even though we know how harmful it is, the “largest business on Earth” has ossified and is proving immovable, he says.

The question is how to break the lock and let in alternatives. Schellnhuber, a wily and worldly climate scientist, has an idea, to which I will return. But first the tar-sands pipeline, known as Keystone XL in the parlance of outsize clothing. Proponents say it would create jobs and improve US energy security. But for environmentalists in the US, the decision – due any time – on whether it should go ahead is a

touchstone for Barack Obama’s willingness to confront climate change in his second term.

Superficially, Keystone XL doesn’t look like a huge deal. Since 2010, there has been a cross-border pipe bringing oil from tar sands in northern Alberta to the US Midwest. But this second link would double capacity and deliver oil to the refineries of the Gulf for global export. It looks like the key to a planned doubling of output from one of the world’s largest deposits of one of the world’s dirtiest fuels. And because the pipe would cross the US border, it requires state department and presidential sign-off.

Environmentalists are up in arms. They fear leaks. No matter what its sponsors suggest, this is no ordinary pipeline. The tar-sands oil – essentially diluted bitumen – is more acidic than regular oil and contains more sediment and moves at higher pressures. Critics say it risks corroding and grinding away the insides of the pipes. The US National Academy of Sciences has just begun a study on this, but its findings will probably be too late to influence Obama.

If there is a leak, clean-up will be difficult, as shown by the messy, protracted and acrimonious attempt to cleanse the Kalamazoo river in Michigan after tar-sands oil oozed into it in 2010.

To make matters worse, the pipeline would cross almost the entire length of the Ogallala aquifer, one of the world’s largest underground water reserves, from South Dakota to Texas. Ogallala is a lifeline for the dust-bowl states of the Midwest. While TransCanada has agreed to bypass the ecologically important Sand Hills of Nebraska, a big unseen spill could still be disastrous.

Climate change is still the biggest deal. Extracting and processing tar sands creates a carbon footprint three times that of conventional crude. Obama would rightly lose all environmental credibility if he were to approve a scheme to double his country’s imports of this fossil-fuel basket case. Yet he may do it. Why? Because of fossil-fuel lock-in. Changing course is hard. Really hard.

Part of the reason for the lock-in is the vast infrastructure dedicated to sustaining the supply of coal, oil and gas. There is no better symbol of that than a new pipeline. Partly it is political. Nobody has more political muscle than the fossil fuel industry, especially in Washington. And partly it is commercial. As Schellnhuber puts it: “Nobody has more political muscle than the fossil fuel industry, especially in Washington.”
that have proven to be profitable.”

The result is domination by an outdated energy system that stifles alternatives. The potential for a renewable energy revolution is often compared to that of the IT revolution 30 years ago. But IT had little to fight except armies of clerks. Schellnhuber compares this lock-in to the synapses of an ageing human brain so exposed to repetitious thought that it “becomes addicted to specific observations and impressions to the exclusion of alternatives”. Or, as Girling puts it, new pipelines become “routine”.

What might free us from this addiction? With politicians weak, an obvious answer is to hold companies more financially accountable for environmental damage, including climate change. But Schellnhuber says this won’t be enough unless individual shareholders become personally liable, too.

Here, he says, the problem is the public limited company (PLC), or publicly traded company in the US, which insulates shareholders from the consequences of decisions taken in their name. Even if their company goes bankrupt with huge debts, all they lose is the value of their shares. The PLC was invented to promote risk-taking in business. But it can also be an environmental menace, massively reducing incentives for industries to clean up their acts.

“If shareholders were held liable,” he says, “then next time they might consider the risk before investing or reinvesting.” More importantly, it could prevent us being locked into 20th century technologies that are quite incapable of solving 21st century problems. Fat chance, many might say. But just maybe Keystne XL and its uncanny ability to draw global attention will help catalyse growing anger at the environmental immunity of corporate shareholders. ■

Fred Pearce is a consultant on environmental issues for New Scientist

One minute with...

Harry Kroto

We must find a way to rescue the Royal Institution from having to sell its historic London home, says the Nobel laureate

Why is it important to save the Royal Institution (RI)?
It is of tremendous historical importance. It’s an iconic building not just for the UK but for the world, a focal point for the public understanding of science and a laboratory where people like Lawrence Bragg and Michael Faraday did cutting-edge research. It should be a world heritage site.

Could the RI continue to exist if the building was sold?
No. It’s impossible to move it out. You can move the National Gallery or the British Library, but not the Royal Institution. The institution is the building, and the building is the institution. If the building is sold, that’s the end.

How bad is the RI’s financial plight?
I don’t think people fully appreciate the problems that the institution faces, partly because the financial details haven’t been divulged. People are bandying about numbers that are probably significantly lower than what is needed. As far as I can see we don’t have a lot of time; it looks as though the plug is being pulled.

How did it come to this?
The problem has arisen partly because the RI got into significant debt. But it has had two years to find a strategy to convince credible sponsors and it hasn’t done it.

How much money is required?
Just to keep the doors open will require at least £2 million a year, meaning an endowment of £60 million. That doesn’t include paying off the debt.

In the grand scheme of things, that’s not a huge amount of money.
That’s correct, but the question is whether we can put together something credible to pull in that sort of funding. The only viable solution I can see is for the Royal Society to enter into some sort of partnership which would provide a level of credibility that potential funders might find acceptable.

“Keystone XL might have global significance. Many see it as a shrine to electricity, the lifeblood of the modern world. But we can’t just rely on that.”

PROFIE

Harry Kroto is a professor of chemistry at Florida State University. He won the Nobel prize for chemistry in 1996. His campaign to save the RI is at savetheri.wordpress.com

You have started a campaign to save the RI...
Yes. I’m doing it as a private individual, but one who knows pretty much everyone who was involved in the institution prior to 2000, when the strategy that led to this demise was put in place.

How has the response been so far?
Amazing. I’ve received messages from all over the world. People recognise that the institution has global significance. Many see it as a shrine to electricity, the lifeblood of the modern world. But we can’t just rely on that.

What does the RI need to do to reinvent itself?
The institution has not moved with the times as much as it could have done, by recognising it could have a global role to play rather than a provincial or UK one. Its position as a central point for UK public understanding of science is already pretty healthy, but it doesn’t bring much money. So it must become the platform for 21st-century educational science outreach on a global scale, by exploiting the potential of the internet.

Interview by Graham Lawton

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CHILDHOOD as an idea may have its origins in the 18th century, when philosopher Jean-Jacques Rousseau described it as a brief period of sanctuary before the hardships of adult life. Before then, art had been in line with the spirit of the times, depicting children as little adults. Historically, too, we can track the change in attitudes. Enforced child labour, for example, gradually became unacceptable.

Even now, however, children are exposed early in life to disadvantage, distress, repeated neglect and abuse, leading to poorer health, learning and social functioning. Early adversity can put individuals on a lifelong trajectory of increasing risk. Fortunately, we know quite a lot about how this happens. Remarkably, we also know that some adversity is not linked to poverty or deprivation, and that there are resilient children who prosper and thrive despite the harsh and often damaging realities of their young lives.

To help those who will face such adverse conditions, and to find out why responses to these stresses are so different, we need to know much more about how experiences of childhood adversity affect cellular pathways and translate into the molecular and genetic changes that result in biological effects on development and health.

Large steps have been made in this field, as was demonstrated by the breadth and depth of papers emerging from a Sackler colloquium entitled Biological Embedding of Early Social Adversity: From Fruit Flies to Kindergartners. This was held in Irvine, California, just over a year ago, and was sponsored by the
PROFILE
Marla B. Sokolowski is professor of ecology and evolutionary biology, University of Toronto. W. Thomas Boyce is professor of child development, University of British Columbia, Vancouver. Bruce S. McEwen is Alfred E. Mirsky Professor of neuroendocrinology at Rockefeller University, New York. Most of the research in this article can be found in the special issue of PNAS (vol 109, supplement 2) that this article draws on.

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US National Academy of Sciences and the Canadian Institute for Advanced Research.

It now seems clear that early adversity does cause biological changes. But how important to a child’s development is this biological “embedding” in specific psychological or health consequences – and why do these changes persist through life?

Ever since the 1980s, when results from work by epidemiologist Michael Marmot at University College London on the relative health of civil servants started to be recognised, socioeconomic status has been understood to be the strongest predictor of human health. Before then, epidemiologists adjusted for it rather than studied it. This obscured a key reality: the relationship with health is graded and continuous, so at all social levels your health is on average slightly better than the person just below you, and slightly worse than the person just above you.

Even more compellingly, socioeconomic status is a predictor of most illness, not just a single disease, such as coronary heart disease, or a category, such as cancer. The effect holds across age groups, so children in disadvantaged or poor communities are, like their parents or caregivers, much more likely to be ill then and later as adults.

One explanation is that people in poorer communities experience more and greater adversity, which undermines their resistance and increases the risk of illness, injury and psychiatric disorders. Thus early adversity puts individuals on a lifelong trajectory of increasing risk: school failure, teen pregnancy, criminality, obesity, elevated blood pressure, depression, coronary heart disease, diabetes, premature ageing, and memory loss in old age.

Many studies on animals and humans, such as those by psychiatrist Michael Rutter of University College London, have pointed towards the importance of experience early in life for health and well-being later in life.

Elsewhere, research by one of us, Bruce McEwen, has closed in on how pre- and postnatal stress affects a complex set of interactions between the hypothalamus, the pituitary gland and the adrenal glands (the HPA axis). These are all part of the body’s neuroendocrine system, which controls our reactions to stress and regulates many things, including digestion, the immune system, emotions, sexuality, and the storage and expenditure of energy. It is also involved in the inflammatory, metabolic and autonomic nervous systems.

Such systems help us cope with stress. But when people face stress in early life in the form of poor nutrition, neglect and abuse, the body increases the production of the stress hormone cortisol. Normally, cortisol washes over our organs, including the brain, increasing blood sugar and stopping the immune system from going into overdrive. But increased levels can suppress the immune system, and impair a part of the brain, the hippocampus, hampering learning and memory.

Programmed for stress
Poverty is not the only driver of poor environments. Children from middle or upper socioeconomic brackets also face adversity, as shown by decades of data from the Adverse Childhood Experience study, run by the Centers for Disease Control and Prevention in Atlanta, Georgia, and the Kaiser Permanente care consortium in San Diego, California. Such experiences are not just about dramatic events – chronic recurrent and often routine aspects of family chaos and neglect also affect development.

There are some interesting twists to these effects. If the early environment signals a lifetime of adversity and struggle, a baby may be “programmed” for physical and behavioural traits to help it cope with future challenges and stressors. This includes storing more fat to prepare for poor nutrition or hypervigilance to prepare for unpredictable environments.

Preparing the body for the worst is not always advantageous. If people with low birth weight go on to face overnutrition as adults, for example, they show high incidence of heart disease, diabetes and high blood pressure, according to work by David Barker of the University of Southampton, UK.

Another twist is that some children show a remarkable capacity to thrive despite being reared in very stressful, chaotic environments. The idea of “dandelion” children, who will grow and flourish under most circumstances, comes from research by one of us, Thomas Boyce, and Bruce Ellis, a developmental psychologist at the University of Arizona in Tucson.

And then some alleles, or variations, on certain genes that make someone more vulnerable, say, to substance abuse or depression are actually genes that, in a nurturing environment, may lead to better-than-average traits. Such “orchid” children need an especially nurturing environment in order to flourish and shine. The key is that the consequences of such environments depend partly on individual susceptibilities.

Although research had provided evidence that early social environments are closely associated with individual differences in responses to stress, no fundamental biological processes had been convincingly linked to these differences until relatively recently. Research into gene-environment interplay is now providing decent candidates.

The first mechanism, gene-environment interaction, concerns how individuals with different alleles differ in their sensitivity to the environment. For example, many children born into adversity carry gene variants that predispose them to damage to the stress-handling system, while others carry genes that buffer them.

Many other genes are also important here, ▶
including those involved in the HPA stress axis, in brain development and in communication within the brain. Even the immune system and gut microorganisms communicate with the brain and affect the way its genes express.

The second mechanism is epigenetics, by which, for example, stably inherited traits result from some genes being appended with a small chemical tag called a methyl group. This methylation can make a gene become less frequently expressed because it is no longer as accessible. Studies on rats by Michael Meaney and colleagues at McGill University in Montreal, Canada, show how this works.

Some rat mothers lick and groom their pups a lot, while others are far less demonstrative. When pups are licked and groomed infrequently, a gene involved in the stress axis that codes for glucocorticoid receptors – which mop up cortisol – is modified by methylation. This methylation means the pups end up with fewer of these receptors in their brains, which will, in turn, affect how well they cope with stress, learn, and act towards their own offspring. Cross-fostering the pups shows that adult females lick and groom according to how they were groomed by their mothers or foster mothers.

Evidence is emerging that major upsets in early life are linked with differences in DNA methylation and the expression of genes that predispose individuals to cope with adversity. Meaney and others have shown that some suicide victims with an early history of abuse have methylation of the gene for the glucocorticoid receptor and a subsequent reduction in its expression in the brain.

Interesting patterns of methylation across whole genomes have been revealed by researchers including psychiatrist Marilyn Essex from the University of Wisconsin-Madison and epigeneticist Michael Kobor of the University of British Columbia in Vancouver, Canada. They found that patterns laid down early in life in those suffering early adversity still seem to be present in adolescence.

Tantalising as these results are, we need to know a lot more before we can say exactly how experiences in early life can affect many aspects of brain development.

The process programs what happens to an infant. For example, how long do epigenetic effects persist, and how stable or reversible are they in the face of interventions such as providing a more nurturing home environment or a school breakfast club?

If we want to make large claims about the molecular processes linking early adversity and what happens later, we are going to need a bigger picture of how genes and environment interact. This will have to show how differences in individuals and the risk of disease spring from the interplay of factors such as the variation of alleles, the many kinds of epigenetic modification and a host of social dimensions.

