

BOMB SHOCK DISEASE

The new Gulf war syndrome

NASA'S CHOICE

Rocket rivals square up

ANTIMATTER EXPLAINED

Could it really blow up the Vatican?

NewScientist

WEEKLY April 23 • May 1, 2009



**GOODBYE
TRASH**

Hello to a future
fuelled by
gasified garbage



Concussed, stressed or just sick of war?

Veterans with injured minds deserve as much care as those with injured brains

CONCUSSION involves a bang on the head followed by unconsciousness or giddiness then a few days of headache and nausea. At least that is the usual understanding.

But on the battlefield it has come to mean something altogether more sinister: a blast-induced brain injury with a catalogue of symptoms such as fatigue, irritability and insomnia (see page 40).

The US military claims 1 in 5 of its soldiers are returning from Iraq and Afghanistan debilitated by such symptoms, which it claims are due to mild traumatic brain injury (mTBI), as concussion is also known, and has launched screening programmes. Veterans groups have even warned of an epidemic.

It seems plausible that mTBI is responsible for this apparent surge in battlefield illness: homemade roadside bombs are one of the greatest dangers coalition troops face in Iraq and Afghanistan, and most soldiers now survive such explosions thanks to their modern body armour.

Yet recent studies into the epidemiology of mTBI suggest that the symptoms soldiers are reporting derive not from head injury but mostly from psychological illness such as

post-traumatic stress disorder (PTSD). In other words, they are triggered largely by the ghastly experience of being on a battlefield.

The distinction is important. Physicians can provide soldiers with more effective treatment if they know what caused their symptoms. And a false diagnosis could well exacerbate the problem: telling patients what is wrong with them can influence how they respond to treatment. That means if soldiers think their distress is due to an enduring brain injury they are likely to take longer to recover.

Inevitably, some people will rush to dismiss the suffering of returning soldiers as “all in the head” and by implication less deserving of

“Psychologically based pain can no longer be dismissed as malingering”

help. Governments have been as guilty as anyone of reinforcing the idea that psychologically based illness is less of a priority: most have justified withholding compensation for battlefield conditions such as Gulf war syndrome on the grounds that it has been hard to link them to physical causes.

Yet psychologically based pain can no longer be dismissed as malingering. The debilitating effects of battlefield stress have been well documented. Treatments for PTSD are well established, even though its precise diagnosis is controversial.

At least military doctors and researchers seem to agree on one thing – that the symptoms reported by veterans of Iraq and Afghanistan are real. It follows that they deserve plenty of support, even if the source of their suffering is still open to debate. ■

Waste disposal needs more light, less heat

NOW that there's a way to cut the mountain of trash we send to landfill and turn it instead into energy (see page 33) you might expect the environmental lobby to be jumping for joy. Far from it. They fear that gasifying our garbage, if done badly, could release pollutants, and they quite rightly point out that it is more energy-efficient to recycle wherever possible.

When used the correct way, though, turning rubbish into energy must surely be better than tipping it into a hole in the ground. Yet so long as the row is between companies that hail gasification plants as a green panacea and opponents who tastelessly liken them to the smouldering remains of the World Trade Center, we will never know for sure. It's time to end the propaganda war by mounting independent studies of their true impact. ■

Crunch for women

COULD the recession be an opportunity for women to finally seize control? A new study suggests that in uncertain times people opt for leaders with feminine faces (see page 10). Older male faces, on the other hand, are the people's choice for wartime. Since our era is unprecedented, both in terms of the economy and dealing with climate change, perhaps feminists could turn this to their advantage. They should view the turmoil as their big chance to change society. Prepare for a new dawn of female leadership. ■

What's hot on NewScientist.com

ROBOTS Autonomous robo-penguins can fly as well as swim

Engineers have developed two types of robotic penguins that not only move autonomously but also communicate with each other and act as a group. AquaPenguins use 3D sonar to swim, while helium-filled AirPenguins float through the air, guided by ultrasonic signals.

GREEN TECH Innovation challenge – the winners View a gallery of the winning entries to an

international competition to find innovative ideas that reduce our impact on the environment. Winners include a solar-powered oven, aerodynamic hubcaps and a garlic extract to prevent flatulence in cows.

SPACE Kepler gets a first glimpse of its planetary hunting ground NASA's space telescope has delivered its first image of a patch of sky that it will scrutinise for the next three-and-a-half years in search of Earth-like planets.

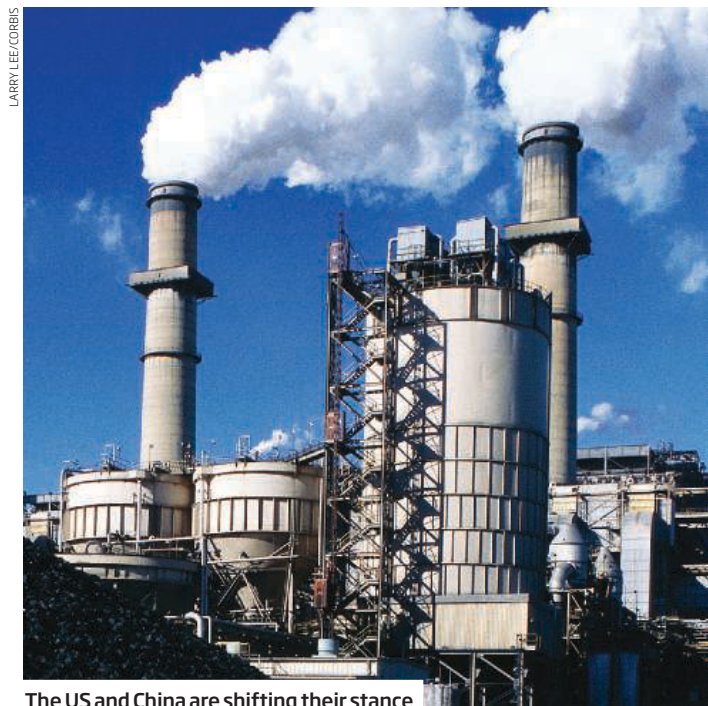
ENVIRONMENT Extreme species rescue From frogs airlifted off a Caribbean island to mountain goats resurrected from frozen skin cells, we survey the most way-out examples of animals brought back from the brink of extinction.

HUMAN EVOLUTION The function of the earliest tools Analysis of million-year-old bone tools suggests they were used for a range of tasks, including fruit processing. Plus: How did we get to where we

are today? Check out our interactive time line of 34 crucial steps on the road to humanity.

FUELS Yeast and a bacterium are turned into fuel factory Some DNA detective work, combined with clever genetic engineering, could provide a way to make carbon-neutral petrol, more cheaply than the polluting kind derived from oil.

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The US and China are shifting their stance

Ozone with ice

BLAME the southern ozone hole. That's why Antarctic sea ice is growing even though Arctic ice is shrinking at record rates. It seems CFCs and other ozone-depleting chemicals in the atmosphere have given the South Pole a respite from global warming.

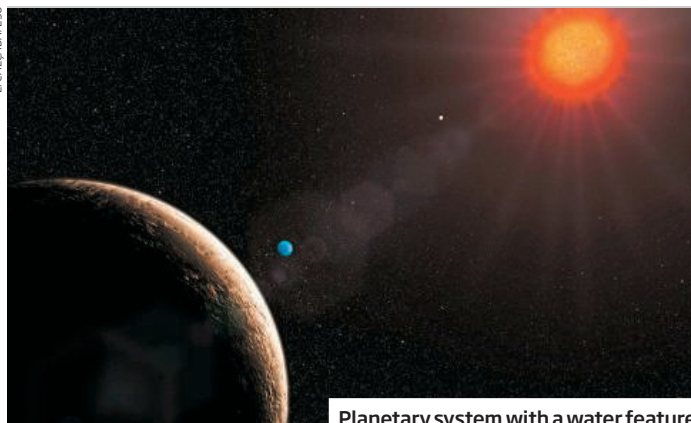
Satellite images studied by John Turner of the British Antarctic Survey and his colleagues show that Antarctic sea ice increases in every month except January. "We're trying to understand why it's increasing now, at a time of global warming," says Turner.

The researchers used an atmospheric model to investigate how the ozone hole has changed weather patterns around

Chile, which has warmed the Antarctic peninsula and may have contributed to the collapse of several ice shelves. However, it has also generated stronger cool-air storms around the Ross Sea, where new ice has formed. Overall, the increase in sea ice has been greater than the reduction (*Geophysical Research Letters*, DOI: 10.1029/2009GL037524, in press).

The respite is temporary, though. The ozone hole will eventually close, Turner says. "In the next decade or so we should see sea ice plateauing and then decreasing massively."

L. CALCADA/ESO



Planetary system with a water feature

"The ozone hole has generated strong storms around the Ross Sea, where new ice has formed"

Antarctica. They found that depletion of ozone has intensified strong winds that swirl around the continent. This vortex has drawn more warm air in from

Climate 'cold war' thaw?

FEARS of a cold war on climate between China and the US, in which each waits for the other to budge first on greenhouse emissions, were replaced this week by sunnier hopes.

In Washington, the Environmental Protection Agency has officially recognised carbon dioxide as a danger to human health. Although this may not result in direct regulation, it may prompt "cap and trade" laws, in which the government auctions emissions permits that can then be traded. "The greater significance may be that it will put more pressure on Congress to pass legislation," says Bob Ward of the Grantham Research Institute on Climate Change and the Environment at the London School of Economics.

In Beijing, Chinese climate negotiators indicated on Monday that

at the UN climate conference in Copenhagen in December 2009, they may be prepared to offer a declared limit on future emissions - at least indirectly. China's current five-year plan includes a target to reduce the "carbon intensity" of the Chinese economy by 20 per cent. That means it is reducing the amount of carbon burned for every dollar the economy makes.

The next five-year plan is likely to include a further reduction, according to China's top climate negotiator, Su Wei, who said the country could "very easily translate energy reduction targets to carbon dioxide limitation". However, an actual reduction in emissions is unlikely for the near future, Su told *The Guardian* newspaper in London.

Dengue detectives

AS DENGUE fever struck Buenos Aires in Argentina for the first time this week, there is renewed hope that a drug to treat the 100 million people infected worldwide each year may one day be possible.

Mariano Garcia-Blanco of Duke University Medical Center in Durham, North Carolina, and colleagues used RNA interference technology to "knock down" the activity of a gene in a fruit fly cell before exposing it to the dengue virus to assess the impact of this gene on infection.

By repeating the experiment on each of the fruit fly's 14,000 genes, they identified more than 100 genes necessary for infection to occur (*Nature*, DOI: 10.1038/nature07967).

Further testing found that inhibiting 42 of the equivalent human genes stopped dengue fever from infecting human cells, suggesting targets for drug treatment. The team also identified a gene necessary for dengue fever to infect its host, the *Aedes aegypti* mosquito, potentially leading to new ways to prevent transmission.

Alien waterworld

A PLANET orbiting a red dwarf star 20 light years away could be the first known waterworld, entirely covered by a deep ocean.

The planet, named Gliese 581d, is not a new discovery, but its orbital period has now been revised from 83 to 66 days, putting it within the "habitable zone" where liquid water could exist on the surface. "It is the only low-mass planet known inside the habitable zone," says Michel Mayor of the

Geneva Observatory in Switzerland, whose team made the revision.

Because Gliese 581d is about seven times as massive as Earth, it is probably not a rocky world like our own. Instead, it is likely to have a make-up similar to Neptune or Uranus, which are dominated by frozen water, ammonia and methane.

In the warmth of the habitable zone, these ices should have melted to form a sea thousands of kilometres deep. "Maybe this is the first of a new class of ocean planets. That is my favourite interpretation," says Mayor. "But whether there is life, I don't know."

Stem cell boom

WHILE new US guidelines on using human embryonic stem cells (ESCs) will surely trigger an expansion of research, they also risk shutting down some investigations that are already under way.

On 9 March, President Barack Obama announced that he would overturn restrictions introduced by his predecessor, George W. Bush, which limit federal funding to about 20 ESC lines isolated before August 2001.

Draft guidelines from the National Institutes of Health, announced on 17 April, would allow federal funds to be used for research on ESCs isolated from "spare" embryos left over from IVF treatments.

To be eligible for such funding, cell lines would also have to meet strict standards for consent from embryo donors. This may be a problem for existing lines, given worries over the adequacy of the original forms used for consent. To prevent existing projects from having their funds cut off, it may be necessary to exempt some older cell lines from the new standards, says Kevin Wilson of the American Society for Cell Biology.

Changes to the guidelines can be suggested over the next month. The final version will be published by 7 July.

Climate of fear

THEY have done little to cause climate change, but indigenous peoples, from Arctic Inuit to Pacific islanders, will be among the hardest hit by it. So they are meeting in Anchorage, Alaska, this week to forge a common position for the negotiations for the post-Kyoto climate protocol.

The meeting is emphasising indigenous peoples' stewardship of nature and their history of adapting to change. But beneath that is the fear that rich countries may try to cut their greenhouse emissions by grabbing indigenous

lands to, say, grow biofuel crops.

"We're having the hardest time we've faced in 500 years," says Dennis Martinez, an ecologist and an O'odham (Pima) American Indian attending the meeting. He says indigenous people living

"Indigenous people fear that they will be trampled by rich countries trying to cut greenhouse emissions"

sustainably off natural resources could be highly resilient to climate change – but not if their cultures are destroyed by the actions of the rest of the world.

Spooks seek science chief

IT MIGHT be the next best thing to being James Bond: a job as Q, and in real life too.

While the fictional Bond and Q work for the UK's overseas intelligence service, popularly known as MI6, it is the Security Service, or MI5, that is in need of a chief scientific adviser. MI5 deals with threats to national security, and the successful applicant will coordinate the use of science and technology across its branches.

The job, which is advertised on MI5's website, unsurprisingly requires someone of high academic standing. "It could be a scientist or an engineer. They're open-minded about areas of scientific expertise," says a spokesman for the UK

government's Department for Innovation, Universities and Skills.

The recruitment agency that is advertising the role says that proficiency in at least one of physics, chemistry, acoustics, optics, materials science, radiofrequency technologies, communications, telephony and data-mining would be an advantage.

"I think it's unlikely the candidate will be required to create a new weapons system for the latest Aston Martin," John Beddington, the government's chief scientific adviser, told the BBC. The deadline for job applications is 24 April.

MI5 also provides advice to other government agencies on how to "reduce their vulnerability" to threats.



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60 SECONDS

Hysterectomy hazard

Women who have their ovaries removed during hysterectomy are at greater risk of fatal illness than those who keep them, say researchers from Harvard Medical School. Removal of the ovaries was linked to a reduced risk of ovarian and breast cancer, but the risk of heart disease and stroke for women under 50 nearly doubled, because of a loss of hormones that have a protective effect on the heart.

Frozen out

Visiting Antarctica just got harder. The 28 signatories to the Antarctic Treaty agreed last week to ban ships carrying more than 500 passengers from landing, and to allow no more than 100 people at a time to land. Since 1992, the annual number of visitors has risen sevenfold.

Keep it dark

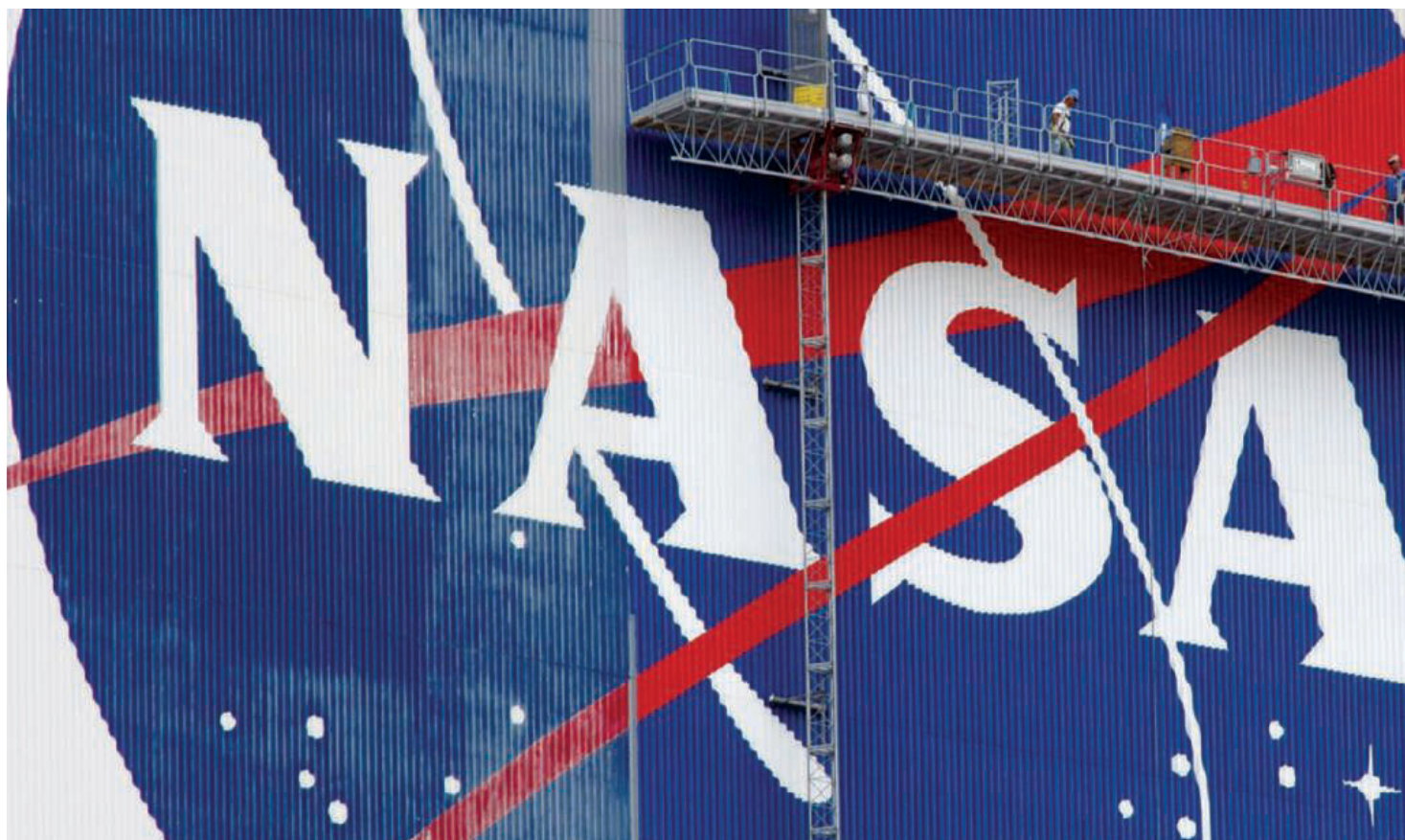
Better-designed street lights would slash light pollution in rural areas. Chris Baddiley of the UK-based Campaign for Dark Skies modelled the way light is reflected by buildings and vegetation, and scattered by dust in the air. He found that downward-shining lights could cut 80 per cent of the glare from rural night skies.

Clean-up call

Coal mined in China now provides more energy than all the oil produced in the Middle East, but the country is proving slow to introduce cleaner coal technology, according to an International Energy Agency report. While China has tough environmental laws, more power to implement them needs to be delegated to lower levels of government, the report suggests.

Danger signal

Unusually high levels of the enzyme PDE7B in the blood of people with chronic lymphocytic leukaemia indicates a more aggressive form of the cancer, researchers at the University of California, San Diego, have found. This could alert doctors to the need for immediate treatment.



At the crossroads, tryin' to flag a ride

From the world-striding vision and giant leaps of the Apollo era, NASA now risks being hobbled

David Shiga

THE US risks losing its edge in human space exploration and faces the humbling prospect of relying on outsiders to put its astronauts into space. Battles are brewing over the direction the agency should take, and decisions made in the next few months may shape US spaceflight for decades to come. So where does NASA's future lie?

In July NASA will celebrate the 40th anniversary of humanity's first steps on the moon. But 2009

sees confusion over the agency's next "giant leaps", and its planned return to the moon is in the balance: the space shuttle fleet is set to retire in 2010, although the shuttles' troubled successor will not be ready until 2015 at the earliest and many space commentators, and even some NASA employees, want to scrap it and start over. Despite safety concerns, there are calls to extend the shuttle's life rather than hitch rides with countries such as Russia. Other groups are pushing instead for NASA to start

paying for their astronauts to travel on commercial spacecraft.

The entire future of US crewed space flight is in question but events are coming to a head: a new NASA boss is to be appointed, possibly in the next month, there are highly anticipated rocket flight tests later this year, and a tightening of purse strings is set to force some difficult decisions.

The stakes could not be higher, says Howard McCurdy, a space-policy analyst at the American University in Washington DC. NASA can no longer afford the spiralling costs associated with expensive disappointments like the space shuttle, which added up to many billions more than planned, he says. "It will kill the human space flight programme."

NASA's latest travails began with the 2003 accident that destroyed space shuttle Columbia and killed its crew. The government directed the agency to begin work

on a new space launch vehicle, retire the space shuttle fleet by 2010 and return astronauts to the moon by 2020. Since then, NASA has been developing the Ares I rocket and Orion crew capsule, which it wants to use to carry its astronauts to the International Space Station (ISS) and to help them fly to the moon. However,

"With the status quo, NASA simply cannot afford to stay on track - something has got to give"

the programme has faced serious technical problems. Ares I suffers from potentially dangerous vibrations, and engineers have struggled to squeeze enough power from the rocket to lift the heavy Orion capsule into orbit.

The programme's fate might be decided in August. That's when NASA plans to launch a prototype called Ares I-X from Cape

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- The faces of our leaders, page 10
- What do autism and anorexia have in common? page 12



Needs more than a lick of paint

Canaveral, Florida. Ares I-X is a modified version of the Ares I rocket, with a functional first stage capped by a dummy second stage and dummy capsule. It will test the rocket's aerodynamics and separation of the first and second stages.

"If it's not a successful flight, it's only going to increase the calls to revisit or even cancel the programme," says space industry analyst Jeff Foust, editor of The Space Review website. "If it succeeds, it's only one hurdle of many that the programme's going to have to overcome."

President Barack Obama endorsed the shuttle's retirement and a return to the moon by 2020 in his proposed budget for 2010, but has so far taken no specific position on Ares I and Orion. If he did throw his weight behind the programme, extra money would have to be found. Keeping Ares I and the rest of NASA's human

space-flight hardware development on schedule in the coming years is likely to require a \$2 billion per year boost to NASA's budget, according to a report issued last week by the Congressional Budget Office. Yet it is not clear that Congress would be willing to pay up. In other words, with the status quo, NASA simply cannot afford to stay on track – something's got to give.

The agency may have to sacrifice its involvement in the ISS (see "This station terminates here", below). To find even more money, it could relax its 2020 deadline for the return to the moon. However, deferral could lead to cancellation, McCurdy warns. "As soon as you loosen the 2020 deadline, you basically say we'll do it someday but we don't know when," he says. "It is really a retreat and would cause substantial reconsideration of the overall concept."

Foust reckons NASA should explore commercial options for launching its astronauts, and he's not alone: an advocacy group called the Space Frontier Foundation is also pushing for this. A leading contender to provide such flights is a company called SpaceX, founded in 2002 by the co-founder of Paypal, Elon Musk, and based in Hawthorne, California. SpaceX has developed a capsule called Dragon that could carry up to seven astronauts into



Any more to come?

Earth orbit, launched by the company's Falcon 9 rocket.

Launching astronauts on a commercial vehicle would be unprecedented, but not far-fetched: NASA has already contracted SpaceX to take cargo to the ISS on unpiloted flights of its Falcon 9 and Dragon system, beginning in 2010, although SpaceX will need to carry out successful demonstration flights by then. The first test flight of Falcon 9 is expected early in the second half of 2009, followed by a second test flight, this time carrying the Dragon capsule, before the end of the year.

"There's nothing like successful flights – that's the ultimate proof of your approach," says Valin Thorn, deputy manager of NASA's commercial crew and cargo programme, which has provided millions of dollars to assist SpaceX with its development work. "At the same time, we know how difficult

this is, and it's not unusual historically to have early failures in a development programme. We have tolerance for a degree of that."

Another factor that could affect the future of US space flight is a possible delay in retiring the space shuttle. Congressional representatives from Florida are particularly keen on this idea because it avoids or delays job losses that would result from the retirement of the shuttle. But the billions of dollars required per year could come at the expense of delayed development of Ares I, and could also make it harder to find money to assist companies like SpaceX in developing commercial launch options.

One thing weighing against extending the shuttles' life is a report issued last week by a panel of independent experts that advises NASA on safety. The panel strenuously objected to the idea of extending the space shuttles' life, given ongoing concerns about the ageing vehicles' safety.

The uncertainty over NASA's future is deepened by the absence of a permanent chief. The previous administrator, Mike Griffin, resigned in January, but the Obama administration has yet to name a permanent replacement. Obama's science adviser, John Holdren, said in early April he hoped the announcement would be made within a month. Even so, the big decisions like those now facing the agency cannot be decided by the new administrator alone – not least because they involve colossal sums of money.

Arguably, the US contribution to human spaceflight is too fundamental to neglect now. After all, Thorn argues that sending astronauts to space is part of a long-term international insurance plan for the human species. "Humanity's survival could depend on developing human space transportation well beyond what we have today, and that's a multi-generational endeavour," he says. "We have to continue to press those boundaries." ■

THIS STATION TERMINATES HERE

Will the International Space Station soon burn up in the sky due to lack of funds?

Though US policy-makers are still debating how long to support the ISS, NASA's long-term budget plans assume the agency will stop using the orbiting outpost after 2015 – just five years after its scheduled completion. This would free up the many billions of dollars NASA needs to finish developing the hardware for the return to the moon. However, international partners, including the European and Russian space agencies,

want to use it until at least 2020.

The US Congress has told NASA to avoid any action that would preclude it from extending its participation beyond 2015, but has not committed to funding an extension. NASA's partners do not appear ready to commit the resources that would be needed to fill the gap should the US pull out.

The orbit of the ISS decays over time and so it requires regular boosts. If abandoned, it would need to be deliberately pushed into Earth's atmosphere, timed to fall harmlessly into a designated region of the ocean.

Dastardly dark matter ripped up early universe

BY ABOUT a billion years after the big bang, our universe was reionised. Hydrogen atoms were torn apart into electrons and protons, but the perpetrator has been something of a mystery. Could dark matter be responsible?

Neutral atoms, mostly of hydrogen, formed about 380,000 years after the big bang, when the universe cooled enough for electrons and nuclei to combine. Most astronomers suspect that the hydrogen was reionised by the first generation of stars. No telescope has ever peered far enough back in time to see the first stars form, but they are thought to have been giants, and their ferocious ultraviolet light could have done the trick.

But Dan Hooper and Alexander Belikov of Fermilab in Batavia, Illinois, think that dark matter – the unseen stuff that makes up about 85 per cent of all matter – could have reionised the universe. Dark matter is thought to be made of massive particles that are predicted to annihilate when they collide, spewing out radiation.

When dark matter clumped together under gravity in the early universe, some of the particles would have annihilated, resulting in high-energy gamma rays. Each gamma ray would have knocked out an electron from a hydrogen atom, which in turn would have dislodged an electron in another atom, and so on (www.arxiv.org/abs/0904.1210). “A single gamma ray might reionise 1000 hydrogen atoms,” says Hooper. “The mechanism could easily have reionised the universe.”

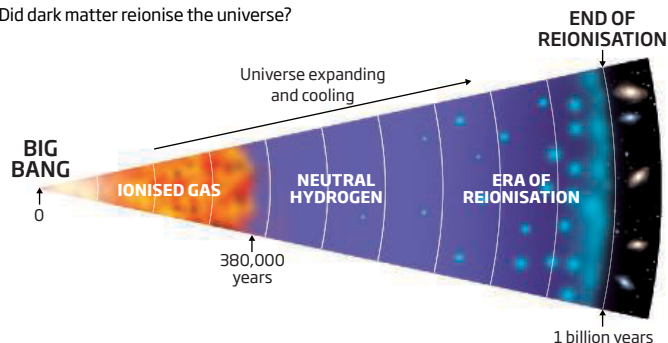
Using one unsolved mystery to

solve another makes some people sceptical. “We have no evidence yet that any dark matter has ever annihilated,” says Charles Bennett, of the Goddard Space Flight Center in Greenbelt, Maryland, and principal investigator on NASA’s WMAP satellite, which has been studying the reionisation epoch. “I am not saying it is wrong, but it sounds a bit too contrived for me to eagerly accept it.”

Hooper says that the European Space Agency’s upcoming Planck mission, the successor to WMAP, will study how reionisation proceeded with time. “The time signature of dark matter reionisation will be different from that brought about by stars,” says Hooper. **Marcus Chown** ■

From atoms to ions

Did dark matter reionise the universe?



How to turn a greenhouse gas into a clean fuel

CONVERTING a greenhouse gas into a clean-burning fuel offers two benefits for the price of one. That’s the thinking behind a novel process for converting carbon dioxide into methanol at room temperature, developed by a team at the Institute of Bioengineering and Nanotechnology in Singapore (*Angewandte Chemie International Edition*, DOI: 10.1002/anie.200806058).

Molecules of CO₂ are very stable, so processes that convert the gas to methanol normally require high temperatures and pressure.

They also use catalysts containing toxic metal ions. “Our catalyst isn’t toxic, and the reaction happens rapidly at room temperature,” says team leader Jackie Ying.

The catalyst used by Ying’s team is a type of chemical called an *N*-heterocyclic carbene (NHC). The mechanism by which the NHC speeds up the conversion is uncertain, but it appears to change the shape of the CO₂ molecule, “activating” it in a way that makes it easier for hydrogen to bond with its carbon atom, says team member Yugen Zhang.

The catalyst may also help to

“It’s a way of taking carbon dioxide out of the air and making it into something useful”

release hydrogen from hydrosilane molecules, which are the source of hydrogen in the new process. Hydrosilane is an expensive chemical usually used to make computer chips, so the team wants to find a cheaper source.

“Potentially, it’s a means for taking carbon dioxide out of the air and making it into something useful,” says Dongke Zhang, director of the Centre for Petroleum, Fuels and Energy at the University of Western Australia in Perth. As well as being a fuel, methanol can be used as a feedstock for the chemical industry. Zhang’s team is developing a technique for converting CO₂ into methanol using high-frequency electromagnetic fields or plasmas to activate the gas. **Rachel Nowak** ■

SOUNDBITES

“I don’t think we had any idea doctors were involved to this extent, and it will shock most physicians.”

George Annas, a professor of health law, bioethics and human rights at Boston University, comments on newly released CIA documents showing the intimate role of psychologists and doctors in “harsh interrogations” (*The Washington Post*, 18 April)

“This was his wish. It’s the last thing I can do for him.”

Gisela Marrero explains why she is harvesting her dead lover’s sperm to have his baby. Soon after Johnny Quintana died, an ice bag was placed on his testicles while a judge decided whether the procedure could go ahead (*Daily News*, New York, 18 April)

“The arguments from those who deny the science look more and more like those who denied the association between HIV and AIDS or smoking and cancer.”

Nicholas Stern, former chief economist to the World Bank, gives climate deniers short shrift in his new book (*The Daily Telegraph*, London, 20 April)

“If a soldier is shot in an ambush, what if he’s trying to call for help and two truckers are discussing soccer?”

Amateur radio operator **Adinei Brochi** on the increasing problem of illegal hijacking of US military transponders in Brazil (*Wired.com*, 20 April)

“I named it *Caloplaca obamae* to show my appreciation for the president’s support of science and science education.”

Even the field of mycology cannot avoid Obamamania. **Kerry Knudsen** of the University of California, Riverside, on why he named a lichen after Barack Obama (*Mongabay.com*, 15 April)

If the bacteria resist, eat them

Catherine de Lange

A VIRUS that gobbles up the bacteria that cause debilitating ear infections could become the next weapon against antibiotic-resistant bacteria, after the first clinical trial of a bacteriophage treatment proved successful.

The trouble with bacteria is that they can evolve to outsmart antibiotics, secreting enzymes that break them down, or developing extra pumps to force drugs out of their cells. Because antibiotic resistance hampers treatment for common diseases including pneumonia, salmonella and tuberculosis, it is a growing public health problem.

Pseudomonas aeruginosa, which can cause ear infections, is particularly hard to treat because it wraps itself in a biofilm – a layer of sugars and proteins that make it up to 1000 times as resistant to antibiotics as a non-biofilm from the same species.

Now a single dose of Biophage-PA, which contains a virus that selectively attacks *P. aeruginosa*, has successfully treated long-term sufferers of antibiotic-resistant ear infections.

The therapy's key ingredients

are viruses called bacteriophages. These “eaters of bacteria” break down the biofilm and destroy target cells, without harming other useful bacteria in the body.

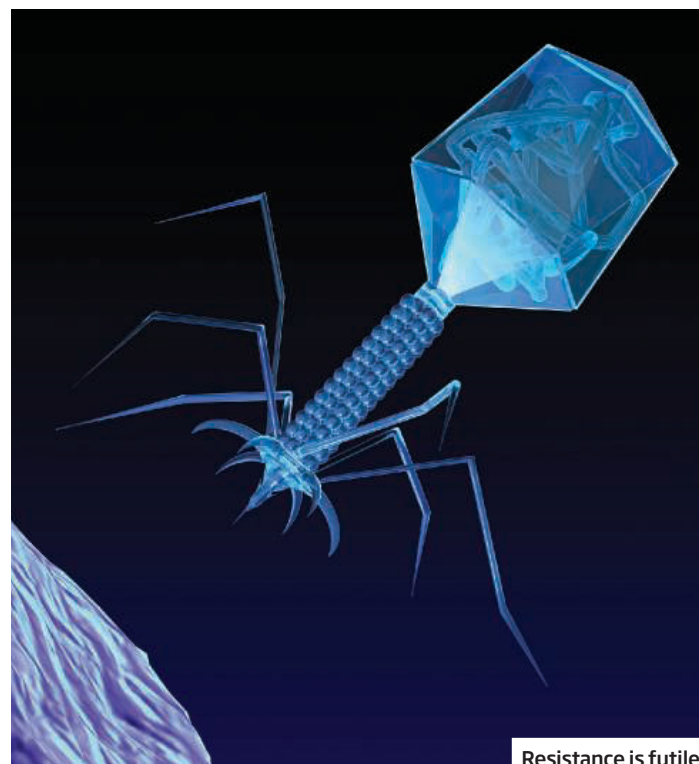
Andrew Wright from University College London Ear Institute and colleagues studied 24 people with severe ear infections (*Clinical Otolaryngology*, accepted for publication). Half the volunteers were given Biophage-PA and the rest received a placebo.

Pain, pus secretion and inflammation were reduced in

“Phages break down the biofilm to destroy target cells, without harming useful bacteria”

both groups, but the change was twice as noticeable in the group on the treatment. The number of target bacteria in the ear was significantly reduced in this group, while there was no significant reduction in the placebo group. By the end of the six-week trial, three patients on the phage were clear of infection.

Phages are routinely used to treat infections in eastern Europe but in an unregulated way, says David Harper, who worked on the



Resistance is futile

trial. “There is a lot of anecdotal evidence,” he says, “but this is the first time it has been tested in a clinical trial to see if it really works.”

There are other advantages too, says Harper. You only need to give one dose, unlike regular courses of antibiotics which people sometimes forget to finish, making resistance more likely. Standard antibiotics can also damage hearing by destroying delicate hairs in the ears needed to transmit sound.

“This trial is an important step forward,” says Lucinda Hall, a microbiologist from Barts and The London School of Medicine, but warns there are challenges ahead, notably the possibility that bacteria might evolve resistance to this treatment too.

Harper is now working with the US army to see if similar phages could treat wound infections, and is developing an aerosol treatment for lung infection in patients with cystic fibrosis. ■

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Would McCain have won in wartime?

Linda Geddes

THE mark of a good leader may be etched on their face but whether he or she gets elected might depend on the state of the nation.

To see whether facial characteristics influence our choice of leader, Brian Spisak and Mark Van Vugt at the University of Kent, UK, manipulated computer images of male and female faces to make them appear more masculine or feminine.

They asked 118 volunteers to choose one of them as a leader for different scenarios: during times of war; when peacekeeping between different groups was important; during periods of transition; to maintain stability after a natural disaster; and when there was a risk of civil war.

The researchers also altered the male and female faces to look older or younger, and then asked

145 volunteers to pick a leader given the same scenarios.

During times of war, the volunteers preferred masculine or older faces, while they picked feminine faces when inter-group peacekeeping was the priority. Interestingly, gender was irrelevant – with masculine-looking women picked over feminine-looking males during times of war, and vice versa.

“This suggests that traditional classifications of male and female are not as relevant a cue as we might think,” says Spisak, who spoke at a meeting of the European Human Behaviour and Evolution Association in St Andrews, UK, earlier this month.

Previous studies have hinted that voters prefer masculine-looking leaders during wartime, as these types of faces are associated with dominant and decisive traits, says Alexander



If the face fits the times

Todorov of Princeton University. “The novelty here is that masculinity or femininity, which is naturally correlated with gender, still influences decisions even when unconfounded by gender.”

Spisak and Van Vugt also found that youthful faces were preferred during times of transition and stability – with young females the leaders of choice.

Spisak believes that facial

characteristics may have played a role in the recent US presidential elections, although other factors were also clearly involved. “Obama was an easier sell,” he says. “He was the relatively younger candidate, and he stuck with this message of change and transition. If McCain had had a stronger and more consistent message on the war, perhaps he would have stood a better chance of winning.” ■



Fossil seal had the feet of an otter

A FOSSIL of a small, otter-like animal from the Canadian Arctic provides clues to how seals got their flippers.

We know that seals and sea lions, aka pinnipeds, evolved from land animals and are closely related to bears and weasels. But until now few intermediate fossils bridged the gap between these terrestrial ancestors and the sleek, flippered pinnipeds.

The new fossil, uncovered by Natalia Rybczynski of the Canadian Museum of Nature in Ottawa and her team does just that. Rybczynski's team found the fossil, dubbed *Puijila darwini*, in freshwater sediments on

Devon Island in the Canadian high Arctic. *Puijila*'s teeth and skull indicate that it is a primitive pinniped – but instead of flippers, the animal seems to have had long, webbed feet much like the modern giant river otter of South America (*Nature*, DOI: 10.1038/nature07985).