Early life is a period of high brain plasticity, where differences in cognitive, social and emotional development start to consolidate. Experiences then can affect many aspects of brain development, including the type (glia or neurons) and number of brain cells made, and the extent of branching and pruning. Luckily, this is not deterministic: critical development periods provide opportunities when the brain is especially open to new stimulation.

Opening the window

About three months before a child is born, for example, the key windows for establishing sensing pathways – including vision and hearing – open. These climb to a peak, and then decline when the baby is 3 months old. Research by Janet Werker at the University of British Columbia, for example, shows how babies learn sounds common to their native language in the womb. Critical periods for language learning peak between 6 and 9 months, then close at about 4 years old.

During critical periods, the neural circuits involved are sculpted and can be changed by experience. Neuroscientist Takao Hensch at Harvard University has identified molecules acting as “brakes” involved in the opening and closing of these critical periods. His team has shown that it is possible to manipulate these molecules to reopen or extend the critical development periods. This has exciting implications for restoring plasticity, increasing the potency of interventions of all kinds, and for treating neurological disorders.

The idea that early social adversity could be biologically embedded has come a long way, but has a long way still to go. We know, for example, that the brain plays a crucial role in embedding – but we still need to know how the interactions between genes and environment link up to social context and to the brain. Which brain circuits are involved? How do different genetic variants influence brain responses to social adversity? Which social conditions strongly affect growing brains? And what are the adaptive processes by which gene networks, epigenetic patterns and neural circuits work together to influence how we turn out?

Many economists agree that returns on investment in the early years – improved success at school, better health, less crime – far outstrip the costs of treating the problems arising from early inequities. Our goal should be to find the biological keys of optimal development. Then we can ensure that all children, especially those growing up in abusive or deprived environments, prosper.
How remote can you go?

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Valley views

From Andrew Hawkins
I wonder if the “uncanny valley”, the discomfort experienced when confronted by a human-like android (12 January, p 35), could be related to the idea that our brains organise things into specific categories, such as dogs and fish under animals (5 January, p 10)?
A robot that looks human but we know is a machine could be creating an anomaly in the brain’s filing system as it attempts to slot it into conflicting categories.

Peaslake, Surrey, UK

It grows on trees?

From Ben Haller
Your look at the ecology of mistletoe was a fascinating read (22/29 December 2012, p 70), but it got me thinking about economics. Trees hang onto the large majority of resources in a woodland and don’t share them with others, and that stifles diversity. In a sense this echoes the accumulation of resources by the super rich, or 1 per cent, in our societies.
Mistletoe is like Robin Hood; it steals from the rich (the trees it grows on) and gives to the poor (other species present). In so doing, it apparently acts as a “keystone resource” promoting diversity.
To what extent do ecology and economics occupy common ground? Could economic experiments be conducted in experimental forest plots? Can models in ecology be extrapolated to human economies? Has this been studied, and if so, what does it tell us about inequality, redistribution, economic productivity and health?
Montreal, Quebec, Canada

Enigma Number 1733

Astronomer royal

ADRIAN SOMERFIELD
I was talking to my granddaughter about the solar system and how planets and comets move in ellipses with the sun at one focus. I told her how you could draw an ellipse by sticking two pins in a sheet of paper both equidistant from and in line with the central point, placing a loop of string around them, and then by putting a pencil in the loop and keeping it tight, go right round. The pencil would thus draw the ellipse, each pin being at a focus.
Then I asked her to draw the biggest ellipse she could on a sheet of paper 50 centimetres long and 30 cm wide, and then to find the area of the rectangle she could inscribe in her ellipse whose longest side was equal in length to that of the shorter side of the original sheet.
How far apart must she place the pins? How long was the string? What was the area of the inscribed rectangle?

WIN £15 will be awarded to the sender of the first correct answer opened on Wednesday 20 February. The Editor’s decision is final. Please send entries to Enigma 1733, New Scientist, Lacon House, 84 Theobald’s Road, London WC1X 8NS, or to enigma@newscientist.com (please include your postal address).

Answer to 1727 Common factors: The consecutive numbers are 17, 18 and 19.
The winner: Ivan Simmons of Edinburgh, UK

Not so elementary

From Paul Waring
As an avid fan and one who uses the stories of Sherlock Holmes to demonstrate inference, I really enjoyed your book reviews on the great detective and his science (5 January, p.40). In them you mention his use of deductive reasoning, which in its strictest definition means that based on the assumption of true reasons the answer is guaranteed true.
However, author Arthur Conan Doyle probably assumed the more common meaning of “deduction” as a process leading to a conclusion so that an audience not necessarily skilled in either science or logic could understand.
Holmes of course uses that form of reasoning which gave 18th century philosopher David Hume so many problems and which produces new knowledge with a high probability of truth – inductive reasoning.
Canberra, ACT, Australia

Natural barriers

From Edward Webber
Mark Pagel’s hypothesis about the distribution of languages, with the widest diversity found in the tropics, is interesting but I suspect it has more to do with topography than climate (8 December 2012, p 38). The New Guinea islands are geologically young and in the early stages of erosion, with high mountains and steeply incised valleys in the highlands. Each valley is home to a different tribe with a distinct culture and language, often out of touch with the rest of the world.
Buderim, Queensland, Australia

Editorial input

From Michael Berkson
You report that Wikipedia is rated harder to read than Encyclopaedia Britannica (15 December 2012, p 27). Information scientists Adam Jatowt and Katsumi Tanaka attribute this to Wikipedia articles often being written by experts, who tend to sacrifice readability for accuracy.
I always understood that Encyclopaedia Britannica contributors were also experts. There is surely a simpler explanation: the Britannica entries are edited by professionals before publication, unlike those in Wikipedia.
Great Shelford, Cambridge, UK

Gainless condition

From David Fee
You report that finger skin wrinkling as a result of soaking in water could be a beneficial adaptation as it gives better grip in wet conditions (12 January, p 15).
Surely this is a classic example of what author Raymond Tallis calls “Darwinitis”.

Not every physical characteristic need confer an adaptive advantage. A characteristic can surely be adaptively neutral, of no great benefit or disadvantage.

Exeter, Devon, UK

Headline figure

From Chris Rapley, climate scientist, University College London

I worry that announcements such as those by the UK’s Met Office predicting little change in the global mean surface temperature over the next five years are so readily translated into “global warming at a standstill” by the mainstream press, as you reported (9 January, newscientist.com/article/dn23060).

The global mean surface temperature is an insufficient, often misleading measure of the real issue. What matters is the energy imbalance of the planet, the climate disruption it is driving, and the consequences for humanity. As you said, 90 per cent of the energy imbalance is accumulating in the oceans – something that is invisible to the global surface temperature data. The continuing rise in global mean sea level as a result of thermal expansion (and a contribution from ice melt on land) shows this accumulation has not ceased.

Even if the global mean surface temperature stayed constant, changes to the geographic patterns of temperature would have consequences for our well-being, water supplies, food production and the frequency and nature of extreme events. The heatwave in Australia this month provides a vivid illustration.

I don’t blame the media for pursuing a catchy headline and provocative story. But the unfortunate consequences are public confusion and loss of motivation to combat climate change. It seems to me the science community needs to be much more circumspect about how it expresses its results and their meaning.

London, UK

Car hacking

From Peter Borrows

Bryant Walker Smith raises a number of legal issues surrounding driverless cars (22/29 December 2012, p 34). But what about the elephant in the room: hacking? Doubtless we will be told that security will be tight, but it often isn’t for new technology, such as cellphones.

Why would anyone want to hack a driverless car? Perhaps for “fun”. Or maybe to kidnap a politician, or their child on the way to school. Worried? You should be.

Amersham Old Town, Buckinghamshire, UK

Consumer rules

From Roy Smith

Peter Ryan’s letter makes a good argument for taxing carbon emissions on the consumption rather than production of goods (22/29 December 2012, p 41). However, recent responses to energy price and fuel duty increases in the UK are not encouraging. Environmental explanations for the underlying policy are overwhelmed by the bad press generated by aggrieved consumers. I don’t think that any sensible system that directly makes the consumer pay for carbon emissions will ever be politically viable.

Burntwood, Staffordshire, UK

Puzzle and a pint

From Mark Dowson

Logician George Boolos may have solved the “hardest logic puzzle” in 1996 (22/29 December 2012, p 50). However, a handful of students of experimental psychology at the University of Sussex, UK, cracked something similar one afternoon in 1968, aided by a few beers.

Our problem was to distinguish the door that led to freedom from the door that led to death when faced by three guardians: a truth teller, a compulsive liar and a randomiser, whose words for “yes” and “no” were “ping” and “pong” (or vice versa). We didn’t need to appeal to the law of the excluded middle, and it didn’t occur to us to publish.

Leesburg, Virginia, US

Bounce, don’t slosh

From James Zhang

Further to your look at how to avoid a scalding when carrying a hot drink (22/29 December 2012, p 65), I find that applying a slight up and down motion to the container while walking works well. This is true regardless of container weight or distance from body.

London, UK

Health shortages

From Tony Waldron

In his letter Peter Wilson bemoans the lack of psychotherapists in the UK’s National Health Service (12 January, p 29), but there are also too few staff to care for the elderly, for dementia care, for treatment for some types of cancer, for health education – in short to provide anything like a service that can satisfy the insatiable demand.

The defining of what our health service can and cannot afford is urgently needed. Until this exercise takes place, it will be underfunded and underachievement the norm.

London, UK

G.O.D.

From John Young

I propose that while there is uncertainty regarding the beginning of the universe (1 December 2012, p 32) the debate about it should be called the Great Origin Dilemma.

Shrewton, Wiltshire, UK

For the record

In our photo competition (22/29 December 2012, p 77) we mislabelled image L as H on page 66. The labelling was correct in the online version, however, where the answers needed to be submitted

Enigma puzzle 1731, “Power play” (12 January, p 28), should have been credited to Gwyn Owen
Midnight sun

Solar power could run all night with a little help from an unlikely source

Naomi Lubick investigates
OST engineers would have been horrified to find even a little bit of rust on their electrodes. But Kenneth Hardee and Allen Bard had made theirs entirely of the stuff. In their pursuit of cheap solar power, the pair had been trying to coax a current out of the cheapest material they could find. And they succeeded: exposed to visible light, it produced a small but decent current.

That happened in 1975, just as silicon was becoming the next big thing. Silicon’s greater efficiency made it the mainstay of photovoltaic solar cells, and it has stayed at the top of the market ever since. Rust simply didn’t have the electrical properties to compete. The small breakthrough at the University of Texas at Austin fell by the wayside and the only time anyone thought about rust, if they thought of it at all, was when they wanted to get rid of it.

But over the past few years, the spotlight has been swinging back to a substance that, contrary to popular opinion, may actually be something of a wonder material. Though iron oxide can’t compete with silicon’s efficiency at turning the sun’s energy into electricity, it can do something silicon cannot: help store the sun’s energy. Humble flakes of rust might be the way around one of the most intractable problems plaguing solar power – the night.

Solar research has focused almost exclusively on efficiency. Every day, the sun bathes our planet in more energy than we can hope to consume in a year. But harvesting it is not easy. Even the best available technology – the billion dollar solar panels made from expensive combinations of rare earth elements used by the International Space Station – can only convert 46 per cent of the sun’s energy to electricity, and that’s under ideal conditions. The usual figure is much lower. Back on Earth, cheaper, silicon-based photovoltaics mop up about 15 to 20 per cent.

Ways to store excess energy so it can be used when the sun is not shining are urgently needed. In part because it can only be used at the moment it is generated, this apparently limitless resource contributes the least of all renewables while remaining about 20 times more expensive than power from fossil fuels (see diagram, page 36).

Batteries are the most obvious solution, but their low energy density combined with the high cost of a system capable of powering an entire home – which would need replacing every few years – makes them an option only for the rich. A far better way to store solar energy is by using it to make hydrogen. The element’s chemical bonds pack a huge punch, storing as much as 170 times the energy per kilogram as standard lithium ion batteries. Hydrogen is also versatile: once you’ve got it, you can use it however you want. Put it in a fuel cell and you can generate electricity on demand by recombining it with oxygen; combine it with carbon monoxide and it becomes methanol biofuel; stored properly, it can even be burned like any other gas fuel.

The simplest way to turn power from photovoltaic cells into hydrogen is by using that power to run an electrolyser. This splits water – \( \text{H}_2\text{O} \) – into hydrogen and oxygen. Simple, perhaps, but also inefficient. Of the miserly 15 per cent of solar radiation that standard photovoltaic cells are able to capture, another 30 per cent is lost in the conversion. By the time you are done, you’re better off with the rechargeable battery.

**Power from water**

The better option would be to find some cheap electricity-conducting material that can bypass photovoltaic cells altogether and simply use the sun’s photons to electrolyse water and make hydrogen.

For a material to electrolyse water directly, it must release electrons of the right energy when hit by a photon. When these electrons are excited enough to vacate the material, they leave behind gaps known as holes. To fill these holes, a water molecule donates one of its own electrons. In this way, electrons and holes work together to oxidise water, and turn it into hydrogen and oxygen.

Silicon is not the right tool for the job; its electrons don’t have the right energy. All materials need different, precise amounts of energy to make their electrons jump free of their atoms. Silicon atoms need only 1.11 electronvolts to loosen an electron – but splitting water requires electrons with at least 1.23 eV.

Materials that do hit the spot can be created from exotic compounds. By combining zinc selenide and cadmium sulphide crystals with a platinum catalyst, for instance, engineers at Bowling Green State University, Ohio, were able to liberate the proper electrons. But the complicated process and rare materials add up to a device that works in the lab but could be too costly to commercialise.
Connecting the sun
Solar power is expensive and inefficient, even compared with other renewable sources of energy. Perhaps changing the way we harvest the sun’s energy will change that (see main story)

In 1975, and even in the early 1990s, this would have been impossible. By the turn of the 21st century, however, nanotechnology had advanced sufficiently for it to be possible to manipulate a material’s physical structure – and yield some surprisingly elegant solutions.

Jordan Katz, at Denison University in Ohio, has created a thin coating comprised of rust rods a few nanometres wide. That narrow width gives the device a very high surface area, while allowing water to seep into the nanosized crevices between the rods. This lets electrons and holes escape the material and meet the surrounding water. But Katz says he is far from finding a material with marketable efficiency.

Researchers at EPFL found a way to do it. To aid the electrons’ escape, Kevin Sivula creates nanorust using “cloud” deposition, which involves spraying a mist of iron solution onto a surface. This deposition method causes the iron oxide to grow into forests of microscopic cauliflower-shaped “trees”, creating the kind of fractal surface area that allows the electrons to make their getaway, but that can also be mass-produced.

Last year Sivula’s group created a working device using nothing more expensive than glass. At 3.6 per cent, its efficiency rivalled that of the Grätzel device, but without help from extra tandem cells (Nature Photonics, vol 6, p 824). And Sivula says he can push that to 10 per cent within a couple of years.

However, his goal might be stymied by a problem that arises, paradoxically, when the rust layer is very thin. A fundamental tension for any electrolysering material is that you need it to be both as thick and as thin as possible. Thinner is better if you want your electrons to have any shot at escape. But to absorb as many photons as possible, the rust layer needs to be thick. A 20-nanometre layer absorbs only 18 per cent of the total absorbable photons. Boost the thickness to 1 micrometre and you catch nearly all of them – but then they get stuck.

To resolve this, Avner Rothschild and his team at Technion University in Haifa, Israel, turned to quantum physics. Their device traps incoming light in 30-nanometre rust films. When the photons enter the device, they are forced into a chamber of facing, V-shaped

“Iron oxide can last for years in a corrosive environment. After all, it’s not like it’s going to rust”
mirrors, which bounce them back and forth until they are absorbed. What’s more, the interference between the ensuing forward- and backward-propagating light waves further boosts the absorption, especially close to the film’s surface. The electrons and holes can easily reach the surface before recombination is possible. Thanks to this tweak, the device is able to absorb 71 per cent of the incoming photons, but it is so thin that electrons can escape, leading to a theoretical efficiency of 4.9 per cent (Nature Materials, in press).

That’s impressive by iron oxide’s low standards, but not exactly the stuff of commercial products – or is it?

Here at last is the real genius of rust, and why it may eventually eclipse silicon despite the most feeble efficiencies. Even if it never reaches its 16 per cent maximum, says Sivula, it’s so cheap that you can make vast swaths of it, which is exactly what he and the other rust researchers are planning. “What ultimately matters is not efficiency, but cost per watt,” says Katz. Even 10 per cent efficiency “at the right price”, he says, would beat a 50-per-cent efficient photovoltaic cell, because it would make rust worth spraying on every surface.

And this is exactly the goal. Sivula thinks you could coat his iron “cauliflower” mixture onto something akin to wallpaper, printing out sheets of solar cells, generating hydrogen everywhere and anywhere. Lonely desert outposts would be a perfect home, and the process could use filtered waste water.

The hydrogen problem

To be sure, a few more issues must be resolved before this dream can be realised. Once water splits, for example, “you’ve effectively created a bomb”, Hellgardt says, because oxygen and hydrogen can react explosively. A more benign yet equally poor outcome is that your hydrogen and oxygen just recombine to form water that is slightly hotter than it was before.

Separating the two gases is straightforward. In Sivula’s cell, for example, a membrane attracts oxygen and hydrogen differentially, letting them bubble up separately. Hellgardt has a different idea: if you don’t plan to use the oxygen, why generate it in the first place? His design uses low-grade waste water to “eat” the oxygen. Instead of becoming a gas, it reacts with the organic compounds in the water, leaving the hydrogen to bubble safely off to the storage tank.

And there’s the final rub for rust solar: while it can store solar energy by making hydrogen, storage presents its own problems. The gas is notoriously difficult to keep confined without relying on expensive, tough materials that won’t corrode – or explode. Indeed, this problem has tripped up the entire promise of the oft-hailed hydrogen economy.

Researchers have been working on a constellation of solutions to the problem. Alongside steady improvements in fuel cells, a number of new approaches are under way. For example, researchers at the University of New South Wales in Australia recently used nanoscale sodium borohydride for storage. Normally, the salt must be heated to 550 °C to release hydrogen stored in its bonds, but at nanoscales, it was coaxed to do so at 50 °C. That is a promising development for portable hydrogen at many scales.

Promising, but maybe not necessary. Simple canisters of hydrogen, stored on site and burned like camping fuel, would also do the trick. This is what Brian Holcroft, director of Stored Solar, sees as the immediate niche in places like Kenya, where sunlight is plentiful and energy infrastructure lacking. He has collaborated with EPFL to use the tandem cell-and-iron oxide setup for his company, which makes off-grid energy solutions. He is keen to get these devices onto roofs in the developed world as well, where their owners could get hydrogen fuel and electricity without a grid.

And maybe they wouldn’t need the tandem cell. Insights from decades spent coaxing rust electrons to split water may move Hardee and Bard’s original dream from the past into the future: a rust photovoltaic device, albeit an inefficient one, coupled with a storage device.

“If you don’t care about efficiency at all, a rust cell could function either to make fuel or electricity, or both at the same time,” says Katz. “It could make electricity during the day during peak electrical demand, but produce fuel instead when demand is not as high.”

Given the economic realities of solar energy, the tiny current Hardee and Bard tapped into in 1975 may yet become a renewable energy source that could cover the planet. Maybe it’s time to enter the Rust Age.

“By the turn of the century, nanotechnology had made it possible to manipulate rust’s physical structure”

Rust: a wonder material – if you can make its electrons behave

Naomi Lubick is a writer based in Sweden
EVEN if you are teetotal, you cannot deny that humans, as a species, like to drink. We consume wine, beer, cider, spirits... in fact, the fermented product of almost anything we can turn to alcohol. Our fondness for this toxic substance, the cause of so much trouble, is something of a mystery. Maybe it is enough to say that we drink because it makes us feel good. But I think that to understand our love of alcohol you need a bigger, more evolutionary, explanation.

The story of alcohol is one of an intimate relationship between humans and yeasts, an affair that began millions of years ago and is still playing out today. We like to cast ourselves as the star of this drama, but in fact yeasts are the unsung lead character. Ours is a symbiotic connection – a mutually beneficial partnership. It is also one in which the balance of power is constantly shifting. If anything, the yeasts seems to have had the upper hand, at least since our ancestors began brewing their own grog. We cultivate yeasts, ensuring they

The 10,000-year bender

Our love affair with alcohol is the result of a long and tempestuous relationship between us and yeast, says biologist Rob Dunn
survive and thrive, and in return we get, at best, a good night out and a hangover the next morning. Once upon a time, however, yeast and alcohol may have offered us more significant rewards.

Today the costs of our love of alcohol often outweigh any benefits. But, being a story of evolution, it doesn’t end there. Already some humans have acquired genetic changes that encourage them to drink less. If this trend continues, it is possible that one day this long and tempestuous relationship will reach a kind of tenuous truce.

We are not the only species that likes a tipple. Fruit flies regularly consume fermented fruit, seemingly without any impairment to their faculties. Other animals don’t hold their drink so well. Cedar waxwings have been spotted partaking of a few too many overripe winterberries and then flopping around among the branches of trees or crashing into buildings. Terrifying accounts of drunk elephants exist, although these are poorly substantiated. There are even records of creatures going out of their way to become intoxicated. These include tree shrews – the closest living relatives to the primates – which seek out nightly nips of a frothy “wine” produced by yeast in the flower buds of the bertam palm.

This kind of behaviour can be traced right back to the evolution of fruit around 130 million years ago, when flowering plants emerged during the Cretaceous era. With a new source of food available, a genus of yeasts known as Saccharomyces evolved to feed on it, and in the process these yeasts acquired a new physiological trick. Instead of using their energy to break down sugar completely, they evolved the ability to partially break it down, producing ethanol as waste when sugar supplies were abundant and oxygen scarce. The partial breakdown of valuable sugars meant that these yeasts were actually less efficient than their forebears. But it gave them a big advantage too. Ethanol kills most bacteria, and bacteria like to feed on fruit, so producing alcohol allowed yeasts to kill off the competition.

From the beginning, Saccharomyces would have fed on ripe fruits – unripe ones often being toxic – so the smell of ethanol might have become a universal sign that fruits were ready to eat. According to Robert Dudley at the University of California, Berkeley, natural selection favoured primates and other fruit-eating mammals that could use the odour of ethanol to locate edible fruit in vast forests. He believes they evolved a fondness for the smell that led them to experience positive

“If anything, the yeasts seem to have had the upper hand, at least since our ancestors began brewing their own grog”
sensations even before they consumed the alcohol itself (The Quarterly Review of Biology, vol 75, p 3). According to this theory, every time a primate sniffs booze, pleasure rings out in its brain. Incidentally, we primates may not be alone in this. Fruit flies’ mouths have a sensory receptor, a kind of taste bud for alcohol. It was identified by a grad student who, in a moment of frustration, offered them beer.

Love at first sight?

Dudley suggests that our ancestors began to make alcohol to feed their sensory bias for it, in much the same way that we farm sugar cane and sugar beets to feed our evolved preference for sugar. If so, alcohol is like all the other things from which we once benefited but now overindulge in. Not everyone is convinced. Doug Levey of the National Science Foundation in Arlington, Virginia, believes primates never had an innate tendency to seek out the smell of ethanol — after all, fruit that smells of ethanol is already en route to being overripe. Instead, he argues, our ancestors only really started enjoying alcohol after they learned to make it themselves. By neurological happenstance, the liquor triggered feelings that they liked and desired more of, and so they sometimes indulged to excess (Integrative & Comparative Biology, vol 44, p 284). If Levey is right, our taste for alcohol is more like our taste for caffeine or cocaine than for sugar.

Alcohol does produce pleasurable feelings — this much no one debates — through its ability to bind to GABA receptors in the brain. Normally, these receptors reduce the activity of the neurons on which they are found, but when alcohol binds to them it releases that pent-up activity and, in doing so, relaxes both our bodies and our inhibitions. Thanks to this, countless babies have been conceived, countless friendships formed and rapprochements achieved. But ethanol also makes us uncoordinated, groggy, reckless and aggressive. It is the fuel behind many accidents, fights and even wars.

Overall, then, alcohol consumption may not have been advantageous to our ancient fruit-gathering ancestors but, interestingly, it seems to have offered real benefits once we began to farm. At the dawn of agriculture, around 10,000 years ago, people in small settlements began to ferment foods and drinks. This would have allowed them to preserve surplus grain, in essence by favouring yeasts in place of food-spoiling bacteria. It would even have made grain more nourishing because yeasts produce other nutrients, including B vitamins, during fermentation. Alcohol consumption might also have helped smooth social interactions, which would have become more complex as communities grew. Perhaps most importantly, fermentation offered a way to stabilise liquids, since ethanol kills not only bacteria — including the one that causes cholera — but also other pathogens. Indeed, animals may self-medicate with it. For example, fruit flies infested with parasitic wasps consume more alcohol, which usually kills the wasp without being fatal to the flies. In the insanitary conditions faced by early settled communities, fermented drinks were both nutritious and potable — not entirely healthy, but better than unfermented alternatives.

As for how we learned to make alcohol, most anthropologists believe that the first farmers stumbled across the trick by accident, when stored wheat and barley became contaminated with Saccharomyces yeasts. There is another, more intriguing, possibility. Anthropologist Solomon Katz at the University of Pennsylvania in Philadelphia has argued that fermentation came first, giving our ancestors a strong incentive to cultivate grain to make grog. As it happens, the oldest vessel for storing alcohol found so far, 7000 years old, is contemporaneous with or may even predate the earliest evidence of farming in China, where it was unearthed (PNAS, vol 101, p 17593). Either way, once alcohol had been manufactured, its producers realised that it could be made again and again simply by taking a sample from one fermenting liquid and using it to kick-start the process in a new batch. It must have seemed like a magical transformation to ancient brewers, but today we know that humanity’s first vats were colonised by Saccharomyces cerevisae. We also have its precise genetic code: it was one of the first organisms to have its genome sequenced. However, we still know very little about basic matters such as where it came from.

An evolving partnership

Brewer’s yeast has changed many times as agriculture spread and different human cultures emerged (Comptes Rendus Biologies, vol 334, p 229). New forms, as distinctive as species, emerged in association with beer and wine production in different regions. Some of these yeasts changed further to give a wide variety of bread yeasts. In a monk’s cave in Germany, the cold-tolerant yeast used to make lager evolved as a hybrid of S. cerevisae and a species that hails from Patagonia. Mysteriously, this occurred more than 100 years before Europeans reached the New World (PNAS, vol 108, p 14539).

In Britain and elsewhere, brewers also began to use an entirely different genus of yeasts, Brettanomyces, which had acquired the ability to produce alcohol independently of Saccharomyces, from which it split 200 million years ago. Brettanomyces is used in the production of several speciality beers, giving an unusual sour, tangy flavour.

Humans have undoubtedly influenced the evolutionary diversification of yeasts, but we did not consciously steer the process any more than the Galapagos Islands controlled the evolution of Darwin’s finches. Fungi such as yeasts often interact symbiotically with other species. Leaf-cutter ants, for example, feed bits of leaf to the fungi in their nests, which in turn produce fruiting bodies that the baby ants eat. Ambrosia beetles carry fungi in little pouches, releasing them onto dead wood where they grow, providing food for their larvae. In these and other cases, animals are often said to have domesticated fungi, but perhaps the reverse is true. After all, the animals are forced to forage and ferry while the fungi just feed, grow and reproduce. Likewise, brewers have to work hard to ensure that their yeasts thrive. What’s more, those varieties that take the most

“In the insanitary conditions faced by early settled communities, fermented drinks were potable and nutritious”
advantage of us are most likely to survive. These include lineages that have evolved to tolerate higher concentrations of alcohol, allowing them to produce more potent brews, so persuading us to work even harder to cultivate them.