Puijila lived about 21 to 24 million years ago, when Arctic regions were much warmer than today. Lakes would probably still have frozen in winter, though, so the animal might have wandered onto land in search of food as otters do today, says Rybczynski. In fact, the need for food may have encouraged them to venture into the oceans, too, which would have remained ice-free for more of the year, driving the evolution of modern-day pinnipeds in the Arctic. Bob Holmes ■

Shining secrets through the centre of the Earth

IF YOU shine a laser on the floor, where does the light go? With the right preparation, some of it might pop out at the other side of the world – an effect that could be exploited to transmit secret messages through the ground.

That is the conclusion of Andreas Ringwald at the German Electron Synchrotron (DESY) in Hamburg, and colleagues, who have explored the possibility of hypothetical particles called “hidden photons” (www.arxiv.org/abs/0903.5300). “If such particles exist, then we can use them to communicate,” says Ringwald. “It’s very simple.”

Hidden photons are a class of particles predicted by so-called

supersymmetric extensions to the standard model of particle physics. Unlike normal photons, hidden photons could have a tiny mass and would be invisible because they would not interact with the charged particles in conventional matter. This means hidden photons would flit through even the densest materials unaffected.

The only place to spot them is in a vacuum, where they should sometimes “oscillate” into normal photons. There are already experiments searching for this effect: the idea is to shine a laser at a wall in a vacuum and see if any of the photons make it through to the other side by

transforming into their hidden counterparts and back again. According to Ringwald’s group, if these experiments succeed it should be possible to scale up the apparatus so that the hidden photons become signal carriers and the “wall” becomes any stretch of ground or water.

The benefit of such a communication method is that, unless someone were in the exact

“Hypothetical ‘hidden photons’ could beam messages through any stretch of ground or water”

line of sight with appropriate equipment, it would be impossible to eavesdrop. For example, submarines could employ the system to avoid communicating via sound, which is easily intercepted. Hidden

photons could even take messages where radio signals cannot reach, such as the far side of the moon.

Physicist Doug Shaw at Queen Mary, University of London, thinks it would be a “technical challenge” to line up transmitters and receivers over large distances, but he agrees a system is feasible in principle. “It’s a nice idea,” he says. “Unlike most hypothetical particles that are only accessible at high energies, these particles, if they exist, would have potentially useful real-world applications.”

However, Malcolm Fairbairn, a physicist at King’s College London, points out that over the 12,700-kilometre diameter of the Earth, the signal capacity would be just 1 bit per second: “At that speed it would take about a year to download an mp3 file, so I’m not sure who would use it.” **Jon Cartwright ■**

2009 Tyler Prize



Professor Richard B. Alley

Evan Pugh Professor of Geosciences
The Pennsylvania State University

Professor Veerabhadran (Ram) Ramanathan

Distinguished Professor of Climate
and Atmospheric Sciences
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The Tyler Prize was established in 1973 by the late John and Alice Tyler as an international award honoring achievements in environmental science, policy, energy and health of worldwide importance conferring great benefit on humanity. The Tyler Prize consists of a cash award of \$200,000 and a gold Tyler Prize medallion.

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The Tyler Prize Executive Committee announces the awarding of the 2009 Tyler Prize for Environmental Achievement on its thirty-sixth anniversary to Professors Richard B. Alley and Veerabhadran (Ram) Ramanathan, for their scientific contributions that advanced understanding of how human activities influence global climate, and alter oceanic, glacial and atmospheric phenomena in ways that adversely affect planet Earth.

Richard B. Alley is recognized for his contributions to understanding the relationships between the cryosphere and global warming, the vulnerability of the Antarctic and Greenland ice sheets, and for alerting us to the potential for contemporary abrupt climate change and its possible impacts and costs to society today.

Veerabhadran (Ram) Ramanathan is recognized for his contributions to the understanding of the dangers to planet Earth, especially from perturbations to its radiation field by trace greenhouse gases, and illumination of how significant regional impacts to humans can be caused by the aerosols in atmospheric brown clouds.

Web: www.geosc.psu.edu/people/faculty/personalpages/ralley/
www-ramanathan.ucsd.edu/

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Brain training can help in anorexia

Linda Geddes

A GROWING appreciation of the links between anorexia and autism spectrum disorders has uncovered new opportunities for treating the eating disorder.

Mental health professionals are now attempting to train the brains of people with anorexia to be more flexible and to see the big picture as well as fine details. In doing so, they hope patients will be less inclined to obsess about body weight and calories and be better equipped to overcome their eating disorder in the long term, as well as gaining weight more immediately.

Last month, the international Academy for Eating Disorders published a paper calling for eating disorders (EDs) such as anorexia and bulimia to receive the same degree of healthcare as other biologically based mental illnesses such as schizophrenia, bipolar disorder and obsessive compulsive disorder (OCD) (*International Journal of Eating Disorders*, DOI: 10.1002/eat.20589). Other groups are even calling for anorexia to be placed in the same diagnostic category as autism spectrum disorders (ASD).

The main reason for this change is a growing understanding of the biological basis of EDs. Twin studies suggest that between 50 and 83 per cent of EDs have a genetic basis. Now, evidence suggests that people with anorexia have cognitive traits associated with ASD. "Eating disorders and autism spectrum disorders are obviously not the same thing, but they do have some things in common," says Janet Treasure of the Institute of Psychiatry in London.

Treasure had already discovered that anorexia was

associated with extreme attention to detail and a rigid, inflexible style of thinking – traits also associated with ASD.

To investigate further, her team used neuropsychological tests to measure central coherence, or the ability to see the big picture as well as the finer details, in 42 women with anorexia and 42 without it. Women with anorexia had weaker central coherence, with a bias towards local, rather than global processing (*International Journal of Eating Disorders*, vol 41, p 143).

In a separate study, Treasure and her colleagues found that 45 per cent of people with anorexia or bulimia have problems "set-shifting", or modifying their behaviour in response to

changing goals, compared to just 10 per cent of healthy people.

This type of focused thinking can be a beneficial skill, but when thinking becomes obsessive, for example, it can be destructive, says Treasure, who presented her results at a meeting of the British Psychological Society in Brighton, earlier this month.

In another series of studies, Treasure's team, together with Kate Tchanturia, also of the Institute of Psychiatry, assessed empathy, systemising ability, and other traits on the autistic

"Anorexia and autism are obviously not the same thing, but they have some things in common"

spectrum in 22 women with anorexia and 45 without it. They found that although those with the eating disorder didn't differ from healthy women in terms of empathising or systemising, they did show elevated scores on other

autistic traits like poorer social skills, and greater attention to detail (*British Journal of Clinical Psychology*, DOI: 10.1348/014466507x272475).

Simon Baron-Cohen of the Autism Research Centre in Cambridge, UK, is also measuring whether adolescents with anorexia score higher on autistic traits than healthy people, as he suspects that some of them may actually have undiagnosed Asperger's syndrome. "We have always known that Asperger's syndrome was diagnosed more often in males," he says. "The new question is whether it takes a different form in females, and can account for at least a subgroup of those who are diagnosed with anorexia."

If it does, this could have important implications for the way that anorexia is treated. "As well as treating the 'eating disorder' the clinician and the patient might [also] focus on social skills," says Baron-Cohen, although he adds that weight gain would remain a key target.

Tchanturia is already conducting a study in around 30 people with anorexia, who are having cognitive remediation therapy (CRT) to encourage flexible and bigger-picture thinking. For example, patients are given an exercise in which they have to summarise several pages of text, to practice seeing the gist rather than the details. "We're putting the focus on how people think, rather than what people think," says Tchanturia.

The technique has already had some success – in a pilot study of 19 patients with anorexia, 17 patients said they felt it helped them to think more flexibly – although it's too early to say whether it will help their anorexia in the long-term. "They found the treatment helpful in reducing their perfectionist tendencies and it helped them to see things more holistically," Tchanturia says (*International Journal of Eating Disorders*, DOI: 10.1002/eat.20536). ■



Don't fixate on weight



Leaded fuel helped our warming planet keep cool

PREVIOUS generations unwittingly found a way to cool the Earth, but it's a polluting approach we are unlikely to want to repeat.

Pure water vapour freezes around dust, pollen and even bacteria at higher temperatures than it can as ice alone. This "nucleation" effect allows warmer clouds to form, causing them to radiate more of Earth's heat into space than cold clouds formed in cleaner air.

Dan Cziczo of the Pacific Northwest National Laboratory in Richland, Washington, and colleagues created artificial clouds from aerosol particles collected

in Switzerland. They found that while only 8 per cent of these particles contained lead, it was present in 44 per cent of the particles that seeded ice.

Cziczo suggests that lead "supercharges" ice-nucleating dust particles. The team calculates that the Earth's global infrared emission would be 0.8 watts per square metre higher if all atmospheric ice crystals contained lead than if none did (*Nature Geoscience*, DOI: 10.1038/ngeo499). By comparison, human-made CO₂ has reduced infrared radiation by around 1.5 watts per square metre since pre-industrial times.

Before leaded fuel was phased out from road vehicles, the atmosphere contained many more leaded particles than today. This may have helped offset greenhouse warming between 1940 and 1980, says Cziczo.

Sprayed signs of salty seas in Enceladus

THE ice plumes that bloom above Saturn's icy moon Enceladus are almost certainly rooted in a subsurface sea of liquid water.

The Cassini spacecraft flew through a plume on 9 October 2008 and measured the molecular weight of chemicals in the ice. Frank Postberg of the Max Planck Institute for Nuclear Physics in Heidelberg, Germany, and colleagues, found traces of

sodium in the form of salt and sodium bicarbonate. The chemicals would have originated in the rocky core of Enceladus, so to reach a plume they must have leached from the core via liquid water. Observations from Earth in 2007 spotted no sign of sodium, casting doubt on such a subsurface sea.

Although the salt could have been leached out by an ancient ocean which since froze solid, that

freezing process would concentrate most of the salt very far from the surface of the moon's ice, says Julie Castillo of NASA's Jet Propulsion Laboratory in Pasadena, California. "It is easier to imagine that the salts are present in a liquid ocean below the surface," she says. "That's why this detection, if confirmed, is very important."

The new results were due to be presented at the European Geophysical Union meeting in Vienna this week.

Stay calm to stay asthma free

IF YOU are prone to anxiety, it's time to chill out or your neurotic personality could triple your chances of developing asthma.

Adrian Loerbroks and colleagues at Heidelberg University in Mannheim, Germany, used a questionnaire to evaluate tendencies to hysteria, anxiety and depression in 4010 adults without asthma.

Nine years later, the team reassessed the volunteers and found that those who had high levels of neurosis were three times as likely to have developed asthma as those with low scores (*Allergy*, DOI: 10.1111/j.1398-9995.2009.02019.x).

Animal studies have shown that chronic stress alters hormone levels, which can inflame airways. Loerbroks believes neurotic character traits may exert similar effects, so treating highly neurotic people could reduce their risk of developing asthma.

How mice sniff out sickness

THE mystery of how some animals sniff out sickness in humans and other animals may have been solved. Ivan Rodriguez at the University of Geneva, Switzerland, and colleagues, have identified a smell receptor in mice that responds to molecules produced by bacteria, viruses and inflammation which are excreted in the urine of sick animals.

Rodriguez's team took tissue from the vomeronasal organ – a pheromone-detecting sense organ found in the nasal cavity of mice – and identified five receptors that were activated by the molecules (*Nature*, DOI: 10.1038/nature08029).

He says the receptors could be engineered into an artificial nose to detect illness in humans.

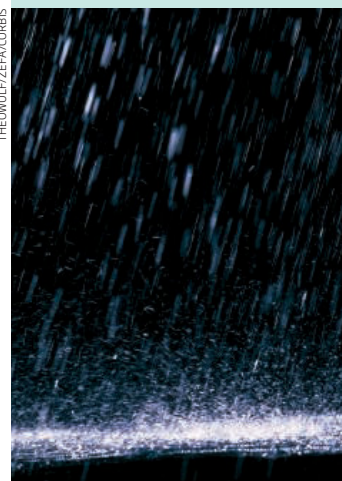
Raindrops splash before hitting wall

WHEN does a raindrop splash? Surprisingly, the process begins before it makes contact.

A liquid drop hitting a surface often flattens into a thin sheet that then bounces to form a crown shape. Previous experiments have suggested the surrounding air plays a role: a droplet doesn't splash so easily when the air pressure is low, instead spreading out into a thin pancake.

Shreyas Mandre of Harvard University and colleagues ran computer simulations of liquid drops hitting a solid surface, accounting for factors such as air pressure and the drop's surface tension. Their results showed that a typical raindrop – roughly 2 millimetres wide and travelling at a few metres per second – compresses air in front of it a few microseconds before hitting a solid surface. This creates an air cushion that causes the raindrop to flatten and spread out, which the team believe would be less likely if the drop was striking a higher friction surface, and may help the splash evolve into a crown (*Physical Review Letters*, vol 102, p 134502).

Splashing is still poorly understood, says Mandre, so describing such processes could help create splash-suppressing materials for use in kitchens, for example.



Easing the pain of growing stem cells

WHAT makes an unspecialised cell turn into a fully functional kidney, liver or blood cell? The short answer is proteins and pieces of RNA that alter gene activity within cells. But with thousands of these “regulatory elements” to choose from, finding the relevant parts is a headache for anyone aiming to manipulate stem cells. A new technique may soon give researchers a lot more control.

Piero Carninci at the RIKEN Yokohama Institute's Omics Science Center in Japan, and

colleagues, combined powerful computer modelling with “deep sequencing” – a process which decodes huge numbers of DNA sequences to discover where and how certain genes are switched on and off.

Using this technique, the team first identified millions of short fragments of RNA located at the start of genes – at the so-called “5[prime]” end, where genes are switched on.

They then identified which of these fragments were active during important periods of cell

growth. By overlaying that information onto a computer model of the whole human genome, they were able to identify key factors involved in cell regulation

The team tested the technique on cells in culture that mimic the transformation of unspecialised white blood cells into full immune cells. It successfully pinpointed known regulatory factors, and also highlighting hundreds more genetic candidates for future analysis (*Nature Genetics*, DOI: 10.1038/ng.375).

Road kill tally hints at wildlife health

IT MIGHT be gruesome, but counting road kill could be a quick and effective way to spot local changes in wildlife populations.

In 1984, 1994 and 2005, Bob Brockie and Richard Sadleir, two retired ecologists, drove the length of New Zealand's North Island, counting dead animals along the way. Then, along with Wayne Linklater of Victoria University of Wellington, they compared their data with road kill counts going back to 1949.

In some cases, the counts agreed with known changes in a population. For instance, the number of dead possums on the roadside fell by 60 per cent between 1994 and 2005, thanks to a government effort to cull the animals. However, the team also noticed an 82 per cent drop in dead hedgehog numbers between 1994 and 2005 (*New Zealand Journal of Zoology*, vol 36, p 123). “Interestingly, the decline coincides with a nosedive in hedgehog numbers in Britain, so perhaps a disease could be responsible,” says Brockie.

Similar work in Australia has shown that bandicoot road kill numbers tally well with known population densities.



BENJAMIN LIPKIN/SCIENCE

Bugs sealed in under red ice for aeons

ANTARCTICA'S Blood Falls – the reddish outflow from the snout of the Taylor glacier – contain microbes that have survived beneath thick ice for millions of years.

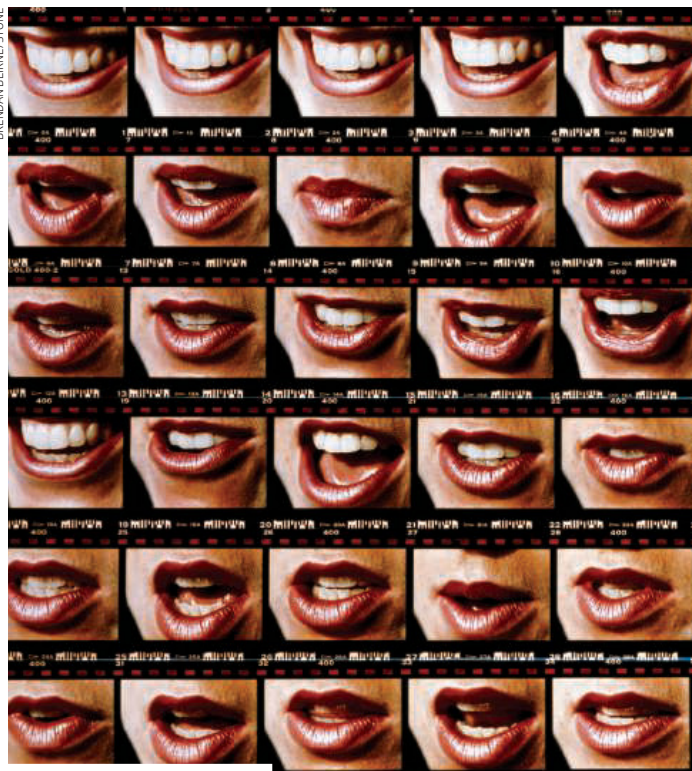
Jill Mikucki of Dartmouth College in Hanover, New Hampshire, and her team analysed the water seeping out from a sub-glacial lake beneath the Taylor glacier in the McMurdo dry valleys. The water stains the ice red because it is rich in iron. DNA analysis showed the bacteria are related to today's marine microbes.

The DNA also revealed that the microbes get their energy from

reactions that use the sulphur compounds in the water as chemical catalysts. These reactions oxidise organic compounds and reduce the iron in the lake. The free electrons from these reactions provide energy for the bacteria. The dead organic matter was most likely sealed in when the Taylor glacier advanced over the ancient lake about 1.5 to 2 million years ago (*Science*, DOI: 10.1126/science.1167350).

“Trust microbes to do something clever given an unusual niche,” says Julia Foght, a microbiologist at the University of Alberta, Canada.

BRENDAN BEIRNE/STONE



French, English or Russian?

Lip shapes betray a language

CAN you tell what language somebody is speaking just by watching the shapes their lips make? A computer developed at the University of East Anglia in Norwich in the UK can, and it could lead to automatic lip-reading and translation systems for deaf people.

Linguists have long suspected that our sequences of lip shapes and lip motions vary strongly with the language we speak, but nobody had put it to the test.

So Stephen Cox and his colleagues at UEA asked 21 people, each fluent in two or three languages that included Polish, Russian, French, German, English, Arabic, Mandarin, Cantonese and Italian, to read to camera the first 16 articles of the UN Declaration of Human Rights - in all the tongues in which they were proficient. The team then used a facial recognition system to track how the volunteers' lips

moved and the sequences of shapes they formed, and used statistical analysis to learn which sequences were telltale signs of a particular language being spoken.

They found they were easily able to tell one language from another - even in people who spoke very fast.

"We found 'lip-rounding' in French speakers. Arabic speakers had prominent tongue movements"

"We found frequent 'lip-rounding' among French speakers and more prominent tongue movements among Arabic speakers," says Cox.

The work will feed into another project developing an automatic lip-reader, and will be useful for police wanting to know what people in CCTV footage are saying.

UK privacy rules must be tightened

A COMPANY planning to target advertising at individual users, based on the content of the web pages they view, is pressing ahead with trials in the UK despite a warning that it is breaching European rules on privacy.