The yeasts have shaped us directly, too. One key change occurred very early – a big divergence between humans and other primates in levels of the enzyme that breaks down alcohol, and where in the body it is found. In non-human primates, alcohol dehydrogenase is found throughout the body. That seems unsurprising as ethanol is a by-product of various bodily processes, so most cells encounter it. The enzyme is also everywhere in our bodies, but it is disproportionately concentrated in the liver, where the alcohol we imbibe ends up. Our ancestors’ increasing consumption of alcohol became increasingly dangerous: a blood alcohol level of 0.4 per cent is considered lethal for adult humans. Those who survived binges tended to have more alcohol dehydrogenase in their liver because they could process alcohol more rapidly. Today, 10 per cent of the enzymes in the average human liver are dedicated to metabolising ethanol.

Given the longstanding relationship between humans and brewer’s yeasts, it is not surprising that each has influenced the other’s evolution. This process is ongoing. No symbiotic relationship is simple – the costs and benefits that each party experiences shift with time and context. Alcohol may once have been a signal of good fruit; in the early days of agriculture, it probably aided our survival. But the balance would have tipped as waterborne diseases became less of a problem and as yeasts became easier to cultivate and their products more intoxicating. People may still benefit from the occasional drink: every few years a study comes out arguing that a little bit of wine or, more rarely, beer is good for you. However, for society as a whole, alcohol now brings more costs than gains, whether measured in life expectancy or money. In 2010, alcohol was the third biggest health risk globally, killing 4.9 million people worldwide (The Lancet, vol 380, p 2071), and problem drinking has an annual economic burden of hundreds of billions of dollars.

In some places, such costs seem to have been incurred for many generations, long enough to allow people to evolve once again. This time, natural selection has favoured an adaptation that encourages individuals to consume less alcohol. The detoxification of ethanol involves two enzymes – alcohol dehydrogenase, to turn ethanol into acetaldehyde, and aldehyde dehydrogenase, which converts acetaldehyde to acetate. This enzyme partnership exists in nearly every organism, including many bacteria, but in some East Asian populations, including most Chinese and Japanese people, the gene for aldehyde dehydrogenase is broken. When people with this version of the gene consume alcohol, drunkenness occurs after fewer drinks, their faces turn red, their hearts palpitate and they feel nauseous.

The mutated gene spread in geographic and temporal lockstep with the spread of rice cultivation and rice wine production some 7000 to 10,000 years ago (BMC Evolutionary Biology, vol 10, p 15). Researchers say it may have evolved for a reason, pointing out that once it arose, it spread more quickly than it would have by chance. They argue that East Asian populations had started to feel the negative consequences of alcohol so strongly that individuals whose bodies discouraged them from drinking to excess were more likely to survive. In this light, the “drink less” gene variant might have been favoured both by natural and sexual selection, at least if ruddy-faced drunks are less likely to find mates.

Evolution does not stand still, so it is interesting to speculate that various “drink less” mutations may be spreading in human populations right now. If so, then one day our love affair with alcohol might end – though one should not underestimate the evolutionary cleverness of yeasts.

In the meantime, alcohol-producing yeasts will keep evolving, as will our understanding of humanity’s intimate relationship with them. Despite the story I have told, more remains unresolved than resolved, hidden in every alcoholic drink. So, while we can still enjoy it, let’s raise a glass to the yeasts. Curse them, and bless them!

Rob Dunn is at North Carolina State University in Raleigh. His most recent book, The Wild Life of Our Bodies, is published by HarperCollins
Close call

With an errant space rock heading this way, just how good are our asteroid defences, asks Nigel Henbest
IT COULD easily be the plot for a Hollywood disaster movie. Last February, a young dental surgeon called Jaime Nomen was sailing along the Mediterranean coast of Spain, checking images on his laptop from an observatory 600 kilometres away. Suddenly he spotted a speck of light speeding through the constellation Boötes. Nomen knew exactly what it was.

He alerted the Minor Planet Center in Cambridge, Massachusetts, which collects information about asteroids and comets. Telescopes around the world swung into action, checking the new asteroid’s orbit. The result was sensational: asteroid 2012 DA14 was on near-collision course with the Earth.

On 15 February 2013, the errant rock will skim Earth just 25,000 kilometres above our heads – that’s 500 times nearer than the much-publicised asteroid Apophis came earlier this month, and even closer than Apophis will get on its much-hyped return in 2029. Asteroid 2012 DA14 will fly inside the ring of communications satellites in geosynchronous orbit but sail safely above the orbits of the International Space Station and the Hubble space telescope.

“I’m not easily surprised by close-Earth approaches any more,” says Don Yeomans, who heads NASA’s near-Earth object office in Pasadena, California. “But this one will be a record close approach by a known object of this size.”

From the fleeting glimpses they have had, astronomers reckon 2012 DA14 is 45 metres across – similar in size to the space projectile that exploded over the uninhabited Tunguska region of Siberia in 1908, ripping up 80 million trees across 2000 square kilometres. While there is no chance that 2012 DA14 will hit Earth, this closest of encounters raises important questions. Will we actually be able to spot the next asteroid with our name on it? And what, if anything, can we do about it?

**Vital effort**

The discovery of 2012 DA14 is all the more amazing because it was made by amateur astronomers, whose observatory in the dark mountains at La Sagra near Granada, Spain, comprises three small telescopes equipped with off-the-shelf cameras. Motivated and skilled teams of amateurs like Nomen’s are vital for asteroid-spotting. The La Sagra team turns up around 15 near-Earth objects (NEOs) each year, a tiny but crucial fraction of the bigger teams’ hauls. “Even the large surveys can’t cover the whole of the sky all the time,”
Near miss

Asteroid 2012 DA14 will come within 25,000 kilometres of Earth, closer than the orbit of our communications satellites

Asteroid 2012 DA14
DIAMETER = 45 metres
MASS = 130 million kg
TORINO SCALE HAZARD RATING = 0
(The likelihood of a collision is zero, or is so low as to be effectively zero)
If Earth were in the firing line:
2012 DA14 would release energy equivalent to a 2.5-megaton explosion, comparable to a good-sized nuclear weapon

and modern amateur-scale equipment rivals the best professional equipment of only 15 to 20 years ago,” explains Steve Larson, who heads the Catalina Sky Survey. The world’s most prolific asteroid-hunters, Larson’s team has bagged over 4200 NEOs using two telescopes in Arizona and one at Siding Spring in Australia. “We very much applaud the efforts of Nomen’s group,” he says.

One discovery made by the Catalina survey shows the value of asteroid-hunting. In 2008, it made the very first prediction that a space rock the size of a truck was about to wallop Earth. The asteroid, named 2008 TC3, was expected to hit north Sudan within a day. Astronomers alerted the Pentagon and even the White House. Right on schedule, an airline pilot saw a fireball over Sudan as the asteroid exploded with the force of a kiloton of TNT. And a few months later, scientists recovered a batch of fresh meteorites scattered over the desert – the equivalent of a “sample return mission” for a NEO. “2008 TC3 was the most exciting discovery we’ve made,” says Larson.

However, there is a region of sky that remains poorly watched. The sky over the south pole never rises above the horizon for telescopes in the northern hemisphere, so is off limits even to the Panoramic Survey Telescope and Rapid Response System (Pan-STARRS), which is twice the size of its predecessors and is based on the summit of Haleakala mountain in Maui, Hawaii. The Siding Spring telescope near Coonabarabran is the only instrument that could spot a dangerous asteroid approaching from this most southerly patch of sky – but the Catalina project cut its funding in mid-2012. When the solitary astronomer still on duty there, Rob McNaught, visited the UK last September, the Siding Spring Survey shut down for a month, leaving a totally blind spot in our monitoring capabilities.

That hole will be plugged in a few years’ time by the Large Synoptic Survey Telescope (LSST) on Cerro Pachón mountain in Chile. At 8.3 metres in diameter, its mirror is one the biggest in the world, and it will pick up asteroids far smaller than Pan-STARRS can see. Uniquely among such large telescopes, the LSST will scan the sky to pick out the faintest objects, from the solar system to the edge of the universe.

“LSST will decrease the risk of unexpected collision with Earth by a factor of 10 to 100 compared to existing surveys,” anticipates its director, Tony Tyson. His team has already cast the giant glass mirror and blasted off the top of the mountain peak to create a level base. The telescope is expected to see “first light” in 2019, and will then begin a survey of NEOs lasting 10 years. “Once LSST comes online, it will be the big dog and dominate the ground-based NEO survey discoveries,” says Yeomans. “That’s all well and good, but taking the hunt for asteroids into space would be even better. Telescopes on Earth can only look for asteroids at night, limiting their surveys to the region of space away from the sun. This leaves us blind to any dangerous space rocks that approach us from inside Earth’s orbit. What’s more, small asteroids that are too faint to see at visible wavelengths glow brightly in the infrared against the cold, dark background of space – but Earth’s atmosphere blocks many infrared wavelengths. That’s why a private consortium is planning to build and launch an asteroid-hunting space telescope known as Sentinel.

Small but dangerous

Sentinel will be modelled on the Spitzer telescope – Hubble’s infrared brother – and on the Kepler telescope that’s currently seeking out planets around other stars. If money can be raised to fund it, Sentinel will launch around 2018 and will orbit the sun near Venus. “It will be much more effective at finding the smaller, yet still dangerous, asteroids,” says ex-astronaut Ed Lu, a veteran of missions on the space shuttle and the International Space Station. He set up the B612 Foundation with Apollo 9 astronaut Rusty Schweickart and Piet Hut of the Institute of Advanced Study in Princeton, New Jersey, who first suggested that cosmic impacts cause mass extinctions of life on Earth. They are aiming to raise Sentinel’s $400 million cost – considerably less than NASA’s Kepler mission – through private donations.

The foundation believes it can keep the price tag down for several reasons. Not only are infrared systems and computers becoming cheaper, but Sentinel will be launched on a private rocket built by the company SpaceX.
If B612 can secure funding — and it’s a big if — Sentinel will be the best way to discover NEOs and will provide much better estimates of the sizes of the objects it finds. And when it comes to asteroids, size is everything. The asteroid that wiped out the dinosaurs was about 10 kilometres across; anything bigger than 1 kilometre could cause a global catastrophe.

Fortunately, there is good news on that front, thanks to the sterling efforts of the NEO-hunters so far. “We’ve discovered about 94 per cent of the largest near-Earth asteroids,” says Yeomans; “and none of these represent a credible threat for the next 100 years.”

So the focus is on objects that could devastate a whole region were they to hit. These potentially hazardous asteroids (PHAs) are bigger than 140 metres across. Larson says that only 1350 PHAs have been discovered out of an estimated total of 30,000. The LSST survey in Chile will increase that measly discovery rate to 75 per cent.

As for smaller, Tunguska-sized objects, we know the orbits of only about one in 100 of them. A Sentinel map, if we get one, would contain more than half of them and will warn us years — if not decades — in advance of an impending cosmic strike. How then do we protect ourselves?

Well, that all depends on how long we have. “The longer the time, the more gentle the nudge that’s needed to mitigate an Earth impact,” says Larson.

The best approach, says Lu, is a concerted campaign of deflection, with one major wallop followed by a smaller nudge to fine-tune the asteroid’s path. There is a precedent for such a “kinetic impactor”. In 2005, NASA’s Deep Impact mission whacked comet Tempel 1 with a lump of copper, although its goal was simply to find out what the comet is made of.

The European Space Agency is planning a similar mission to Didymos, the larger of a pair of nearby asteroids. Due for launch around 2020, the Asteroid Impact and Deflection Assessment (AIDA) mission will carry an impactor to smack into the 800-metre-wide asteroid, and a second spacecraft to observe the results.

“The impact should produce a change in the orbital period that can be noticed, both from ground-based and space observations,” says AIDA’s planner Andrés Gálvez. “This will give us assurance in case we need to use a kinetic impactor at relatively short notice — though I hope we do not.”

For a secondary deflection, Lu recommends a gravity tractor — which he says can be built with existing technology. Here, a spacecraft comes so close to an asteroid that they feel each other’s gravity. Rockets on the spacecraft propel it gently away from the space rock; the mutual gravitational bond pulls the asteroid along, like a dog on a lead, out of harm’s way. It should work regardless of how fast the asteroid is spinning or what it is made of.

Even more imaginative ideas have been banded around, such as fitting a rocket on an asteroid; using a “mass-driver” to fling matter out of the asteroid and so propel it the other way; focusing sunlight on the asteroid’s surface to vaporise its rocks and again force the asteroid to move; or even to “paintball” the surface white, so the pressure of sunlight will gradually force the asteroid away from its threatening orbit. “These are all in the realm of science fiction for now,” concludes Lu.

If we happen to be faced with a Tunguska-style airburst rather than a global disaster, deflection might not even be necessary. “A 40-metre object would need to pass over populated areas before it would cause major concern,” says Yeomans. “Policymakers would have to decide whether to deflect it (if there’s time), to take the hit (it would more than likely hit harmlessly in an ocean or an unpopulated area), or whether to evacuate the threatened area.” Coping with an asteroid impact would then move into the much more familiar territory of disaster mitigation — akin to dealing with predicted hurricanes, earthquakes or volcanic eruptions.

Might we still be taken unawares by the Big One, perhaps a comet zipping in unannounced from the outer parts of the solar system? A subcommittee of the United Nations is working on an action plan for an international response. Ironically, its next meeting will take place when asteroid 2012 DA14 is whizzing over our heads.

Meanwhile, NASA has contingency plans for a global threat, a version of the Bruce Willis solution: to nuke an asteroid with our name on it. “For such a last-minute mission, without warning times of 10 to 20 years, a disruption using nuclear explosive devices is the only technically and economically viable option,” says Bong Wie of Iowa State University in Ames. On NASA’s behalf, his Asteroid Deflection Research Center is designing a nuclear missile that will blow a dangerous asteroid or comet apart.