In trials the company, Phorm, is running with a UK internet service provider, it intercepts the addresses of any web page that a user requests, and then goes to that page to discover what it contains. Last week, Amazon and Wikipedia said they would deny Phorm access to their web pages, and others are expected to follow.

The European Commission says that Phorm's system contravenes a European directive safeguarding the confidentiality of citizens' communications. It has given the UK two months to tighten regulations governing the interception of users' private data.

55%

of US adults went online in 2008 to get news and information on the presidential election or to take part in the political process

Sunshade no good for solar power

PUMPING aerosol particles into the atmosphere to create a sunshade could take a heavier toll on solar power generation than expected.

For every 1 per cent of the sun's rays deflected into space, the average output of solar systems that rely on direct sunlight would drop by 4 to 5 per cent, says Daniel Murphy at the US National Oceanic and Atmospheric Administration in Boulder, Colorado. Geoengineers propose scattering 1 to 2 per cent of sunlight.

Aerosols scatter the light that hits them, but only 20 to 25 per cent of that is reflected into space.

The rest reaches the ground as diffuse light. Since this light doesn't come directly from the sun, it isn't collected by solar systems that concentrate sunlight onto thermal power generators or high-efficiency solar cells. Their optics track the sun during the day and focus an image of it onto the power-generating elements, so they can produce much more power than flat solar cells.

Losses could reach 20 per cent in the late afternoon during summer, Murphy warns, because more light is scattered when the sun is lower (*Environmental Science and Technology*, vol 43, p 2784).

Research has previously shown a sunshade could also trigger droughts in some regions.



"Every time you get rid of one, a bigger one pops up"

Mark Mulligan, a music analyst at research firm Forrester, on file-sharing websites, following a decision by the Swedish courts to jail four men linked to one of the world's biggest, The Pirate Bay. The men were also ordered to pay \$3.6 million in compensation (Reuters, 17 April)

Robots go where only geckos have gone before

Walls and ceilings will hold no fears for a new breed of supersticky robot that uses smart mechanics to cling to a variety of surfaces

Paul Marks

THE ability to scale walls and hang off the ceiling with gecko-like ease may be within reach – for robots at least.

Metin Sitti and Ozgur Unver of Carnegie Mellon University in Pittsburgh, Pennsylvania, say their new robots – a sticky-tracked wall climber and a 16-legged ceiling walker – could tackle many jobs in the home including painting ceilings and clearing cobwebs. They could also play a

part in exploration, inspection, repair and even search and rescue.

Previous wall and ceiling climbers have used suction for locomotion. But suction has drawbacks: it requires lots of energy to drive a vacuum pump, and motion is limited to smooth surfaces like glass.

The new robots, however, rely on a “sticky” elastic polymer, or elastomer, that can adhere to a variety of surfaces, including wood, metal, glass and brick. The idea is to mimic the mechanism

which geckos use to climb walls and walk upside down.

Geckos can cling fast, and also detach themselves easily to move on, thanks to millions of tiny hairs called setae on their toe pads. Engineers at the University of California at Berkeley, including Sitti, showed in 2002 that the geckos’ setae do this by harnessing van der Waals forces, a weak electrostatic attraction which operates only at an intermolecular level. Although each hair’s attraction is tiny, the

combined force provided by the huge number of hairs is enough to support the weight of the lizard.

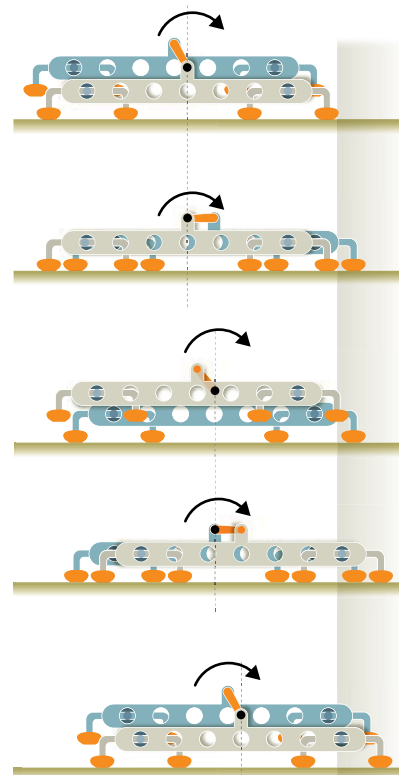
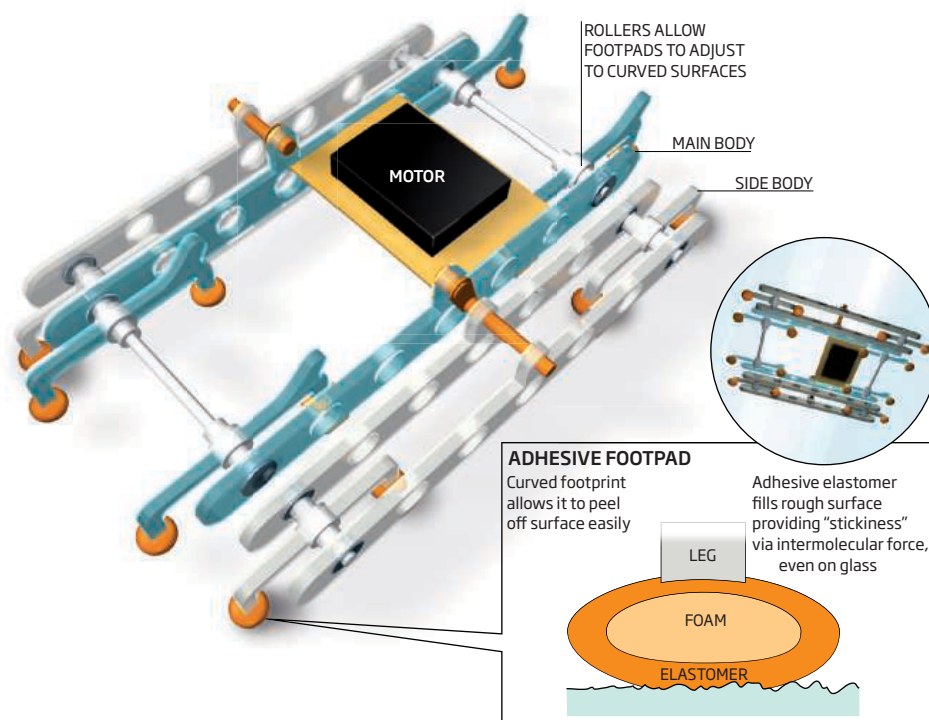
Since then, Sitti has been experimenting with squishy elastomers to mimic the forces that geckos’ setae use (*New Scientist*, 17 May 2003, p 15). One method uses a nanoscale probe in an electron microscope to punch indentations in a wax mould. When filled with a liquid polymer, it sets to create hairs of the right size. Each has the same attractive force as a gecko hair.

Now it is time to try out such biomimetic technologies in robots, Sitti will tell delegates at the annual International Robotics and Automation Conference (ICRA) in Kobe, Japan, in mid-May.

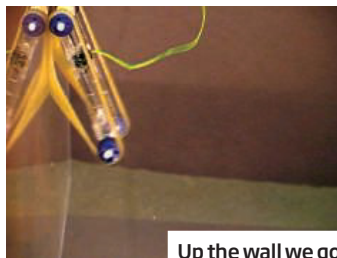
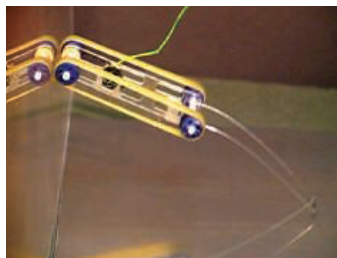
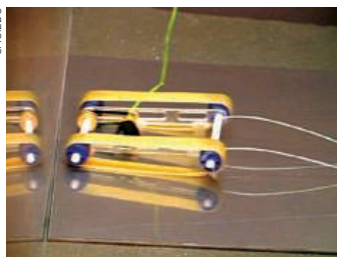
Both his robots use sticky elastomers, though not in the form of hairs, to grip surfaces using van der Waals forces. Their wall-climbing robot is a palm-sized, 60-gram machine with a tacky elastomer tank track on

Climbing robot

The FourBar robot always has 8 of its 16 feet firmly on the ceiling so it moves without falling off



CHUJEDU



Up the wall we go

either side of it. Called Tankbot, its trick is to keep its tracks in close contact with the surface whilst continuously “unpeeling” itself.

To make this rolling attachment and detachment happen, Tankbot has a spring-loaded U-shaped “tail”, which trails behind the robot pressing down on the surface. The tails keeps the rear end of the track clear of the ground, so the full length of the track is never in contact with the surface. This leaves the front of the tracks doing the gripping while the track gradually unpeels towards the rear.

In tests, (see above) Tankbot deftly scales walls and even carries small payloads. However, its

a surface, the outer bars unpeel their footpads and move forwards. When they are safely restuck, the inner bars unpeel and move forwards.

In tests, Sitti and Unver got the robot to move 30 metres upside down. But one problem with both robots is that their elastomers can clog with dirt and dust and lose their crucial tackiness. Sitti hopes to overcome this on future bots by using his hairy gecko-like elastomers. Ultrafine nanoscale hairs do not provide micro-scale dirt particles with enough contact – so they simply roll off.

Other researchers reckon the climbing technology has potential. “These robots could extend the work of robotic builder’s

assistants. And there are often diagnostic and repair jobs for plumbers and electricians that are tricky to reach,” says Noel Sharkey at the University of Sheffield in the UK. Tony Pipe at the University of the West of England in Bristol envisages the robots in search and rescue. “A small robot that can negotiate contorted spaces from any angle, whilst carrying a significant payload of medicines and other recovery equipment, could be very useful.”

There could be sinister uses though: “A less palatable idea would be a surveillance robot that hugs the ceiling,” Sharkey adds. ■

“The robots could play a part in exploration, inspection, repair and even search and rescue”

“adhesion falls short for upside-down ceiling climbing”, Sitti says.

So for scampering on ceilings, the pair are working on another design with stronger adhesion: the FourBar robot. This has four tough plastic bars that move parallel to one another driven by a motor (see diagram). Each bar has four tacky elastomer footpads, mounted in pairs on rockers. When the eight footpads on the interior bars are stuck to

3D advertising and flash-bang defences poised to explode

ADVERTISING displays could soon appear out of thin air, thanks to a laser system that projects moving 3D images in the sky.

The system, developed by Burton of Kawasaki, Japan, focuses a laser pulse onto a point in the air to ionise it, briefly creating a ball of glowing plasma, dubbed a flashpoint. By firing hundreds of laser pulses each second, the system creates the illusion of many constant points of light.

An early version of the system, created in collaboration with teams at Japan’s National Institute of Advanced Industrial Science and Technology and Keio University, Tokyo, was unveiled in 2006. It produced 200 flashpoints per second and used a mechanical system to move the laser. This limited it to displaying basic 2D images.

A new laser has increased the firing rate to 1000 flashpoints per second, while the pulses are now directed automatically using optics, allowing the system to create more complex 3D images – and even animations. New images released by Burton include stick figures and a version of the “Utah teapot” – a long-standing reference object in 3D programming.

The company is now investigating the use of the technology for outdoor advertisements, for which they will

need to increase the size of the projections – currently less than a metre wide – by using more powerful lasers. It is aiming for a practical device by 2011. Other suggested applications include light displays that resemble fireworks, and 3D TV.

The Pentagon is developing similar technology as a defensive device for military vehicles. Called the Plasma Acoustic Shield System (PASS), it creates violent effects by using an additional laser pulse to explode the initial plasma ball, producing a bright

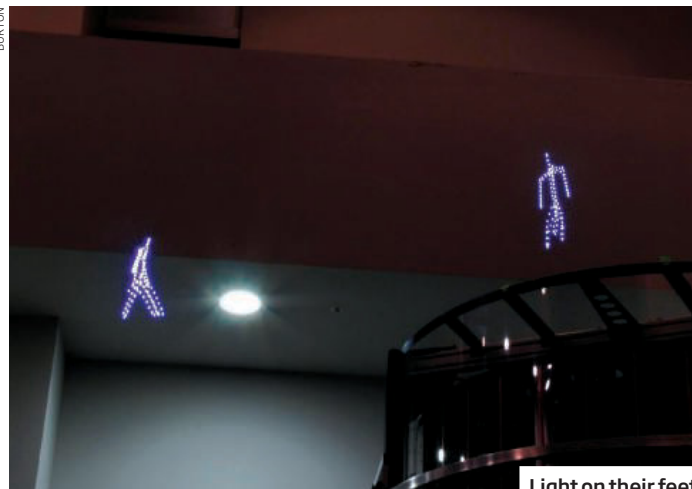
“Firing hundreds of laser pulses each second creates the illusion of constant points of light in the air”

flash and a loud bang. It has recently been installed and successfully tested in a military vehicle.

A curtain of flash-bangs could be created instantly up to 100 metres away to provide a visual screen against snipers, says Keith Braun of the US army’s Weapon Systems and Technology Directorate.

Stellar Photonics of Bellevue, Washington, which developed PASS, plans to increase the number of laser pulses per second, says Braun, “to create a wall of light and sound”. David Hambling ■

BURTON



Light on their feet

A great white hope for light-emitting diodes

IN THE search for cheap, efficient sources of white light, LEDs have long been touted as offering the most potential. Now a new generation of white organic LEDs could become the source of choice for homes, offices and even computer displays.

LEDs are preferable for many applications because they convert electrical energy into photons so efficiently. While incandescent light bulbs convert only 5 per cent of the energy passing through them into light and compact fluorescent bulbs manage 20 per cent efficiency, LEDs routinely achieve 30 per cent or more.

The problem is that conventional LEDs produce light only at specific wavelengths, so manufacturers have had to employ two tricks to make white light. One is to use several LEDs that each emit a primary colour. When combined, these colours look white to the human eye. The other approach is to cover a blue LED in a phosphorescent chemical, or phosphor, that

absorbs a portion of the emitted bluish light and re-emits it as amber. Again, we see the combination as white.

These solutions are relatively costly, though. Now a potentially cheaper option is emerging thanks to the development of organic dyes that emit blue and amber photons, and the ability to combine both in the light-emitting layer of an LED. The result is an organic LED (WOLED)

that produces white light directly.

WOLEDs have not made it out of the lab yet, however. One problem is that high currents tend to break down the organic dyes they rely on and this dramatically reduces their lifetime compared with inorganic LEDs made of materials such as indium gallium arsenide. One way around this would be to find a way to achieve an acceptable brightness with as low a current as possible.

Now a group led by Dongge Ma at the Changchun Institute of Applied Chemistry at the Chinese Academy of Science has come up with a simple way of

doing this: stacking two white-light-emitting layers in a single device so that they operate in series (*Journal of Applied Physics*, DOI: 10.1063/1.3106051). "The stacked structure allows higher brightness at lower current," says Paul Burrows, an electronics engineer at Reata

"Conventional LEDs produce light only at specific wavelengths. Making white light from them is costly"

Research, a science and technology consultancy in Kennewick, Washington.

The new device does have a potential drawback, though. The stacked structure requires double the voltage, which might change the device's efficiency, though whether it will is not yet clear.

Colin Humphreys, a materials scientist at the University of Cambridge, warns against too much optimism at this stage. "There has been a lot of hype over WOLEDs," he says, but before they reach the market various technological hurdles must be overcome. "They could be a huge market or a very small market, and it is not obvious which it will be," he says. **Jessica Griggs ■**



The secret to a long life is stacking

Nanowire network measures cells' electrical signals

ELECTRICAL signals from different parts of the same cell have been simultaneously recorded for the first time, thanks to a new technique for attaching nanowire probes. This could aid the study of how heart, muscle and brain cells function and communicate.

The method uses a device called a nanowire field effect transistor (NWFET). This consists of a silicon wire just 20 nanometres in diameter attached to metal electrodes on a substrate of silicon dioxide. The nanowire, which sticks out by 30 to 40 nanometres, can be used as a

probe to amplify the electrical signals produced by anything it touches.

Many NWFETs can be fabricated on the same substrate, allowing several signals to be measured at the same time. The difficulty had been in growing the cells directly over the nanowire arrays. It was a matter of chance whether cells grew in the right place for the signals to be measured.

Now Charles Lieber at Harvard University and colleagues have created a technique that overcomes this problem. They grow heart cells taken from chicken embryos on transparent polymer substrates

and then transfer the cells to the nanowire array. Each cell is then positioned over up to 10 nanowires with the aid of a microscope. "We can do measurements that weren't possible before," says Lieber.

Besides making simultaneous measurements from different parts of the same cell, the wires can record the signals produced by several cells in the same tissue culture at the same time. For example, the team was able to measure the "contractile wave" produced by heart cells to coordinate beating as it passed through the culture (*Proceedings*

"This technique could improve the interface between the body and artificial limbs"

of the National Academy of Sciences, DOI: 10.1073/pnas.0902752106).

Cell biologists will be able to use the technique to study electroactive cells such as neurons, cardiac cells and muscle cells, as well as the effects of drugs on these cells. As the wires can penetrate the cells, the signals can be studied from the inside. The technique could even be used to improve the interface between the body and medical implants, such as drug delivery devices and artificial limbs, Lieber says.

Zhong Lin Wang at the Georgia Institute of Technology in Atlanta says the technique will eventually give new insights into cell function, such as how neurons communicate with one another. "It is very advanced research," he says. **Kurt Kleiner ■**

Science has talent

If you're peeved with the way science is presented by the media, don't rant – step right up and give it a go yourself, says **Kathy Sykes**

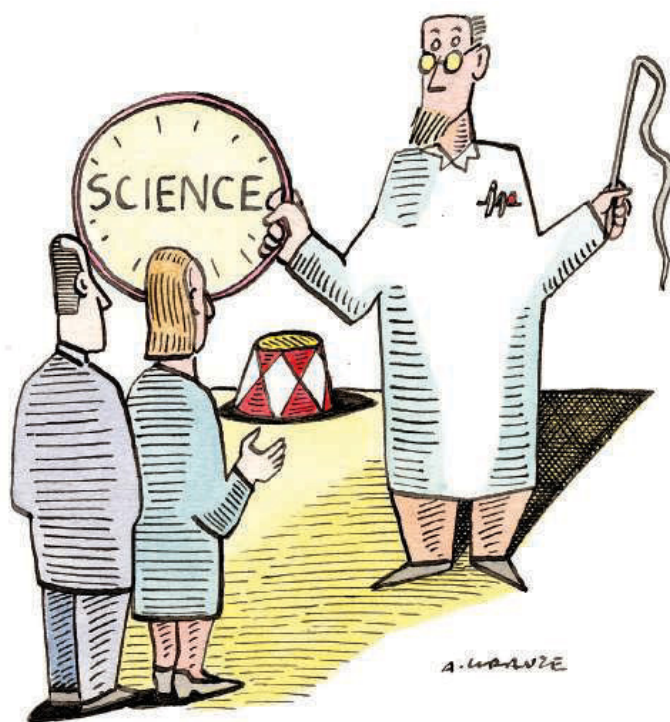
MOST scientists want to see more science and technology in the media, but we're making life hard for ourselves by forever criticising each other's efforts or denouncing journalists and film-makers for not portraying science in ways we approve of. While healthy debate can improve science communication, I think we could all shut up a bit, and stop the more rabid criticism altogether. I include myself here.

As just one example of excessive criticism, the editor of BBC TV's flagship science series *Horizon* is regularly barraged with complaints from angry scientists about "dumbing down", particularly in response to the programmes that attract people who don't usually watch science. I think we should be grateful for the new viewers.

Similarly, *New Scientist* recently took flak over its cover that proclaimed "Darwin was wrong". The article inside described discoveries that are leading to modifications to the theory of evolution. A cheap trick to sell magazines while giving fodder to the enemies of evolution? Sales certainly went up that week, but if more people than usual bought the magazine and read the article, more people will have found that scientists agree that Darwin was fundamentally right.

As well as the thought police who castigate communicators for simplifying, selling out or making things too accessible, there are others who criticise scientists for being elitist.

I admit that I am guilty on both counts. I have ranted and railed at



scientists and journalists who treat tentative results as if they are certain. I get angry with scientists who are pompous or dismissive of other ways of thinking, and even angrier at those who don't take legitimate public concerns about their work seriously.

Does ranting do any good? In some cases it does, especially if science is being carelessly mangled or deliberately distorted. But in many cases communicators are passionate about science and are simply trying to communicate it

"We risk drowning out good science communication with a stream of bickering"

as clearly as they can to as large an audience as possible. We risk drowning out what's good with a stream of public bickering. We also risk discouraging a new generation of communicators.

I am not arguing for science coverage at all costs. Much of my work is devoted to improving science's engagement with the public. But there's space for a range of characters, approaches and styles of communication: such diversity can appeal to a wider range of people. The public are savvier than we might think and appreciate that human beings, including scientists, are a diverse bunch.

If you're still troubled by how

others communicate, why not spend less time ranting and get out there and communicate in ways you do like? Blogging is easier than ever, for example. Or if you prefer a more hands-on approach, in the UK or Europe you could enter NESTA FameLab's "Talking Science" competition (www.famelab.org). Alternatively, your nearest science centre, science festival or local media will welcome offers of help. ■

Kathy Sykes is professor of sciences and society at the University of Bristol, UK, and co-director of *The Times* Cheltenham Science Festival

Honest exchanges with ET

Our messages to aliens are more likely to get a response if we stop being so boring, argues

Douglas Vakoch

FOR nearly 50 years, the Search for Extraterrestrial Intelligence (SETI) has scanned the heavens for signs of alien life. At the same time, scientists have painstakingly crafted messages to send in reply. When NASA launched its Voyager missions in 1977, for example, both spacecraft carried audio recordings depicting the diversity of life and culture on Earth.

But those messages have never truly represented all of humanity. On 15 May that will change as the SETI Institute launches a project to collect messages from people around the world. As yet there are no plans to transmit these into space, but the project aims to get a discussion going about what kinds of message we should send and what we should say.

The standard wisdom in interstellar diplomacy is to avoid controversy. In the early 1970s NASA attached plaques to two Pioneer spacecraft etched with basic mathematics, science and line drawings of a naked man and woman. Some people complained the agency was sending “smut into space”.

Later messages have avoided such criticism. One from the Arecibo Observatory in Puerto Rico depicts the human form in so few pixels that its sex is not clear. The Voyager recordings excluded war, poverty and disease.

However, messages to the stars should not shrink from the details. Might not an advanced extraterrestrial species, savvy in the ways of intelligent beings, notice that something was missing from our description of ourselves? An acknowledgment of our flaws and frailties seems a more honest approach than sending a sanitised, one-sided story. Honesty is a good starting point for a conversation that could last for generations.

If we continue to dodge controversy we risk sending messages that are both brief and boring. We sometimes clash in our beliefs and customs; we disagree over matters of taste and morality. In no small part this is what characterises us as a species. And it may just make us intriguing enough to the inhabitants of other worlds to elicit a reply. ■

Douglas Vakoch is director of interstellar message composition at the SETI Institute in Mountain View, California. Join the SETI message project at <http://messages.seti.org>

Viewfinder

Opinions from around the world

“In 1991, the government of Somalia collapsed. Its 9 million people have been teetering on starvation ever since – and the ugliest forces in the western world have seen this as a great opportunity to steal the country’s food supply and dump our nuclear waste in their seas.”

Johann Hari argues in *The Independent* that Somali piracy has its roots in environmental injustices perpetrated by western governments

“It might surprise you to learn that one of the largest and most celebrated new-media ventures is burning through cash at a rate that makes newspapers look like wise investments. It’s called YouTube.”

Farhad Manjoo in *Slate* on how websites full of user-generated content are losing money hand over fist

“When I look back at almost every “environmentally friendly” alternative product I’ve seen being widely touted as a cost-free way to lower our footprint... I notice a common theme: the replacement good has *really really sucked* compared to the old, inefficient version.”

Megan McArdle in *theAtlantic.com* on why consumers avoid green products

What we learned this week

The vexed question “Cleopatra: hot or not?” could soon be laid to rest by archaeologists from Egypt and the Dominican Republic who say they are closing in on her tomb. In 2007 researchers from Newcastle University in the UK claimed she was not drop-dead gorgeous but pointy-nosed and thin-lipped with a jutting jaw



The word

FLOTSAMETRICS

The use of floating trash, such as a huge consignment of training shoes washed off a cargo ship in 1990, to study ocean currents, as explained in a book of the same name by Curtis Ebbesmeyer and Eric Scigliano

Autism controversy

From Ben Haller

Simon Baron-Cohen complains that the media trumpeted the imminence of prenatal testing for autism based on links to prenatal testosterone levels, when in fact his study did not support such conclusions (28 March, p 26).

However, his own description of the research may show why this error happened. He insists that the traits he measured are “not necessarily indicative of autism” and that none of the children he measured were autistic. Why, then, does he use the term “autistic traits” to describe what he measured?

I imagine it is the standard jargon for these traits in his area of research; but given how politically charged and sensitive the issue is, the jargon ought to be changed to avoid such misunderstandings. Blaming the media for this confusion does not solve the problem.

It is natural for a layperson to

assume that “autistic traits” are associated with autism, and that a link between “autistic traits” and fetal testosterone is the same thing as a link between autism and fetal testosterone.

Menlo Park, California, US

From Nicholas Humphrey

Baron-Cohen complains that *The Guardian* “distorted” his research with its headline “New research brings autism screening closer to reality” and “Call for ethics debate as tests in the womb could allow termination of pregnancies”.

Yet, in an interesting opinion piece Baron-Cohen published on the BBC News website in January, he wrote: “Research published this year showed a link between higher levels of the male hormone testosterone in the amniotic fluid surrounding a fetus and autistic traits when the child was eight... Research is not yet at the stage where autism can be detected prenatally using a biological test, but this may not be far off... assuming such a test is developed,

we would be wise to think ahead as to how such a test would be used. If it was used to ‘prevent’ autism, with doctors advising mothers to consider termination of the pregnancy if their baby tested ‘positive’, what else would be lost in reducing the number of children born with autism?” (<http://news.bbc.co.uk/1/hi/health/7736196.stm>)

It is right and brave to invite people to think ahead about the ethical consequences of your research. However, when you do so, is it fair to cry foul when journalists take you at your word? Cambridge, UK

survive. The evidence is the teenage desire to procreate as soon as possible, to ensure their genes are passed on.

Brentwood, Essex, UK



Self-regard

From Ken Brown

In his review of Thomas Metzinger's *The Ego Tunnel*, Owen Flanagan includes Buddha in his list of figures who “endorsed” the idea that there is no self (21 March, p 44). This is somewhat simplistic.

Sanskrit, the language spoken by Buddha in its variant form, Pali, has several terms that could translate into English as “self”. The Sanskrit word “jiva” refers to an individual soul, “atma” can mean either an individual or universal self, “aham” means “ego”, and Brahman is a self that is coextensive with the universe.

These terms refer to different things. It is probable that the Buddha rejected the reality of jiva, but would have found rejection of Brahman illogical. It is a weakness in the English language that it uses imprecise terminology for discussing concepts of self.

Chatswood, New South Wales, Australia

From Michael Hughes

Owen Flanagan states that the consensus among scientists and philosophers is that there is no self. Consensus it may be, but they are wrong. Those among us who are not automata will be aware of the absolute reality of subjective experience; the self is the subject that is doing the experiencing. Jarrow, Tyne and Wear, UK

Growing brains

From Morag Parnell

Caroline Williams reassures us that the placenta does a pretty good, if imperfect, job of protecting the fetus from unwanted substances, and cites a few cases where it fails (4 April, p 26). In fact, this is quite an underestimate of the failure.

In 2005 the US Environmental Working Group commissioned a study of the umbilical cord blood of 10 newborns (www.ewg.org). They tested for 400 industrial chemicals and found an average of 287 in the babies’ blood, which included toxins that are known to cause cancers and developmental disorders. The test was limited to 400 substances due to costs but we know that we are exposed to thousands of such chemicals. Linlithgow, West Lothian, UK

From Brian Robinson

When modern humans first evolved, their life expectancy was low: reaching adulthood was rare. Could the teenage brain only have evolved far enough for early humans to live out their 18 years? As humankind started surviving into adulthood, a second kick in evolution was necessary to produce a grounded adult.

Teenagers are still in the Stone Age of human evolution, developing further only if they

Enigma Number 1542

Recycling points

RICHARD ENGLAND

The recycling plant accepts glass, metal and plastic items. For every four items of the same type that I feed it I receive 1 green point, so I will receive 10 points whether I feed it 40, 41, 42 or 43 plastic items.

I fed it a 2-digit number of glass items, a larger 2-digit number of metal items and an even larger 2-digit number of plastic items. I received a 1-digit number of points for each type of item.

The digits 1 to 9 each appeared only once among those 2-digit and 1-digit numbers.

If I told you the total number of items that I fed it you would be able to deduce with certainty how many of them were glass, how many were metal and how many were plastic.

How many were metal?

WIN £15 will be awarded to the sender of the first correct answer opened on Wednesday 27 May. The Editor’s decision is final. Please send entries to Enigma 1542, New Scientist, Lacon House, 84 Theobald’s Road, London WC1X 8NS, or to enigma@newscientist.com (please include your postal address).

Answer to 1536 List of primes: The sum of the prime numbers is 1287

The winner Bill Payne of Westfield, Surrey, UK

ECT can work

From Raphael Fraser, Blacktown Hospital
Chris Callaghan wonders whether it is the anaesthetic used in electroconvulsive therapy (ECT) that is responsible for any beneficial effects the treatment may have (21 March, p 23).

ECT has long been controversial. As a psychiatrist I can attest that its benefits are not "occasional": ECT is the most effective antidepressant treatment we know. The response rate is as high as 80 per cent, and it is most effective for severe depression. Numerous studies have been done comparing the effects of ECT with general anaesthetic alone, where the patient undergoes the same preparation but does not receive the treatment. ECT was undoubtedly effective.

My colleagues and I put a great deal of effort into helping people understand that ECT is a powerful tool for treating major depressive disorder, mania and psychosis. Opinion pieces, such as Callaghan's letter, that stem from emotive rather than scientific evidence can delay what can be a life-changing treatment for some individuals. Blacktown, New South Wales, Australia

Sink or swim

From Ted Lovesey
According to your article "Sea level rising faster", recent measurements show the sea level rise since 1993 to be 3 millimetres



per year (14 March, p 7).

The UK Defence Standard on body size from 1997 quotes an increase in average stature for Australians and Dutch of 1.3 mm a year for men and 0.9 mm for women. Is this Darwinian evolution attempting to keep heads above water? If so, it is fighting a losing battle. Stoke Gabriel, Devon, UK

Depressed ME

From Tony Waldron, University College London
Charles Shepherd asks for an objective position to be taken on the aetiology of myalgic encephalomyelitis (ME) (4 April, p 22). Why are those who support ME reluctant to accept a psychological basis in some cases?

In my experience, the response from a patient to such a suggestion is either to say "I'm not making it up", or to make a quick exit from the consulting room. Most of those who treat ME accept that symptoms can result from a number of different causes, including depression.

It is likely that in the survey Shepherd mentions, respondents are biased towards those who have not benefited from treatment. Shepherd makes much of the fact that more than half the respondents had found that cognitive behavioural therapy and graded exercise was either unhelpful or made them worse. It would be interesting to know what proportion were made worse rather than simply not helped. Is it not worthwhile that the other half of the respondents might have been made better? There is, after all, no other treatment that has any effect. London, UK

Auraculous

From Neil Doherty
You report that auditory rivalry was discovered in 2006 in France

(14 March, p 34) but this idea has been around for at least a decade.

In 1994, during an Open University tutorial at Durham University in the UK, my professor conducted an experiment showing that sounds could be heard in two different ways.

He played the class a recording and then asked us if we could differentiate between the two different sound repertoires contained in it. On his playing the recording again, I found that I could swap from one perception of the type of sound to another. I called it an "auricle illusion". Wilthorpe, South Yorkshire, UK

Two fingers

From Edmond Wright

With regard to your recent article on tactile illusions (14 March, p 33), I think I may have been the first to notice the possibility of the transfer of tactile experiences from one part of the visual field to another. In order to show how qualia (inner sensory experiences) have no given connection with what we take them to represent, I make reference to the effects of squinting.

Place your finger on the edge of a table and squint to produce a double image. You will find you can shift the "feel" of the table from one of the images of the finger to the other (*Theoria*, vol 56, p 3). Cambridge, UK

Optical tricks

From Deborah Moore

I found "That freaky feeling" very interesting (14 March, p 33). Though I did not try any of the tactile illusions on myself, I discovered that you had arranged for readers to get a demonstration of a different kind of illusion.

For a couple of minutes after reading item 7, which is printed in white on a black background, all

the pages I looked at appeared to have stripes across them. Chippenham, Wiltshire, UK

Population control



From Neil Fairweather

Tracy Chandler (28 March, p 24) says that the way to ensure that your children don't starve to death is not to have so many. Unfortunately, this will not work. The way to ensure that your children don't starve to death is to make sure everyone else doesn't have so many. This is the epitome of the Tragedy of the Commons. Risley, Warrington, UK

For the record

- The Dark Energy Survey will catalogue 2000 supernovae that exploded in the last 7 billion years (11 April, p 6).
- Sunlight provides the Earth with 120,000 terajoules per second of power, not terawatts as we stated (4 April, p 24).
- In a story on Alzheimer's, we misspelled the name of Stanford University neurologist Michael Greicius (11 April, p 10).

Letters should be sent to: Letters to the Editor, New Scientist, 84 Theobald's Road, London WC1X 8NS
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Photography: Pål Hansen

The art detectives

Distinguishing a genuine artwork from a forgery can be worth millions. Art detectives **Peter Paul Biró** and **Nicholas Eastaugh** analyse pigments, fingerprints and DNA to tell you who painted your family heirloom, and when. The art world loves to loathe them, but as the pair explain to **Laura Spinney**, it can't live without them

How did you become sleuths?

Peter Paul Biró: I'm an art conservator, and in 1983 a fellow came to me and my brother with a big ugly landscape he wanted restored. When we told him the cost he nearly fainted. He asked a small sum for it instead, and we bought it, intending to use it to show what cleaning can do to an old painting. We soon realised that there was an intact painting underneath, and it was no sloppy amateur job either. We eventually identified it as a Turner, based on fingerprint and pigment analyses. After that I began researching the use of physical evidence from paintings – DNA and fingerprints.

Nicholas Eastaugh: In the early 1980s I was working in art conservation, but I have a background in physics and I felt frustrated that analytical technology was not being applied to the authentication of art. Scientific departments in museums and galleries tended to concern themselves with conservation and documentation. So I set up The Pigmentum Project, an organisation which researches historical pigments.

What is scientifically novel about what you do?

PPB: The fingerprint and DNA analysis I do has been used to solve crimes for years. The novelty is in the realisation that artists have not only left their art behind, but also marks of themselves, in the form of fingerprints and other contact evidence.

NE: A lot of the techniques I use – X-ray, infrared, chemical analysis of pigments – were established by the 1920s. To apply them to art I realised we needed to develop a more probabilistic approach. That's what is new. For example, if a pigment was invented in the early 18th century, but didn't become widely

available until the middle of that century, we can use the pigment's presence or absence in a painting, together with other historical information about it, to calculate the probability that it was painted between those dates. A probability, mind you, not a certainty.

What can you offer by collaborating that you can't offer separately?

PPB: Corroboration. Converging strands of evidence. Take a case that came to Nicholas some years ago. It was a large painting that looked like a Turner. The pigments checked out, but plenty of other painters used those pigments at the same time, so they didn't nail Turner. I came to London and found a fingerprint in the painting that matches one in the Turner bequest at the Tate Britain gallery. The evidence began to accumulate.

NE: Turner was also highly experimental when it came to pigments, all of which makes his work amenable to our techniques.

Have you been involved in analysing the work of many other painters?

NE: Yes. At the moment, for example, I'm

PROFILE

Peter Paul Biró (framed, right) is an art conservator based in Montreal, Canada, who for 20 years has used forensic evidence to authenticate art. He is best known as the subject of a film about a disputed painting, called *Who the #&% Is Jackson Pollock?* Nicholas Eastaugh (far right) is a London-based physicist, art historian and co-founder of The Pigmentum Project which researches historical pigments. This month the pair launched Art Access & Research, a company which analyses and authenticates works of art.

doing a lot of consultancy work for the Russian art market. The boom in the Russian economy has brought in its wake a renewed interest from Russians in their own culture, and at the same time an increase in the number of fakes, so there is demand for this kind of analysis.

Paul, you were famously involved in an attempt to authenticate a Jackson Pollock painting that was bought for \$5 in a thrift shop.

PPB: Yes. I matched a partial fingerprint on the canvas to a fingerprint on a can of paint in Pollock's studio and to fingerprints on two authenticated Pollock canvases. I found hair samples on the painting too – Pollock suffered from male pattern baldness – but they were too small for analysis. The provenance of the painting – the paper trail linking it to its maker – is unknown and it remains unsold. We are working on other possible Pollock cases where DNA is involved. I have samples of hairs from Pollock's studio floor and I found a descendent of Pollock's mother who agreed to donate her DNA. It matched the DNA from the hairs.

Can you ever be certain who created an artwork?

PPB: Yes, but not often. Take Picasso. He made several plaster casts of his hands, and on at least one occasion, he covered his palm with paint, pressed it inside a book cover and autographed it. In a case like that we can make a definite identification, but in most cases, the most you can say is that the print on this object matches one on that object. It is all about demonstrating connections, even if the artist may not be specifically identifiable.

Has your work ever dramatically changed the value of a painting?

NE: A good example is the *Massacre of the Innocents* by Rubens that sold in 2002 for just under £50 million. It was lost for many years under another name. My scientific analysis was a key part of the documentation for sale.

PPB: We're working on a possible Turner right now. If it's genuine then the owner, who bought it for pounds, will be able to sell it for millions.

How has the art world, which usually relies on the intuition of art experts, responded to you?

NE: There has been resistance. Even the notion that scientific methods can be used is not universally accepted. There is a perception that art and science are in opposition, yet the latest approaches allow us to use both art history and scientific evidence to reach a conclusion. I often encounter people saying



“There is a perception that art and science are opposed, but they should be complementary”

“You can’t tell anything from pigment analysis. It’s too broad. You don’t know enough about what everybody else was doing at the time.”