There is always a worry that the shrapnel from the explosion could cause just as much damage as the original object. But Wie says the blast will pulverise and disperse the asteroid: “If we have a warning time of at least a few months, the size of the debris cloud will be much larger than the Earth,” he says. His calculations show that less than 0.1 per cent of the object will end up hitting our planet.

To blow the asteroid apart, the nuclear device has to explode inside it, not on the surface. So Wie’s spacecraft comes in two parts: a front section that blasts out a crater, and a nuclear section that explodes deep within the crater. He is planning a test mission – which he is calling Deep Impact 2 – to smash a spacecraft, minus nuclear explosive, into a small asteroid.

The United Nations Outer Space Treaty forbids countries from deploying nuclear weapons in space. But Wie doesn’t foresee any real objections if his system is ever needed in earnest. “If we have a real impact threat with short warning time,” he predicts, “I don’t think there will be a legal problem!”

Nigel Henbest’s latest book, written with Heather Couper, is Stargazing 2013 (Philip’s)
I spy, with my faraway eye

When Sara Reardon visited a US air force drone school, she discovered how tough being a remote pilot can be.
around for the aftermath,” says Mike Weaver, a veteran jet pilot who commands the drone training programme at Holloman. When dropping a guided missile from a jet, “you might never see the target”.

With drones, that target is often a person. The legality and ethics of killing individuals with missiles carried by remotely operated aircraft has been the most controversial aspect of the US drone programme. The military and CIA do not disclose how many targets, or indeed bystanders, their drones have killed – the total number is believed to be in the thousands. But when it comes to who is a target, “that’s for the politicians to decide”, says Weaver. For the soldiers, their orders take precedence, like in any other mission.

The difference is that rather than killing an enemy in self-defence, the operators may follow their targets for days in complete safety. Weaver sees this separation of combatants as the natural progression of warfare, along the same lines as progressing from hand-to-hand combat to a rifle.

But ironically, drone operators’ widescreen view puts them up close and personal with their targets. The operators see them living human lives, in between their insurgent actions. “If you’re watching a high-value target, if he’s planting an IED, I might feel differently about him than someone who’s sitting at a table eating,” says Weaver. “But there’s not a lot of time for emotion.”

What will be the psychological effects on the split ops warriors of the future? The field is still too new for us to know, says Wayne Chappelle, a military psychologist at Wright-Patterson Air Force Base in Ohio. He and colleague Kent McDonald recently completed the first clinical study of drone pilots. Although there’s significant variation between individuals, they found that nearly half the drone pilots reported high stress and burnout. This was primarily due to long, overloaded work hours and excessive stimuli and information competing for their attention.

Only 3 to 5 per cent suffered from PTSD, however, compared with up to 20 per cent of soldiers deployed to Afghanistan and Iraq. “It’s the exception, not the rule,” Chappelle says. That doesn’t mean there aren’t effects. What may emerge with future study, he suspects, is a new form of PTSD similar to “vicarious traumatisation”: a term coined to describe the symptoms experienced by mental health workers who listen to first-hand accounts of war horrors. “As therapists listen, their mind has to create an image and movie so they understand what the person experienced,” Chappelle says. This can cause the same flashbacks and sleepless nights common in people with PTSD.

**Good communicators**

The military takes such worries seriously, says Chad. At Creech Air Force Base in Nevada, the hub for drone missions, he says, a new policy has operators contact a military psychologist each time they deploy a weapon.

And the US air force recognises the need to recruit aircraft pilots for remote operations who are stable and good communicators.

“A lot of times people default to thinking that pilots are the kids who grew up on video games,” says Chappelle. “Those are the kids who were socially isolated. What we’re seeing is it really takes a person who is cognitively sharp, healthy and can relate to people.”

The Holloman instructors say that with the exception of some factors, such as the ability to withstand $g$ forces, the criteria for becoming a drone pilot are identical to those for a jet pilot.

Of course, drones are more than just weapons. Amidst all the political debate, it’s easy to forget that the US military has used Predators for surveillance since the 1990s. Strapping Hellfire missiles beneath the wings of the little planes is a fairly recent innovation. Their most powerful asset is the glass ball that hangs under the plane’s nose.

Here are housed multiple powerful cameras that can read a licence plate from miles away, or film scenes through smoke and operate in darkness with infrared. “Ninety nine per cent of what we do is looking at things,” says a lieutenant colonel named Jon. Drones are so good at collecting imagery information, in fact, that their footage has clogged military networks and created a massive backlog of unanalysed data.

The rapid influx of information that drone operators receive has proved to be a serious problem. A recent skirmish in Afghanistan in which 23 civilians were killed could have been avoided had an operator passed on relevant information about the crowd that was gathering. *The New York Times* claimed in 2011...
Overloaded and the whole mental model of the airspace they’ve built up collapses.

The instructors at Holloman are well aware of this phenomenon. In training, Jay says, they will sometimes overload students with tasks in order to stimulate the problem.

But what they cannot train them for, says an instructor named Chris, is how quickly events can unfold. That switch from dull monitoring to all-out warfare is what he says shocks students the most when they move from training to flying drones in a combat zone. “It’s the classic hours of boredom punctuated by moments of terror,” says Raja Parasuraman of George Mason University in Fairfax, Virginia, quoting a phrase often used to describe modern warfare.

The long-term effects of these repeated swings on the human psyche are not well known, Hancock says. “But in general, nature doesn’t like to swerve in wide oscillations like that.” The boredom end of the pendulum can be just as stressful as overload, he says. “We call extreme underload ‘torture’.”

Day to day, there is often little going on in the Middle Eastern deserts and villages above which remote planes operate. The Holloman airmen say they try to keep busy analysing imagery, but without stimulation it can become very difficult for soldiers to maintain their vigilance. That can hurt their performance if something happens suddenly.

Szalma hopes to help soldiers get used to coping with monotony. He’s developing the most boring video game in the world: a virtual reality training program in which players sit in a rural village with nothing to do but monitor it. The average person can only pay attention for 10 to 15 minutes. “You can see the energy draining from them over time,” he says.

Desperate for action, participants will initially be alert to any potential threat—every package might be an IED, every truck driven by insurgents. But as nothing continues to happen, their vigilance drops and they become less likely to consider anything a threat. “You end up being more vulnerable to missing events,” Szalma says. “It’s not well understood how long that effect lasts.” He hopes such a training programme will at least help make soldiers aware of how quickly their minds cease to be attentive.

**Max out**

The military is pursuing many such ways to help soldiers cope with split ops, whether this involves improving the data or improving the human. For instance, while pilots mostly rely on visual input, tactile or auditory input could be added to vary the way they get information.

“If you max out one sensory capacity, you could transfer to another,” says Hancock.

His lab has created a belt for soldiers that consists of a ring of vibrating transducers. Their pulses can direct a wearer to turn in a given direction, speed up, or alert them to a threat. The US military is testing the belt for use in extreme conditions, but it could also be used by drone operators, he says.

Some researchers question such solutions, however. “The whole security system optimises the technology and doesn’t optimise the human,” says Stanley. “It creates a vicious cycle.” Far better, she believes, is to train soldiers to be aware of the various stresses of modern war through mindfulness exercises designed to make them aware of the stresses they will face before they are deployed. Preliminary studies of such techniques have shown some success in increasing soldiers’ ability to juggle numerous tasks at simultaneously.

Meanwhile, the Pentagon is funding Parasuraman to study how many vehicles a person can control at once. The answer, he says, is one—unless the pilots have automated systems to help them out. That automation is on the horizon: soon, remotely operated aircraft are likely to be able to fly themselves and control their own cameras. Humans, presumably, will retain control over decisions such as dropping a bomb. The interesting question now, Parasuraman says, is how to adapt this automation to bring out the best in the human-drone collaboration.

The soldiers at Holloman are not using such next-generation systems quite yet, but despite the challenges of their job, they are excited to be working with state-of-the-art technology. “Who wouldn’t want to be at the forefront?” asks Chris, standing on the tarmac in front of a Predator aircraft. Enthusiasm for the technology is one thing, but Chris stresses that it is his comrades on the ground in combat zones that are always on his mind. “They do thank you over the radio, say ‘Hey man, thanks for the support.’ And you feel good.”

Sara Reardon is a reporter based in New Scientist’s San Francisco office.
Heart of Darkness: Unraveling the mysteries of the invisible universe by Jeremiah P. Ostriker and Simon Mitton, Princeton University Press, £19.95/$27.95

WE HAVE all heard of the Hubble Space Telescope, named after Edwin Hubble, but where is the Tinsley telescope? Beatrice Tinsley was an excellent astronomer, but her career was stymied by an establishment set against giving a salary to the wife of an academic – even if she was also a gifted scientist. Tinsley made at least two vital contributions to our understanding of the universe’s history, but she had to divorce her husband and grant him custody of the children to get any recognition of her talents.

In Heart of Darkness, Jeremiah Ostriker and Simon Mitton explore modern cosmology while recasting what they term the “simple linear parade of heroes” of standard accounts. Among the uncelebrated stars of cosmology they discuss, Tinsley shines brightest, but there are others: Milton Humason, a poorly educated mule-driver and janitor who assisted Hubble in his observations, and Vesto Slipher, who, despite working in the shadow of a boss obsessed with finding evidence for Martian civilisations, made the first observations that told us about the expansion of the universe.

Why do some names last and others fade? As well as being a great astronomer, Hubble was a “showman”, and a “comfortable celebrity”, say Ostriker and Mitton. Tinsley, meanwhile, was diagnosed with cancer the year she finally made full professor (at Yale). She died four years later, aged 40. Like a supernova, she burned brightly but briefly. Hopefully, this thorough and inspiring book will secure her a place in cosmological history.

Not that Ostriker and Mitton’s book is focused solely on people – quite the opposite. Relatively few biographical details are given: it is their scientific contributions that are explored – and with aplomb. This is a strong, confident book, easily one of the best guides to why cosmologists make the claims they do. Yet for all their redistribution of credit, the cosmology that the authors set out remains uncontroversial. It is the universe that began in a singularity, passed through a period of rapid inflation, and is now dominated by dark matter and dark energy. The state of our knowledge, they say, represents a “stunning” accomplishment.

This is the dilemma of modern cosmology: what counts as success? Summing up, Ostriker and Mitton simultaneously cite a “pretty impressive list of successes” while acknowledging that cosmology is “profoundly incomplete”. We don’t know what caused the inflation, what constitutes dark matter or what lies behind dark energy. In the end, the authors settle for a declaration that there’s plenty for future cosmologists to do.

If there is one flaw in this crystal clear book, it’s a lack of depth in the discussion of the dark side of the universe. It provides the book’s title and is supposed to account for 96 per cent of the universe, but is confined to two chapters towards the end.

“...it’s better to be a showman than a troublemaker”

Alternatives to dark matter are dismissed in little more than a paragraph and compared to pre-Copernican efforts to keep the Earth at the centre of the cosmos. When many respected scientists support the continued search for alternatives, that seems somewhat disingenuous.

Were she still with us, Tinsley would no doubt argue that there are compelling reasons to believe in the existence of dark matter, but that there are good reasons to consider alternatives, too. Her unique contribution to cosmology was to persuade a dismissive establishment that galaxies change their properties over time. In so doing, she exposed a gaping hole in the cosmology of the 1970s. It was a supreme achievement, if unwelcome.

Clearly, if you want your name to go down in history (or onto a telescope) it’s better to be a showman than a troublemaker. But if the history of science teaches us anything, it’s that the troublemakers should be celebrated too.
The fun in fungus

Forget flat-pack furniture, Phil Ross’s mouldy chairs look better and could outlast the lot

Yamanaka Chairs by Phil Ross at The Workshop Residence, San Francisco
Reviewed by Amy Maxmen

I’M INTERVIEWING Phil Ross on mushrooms. The fungal chair he’s sitting on slopes ergonomically under his back; the underside of mine is shaped by the wheelbarrow in which it grew. The chairs differ in the details too, with small antler-shaped fungi blossoming out of the white, grey and brown-speckled surfaces at seemingly random spots.

Ross, an artist, inventor and self-taught mycologist, says he “just allows these monstrosities to emerge”. He is modest. These organic beauties are the product of years of experimentation which began with controlling the light available to sprouting fungi and mushroomed into full-scale chemical tinkering.

To design the furniture, Ross says, “you think about space in terms of the cellular arrangements of fungus, and about its relationship with gases and other physical qualities in the material around it.”

Ross builds on tips from mycologists, industrial designers and farmers, but his technique primarily derives from thoughtful testing. “It’s all about precision, measurement and repeatability,” Ross says. “It’s good to be a little sloppy, as long as you take measurements so that you can repeat a positive outcome.”

For instance, an unwanted green mould once invaded one of Ross’s fungal sculptures. In desperation, he mixed kerosene with Vaseline to create what he hoped was an anti-fungal preparation and dabbed it onto the spots of mould. Instead, his fungus sprouted antler-shaped fruiting bodies.

With tools such as the serendipitous kerosene-Vaseline mix, Ross determines where a mushroom blossoms, where fuzz forms, and where the main substance of his pieces, the body of the fungus, or soma, hardens. Fungus taxidermy: grown to shape then baked to death

Currently, his chosen fungus is Ganoderma lucidum (commonly called reishi or lingzhi), which has been hailed for its healing powers in traditional Chinese medicine for more than 2000 years. It feeds on various woods, but the fungal furniture on display during his residency at The Workshop Residence gallery once feasted upon red oak sawdust. As it digests the wood, it rearranges the fibres and forms a hard substance called chitin, also found in crab shells. The arrangement of the sawdust and the size of its chunks alter the chitinous forms that result.

All this engineering means that Ross’s chairs, footstools and tables are incredibly tough. They are strong enough to blunt a saw, and can stand a fair bit of fire or water before they start to degrade. Fungal furniture easily outlasts IKEA’s flat-pack wares, Ross says.

Ross dismisses the notion that his furniture is a dangerous addition to anyone’s living room. Once a fungus reaches a shape of his liking, he kills it by cooking it in a 67 °C oven, before coating it with a biodegradable lacquer. That means the finished furniture contains no live fungus and spores to spread it no longer form.

“To have a general fear of fungus is like having a general fear of animals or technology,” Ross says. “There are zillions of fungi, so to vilify them all because of a couple of flesh-eating kinds – well, that’s just not fair.”

Savour slowly

This Explains Everything delivers. Its editor, John Brockman, is the man behind the Edge website, which has been inviting scientists, philosophers, artists and science journalists to tackle a big question annually since 1998.

The 2012 question comes from neuroscientist Steven Pinker: “What is your favourite deep, elegant or beautiful explanation?” It draws thoughtful responses, collected here, from a diverse band that includes Nobel prizewinning physicist Frank Wilczek, philosopher Gloria Origgi and Pixar co-founder Alvy Ray Smith.

Charles Darwin’s evolution by natural selection earns many nominations, but other answers range widely. For example, psychologists Stephen Kosslyn and Robin Rosenberg celebrate classical conditioning, discovered by Ivan (salivating dogs) Pavlov.

“Hamlet captures an essential truth. With every door to nature we nudge open, 100 more appear”

This Explains Everything edited by John Brockman, Harper Perennial, £9.99/$15.99
Reviewed by Tiffany O’Callaghan

A COLLECTION of essays by big thinkers answering big questions may never be a page-turner, but should still be deeply satisfying. And
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sangerinstjobs
NERC is seeking to appoint a new Director of Science, a key role within its senior leadership team at its Swindon-based offices. Reporting directly to the Chief Executive, the successful candidate will have responsibility for the excellence of NERC science research and capabilities. This will be achieved through developing strategic plans into research funding opportunities, developing partnerships with other Research Councils and Government Departments, and monitoring NERC research investments to ensure that they deliver excellence. A close working relationship with the Innovation Team will ensure NERC science investment has wider impacts on business, policy and quality of life.

The role involves developing a vision for and direction of NERC’s £250M research resource and capital budgets. Identifying and pursuing opportunities for partnerships and collaborative funding will be important. It requires leading a team of around eighty scientific administrators who manage NERC science funding and who ensure that proposals are appropriately reviewed. Seeking opportunities, with other Swindon-based Research Councils, to improve and simplify NERC’s existing processes will be a key part of the role.

The successful candidate will work closely with the Chief Executive and with NERC’s Science and Innovation Strategy Board. They will be a member of the NERC Executive Board and of the NERC Investment Committee. They must have the credibility to command the confidence of all these groups and of the community that NERC supports. The ideal candidate is therefore likely to be able to operate at the equivalent of Dean of Faculty or Head of Department level within a research-intensive University.

Strong communication skills are needed for this role and the ability to motivate and lead professionals is essential.

To apply for this post you will need to complete an application form and provide an up-to-date CV.

For all information, including a job description, go to the website www.nercsourcedirector.co.uk. You can also download an application form from this site or request one by emailing sciencedirector@nerc.ac.uk, alternatively you can telephone Susan Allwright on 01793 442592.

Closing date for applications: 21 February 2013
Interviews will be held in Swindon: 25 April 2013

The Research Councils are committed to equal opportunities. No agencies please.

**RESEARCH SCIENTIST IN SOIL SCIENCE (REF: 1233)**

Rothamsted Research, the UK’s oldest and largest agricultural research centre, is seeking a Research Scientist in Soil Science. Rothamsted Research has secured funding from Defra and the HGCA to investigate means to improve crop yield without damaging environmental quality. The key hypothesis is that organic materials such as compost or manure that would otherwise need disposal or crop residues from rotation, can act as substrate for soil organisms which improve soil structure and thus a range of important functions of soil including crop production. A network of experimental resources has been set up or brought under the umbrella of this project and now an individual is sought to help manage these experiments and a series of measurement campaigns.

The experimental resources are located chiefly in the East of England but one partner is in the East of Scotland. Some travel will be required and the appointee should have a full driving licence because some of the farm locations may be awkward to visit via public transport. Since the post requires the interaction with a large number of farmers and significant players in the industry, the post would suit an individual with good interpersonal skills.

The successful candidate is likely to have a degree in agriculture, soil or environmental science, but we would also welcome applications from post-doctoral scientists in these disciplines: the project offers considerable opportunity at the higher grade for an individual to develop a career in soil and agricultural research in an area that underpins current efforts to make UK agriculture more environmentally sustainable. The project falls within Rothamsted’s programme of research on Delivering Sustainable Systems.

This post is fixed term for three years and is full time at either Band C or Band D (starting salary within the range of £22,230 to £25,038 for Band C or Band D starting salary within the range of £28,110 to £31,677 per annum). The post is based at the Rothamsted campus.

**RESEARCH ASSISTANT (REF: 1234)**

Rothamsted Research, the UK’s oldest and largest agricultural research centre, is seeking an experienced Analytical Chemistry Technician to join the metabolomics team for a period of 12 months (part time) and help establish plant cell wall dissolution methods for subsequent 2D NMR analysis. The post is part of an exciting new EPSRC funded project between the Rothamsted Cell Wall group and the Dupree group at University of Cambridge, in which the new method will be applied to transgenic Brachypodium and wheat material which has been modified to alter arabinoose substitution and feruloylation of xylan.

The post holder will be expected to carry out repeated solvent extractions to generate the cell wall tissue. Establishment of appropriate milling and grinding routines, applicable to wheat and brachypodium is also a key component of the job and will be conducted by the post holder as will gel dissolution and 2D NMR analysis of the final samples. The post holder will be required to work in a logical, iterative fashion until the best conditions for the sample preparation have been achieved. They will work within a small team of technicians, analytical chemists and spectroscopists.

Applicants are expected to have a degree in chemistry (or related subject) and working experience of plant tissue handling, milling and solvent extraction. Experience in the interpretation of 2D NMR data or carbohydrate NMR spectra would be advantageous but is not essential. The post will be located in the Department of Plant Biology and Crop Science.

This appointment is graded at Band C/D (depending on experience) with a starting salary normally in the region of £22,230 and £31,677 per annum. The post is available for 12 months part time (50%) or may be offered as a 6 month full time post for a candidate with the right level of experience.

Apply by application form only, available with further particulars from www.rothamsted.ac.uk or from the HR Group, Rothamsted Research, Harpenden, Herts AL5 2JQ, res.hr@rothamsted.ac.uk

Please use the Personal Statement section (2.4) of the Application Form to describe your vision and ideas for developing our research and include a full CV and publication list.

Please quote appropriate reference.

Closing date for both posts: 15 February 2013.

An Equal Opportunities Employer.

As users of the disability symbol, Rothamsted Research guarantees to interview all disabled applicants who meet the minimum criteria for our vacancies.
Sherwood Forest Hospitals
NHS Foundation Trust

SFHT provides district general hospital services throughout central Nottinghamshire from four hospital sites. We have a current turnover of approximately £200m, and our workforce of approximately 4,000 provides services to a population of around 350,000. In addition, we have undertaken a £320m modernisation of acute services including the redevelopment of the King’s Mill Hospital and Mansfield Community Hospital. We offer a strong commitment to your well-being and development and a range of staff benefits, including flexible working, access to a Staff Support and Benefits Co-ordinator, an on-site nursery at the King’s Mill Hospital and the opportunity to participate in a range of salary sacrifice schemes, including Workplace Nursery and Childcare Vouchers.

KING’S MILL HOSPITAL
Quality Control Section Leader
Band 8A – £38,851 - £46,621 per annum
Permanent/Full time 37.5 hours per week
Ref: 214-DRD3-01-09

We require a suitably experienced, motivated full time person who is a Pharmacist or Chemistry/Biology Graduate, who can register as a member of the Royal Society of Chemistry or Member of the Institute of Biology or a person who can demonstrate sufficient competence and experience in Quality Control matters gained by working for 3 years in Quality Control/Assurance activities to the equivalence of a qualification in Pharmacy Technology Quality Assurance and/or hold a Certificate or Diploma in Pharmacy Technology Quality Assurance.

You will be required to manage the busy Quality Control based in the Pharmacy Department. The post involves a wide range of activities including the release of in-house licensed medicines pre-packed by our Pharmacy Production Unit, testing of medical gases, responsibility for environmental monitoring, quality assurance associated with medicines management issues and managing unlicensed medicines used within the Trust.

As a section leader, you will work closely with the Production team and other relevant sections to ensure that their development, output and services are to agreed local and national standards, including MCA licensing agreements and GMP.

You will act as the HTM 2022 ‘Qualified Person’ in relation to medical gas and suction testing for the Trust.

Opportunities may exist for further study e.g. Diploma or Masters in Pharmacy Technology Quality Assurance

Closing date: 8th February 2013.
Interview date: 21st February 2013.
If you are interested and would like further information call Alan Sayers, Pharmacy Manager, Operational Services, on 01623 672234 or alan.sayers@sfh-tr.nhs.uk

www.sfh-tr.nhs.uk

SCOTTISH POLICE SERVICES AUTHORITY

TEAM MANAGER SCENE EXAMINATION EAST
£37,029 Ref: 46329-0113
Closing date 29th Jan 2013.
FORENSIC SCIENTIST CHEMISTRY AND DOCUMENTS
£29,931 Ref: 46526-0113
Closing date 29th Jan 2013.

All positions offer benefits including a final salary pension scheme, 24 days holiday and 8 public holidays.

HOW TO APPLY:
Further information and application packs are available from our website: www.spsa.police.uk/recruitment/vacancies or call 0141 585 8444.

www.spsa.police.uk/recruitment

POST DOCTORAL HPC CLINICAL SCIENTIST
Molecular Microbial Diagnostics

We are looking for a Post-doctoral HPC registered Clinical Scientist, with Molecular Microbial experience, to work within Micropathology Ltd, a busy specialist laboratory providing a clinically supported service for the rapid diagnosis and management of infectious and genetic disease.

The successful applicant may expect to be appointed to a permanent post after a satisfactory probationary period of 11 months. Pay will be competitive and satisfactory performance will lead to an increase in pay.

The appointee will work with our HPC-registered Clinical Scientists, where he/she will become familiar with our laboratory routine and then be expected to operate with minimal supervision. Daily duties will include sample reception, processing and testing, supervision of laboratory staff and authorising of pathology reports. The appointee will also be expected to participate in administrative duties and the Saturday morning sample receipt rota (currently 1 in 8) as required. It is expected that the successful candidate will maintain their HPC registration and should actively participate in CPD.

The candidate will possess a degree in life sciences, post-graduate/post-doctoral experience/degrees and have significant clinical diagnostic experience with HPC Registration. Literacy, IT and mathematical skills are expected. Familiarity with Quality Management Systems is essential as the laboratory is accredited to CPA (UK) Ltd standards. A solid scientific knowledge combined with a logical approach is preferable.

Applications (by CV, including three referees, and a hand written covering letter) should be made to Dr Andrea Collins, Quality Manager at the address detailed above. Requests for more specific information should be made to Dr Andrea Collins by email a.collins@micropathology.com

The closing date for applications is February 28th 2013.

www.micropathology.com E-mail: info@micropathology.com
The Health Protection Agency: Protecting the nation’s health.

Head of Unit ■ Microbiology Services Division ■ Birmingham ■ Accountable to: Director, FW&E Microbiology Laboratories ■ £54,454 to £67,134 per annum (depending upon experience) ■ Band 8c ■ Good Hope Hospital, Sutton Coldfield, Birmingham ■ Full-time – 37.5 hours per week

The Health Protection Agency (HPA) is an independent body that protects the health and well-being of everyone in England and Wales. The Agency plays a critical role in protecting people from infectious diseases and in preventing harm when hazards involving chemicals, poisons or radiation occur. We also prepare for new and emerging threats, such as a bio-terrorist attack or a virulent new strain of disease.

The Food, Water and Environmental Microbiology laboratories provide specialist microbiology services that are essential to support Local Authorities and the Food Standards Agency in carrying out relevant statutory functions. In addition, the FW&E laboratories provide expert advice on food, dairy, environmental and waterborne infections to HPA professionals, epidemiologists, environmental health staff and other agencies.

We are seeking an experienced scientist who will provide leadership to the FW&E Microbiology Laboratory at Birmingham and who is capable of addressing present and future challenges within the region. You will be responsible for the overall service, strategic and wider public health delivery of regional food, water and environmental laboratory services.

You will have a postgraduate qualification to PhD level with a major component of public health, medical microbiology, food and water or environmental microbiology. A management qualification in this post would be desirable. You will have demonstrable management experience from within either an FW&E or clinical laboratory and have an understanding and strategic awareness of the environment in which the HPA operates. In order to be successful in this post you will also have comprehensive experience of managing and leading a team as well as experience of financial and commercial management.

For further information please contact Jim McLauchlin on 020 8327 6530 or jim.mclauchlin@hpa.org.uk

For more information and to apply please follow the link: www.jobs.nhs.uk and quote the post reference number.

Post reference: 919-MS-SSC-9416302

Closing date: 7 February 2013.

In line with other NHS employers, this post is subject to a terms and conditions review (Agenda for Change)

The Health Protection Agency is an equal opportunities employer.

2013 NEW SCIENTIST CAREERS GUIDE
The careers handbook for scientists

Need science career advice? Looking for a new job in science?

Then you need to read the 2013 New Scientist Careers Guide, containing:

• The results of our third salary and benefits survey for scientists
• How life has changed for scientists now smartphones & tablets have become extensions of our bodies
• Scientists reveal what keeps them up at night

Alongside this you’ll also find:
• Full profiles of the major employers in science
• An employer directory including contact details

Download or read your copy online now: newscientistjobs.com/careersguide2013
Director of Science and Technology
British Geological Survey
Ref: IRC78650

We are looking to make a senior appointment as Director of Science and Technology to join the BGS Executive team. You will optimise the delivery of BGS science underpinning a science strategy that is tuned to the needs of the Natural Environment Research Council (NERC) the UK government and international collaborators. You will refine and develop the BGS science programme and working in partnerships with numerous stakeholders, ensure BGS delivers national capability in the geosciences and innovative research. You will develop collaborative programmes with universities, research agencies, industry, and other geological surveys in developing earth and environmental science leading to scientific results that will influence decision making.