PPB: In the documentary *Who the #\$%& is Jackson Pollock?* a New York art lawyer questions the relevance of fingerprint evidence. I think that says it all. I grew up with art and I think intuition is absolutely relevant, because in the end how a painting looks is subjective. A person has to develop a language of seeing, a visual vocabulary, to articulate what he sees when he looks at art. The trouble is, even the highly visually aware can be fooled, and that’s where our techniques come in. Ideally, the two approaches are complementary.

Despite its resistance, the art world has come to rely on you, hasn’t it?

PPB: The provenance of a painting has always been important in the buying and selling of art. But faking a provenance is far easier than faking the art itself, so now, as well as the usual documentation, a buyer wants to know the results of a scientific analysis. The seller knows he’s wise to have had that analysis done. The mindset has changed over the last 20 years.

Is demand for your services growing?

PPB: Yes, especially as the world becomes embroiled in financial turmoil. As people lose faith in currency and

investment schemes, they turn to blue-chip art – the secure, high-value art that you know you can buy for a million and sell for a million.

What can you do if you suspect the heirloom hanging on your wall is a lost masterpiece?

NE: The problem is getting heard. Specialists on big names like Constable or Rembrandt are being approached all the time, and sorting the good from the bad is time-consuming for them. People like us know how to present your case to the art world. We can steer your painting through the many pitfalls that exist between the wall at home and the wall in the museum. ■



Stones and bones can only tell us so much, but living primates hold a wealth of untapped knowledge about what our ancestors were like, says **Dan Jones**

A window on the past

DAYBREAK, and a group of apes are dancing around a rectangular monolith so dark it seems to suck light in. Inspired by this mysterious object, one of them grabs a bone and begins to wield it as a tool – then as a weapon. The armed ape goes hunting, makes a kill and eats flesh for the first time. Next day, he drives a rival group of apes from a watering hole and murders their leader. This, according to Stanley Kubrick’s sci-fi masterpiece *2001: A space odyssey*, is the dawn of humankind.

If only it were that simple. Anyone trying to understand our origins soon realises that no one thing pushed our ape ancestors across the threshold of humanity. It is difficult to pin down what makes us human anyway. We walk upright on two legs, with disproportionately large brains held high, communicating in spoken languages, navigating the complexity of human social life, producing sophisticated tools and artefacts, and creating culture. The story of how we became human is woven from many strands.

Attempts to unravel that tale have until recently relied on the hard evidence of fossilised bones. This has allowed us to make inferences about certain aspects of our ancestors: how big they were, how they moved and their cranial capacity. But there is a limit to what you can learn from bones. In particular, they tell us little about our ancestors’ less tangible traits, such as how fast they grew, their age at weaning and sexual maturity, and how many offspring they had.

They also tell us almost nothing about thought and behaviour. This is a problem, says Robin Dunbar of the University of Oxford, because such factors are important in human evolution. “They’re all part of the big story.”

To get a handle on when and how humans developed these traits, some researchers are turning to information of a different kind. They are looking at living primates in the hope of discovering general rules governing how these animals’ anatomy, ecology, life history and behaviours are linked. By taking such rules and applying them to our fossil ancestors, they hope to learn more than the bare bones alone can reveal. “We’re trying to flesh out the social, behavioural and cognitive contexts that those bones are wrapped in,” says Dunbar.

Reasonably enough, Dunbar and his colleagues Amanda Korstjens and Julia Lehmann at the University of Liverpool, UK, have focused their study on our closest living relatives, the chimpanzees. It turns out, for example, that the size of the groups in which chimps live is related to local climate, which affects the food available. Group size can be tied to three key climatic factors: mean temperature, annual rainfall and fluctuations in climate over the year. In turn, group size has a bearing on other aspects of chimpanzee life. The first is ecological: as groups get bigger, individuals have to spend more time, and roam further, to get enough food to feed the group. The second is social: bigger groups

mean more social bonds to maintain, which translates to more time spent grooming one another (*Evolutionary Ecology*, vol 21, p 613).

Dunbar and his Oxford colleague Caroline Bettridge are now applying what they have learned about chimps to our early ancestors the australopithecines. This group of hominins, consisting of around half a dozen species, lived in Africa between 3.5 and 1.8 million years ago, when the climate was generally warmer than now. Dunbar and Bettridge’s study is based on 68 sites at which fossilised remains have been found. Information about climate at these sites – and hence likely group size – can be gleaned from geological formations and the fossilised plants and animals they contain. Another indicator of group size comes from measuring the cranial volume of the fossils: larger brains seem to correlate with bigger group size, reflecting the cognitive capacity required to maintain complex social networks. Based on fossil remains, australopithecines probably had the brainpower to live in groups of up to 70 individuals.

With this information, the researchers have started to make educated guesses about australopithecine behaviour. It seems unlikely that they roamed and foraged in the same way as modern chimps. “If their ecology had been like that of chimpanzees, they would have been hard pressed to survive in most of the places that we know from the fossil record they did in fact occupy,” Dunbar says. In ➤

their hot open homelands, they would have had to spend too much time on the move to feed themselves. “We can then ask which parameter values need to be tweaked to ‘get them to live’ in the habitats we know they lived in, and not in those we know they didn’t.”

The tweak may be that australopithecines were able to move more rapidly than previously thought. Alternatively, it could be a more fluid group structure: small groups move more quickly, so it is possible that large

clarify which aspects of australopithecine behaviour need to be tweaked to fit their environment. “Once we’ve done that, the objective is to do the same sort of analysis throughout the hominins,” Dunbar says.

Michael Plavcan from the University of Arkansas in Fayetteville is adopting a related approach. His starting point is the relatively low level of sexual dimorphism – that is, the physical differences between males and females – that we see in the size of humans today. “People have tended to assume that species that are very dimorphic must live in polygamous systems, and those that are not must be monogamous,” says Plavcan. Male gorillas, which are much bigger than females, can monopolise the members of their harem and must defend their patch from rival males. By contrast, pair-bonded species such as gibbons show little or no difference in size. On the basis of such differences, humans’ limited sexual dimorphism in size, amounting to about 10 per cent of body weight, has conventionally been taken as a sign that we are a species that is naturally quite monogamous.

However, as dimorphism and sexual behaviour are assessed in more primate species, the picture has become less clear (*American Journal of Physical Anthropology*,

vol 116, p 25). “Dimorphism is complicated,” says Plavcan. Species that have big differences in size between males and females are usually polygamous, he says, but smaller differences do not necessarily mean monogamy. Despite this, Plavcan reckons size dimorphism can yield important clues about the process of becoming human.

The fossil record indicates that around 6 million years ago, just after the split with chimp ancestors, the size difference between male and female human ancestors was substantial: greater than that seen in modern chimpanzees, though less than in gorillas. Size dimorphism then gradually decreased as females became larger while males stayed around the same size, until modern size differences appeared with *Homo erectus* around 2 million years ago. This, Plavcan says, suggests something interesting was going on. In most primate groups, when females get bigger, males tend to follow suit. Why didn’t our ancestors follow this pattern?

Plavcan points out that size dimorphism can only persist if the biggest males can monopolise females and so pass on their genes at the expense of smaller males. That cycle can be broken if females change their behaviour in a way that makes it more difficult

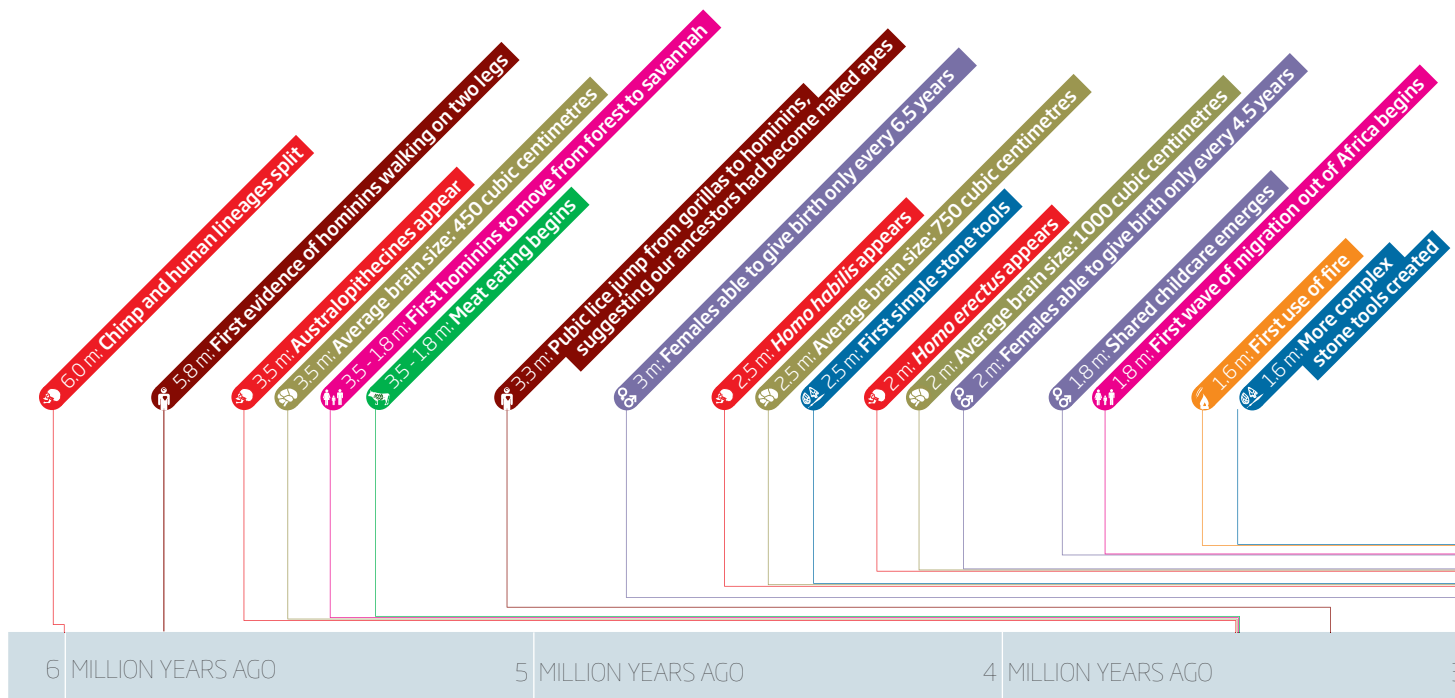
“We are now applying what we have learned about chimps to our early ancestors”

bands of australopithecines split into smaller parties when on the move. A more radical suggestion is that australopithecines might have been able to reduce their foraging time by changing from a herbivorous diet to one containing meat, which is more calorific – a shift that is generally thought to have taken place later in human evolution.

This is a work in progress. Dunbar needs more data from species such as baboons to

Becoming human

The evolution of us in 34 short chapters



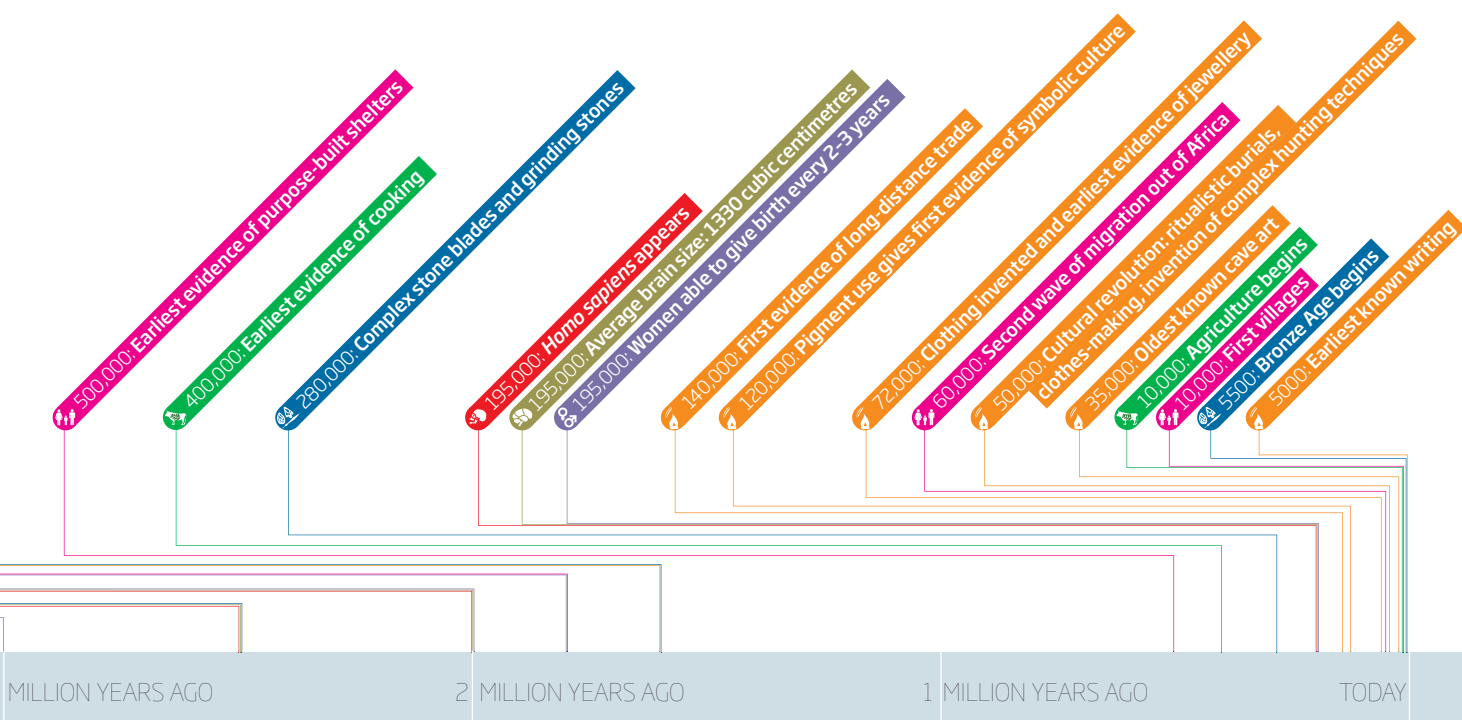


What's 6 million years between close relatives?

for a single male to monopolise them. If that happens, more males become able to pass on their genes, reducing competition for females and removing some of the pressure to be big, leading to a reduction in size dimorphism. The decreasing size differences of our ancestors "tells us that the way females behave is changing", Plavcan says.

But how? One possibility is a shift in foraging behaviour led by a change in the availability of food. When food sources are patchy, groups of females tend to cluster around them, making it easier for dominant males to monopolise the females. When resources are spread out more widely, this is not so easy. Then the reproductive success of a male becomes tied to that of individual female partners: if she doesn't survive and thrive, she can't bear his offspring.

Once a connection between male and female reproductive success is forged, the pressures for males to be big relax, argues Plavcan. That could be what happened to narrow human size differences. ➤





PENNY TWEED/CORBIS

Australopithecus skulls give clues to the sizes of their groups



JOHN REAPER/SPL

Yet this is not the only explanation on the table. A seemingly unrelated fact of our evolutionary history – the ever-expanding brain – may hold part of the answer too.

Big brains have benefits, but they come at a price. They are metabolically expensive to run, and building them demands not only a lot of energy but also significant nurturing. These costs hit where it hurts: in the currency of reproductive success. Another comparative analysis drives home the point. When Karin Isler and Carel van Schaik from the University of Zurich, Switzerland, surveyed 1247 animal species, including some primates, they found that in general the bigger the brain relative to

in wolves, foxes, coyotes and jackals. The common factor is allomaternal care, where mothers raising young can call on help from others, including fathers, older offspring or even unrelated individuals.

By virtue of their demanding brains, human children also require input from both parents to maintain reproductive rates, which ties the reproductive interests of males and females together. This outcome is the same as that of Plavcan's end-of-the-harem model, but the causes are different. Which explanation is correct? "If dimorphism is lost before infants needed a lot more care, it would be a purely behavioural ecological model that explains the loss," says Plavcan. "If they need a lot of care and then the dimorphism is lost, that would suggest that there is a change in the degree of maternal care that might factor into the reduction in dimorphism."

So when did the hominin brain become so large that shared care was essential if high fecundity was to be maintained? Isler and van Schaik calculate that for australopithecines 3 million years ago the inter-birth interval was around 6.5 years, decreasing to around 4.5 years by 2 million years ago as *H. erectus* was emerging, and to something comparable to today's hunter-gatherer societies from about 1 million years ago. "We calculated that allomaternal care is required once adult brain size reaches about 1000 cubic centimetres, or about *Homo erectus* size," says Isler. Above this size, ape-like caring systems cannot sustain reproductive output at a level to keep the species viable, and it would be likely to die out, she argues.

So can we now be confident that allomaternal care emerged in our ancestors somewhere between 1.5 and 2 million years ago? Not quite. "Our calculations of inter-birth

intervals are rather rough," Isler admits. "And the estimate of a 'grey ceiling' of 1000 cubic centimetres, beyond which a traditional ape-like childcare style would not be feasible, is based on some assumptions that are not easy to test, such as infant mortality rates in extinct species." Plavcan is even more cautious, given that the deductions made from studying living primates have yet to be corroborated with fossil evidence. "The fossil record is thin on this issue," he says. While there could well be a link between brain size, child care and dimorphism, he recognises that we cannot be sure about the chronology without stronger evidence of the cranial capacity of *H. erectus*.

If even the proponents of using living species to gain insights into our evolutionary past are so cautious, where does that leave the endeavour? "There's so much variability, even between different populations of the same species, that it's difficult to draw any firm conclusions," says anthropologist Nicholas Malone at the University of Notre Dame in Indiana, who has also used this approach. "The more data we collect, the more we realise how difficult it is to make direct inferences about ape sociality, because there is so much flexibility in what they do."

Others take a more pragmatic view. They recognise that living species are the only real source of insight into human evolution beyond the stones and bones our ancestors left behind. "I think what's changing is what we can predict and the kinds of inferences we can make," says Plavcan. Dunbar agrees. "We're now in a position to make more of the fossil record, partly because we now know so much more about the behaviour of humans and primates." ■

Dan Jones is a science writer based in Brighton, UK

"Babies are helpless when born and demand massive parental investment, yet humans are highly fecund"

body size, the less fecund the species.

This leaves humans in an odd position. Human babies are helpless when born, take a long time to grow and reach independence, and demand massive parental investment. Yet humans are highly fecund: in hunter-gatherer societies without modern birth control, the interval between births is around two to three years, compared with five years in chimps and eight in orang-utans.

There are other exceptions to the rule that big brains equal low fecundity. Large-brained birds such as owls and woodpeckers are often blind when they hatch and always require lots of nurturing, yet produce chicks as frequently as their smaller-brained relatives (*Biology Letters*, vol 5, p 125). The same combination of large brains and high fecundity is also found



Into thin air

Could vaporising trash kill two of humanity's dirtiest environmental problems with one stone?

Phil McKenna investigates

AT FIRST glance, 303 Bear Hill Road in Waltham, Massachusetts, doesn't look like the scene of an environmental revolution. But packed into a shipping container in the car park of this modest suburban commercial building is a compact piece of technology that its maker IST Energy insists can turn even the filthiest waste into clean, green energy. "Trash will move from being a liability to an asset, providing a clean source of energy that can be used right where it is produced," says Stuart Haber, the company's CEO.

IST is not alone in this revolution. It is one of a growing number of companies and research groups around the world working on gasification – a process that zaps household waste into energy and which, its advocates say, produces few or no harmful emissions. Yet as pilot gasification plants begin to spring up around the world, this apparent environmentalist's dream is not being universally welcomed. Opponents argue that the process is far from clean and

that its track record in terms of energy efficiency and emissions can hardly be considered green. Not to mention the fact that it encourages the throwaway society that the environmental movement has been trying so hard to get rid of. So what is the real story? Is vaporising trash the answer to our energy and waste-disposal woes, or an environmental wolf in sheep's clothing?

The idea of converting waste into energy has been around for decades. Heat from garbage-fuelled incinerators can generate steam that drives a turbine that in turn drives an electrical generator. Now fears over energy security and climate change, combined with the rising cost of dealing with the world's waste, are raising the possibility of disposing of household trash using higher-energy methods once reserved for hazardous materials such as medical waste and asbestos.

Gasification, and its cousin plasma gasification, involve heating waste to a high temperature inside a sealed chamber. ➤

This is done in the near absence of oxygen, so organic components in the waste do not burn but instead reform into syngas, a mixture of carbon monoxide and hydrogen. This can be filtered and chemically “scrubbed” to remove toxic particles and gases, and then burned to produce energy or converted into other fuels such as methane, ethanol or synthetic diesel. All that’s left to dispose of at the end is ash, dirty filters and chemicals from the scrubbing process, which can be treated and sent to landfill or into the sewers.

Gasification yields more energy per volume of trash than incineration, but the possibilities don’t end there. Adding an arc of superheated plasma to the mix can increase that yield further. Plasma gasification vaporises waste at much higher temperatures – up to 10,000 °C compared with up to 1600 °C for normal gasification – which ensures that more of the organic waste is gasified.

In this kind of gasification, plasma arcs are created by passing a high-voltage current through a chamber filled with an unreactive gas such as nitrogen (see diagram, opposite). As the current flows through the enclosed space, it tears electrons from the gas to form a superheated plasma that rips apart the molecules in whatever is fed into the chamber. “It’s like a continuous bolt of lightning that disintegrates almost anything that crosses its path,” says Daniel Cohn of the Massachusetts Institute of Technology, who has been working on plasma gasification since the 1980s and now sits on the board of InEnTec, another waste-to-energy company.

A further advantage of this technique is that the very high temperatures cause the waste to end up not as fine ash but as a glassy solid, which could in principle be used as filler in the construction industry. And while the power



STEPHEN WILKES/GETTY

There’s got to be a better solution to our waste problems than a hole in the ground

required to run InEnTec’s pilot plant in Richland, Washington, amounts to one-third to half of the power it produces, Cohn insists that the process is financially viable. He says syngas can be converted to ethanol and synthetic diesel at costs that can compete with petroleum-based equivalents. “We think we can produce fuel at a cost of about \$2 a gallon of gas equivalent,” he says. If he’s right, trash could become the new oil.

Pilot gasification plants are being set up at various sites in the US, Canada, France, the UK and Portugal, most of them using the plasma technique. Japan already has two commercial plasma plants, but these are focused primarily on simply disposing of household waste rather than generating energy from it.

While these new plants will all be large

installations, IST Energy believes that small is the way to go. Its container-sized non-plasma GEM system (short for Green Energy Machine) can convert almost 3 tonnes of municipal waste a day into enough syngas to heat and power an office building holding 500 people.

Keeping the system small and avoiding the expense of creating plasma makes it affordable for businesses to deploy: excluding the gas burner, the system costs \$850,000 and, according to Haber, will pay for itself in four years through savings on electricity, heating and waste disposal charges.

Haber says the entire system can save the equivalent of about 500 tonnes of carbon dioxide emissions a year through reductions in landfill gases, fossil-fuel use and the transport of waste. Haber also claims that, compared with traditional incineration, the quantity of toxic gases produced by the GEM system is negligible. “It’s really a night-and-day difference,” he says.

Gasification is not without its detractors, partly because early attempts to gasify garbage were environmentally and financially disastrous. A series of economic and environmental problems at an early commercial gasification plant in Karlsruhe, Germany, including a leak of toxic gases that temporarily closed the plant in 2000, caused the facility to shut down for good in 2004. These troubles have tainted the reputation of gasification – and, by association, plasma gasification – ever since.

One objection that sceptics raise is that gasification still produces CO₂ emissions. Neil Tangri of the Global Alliance for Incinerator Alternatives (GAIA) dismisses gasification plants as glorified incinerators. “There is an intermediate step with gasification, but the end result is always combustion,” he says.

To burn or to zap?

There’s more than one way to get energy from waste, and some methods could reach 80% efficiency

INCINERATION

Burning of trash

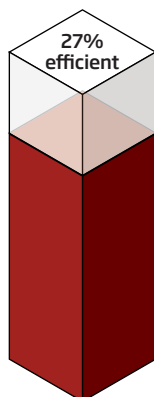
850-950°C

PRO

Proven technology

CONS

Can only be used to create steam, which yields low efficiency and is limited to electricity production



GASIFICATION

Convert to syngas

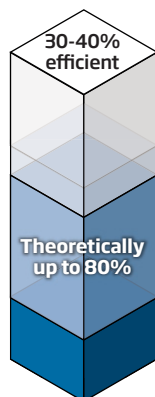
900-1600°C

PROS

Yields more energy than incineration, produces highly flexible fuel

CON

Commercial viability for energy production still being established



PLASMA GASIFICATION

Convert to syngas

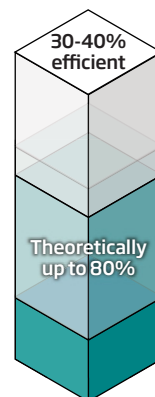
Up to 10,000°C

PROS

More robust and produces a cleaner gas than gasification alone

CONS

Commercial viability for energy production still being established. Despite producing more energy than gasification alone, much of this is consumed in producing plasma



Another concern is that the waste gas from gasification may contain dioxins, which form when organic material is heated to high temperatures in the presence of chlorine-containing compounds, which are ubiquitous in municipal waste.

"Any attempt to turn garbage into energy will most likely cause the production of significant amounts of dioxin, which many consider the most significant carcinogen known to science," says Ron Saff, a physician in Tallahassee, Florida, and a member of Physicians for Social Responsibility.

Clean and green?

Others say that chlorine can cause an additional problem in the extremely hot, oxygen-starved environment of a plasma gasification chamber. "If you pass mixed waste with chlorine in it through a plasma arc, you get metal in the [syn]gas that otherwise shouldn't be there," says Thomas Cahill, an emeritus professor of physics and atmospheric science at the University of California, Davis. These metal pollutants could escape into the environment when the gas is burned, he argues.

Companies already running gasification systems point out that the process is as clean as you make it: what matters is how efficiently the syngas is scrubbed and how effectively the ash is disposed of. They also say that they operate to strict national or regional standards governing emissions from waste-to-energy power generation.

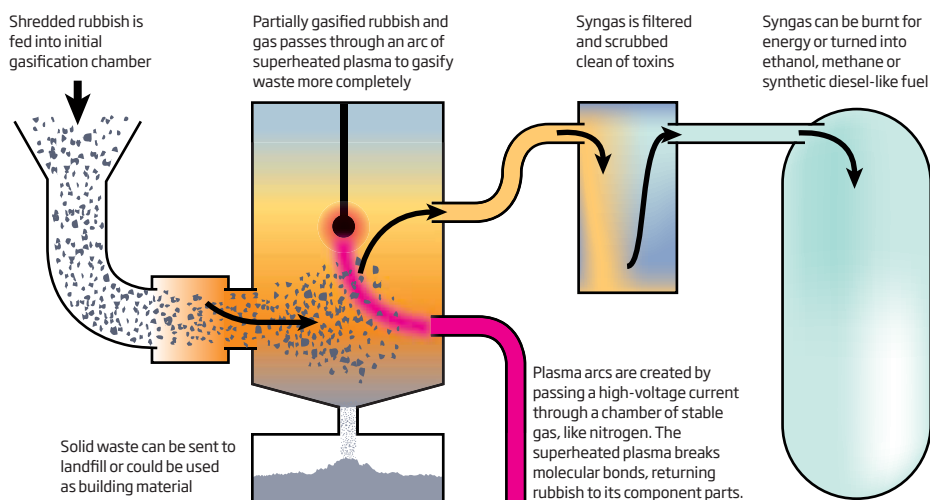
"The regulations that they have to comply with are much more stringent and focus on a wider range of toxins than for a conventional power plant," says Marc Wolman of the Massachusetts Department of Environmental Protection in Boston. "If they don't meet these limits they get shut down, period."

On the issue of dioxins, at least one waste-to-energy company is making reassuring noises. Andreas Tsangaris of the Plasco Energy Group in Ottawa, Canada, which has been running an 85-tonne-per-day waste-to-energy pilot plant since September 2007, says: "We remove virtually all the chlorine before combustion. There is no chance for dioxins to form." The company's own monitoring shows that its emissions, including those of dioxins and heavy metals, have remained at or below the most stringent regulatory limits in North America and Europe.

Nevertheless, a newspaper article by Cahill, based in part on his studies of emissions from the smouldering remains of the World Trade

From trash to gas

Vaporising household waste could reduce landfill and produce energy



Center in New York – which he says are “eerily similar” to those from gasification plants – plus a strongly worded editorial by Saff, had a direct impact on two proposals for high-profile commercial plasma gasification plants in the US. A plant in St Lucie, Florida, has been scaled back significantly, partly in response to environmental concerns, and plans for a similar plant in Sacramento, California, have been delayed indefinitely.

Another question mark over the green credentials of waste gasification concerns just how efficient these plants are at producing

“Plasma gasification is like a continuous bolt of lightning that disintegrates almost anything in its path”

energy and minimising greenhouse gas emissions compared with other methods of waste disposal. A recent study by the Tellus Institute, an independent think tank based in Boston, compared gasification with landfill sites where methane is captured to be burned for energy. It concluded that while gasification produces six times as much energy per tonne of waste as landfill sites, landfills with methane recapture systems save two-and-a-half times as much CO₂ equivalent as the combination of gasification and syngas burning. The Tellus report also found that the energy saved by recycling a given amount of waste is 3.4 times the energy that can be

produced through gasifying it.

Some are opposed to gasifiers on principle. They say their very existence discourages efforts to tackle the garbage crisis at its source. “Once you build a gasifier, you have to feed it,” says Tangri. “It creates a financial disincentive to do waste reduction and recycling.”

Ultimately, it may be some time before we realise the full effects, for good or bad, of zapping our rubbish. Few long-term independent studies have been carried out into emission levels, dioxin contaminants and the potential for toxins to leach out from waste ash. Nor is it clear how much energy can be created by gasifying various types of waste, or how reliable energy generation can be, given variations in the waste stream from day to day and in different parts of the world. So far, though, the indications are that gasification is neither the panacea for our waste and energy woes that some are claiming it to be, nor an environmental catastrophe waiting to happen.

For Kevin Whiting of Juniper, a British waste-processing consultancy based near Dursley in Gloucestershire, the way forward may be on some kind of middle ground. “If there is a market for recyclables, we should recycle as much as is practicable and not take resources from our great-grandchildren,” he says. “But if waste can’t be recycled, it has an energy value. And the more energy you can generate [from it], the better.” ■

Phil McKenna is a freelance writer based in Cambridge, Massachusetts

WHY ISN'T THERE AN ANTIWORLD?

AND OTHER ANTIMATTER MYSTERIES

There's a lot we don't know about antimatter – but it is not as scary as we think, says **Amanda Gefter**

“No!” Vittoria said from above, breathless. “We must evacuate right now! You cannot take the antimatter out of here! If you bring it up, everyone outside will die!”

Angels and Demons Dan Brown, Pocket Books

IT WAS not so long ago that we were hearing how CERN's Large Hadron Collider would produce planet-destroying black holes. Now Dan Brown's blockbuster, due to hit the big screen next month, provides us with another supposed danger emanating from the particle physics laboratory near Geneva,

Switzerland: antimatter, the seed of a weapon of unsurpassed destructive power.

While Brown's take on antimatter is fictional, the stuff certainly isn't. We see its signature in cosmic rays, and it is routinely made in high-energy collisions inside particle smashers the world over. In hospitals, radioactive molecules that emit antimatter particles are used for imaging in the technique known as positron emission tomography.

Brown was right about one thing, though: if you want answers to the burning questions of antimatter, CERN is the place to go.

Where is all the antimatter?

If you were to list the imperfections of the standard model – physicists' remarkably successful description of matter and its interactions – pretty high up would have to be its prediction that we don't exist.

According to the theory, matter and antimatter were created in equal amounts at the big bang. By rights, they should have annihilated each other totally in the first second or so of the universe's existence. The cosmos should be full of light and little else.

And yet here we are. So too are planets, stars and galaxies; all, as far as we can see, made exclusively out of matter. Reality 1, theory 0.

There are two plausible solutions to this existential mystery. First, there might be some subtle difference in the physics of matter and antimatter that left the early universe with a surplus of matter. While theory predicts that the antimatter world is a perfect reflection of our own, experiments have already found suspicious scratches in the mirror. In 1998, CERN experiments showed that one particular exotic particle, the kaon, turned into its antiparticle slightly more often than the reverse happened, creating a tiny imbalance between the two.

That lead was followed up by experiments at accelerators in California and Japan, which in 2001 uncovered a similar, more pronounced asymmetry among heavier

cousins of the kaons known as B mesons. Once the LHC at CERN is back up and running later this year, its LHCb experiment will use a 4500-tonne detector to spy out billions of B mesons and pin down their secrets more exactly.

But LHCb won't necessarily provide the final word on where all that antimatter went. “The effects seem too small to explain the large-scale asymmetry,” says Frank Close, a particle physicist at the University of Oxford.

The second plausible answer to the matter mystery is that annihilation was not total in those first few seconds: somehow, matter and antimatter managed to escape each other's fatal grasp. Somewhere out there, in some mirror region of the cosmos, antimatter is lurking and has coalesced into anti-stars, anti-galaxies and maybe even anti-life.

“It's not such a daft idea,” says Close. When a hot magnet cools, he points out, individual atoms can force their neighbours to align with magnetic fields, creating domains of magnetism pointing in different directions. A similar thing could have happened as the universe cooled after the big bang. “You might initially have a little extra matter over here and a little extra antimatter somewhere else,” he says. Those small differences could expand into large separate regions over time.

These antimatter domains, if they exist, are certainly not nearby. Annihilation at the ➤

borders between areas of stars and anti-stars would produce an unmistakable signature of high-energy gamma rays. If a whole anti-galaxy were to collide with a regular galaxy, the resulting annihilation would be of unimaginably colossal proportions. We haven't seen any such sign, but then again there's a lot of universe that we haven't looked at yet – and whole regions of it that are too far away ever to see.

Finding anti-helium or other anti-atoms heavier than hydrogen would be concrete evidence for an anti-cosmos. It would imply that anti-stars are cooking up anti-atoms through nuclear fusion, just as regular stars fuse normal atoms. The Alpha Magnetic Spectrometer is a \$1.5 billion piece of kit built to scour cosmic rays for just such signs. It is grounded at the moment, waiting for a lift up to the International Space Station, but will hopefully hitch a ride on one of NASA's final space shuttle launches in 2010 or 2011.

How do you make antimatter?

If we really wish to fathom the mysteries of antimatter, we must first get to grips with the stuff itself. Easier said than done. How on earth do you pin down a substance that vanishes the moment it touches anything?

Two CERN experiments, ATRAP and ALPHA, are grappling with that question. Their aim is to make antihydrogen – the simplest anti-atom possible, just an antiproton and a positron bound together – in sufficient quantity and for long enough to compare the spectrum of light it emits with that of regular hydrogen. Even the slightest difference between the two would shake up the standard model.

The experiments require a near-perfect vacuum, as encountering a mere atom of air would spell the end for any antiparticle, and there must be some way of trapping the antiparticles: not in a conventional container, but using electric and magnetic fields.

ATRAP and ATHENA, ALPHA's forerunner, did successfully isolate antihydrogen in 2002, bringing together antiprotons from a particle accelerator and positrons from a sodium radioactive source in a magnetic trap. Unfortunately, such success is fleeting: magnetic traps work just fine for charged particles such as antiprotons and positrons,

but antihydrogen is neutral, so it can slip right through the containing field lines.

It's a problem ATRAP and ALPHA are still working on. "Capturing antihydrogen atoms is the current frontier, and it's a challenge," says Rolf Landua, a physicist at CERN who advised on the *Angels and Demons* movie and is rumoured to be the inspiration for Leonardo Vetra, an antimatter scientist in the original story. "So far nobody has managed to do it, but I'm pretty sure we will." Still, encasing a smouldering chunk of antimatter in a portable antihydrogen trap as happens in the book is a quite a way off, he says.

Does antimatter fall up?

Gravity, we think, works the same way on all matter. But what about antimatter?

AEGIS, a CERN experiment that has just been given the go-ahead, is designed to find out. Gravity is a relatively weak force, so the experiment will use uncharged particles to prevent electromagnetic forces drowning out gravitational effects. It will first build highly unstable pairings of electrons and positrons, known as positronium, then excite them with lasers to prevent them annihilating too quickly. Clouds of antiprotons will rip these pairs apart, stealing their positrons to create neutral antihydrogen atoms.

Pulses of these anti-atoms shot horizontally through two grids of slits will create a fine pattern of impact and shadow on a detector screen. By measuring how the position of this pattern is displaced, the strength – and

direction – of the gravitational force on antimatter can be measured.

It's a clever idea, but the devil is in the detail, says AEGIS spokesman Michael Doser. "No one has ever made controlled positronium like this, nobody has ever made a positronium excited state with lasers in an environment like this and nobody has ever made an antihydrogen pulse like this."

If the researchers succeed, it will be well worth the effort. If gravity does affect antimatter differently, it will tell us something not just about antimatter but also about the fundamental theories that underpin modern physics. Einstein's general relativity, the currently favoured theory of gravity, tells us that the force should work identically on any type of matter. Equally, the standard model predicts that matter and antimatter are identical to all intents and purposes. "If we find that either of these things differ," says Landua, "then we have found something extremely important."

Doser is hedging his bets. "I'll wager a crate of champagne that we won't see a difference," he says. "But I'd gladly lose that crate."

Can we make an anti-world?

At the moment physicists are having enough difficulty just taming antihydrogen, the simplest possible anti-atom. Can we ever expect them to make antihelium, and then organic antimolecules made from anticarbon and a whole anti-periodic table, too?

The problem here is that every anti-atom

ANTIMATTER: A BRIEFING

■ Every particle has an antiparticle with the same mass but the opposite electric charge. The proton has the negatively charged

antiproton; the electron has the positively charged anti-electron, or positron.