You will be an international leader of science and research and have a good general knowledge of areas of geoscience in the present and emerging core mission for BGS. You will have experience of delivering scientific results at the highest level and running complex scientific research programmes. You will be able to provide evidence of high-level communication and negotiation with stakeholders in your area.

If you are interested in the role, please contact Marion Squires – Head of Human Resources – for an informal discussion; she can be contacted on 0115 9363512; e-mail: masq@bgs.ac.uk.

Applications are handled by the RCUK Shared Services Centre; to apply please visit our job board at http://www.topcareer.jobs/ and upload your up-to-date CV and a covering letter. Applicants who would like to receive this advert in an alternative format (e.g. large print, Braille, audio or hard copy), or who are unable to apply online should contact us by telephone on 01793 867003. Please quote reference number IRC78650.

Closing date for applications will be 31 January 2013.

Interviews will be held in February 2013 at our Headquarters in Keyworth, Nottingham.

The Natural Environment Research Council is an equal opportunities employer and welcomes applications from all sections of the community. People with disabilities and those from ethnic minorities are currently under-represented and their applications are particularly welcome.

The Survey has a no-smoking policy in all of its buildings. The British Geological Survey is an Investors in People organisation. There is a guaranteed Interview Scheme for suitable candidates with disabilities.
Trainee Healthcare Scientists

Exciting opportunities to use your science degree for patient and public benefit

Salary c.£25,500 plus location allowance

Healthcare Science is one of the most exciting and dynamic areas to work within the NHS.

Join a unique team who are inspired to apply their exceptional scientific knowledge and skills to the prevention, diagnosis and treatment of disease and the rehabilitation of patients.

Excellent training opportunities are offered within this national postgraduate training programme located in hospitals and health services throughout England.

This is a three year postgraduate programme and successful candidates will be employed by an NHS Trust for the duration of their training. Trainees are also enrolled for a fully funded part time vocational master’s degree in their chosen specialism.

Posts are available within one of the following areas:

- Life sciences – infection control and epidemiology, mycology, virology, bacteriology and parasitology, clinical biochemistry, haematology/transfusion science, immunology, histopathology, cytopathology, reproductive science, genetic sciences
- Physiological sciences – audiology, neurophysiology ophthalmic and vision sciences, cardiac science, respiratory and sleep sciences, vascular science, gastrointestinal physiology and urodynamic sciences, critical care science
- Physical sciences and biomedical engineering- rehabilitation engineering, clinical measurement and development, device risk management and governance, radiation safety, radiotherapy physics, imaging with ionising radiation, imaging with non-ionising radiation, clinical pharmaceutical science, reconstructive sciences (maxillofacial prosthetics – applicants for maxillofacial prosthetics will require dental registration)

Some of the areas may be grouped into themes for application purposes. Posts are due to start in September 2013.

To apply and for full information about the opportunities available and details of the qualifications and experience you need follow the link

www.nhscareers.nhs.uk/hcstp

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Fera is an executive agency of Defra, our role is to support and develop a sustainable food chain, a healthy natural environment and to protect the community from biological and chemical risks.

Research Scientist – National Bee Unit YORK

Ref: CSP 3774 Fixed Term Appointment (2 Years) circa £25,560 pa

The National Bee Unit at Fera is concerned with all aspects of the husbandry and protection of bees in the UK. This includes support to policy groups, providing advice and training to the beekeeping industry and applied R&D on matters concerning the health of bees. The Research Scientist will ensure the smooth running and delivery of the existing research project portfolio by contributing to delivery whilst coordinating the scientific input of multidisciplinary staff from across the agency. Under the guidance of the Research Coordinator, the Research Scientist will help in writing and securing small grant applications which contribute to our understanding of bee health. The research scientist will assist with the preparation of manuscripts for publication and advisory materials for end users including policy and the beekeeping community.

A degree in a relevant science subject, or equivalent qualification, is required. Candidates without this level of qualification will need equivalent practical experience. You must be able to demonstrate the ability to organise, prioritise and complete work to required standards and timescales. Good written and oral communication skills along with line management or supervisory experience is important. Experience in molecular biology, microbiology or entomology is essential.

There is a possibility of a change to a longer period of employment with Fera in the future. Fera is an Equal Opportunities Employer. Benefits include a choice of valuable pension arrangements and we operate flexible working practices.

Closing Date: 8 February 2013

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NIAB Innovation Farm is a high profile project, with funding from ERDF and UK industry. The postholder will interact with UK Researchers and Innovators and identify and interact with small and medium sized companies based in the East of England to promote knowledge exchange, research collaboration and business growth. You will contribute to the achievement of ERDF targets and help develop the remit of Innovation Farm. You must be a self-starter, capable of working independently, with good interpersonal and communication skills and a flexible approach to work.

You should hold a first degree in a relevant subject, together with some post-graduate experience in plant sciences. A full driving licence or access to independent means of transport is essential.

Starting salary in the range £22,000-£28,000, dependent on skills, experience and qualifications. Company benefits include Group Income Protection, Stakeholder pension, generous holidays and free car parking. Initially, this will be a fixed term contract until 31 March 2015.

Further details are available on our website: www.niab.com or from the HR Office, Huntington Road, Cambridge CB3 0LE, Tel: 01223 342282, Email: jobs@niab.com, quoting Ref: T/259. Closing date for applications: 8 February 2013.
Department of Applied Sciences

**Associate Head of Department for Biomedical and Health Sciences**

£45,941 - £54,826  
Ref: 1300866

Building on the department's established reputation in providing teaching and research excellence, you will lead the Biomedical & Health Sciences Subject Group and contribute to the development of a strategy and plan of action to deliver department objectives and meet key performance indicators.

**Lecturer/Senior Lecturer in Physical Science**

£30,424 - £45,941  
Ref: 1300873

We require a Lecturer/Senior Lecturer to further strengthen the department's teaching and research profile across a range of aspects of the applied sciences.

You will contribute to teaching on the spectrum of BSc and MSc programmes in the biological, biomedical, environmental, forensic and healthcare sciences. Preference will be given to candidates whose expertise relates to one or more of the following: energy from waste, carbon mitigation strategies, renewable energy and other energy technologies.

Both posts are permanent and full time.

For an informal discussion please contact Dr Peter Spencer-Phillips (Head of Department) on 0117 32 82504 or email Peter.Spencer-Phillips@uwe.ac.uk

Closing date: 10 February 2013.

Interviews will be held during the week commencing 25 February 2013.

Applications for these posts must be submitted using our online eRecruitment system, which can be accessed via our vacancies website:

**www.uwe.ac.uk/jobs**

UWE is an equal opportunities employer.

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**MSc Taxonomy and Biodiversity**

A one year full-time interdisciplinary postgraduate course, based at the Natural History Museum, providing a diversified curriculum in systematics, comparative biology, biodiversity and conservation biology.

The course is comprised of two terms of taught modules, a one week field course at Imperial College Silwood Park campus, and a 16 week research project of the student's design. The course can also be taken part-time over two or three years. Minimum 2ii (Hons) required.

**MRes Biosystematics**

A one year Masters by Research postgraduate course providing hands-on laboratory-based training in modern phylogenetics and taxonomy. Students work within research groups at the NHM and Imperial College, undertaking three 16-week projects in morphological techniques, molecular systematics and bioinformatics. In addition they attend key MSc lectures, research seminars and transferable skills courses.

The course is aimed at students planning on a PhD in systematics and evolutionary biology. Minimum 2i (Hons) required.

Both courses taught jointly by Imperial College London & NHM

Department bursaries may be available

See [www.nhm.ac.uk](http://www.nhm.ac.uk) for details and [www.imperial.ac.uk](http://www.imperial.ac.uk) to apply

Or contact:

Ms Amoret Whitaker, Department of Entomology, Natural History Museum, Cromwell Road, London SW7 5BD, UK

Tel: +44 (0)20 7937 2805  
Email: a.whitaker@nhm.ac.uk

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**NewScientist Study**

Science courses to take you there

[www.newscientiststudy.com](http://www.newscientiststudy.com)
Master your Scientific career at Cranfield

Cranfield works in partnership with leading global organisations such as Astra Zeneca, GlaxoSmithKline, Philips, Quintiles and Unilever; helping to develop the technology and techniques which have a global effect on people’s health and wellbeing.

Our collaborations inform our portfolio of specialist full and part-time MSc courses; ensuring they meet the requirements of industry and academia – enabling our graduates to successfully pursue a variety of career opportunities.

Our students are taught by a combination of world-renowned academics and industry experts, and they have the opportunity to carry out their research projects in industry; allowing them to network with potential employers before even completing their course.

Course start dates are flexible. Bursaries are available.

www.cranfield.ac.uk/health/newsjan

TEMASEK RESEARCH FELLOWSHIP (TRF)

A globally connected cosmopolitan city, Singapore provides a supportive environment for a vibrant research culture. Its universities Nanyang Technological University (NTU), National University of Singapore (NUS) and Singapore University of Technology and Design (SUTD) invite outstanding young researchers to apply for the prestigious TRF awards.

Under the TRF scheme, selected young researchers with a PhD degree have an opportunity to conduct and lead defence-related research. It offers:

- A 3-year research grant of up to S$1 million commensurate with the scope of work, with an option to extend for another 3 years
- Postdoctoral or tenure-track appointment (eligibility for tenure-track will be determined by the university)
- Attractive and competitive remuneration

Fellows may lead, conduct research and publish in these areas:

- Advanced Materials for Aerospace Applications
- Bio-mimetic Aerodynamics
- Cognitive Science and Neuroengineering
- Cyber Security
- High Power Laser Diode
- High Speed High Voltage Switching Devices

For more information and application procedure, please visit:

NUS – http://www.nus.edu.sg/dpr/funding/trf.html
SUTD – http://www.sutd.edu.sg/trf

Closing date: 15 March 2013 (Friday)

Shortlisted candidates will be invited to Singapore to present their research plans, meet local researchers and identify potential collaborators in July 2013.

School of Biological Sciences
Ranked in the top10 UK Bioscience Departments (2008 RAE)
Applications are invited for PhD Studentships

Full UK Research council funding is available for the following projects:

- New approaches to the characterisation of complex, degraded DNA extracts (Dr I Barnes)
- Molecular systematics and the evolution of the Caribbean mammal fauna (Dr I Barnes)
- RNA-based silencing of fungal effectors in plants to control diseases in crops: Barley powdery mildew as a case study (Dr L Bindschedler)
- How plants sense they are thirsty and adapt their growth to drought: the role of MAPK and RUS signalling (Prof L Bogre)
- Elucidation of host processes required for the growth of pathogens to uncouple stress-induced growth in plants (Dr A Devoto)
- Molecular and biochemical characterisation of colour related traits in fruits and vegetables (Dr P Fraser, BBSRC CASE)
- High value terpene compounds from diverse Yam genotypes (Dr P Fraser)
- Metabolute profiling of microorganisms from extreme environments (Dr P Fraser)
- Modelling the evolution of virulence in a bacterial pest control agent (Prof V Jansen)
- Effects of plant genotypic diversity on resistance to insect pests (Prof J Koricheva)
- Effects of pesticide exposure on bee larvae: how does larval exposure influence worker behaviour and colony function? (Dr N Raine)
- Power, corruption and cooperation in microbial societies (Dr F Ubeda de Torres)
- Fish that don’t taste of mud: Bioengineering to eliminate an unpalatable taste from a farmed fish (Dr C Wilkinson).

For further information on these projects and instructions as to how to apply please visit http://www.mull.ac.uk/biosciophd.

The closing date is 31st January 2013.

The College is committed to equality and diversity, and encourages applications from all sections of the community.
Society for Experimental Biology
PhD Studentship 2013

The Society for Experimental Biology (SEB) supports non-biomedical biological science research and is offering funding for a prestigious 4-year PhD studentship.

Applications are invited from potential supervisors for a PhD studentship beginning October 2013 for projects to be supervised at a university in the UK. Potential supervisors should submit a summary curriculum vitae of both the supervisor and the nominated student, together with an outline of the proposed project of no more than 400 words.

Projects should address important questions of experimental biology that align with the Cell Biology Section of the Society. The Cell section is particularly interested in multidisciplinary approaches to address problems at the cellular level. Further details on the range of interests of members of the SEB are available at [http://www.sebiology.org/cell/Groups.html](http://www.sebiology.org/cell/Groups.html)

Studentships will provide tuition fees up to the UK/EU rate, a maintenance fee for the student (currently £13,000 pa) and a bench fee of £5,000 pa for the host laboratory. The successful student will also be funded to attend the SEB Annual Main Meeting during the period of the studentship, and will be expected to present their results either as a poster or an oral presentation.

Applications should be submitted by email to Paul Hutchinson, at p.hutchinson@sebiology.org to be received no later than 5 pm Friday 15th February 2013. Short-listed candidates will be invited to interview on March 14th 2013.

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The Faculty of Physics of the University of Warsaw invites applications for research fellowships and research professorships in photonics and quantum science. The eight positions to be filled are funded from the European Union’s 7th Framework Programme project PhoQuS@UW: Fostering Excellence in Photonics and Quantum Science which aims at expanding experimental and theoretical research in widely defined optics and quantum physics including quantum optics and quantum information, ultrafast optics, atto-science, photonics, biophotonics, plasmonics, and related areas of research.

The University of Warsaw offers an exciting work environment located in one of the most vibrant cities of Central Europe. It is the top Polish academic institution with an extensive research programme, attracting best students from all over the country and beyond. The University science campus currently undergoes a major expansion with the opening of new facilities planned in 2013.

The candidates are expected to hold a doctoral degree, exhibit an outstanding academic record, and demonstrate the ability to carry out cutting-edge research. It is anticipated that conversion of research positions funded by the project into tenured or tenure-track posts will be possible in substantiated cases.

Enquiries and applications should be submitted via e-mail to: phoquisjobs@fuw.edu.pl before February 4th 2013. Candidates are requested to provide a curriculum vitae, a research statement, and names and contact information of at least three referees familiar with their work. Equal opportunities policies will be applied in the recruitment process. Further information about the Faculty is available online at [http://www.fuw.edu.pl/](http://www.fuw.edu.pl/)
Amgen Scholars
An Undergraduate Summer Research Programme in Science and Biotechnology

Discover Your Potential

The Amgen Scholars Europe Programme provides selected undergraduate students with the opportunity to engage in a hands-on research experience at some of Europe’s leading educational institutions. Currently, three universities in Europe host the summer research programme. The Amgen Foundation has committed $34 million over eight years to this global initiative to make this opportunity possible to more than 2,400 students.

Inspiring the Scientists of Tomorrow
As Amgen Scholars, students will have the opportunity to:
- Take part in important university research projects, gain hands-on lab experience, and contribute to the advancement of science;
- Interact with and receive guidance from faculty mentors, including some of Europe’s top academic scientists; and
- Attend scientific seminars, workshops, and other networking events.

The Amgen Scholars European Symposium
A signature component of the summer programme is a symposium where students hear firsthand from leading scientists working in industry and academia. The European symposium is held in England and provides students with a valuable opportunity to network with other Amgen Scholars from across Europe.

www.amgenscholars.eu
STUDENTSHIPS & COURSES
Booking Deadline: 15th February

THE FEATURE
Our Studentships & Courses feature will provide science students, graduates and postgrads with the relevant information they need to gain funding for their courses or PhDs. It will advise them of the level of debt expected and the best way to organise adequate funding and how best to pay it back.

With the full impact of tuition fee rises hitting the next generation of science entrants in this academic year, the feature also looks at the popularity and hype surrounding free options such as MOOCs.

Issue date: 23rd February 2013

OUR AUDIENCE
The Insider reaches:
- Over 77,000¹ students, graduates, and potential candidates in print
- Over 18,000² science graduates via our regular e-newsletter
- Over 180,000³ online users across our jobs and study sites

Find out more about our audience at:
http://newscientiststudy.rbirecruitment.com/our-audience-and-brand

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Our Insiders are heavily promoted to potential jobseekers and online users to gain maximum exposure and readership of the features. With coverage online, in print, on social media platforms and through targeted emails, we reach the most relevant audience for your opportunities.

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+44 (0)20 8652 4444 or email recruitment.services@rbi.co.uk

NewScientist Jobs    NewScientist Study

Newcastle Biomedicine is recognised internationally. Research in the biosciences and biomedical sciences is strong particularly in ageing and cell and molecular biology, including cancer, neurosciences, cellular medicine of chronic diseases and genetics. There is an emphasis on translational research directed towards disease prevention, delivery of new treatments and improved patient stratification. These endeavours are supported by fundamental research in mitochondria, stem cell biology, cancer, bacterial cell biology, and in diet and health and animal behaviour.

### Doctoral programmes in Biosciences and Biomedical Sciences

**PhD and integrated MRes/PhD programmes**

Newcastle Biomedicine is currently recruiting to fully funded 4-year integrated MRes/PhD studentships available to start in September 2013. Candidates with a Masters may be considered for a 3-year award. Further opportunities are advertised as available on the Web. All research is in modern state-of-the art facilities. Applications are taken until a studentship is filled: early application is advised. Please quote the reference number on the application form. Details of studentships are available at: [www.ncl.ac.uk/biomedstudentships](http://www.ncl.ac.uk/biomedstudentships)

*International students* may apply in related areas or in other research areas.

*Competitive ORS awards* are available for outstanding international students.

### Masters programmes

Applications to these programmes are invited from science graduates and from medical and dental graduates or students in their intercalation year.

**Competitive MRes and MSc International Scholarships** are available.

#### MRes Programmes

The emphasis of these Programmes is on the research element of the year of study.

There are opportunities for specialisation in several different areas of expertise within the Faculty including: ageing, animal behaviour, biosciences, biotechnology, cancer, diabetes, genetics, immunobiology, microbiology, neuroscience, stem cells, therapeutics, toxicology and transplantation.

Further information is available at: [www.ncl.ac.uk/biomedmres](http://www.ncl.ac.uk/biomedmres)

#### MSc in Medical Sciences

The emphasis of this taught Programme is on the basic science of clinical and translational medicine in which Newcastle University excels.

This MSc Programme is designed to provide you with a broad education in diverse areas of medical sciences.

The Programme allows students to tailor their study to their own particular interests.

Further information is available at: [www.ncl.ac.uk/pgmscms](http://www.ncl.ac.uk/pgmscms)

**Graduate School, Faculty of Medical Sciences, Newcastle University,**

**Framlington Place, Newcastle upon Tyne NE2 4HH**

**Tel: (0191) 222 7002, Fax: (0191) 222 7038**

**Email: medpg-enquiries@ncl.ac.uk**

[www.ncl.ac.uk/biomedstudentships](http://www.ncl.ac.uk/biomedstudentships)
Robert Bright’s carton of Flora margarine told him on the top-right corner of the lid that it was “new”, and on the bottom-left corner that it was the “original”.

IN OUR holiday issue, Bryn Glover suggested swapping the names “astrology” and “astronomy” and went on to wonder if there were “any other areas where swapping names would lead to greater clarity” (22/29 December 2012).

Several readers responded with what a little searching reveals to be the justly popular idea that Iceland and Greenland should swap names.

Maya Keshav sums it up: “Iceland is mostly green and Greenland is mostly ice,” she notes, and adds that, according to legend: “Erik the Red discovered Greenland and wanted his Viking mates to go populate it, so he made it sound like an attractive spot to live.”

We also enjoyed Alan Bundy’s idea that “atom” and “quark” should swap. “The word ‘atom’,” he says, “was originally intended to name the smallest possible, and therefore indivisible, particle. Unfortunately, it was applied far too early. For the moment, quarks seem to be playing the role intended for ‘atom.’” (Though readers will be forgiven for wondering how long that will last.)

Meanwhile, Peter Mabey points out that as “oxygen” has the derivation of “acid generator”, the name really belongs to hydrogen (“water generator”), and the name “hydrogen” would then more appropriately be applied to water’s larger constituent by mass (currently called oxygen).

THE instruction booklet that came with the electric appliance Don Wycherley bought from Marks and Spencer warned him: “The appliance becomes hot during operation - this is normal.”

Don tells us: “In view of the fact that the appliance is actually a kettle, I think I might have figured this out for myself.”

Robert Bright’s carton of Flora margarine told him on the top-right corner of the lid that it was “new”, and on the bottom-left corner that it was the “original”.

CONTRACTS, in the law of countries such as England, Wales and Australia, exist only where the parties concerned exhibit the intention to make an agreement, where there is an offer of something of value, and where there is acceptance. Weird and wonderful are some companies’ attempts to bind online purchasers into a contract, despite the difficulty of regarding a stream of photons on a computer screen as proof of acceptance.

But why does the above-mentioned appear in New Scientist and not New Lawyer? Because of the odd things that happen when warranty-drafting lawyers collide with a Feedback reader, is why.

Michael Jones was initially delighted to receive an email from Umart, an Australian online computer vendor, accepting his money in return for promised goods and informing him of the “warranty return procedure”. Then he read: “Please read the terms carefully as by reading them, you agree to be bound by the terms of the warranty return.”

Feedback imagines a mental crunching sound at this point.

“Thanks for sending me details of the Umart warranty return procedure,” Michael replied. “Unfortunately I am unable to read the terms, as you claim that by reading them I automatically agree to be bound by them... For all I know, the terms might state that I must do something very painful to myself with an item before I return it.”

Then a solution occurred: “Perhaps I should have a friend read the terms to me rather than reading them myself?” he suggested.

Finally, a brainwave. His email to Umart continued: “By reading the above you agree to send me a $100 voucher redeemable at any Umart store. Thanks for your generosity.”

A month later, Michael is still waiting for Umart to reply.

THE emailed response from dating site eHarmony’s customer care department to the message sent by Richard Eibeck took him aback somewhat.

“Having told him to send his enquiries via the form on the FAQ page of the company’s website, it went on to conclude enigmatically: “Please Note: We regret to inform you that the e-mail message that you have submitted was not received and you will not receive a response.”

Robert Bright’s carton of Flora margarine told him on the top-right corner of the lid that it was “new”, and on the bottom-left corner that it was the “original”.

For more feedback, visit newscientist.com/feedback

“NO SWIMMING. Danger of contracting waterborne diseases. Offenders will be liable to prosecution.”

Raffi Katz sends us a photo of a sign bearing these words on a bridge over the Grand Union Canal near Watford, north of London.

“Raffi finds the wording unsatisfactory. ‘Isn’t the threat of contracting a waterborne disease much greater than being prosecuted?’ he asks. He suggests that instead the sign should read: ‘Danger of contracting waterborne diseases. Offenders will be liable to contract a waterborne disease.”

FINALLY, thanks to the readers who tipped us off about this quote from “carnivores handler” Andy Wolfenden in an interview in London newspaper The Guardian on 7 January: “When [tiger] Kirani arrived [at Chester Zoo], she was particularly aggressive. I spent a long time sitting with her, reading her extracts from the New Scientist to calm her down. It did the trick.”

We would also like to thank the reader, or readers, who made good the lack of a section on “Appearances in Popular Culture” in the Wikipedia page about New Scientist. We complained about this omission on 5 January. Lo and behold, the section is now there. Wonder what else we should complain about.

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address.

This week’s and past Feedbacks can be seen on our website.
**Blind as a cat**

My son took in a blind kitten four years ago. The cat now has extraordinarily long whiskers and eyebrows. She also has long hairs from the ears and scattered long ones over her body. The whiskers approach 60 millimetres and appear to be sensory compensation for sight loss. Is this likely, and how does it work?

I cannot compare the cat in question with any of its siblings, so this response is speculative to some extent.

The hair and whiskers of cats do vary dramatically, whether or not the animals can see. Cats have straight, non-woolly guard hairs that are extremely sensitive, especially at points such as the tips of their ears. Whiskers on the cat’s muzzle and wrists, and the ones forming its “eyebrows”, stimulation, and grows but becomes more complex if regularly stimulated by both the central nervous system and the environment.

Nerve fibres and the capillaries that supply them with blood tend to grow practically in unison. What’s more, increased blood supply and associated hormonal stimuli promote tissue growth. It is therefore plausible that whatever growth factors stimulate nerve development at the roots of tactile hairs in a blind cat might also stimulate both the activity and vigour of the follicles. The result is long, infrequently shed sensory hairs and whiskers.

As a rule, sensory tissue atrophies if it receives little stimulation, but grows and becomes more complex if regularly stimulated by both the central nervous system and the environment.

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_**Whatever stimulates growth of nerves at the roots of hairs might also stimulate the follicles**_

are even more sensitive. Their stiffness has the effect of extending the cat’s reach and lends precision in assessing the position and texture of anything that they touch.

Not surprisingly, the root of each hair has its own touch-sensitive nerve supply. Around a whisker follicle, the nerve tissue is exceptionally dense.

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_**With their extreme sensitivity, whiskers aid the cat in matters of spatial awareness**_

A cat’s whiskers are regarded as tactile hairs or vibrissae. As a rule of thumb, their tips extend out to span a distance equal to the width of the cat’s body. With their extreme sensitivity, these whiskers aid the feline in spatial awareness.

Vibrissae are primarily found on the face, although they do grow elsewhere on the cat’s body – predominantly on the forelegs, with a few on the abdomen.

People with a sensory impairment commonly compensate by developing enhanced abilities in their other senses – blind people sometimes have better hearing than sighted people, for example. This phenomenon exists in many animals, too.

In 1995, Josef Rauschecker described an example in a study of cats that had been visually deprived from birth. He discovered that auditory and somatosensory – touch-related – inputs dominated the anterior ectosylvian cortex, a brain region that normally processes visual signals (Trends in Neurosciences, vol 18, p 36).

Interestingly, Rauschecker found that these cats had enlarged facial vibrissae, and in turn their brain’s somatosensory cortex differed from those in cats that could see. Rauschecker concluded that motor feedback had helped reorganise the processing of sensory stimuli. This would explain why the cat mentioned in the question has enlarged vibrissae.

**Jessica Harvey-Cox**

Colchester, Essex, UK

**This week’s questions**

**THAT TINGLING FEELING**

I was sitting in my tent, warming my legs with a fan heater, when my mum’s foot brushed my calf and I felt an electric sort of tingling in my leg. What could explain this? My dad felt the same sensation when he simply ran his finger over his calf, but when he greased his finger with butter and repeated the test, the feeling went away. He suggests that a certain amount of sticking when the finger is not greased causes a vibration, which the nerves detect. Could this be right?

**Patrick Nevill**

Nantwich, Cheshire, UK

**ECO-FRIENDLY KILLING**

Chainsaw sculptor Peter Bowsher has created a magnificent tree carving for us, depicting Edward Lear’s poem _The Owl and the Pussycat_ (see photo). Now we need to kill off the tree without chopping it down. How can we do this with the least contamination of the surrounding environment? It is a lime (linden) tree, 3.6 metres tall and half a metre in diameter.

**Tom and Oonagh Gray**

Edinburgh, UK

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Questions and answers should be concise. We reserve the right to edit items for clarity and style. Include a daytime telephone number and email address if you have one. Restrict questions to scientific enquiries about everyday phenomena. The writers of published answers will receive a cheque for £25 (or US$ equivalent). Reed Business Information Ltd reserves all rights to reuse question and answer material submitted by readers in any medium or format.

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For a list of all unanswered questions send an SAE to LWQlist at the above address.
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