■ Neutral particles can have antiparticles, too. The neutron might have no charge, but quarks – the smaller particles

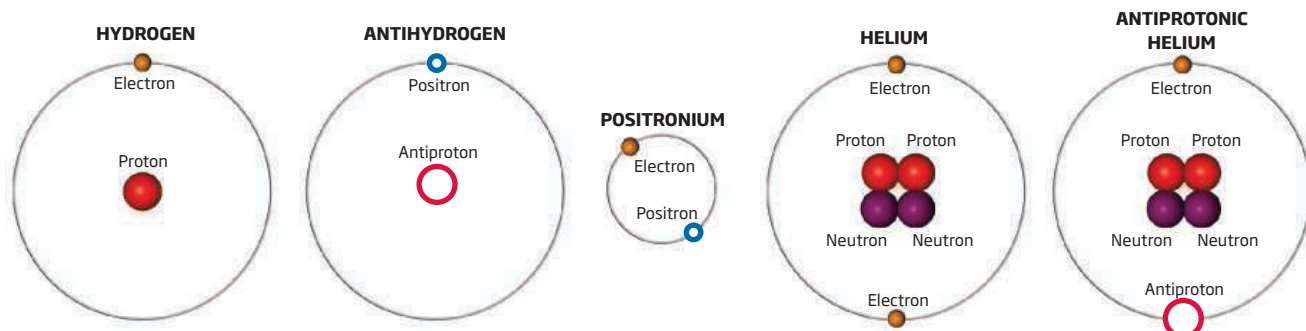
that make it up – do. Turn these quarks into antiquarks by flipping their charges, and you've made an antineutron.

■ The possibility of antimatter first surfaced in equations formulated by British theoretical physicist Paul Dirac in 1928 – four years before American experimenter Carl Anderson found positrons in cosmic rays.

■ Notoriously, matter and antimatter destroy each other, or annihilate, whenever they come into contact. An electron and a positron mutually destruct in a puff of light consisting of two photons sent out in precisely opposite directions, each with an energy corresponding exactly to the mass of the electron (and positron).

Anti-engineering

So far physicists have managed to make mirror-image hydrogen, electron-positron pairings called positronium, and helium with an antimatter twist



"Whether we ever make complex anti-atoms will depend on how long the human race lasts"

As for our chances of making anything more complex, Close is pessimistic, saying it will take a billion years, give or take. "It depends on how long the human race lasts," he says. It seems that our best bet for spying more exotic elements of the anti-periodic table is to look up at the sky – and hope that somewhere antistars are busy churning them out for us.

What about antimatter bombs?

"Antimatter was a lethal weapon. Potent, and unstoppable. Once removed from its recharging platform at CERN... A blinding light. The roar of thunder. Spontaneous incineration."

The idea that humanity might one day harness the annihilative power of antimatter for destructive purposes has a ghastly fascination – and it's a central part of the *Angels and Demons* plot, in which a bomb containing just a quarter of a gram of antimatter threatens to obliterate the Vatican.

Relax, says Landua. There's a very good reason why nothing like that is going to happen any time soon. "If you add up all the antimatter we have made in more than 30 years of antimatter physics here at CERN, and if you were very generous, you might get 10 billionths of a gram," he says. "Even if that exploded on your fingertip it would be no more dangerous than lighting a match." Patients undergoing PET scans have natural radioactive atoms in their bloodstreams emitting tens of millions, if not more, positrons to no ill effect.

Even if physicists could make enough antimatter to build a viable bomb, the cost would be astronomical. "A gram might cost a million billion dollars," says Landua. "That's probably more than Barack Obama wants to invest right now." Close points out the time problem, too. "It would take us 10 billion years to assemble enough anti-stuff to make the bomb Dan Brown talks about," he says.

If that seems reassuring, unfortunately the same kind of reasoning does for antimatter as a clean, green energy source. "Maybe it would work if there were lumps of antimatter that nature had spent 15 billion years making for us," says Close. As it is, we would have to make them one anti-atom at a time, which costs far more energy to make it than we would get out of it – about a billion times more, says Landua.

That's not to say we can't harness antimatter in new ways. In 2007, physicists David Cassidy and Allen Mills of the University of California, Riverside, made the first molecules comprised of more than one positronium atom. Positronium atoms quickly annihilate into high-energy gamma rays, so pack lots of them together, and it should be possible to get them annihilating and emitting light in synchrony – creating an enormously high-powered "gamma-ray annihilation laser" that could be used to image objects as small as atomic nuclei, or to set off nuclear fusion in reactors. ■

Amanda Gefter is an editor at *New Scientist*. Further reading: *Antimatter* by Frank Close (Oxford University Press, 2009)

COMING ON 9 MAY - FREE POSTER

THE STRANGE WORLD OF ANTIMATTER
Where to find it, what it will tell us about the universe and how to harness it

has to be built one subatomic antiparticle at a time. For example, if you want to make antideuterium – like antihydrogen, but with an added antineutron – you first have to make the antineutron. Antineutrons are neutral, making them impossible to steer in the conventional way with electromagnetic fields, so you just have to make great numbers of them and hope that for every million or so antineutrons you make, one ends up in the right place to make an antideuterium atom. "And for every further antineutron or antiproton you add, you lose another factor of a million," says Doser.

While no one's cracked that problem yet, one experiment at CERN is making use of a neat short cut to at least make something other than antihydrogen. ASACUSA has created atoms of "antiprotonic helium", in which one of the electrons orbiting a helium nucleus is replaced by an antiproton. By studying the light spectra emitted by this composite matter-antimatter atom, the electrical and magnetic properties of the antiproton can be measured with great precision – and compared with those of a regular proton.

Are the mysterious symptoms plaguing bomb-blast survivors a scary new phenomenon or simply a twist on an old problem, asks Michael Bond

Brain shock

ONE look at the effects of a bomb blast suggests that you'd have to be extremely lucky to emerge from one unscathed. If you were not burned by the explosion or blasted by shrapnel, the chances are you'd be hit by the shock wave. Travelling at several hundred metres per second, this causes massive fluctuations in air pressure which can knock you unconscious, rupture air-filled organs such as eardrums, lungs and bowels, and stretch and distort other major organs.

Soldiers serving with coalition forces in Afghanistan and Iraq know only too well how devastating bombs can be. The effect of shrapnel on bodies – amputated limbs, broken bones, lacerated and burned flesh – is plain enough. Less obvious and harder to understand are the long-term effects of the shock wave on the brain.

Weeks, months, or sometimes years after being concussed in an explosion, thousands of soldiers are reporting a mysterious clutch of problems. Dubbed post-concussion syndrome (PCS), symptoms include memory loss, dizziness, headaches, unexplained pains, nausea, disturbance of sleep, inability to concentrate and emotional problems.

The US military and veterans' groups see PCS as a growing problem, and the US government is pouring millions of dollars into investigating it. Some doctors, however, particularly in the UK, believe that for many patients the symptoms ascribed to PCS are not caused by concussion at all, but by the shock and stress of wartime events. It may even be

getting mixed up with post-traumatic stress disorder (PTSD), an acknowledged psychological reaction to disturbing events. "Some people are saying it's a hideous mistake and that we're talking up a problem," says Simon Wessely, a psychiatrist and director of the King's Centre for Military Health Research at King's College London.

Simple concussion from a blow to the head is not a new problem, of course. Common causes are falls, car accidents or sports such as rugby and football. It can lead to a brief loss of consciousness, amnesia or confusion. Although longer-lasting symptoms are occasionally reported, sufferers usually recover within days or weeks.

Battlefield explosions are nothing new either. For soldiers serving in Iraq and Afghanistan, one of the biggest threats they face is from roadside bombs, often improvised from cast-off artillery shells or other weapons. While more soldiers than ever are surviving such blasts, thanks to better body and vehicle armour, they are often left with concussion, or mild traumatic brain injury (mTBI) as it is usually termed in this context.

In the 1990s, soldiers returning from the first Gulf war started to report persistent cognitive problems after an mTBI. The Brain Injury Association of America and others have described mTBI as a "signature injury" of the Iraq and Afghanistan conflicts. Veterans organisations have voiced growing concerns and are even using words like "epidemic".

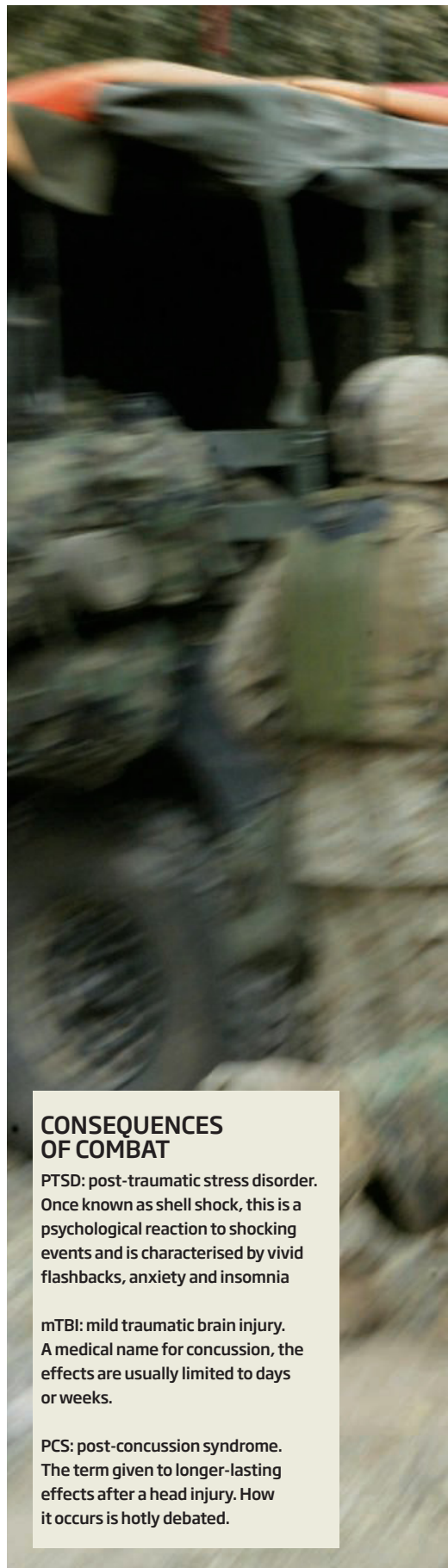
But why should a bomb blast be more ➤

CONSEQUENCES OF COMBAT

PTSD: post-traumatic stress disorder. Once known as shell shock, this is a psychological reaction to shocking events and is characterised by vivid flashbacks, anxiety and insomnia

mTBI: mild traumatic brain injury. A medical name for concussion, the effects are usually limited to days or weeks.

PCS: post-concussion syndrome. The term given to longer-lasting effects after a head injury. How it occurs is hotly debated.





Concussion has been called the "signature injury" of the conflicts in Iraq and Afghanistan

GARY KNIGHT/VII



Combat can take a heavy mental toll as well as a physical one

likely to trigger PCS than a sports injury? The jury is still out, although various theories are being investigated (see “Blasted”, right). Despite the uncertainties, the US military, government and patient groups designate mTBI and PCS as battlefield disabilities with a high priority. The Defense and Veterans Brain Injury Center (DVBIC) in Washington DC was set up in 1992 to help military personnel with brain injuries. In 2007, the US Congress agreed to provide \$900 million for research into and treatment of battlefield traumatic brain injuries and PTSD. Then in 2008, President George W. Bush reauthorised the Traumatic Brain Injury Act, which compels federal health bodies to improve care and treatment of both civilians and soldiers suffering brain injuries and to fund monitoring and research.

Meanwhile, attempts to identify soldiers with mTBI have been stepped up. Both the British and the American military routinely carry out simple mental tests on soldiers exposed to blasts, investigating symptoms and what they remember of the event. Anyone with concussion should be removed from combat and given light duties until they recover. “The key is to limit the exposures [to concussion] and limit the exposures that come on top of each other,” says Jeffrey Barth, a neuropsychologist at the University of Virginia, Charlottesville, and an expert on concussion injuries.

The US army also screens for symptoms of mTBI when soldiers return from a tour of duty, and again three months later. The army is also

carrying out neurocognitive tests on recruits before they are sent into combat so that doctors can check for deterioration in later tests. However, even if PCS is diagnosed there is no specific treatment. All doctors can do is target individual symptoms, for example, with antidepressants, analgesics and sleeping pills, as well as psychotherapy and behavioural therapy. And the intense focus on identifying cases of mTBI and PCS belies the fact that the mechanism by which mTBI could lead to

“Labelling this as an epidemic is fraught with danger because it might become self-fulfilling”

PCS is still unclear. PCS is not so much a discrete entity as a constellation of symptoms that overlap widely with other mental and physical illnesses. There is no blood test or brain scan that can diagnose it – doctors can only ask if the patient ever had an mTBI, run through the check-list of symptoms, and rule out other causes.

Those sceptical about PCS do not dispute that a worryingly large number of soldiers are returning from Iraq and Afghanistan with persistent cognitive problems. What they question is whether these symptoms can be attributed to an mTBI. “There was this sudden view that we’d stumbled on something completely new,” says Wessely.

“But blasts are not a new problem in warfare.”

The debate has heated up in the past year with the publication of three studies that have cast doubt on the view that PCS is a direct consequence of concussion. In one, a team at the University of Sydney looked at 175 civilians admitted to hospital because of physical injuries (*Journal of Neurology, Neurosurgery and Psychiatry*, vol 79, p 300). About half of the group had sustained an mTBI, and after a few days 43 per cent of them had symptoms consistent with PCS. But 44 per cent of the other group, whose injury was not brain related, also had these symptoms. While this study looked at patients in the first few days after their trauma rather than months, it shows that PCS symptoms aren’t necessarily the result of brain injuries.

The other two papers are perhaps more significant as they involve large epidemiological studies in soldiers, rather than civilians, and looked at symptoms over the long term. Both research teams concluded that persistent cognitive problems after an mTBI were in most cases due to psychological causes such as depression and PTSD.

In the first study, researchers questioned more than 2500 US infantry soldiers three to four months after they returned from a year-long tour of duty in Iraq, asking them about their combat experience, any injuries they had suffered and any persistent symptoms. Around 15 per cent of them had suffered an mTBI, and these soldiers had significantly more mental and physical problems than

those with other injuries (*The New England Journal of Medicine*, vol 358, p 453). Charles Hoge at the Walter Reed Army Institute of Research in Silver Spring, Maryland, who led the study, thinks the primary cause of their ill health was probably not concussion but “exposure to a very intense traumatic event that significantly increases the risk of PTSD”.

Hoge reasons that PTSD is a more likely cause than mTBI, having many common symptoms. In addition, the psychological symptoms of PTSD persist, while the effects of concussion usually disappear quickly. “When a soldier gets concussed as a result of a blast on the battlefield, that is clearly a close call,” says Hoge. “Such traumatic events can set up a cascade of neurochemical events that happen with PTSD, and that can lead to a host of symptoms.”

I saw dead people

The second study, by Wessely’s team, which looked at nearly 6000 British soldiers who had served in Iraq in 2003, reached similar conclusions (*Psychological Medicine*, DOI: 10.1017/S0033291708004595). The researchers found no indication that the symptoms ascribed to PCS were caused by an mTBI. While many of those who reported such symptoms had indeed been caught in a blast, some had not. In fact, blast exposure proved no more predictive of PCS symptoms than other stressful combat situations, such as seeing dead bodies or knowingly being exposed to depleted uranium. The findings suggest that the symptoms “are most often an expression of psychological distress”, says Wessely.

Michael Jaffee, however, who is national director of the DVBIC, warns against assuming that the symptoms ascribed to PCS are caused exclusively by either an mTBI or by PTSD. Since any kind of combat injury raises the risk of PTSD, and since you are more likely to show PTSD symptoms after a head injury, “there is bound to be overlap”, he says.

Jaffee wonders if there might be something about blast-induced brain injury that makes people more vulnerable to psychological disorders, and to PTSD in particular. PTSD is characterised by impaired function in parts of the prefrontal cortex that help regulate how we deal with fear and anxiety and mTBI often involves damage to the prefrontal cortex. Jaffee and others suggest that this sort of damage may disrupt a person’s capacity to deal with fear and thus make them more susceptible to PTSD (*Journal of Rehabilitation Research and Development*, vol 44, p 895).

Wessely questions this kind of association because “when you get concussion you lose your memory, so how can you have flashbacks when you don’t remember the incident?”. But concussion does not always involve amnesia. Furthermore, Hoge says, traumatic memories can trigger PTSD

BLASTED

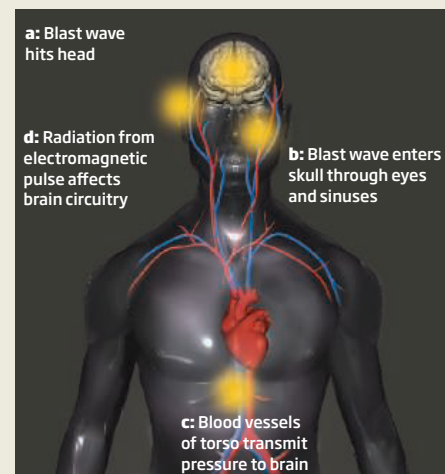
The mainstream view of concussion from an explosion is that the blast wave hits the head, throwing the brain around inside the skull (a). In some cases this could be enough to tear axons, the microscopic fibres that carry messages between neurons.

In the past few years, however, there has been a surge of research into whether other mechanisms could account for the apparently high rate of post-concussion syndrome among US soldiers returning from Iraq and Afghanistan.

Computer modelling by neurologist David Moore, deputy director for research at the Defense and Veterans Brain Injury Center in Washington DC, suggests that the pressure wave enters the head more through the eyes and sinuses than the skull (b). Another theory, championed by neurologist Ibolja Cernak at the Johns Hopkins University Applied Physics Laboratory in Baltimore, Maryland, is that when the blast wave hits the torso, pressure travels up to the brain through major blood vessels (c).

Meanwhile, the US Defense Advanced Research Projects Agency is exposing pigs to explosions to

investigate whether a blast’s electromagnetic pulse could interfere with the brain’s electrical circuitry (d). DARPA is also closely following the health of a group of military explosives experts who are exposed to multiple blasts while training, with results expected in the next few weeks.



even when you are not conscious of them.

In any case, does it matter to the patient what the cause of their symptoms is? Many researchers say it matters a great deal. Plenty of studies have shown that what you tell a patient about what is wrong with them has a big influence on how long they take to get better. “If they believe they are going to have lifelong impairment as a result of a brain injury, they are more likely to have persistent symptoms,” says Hoge. “On the other hand, individuals who have positive expectations, who are told they are going to get better, actually do better.”

Wessely and Hoge even avoid the term mTBI when talking to patients. “The phrase ‘traumatic brain injury’ makes it sound like you have shrapnel in your skull and will end up in a wheelchair,” says Wessely. “Call it concussion and they’ll think, I had that playing rugby.”

Another reason why understanding the true cause of PCS matters relates to whether it should be screened for. The US military screening programmes have found that up to 18 per cent of its returning personnel have had an mTBI. Figures from the UK military, on the other hand, which does not carry out mass screening, suggest that fewer than 1 per cent of its troops have suffered an mTBI.

Why such a big difference? It is possible, of course, that US troops get blown up more, or perhaps have weaker protective helmets. But another explanation is that US doctors find more head injuries simply because they have systematic screening in place, while British

soldiers have to decide they have a problem and take the action of going to see their doctor.

So might the US be overdiagnosing the problem, or the UK underdiagnosing it? Lionel Jarvis, the UK’s assistant chief of the UK defence staff (health), thinks the former. Jarvis points out that any soldier returning from a six-month tour of duty in Afghanistan, where they’ve been away from their family and in an extreme, high-pressure environment, is likely to show symptoms of distress: “How on earth do you unpick the different symptoms and explain whether they are due to a head injury or one of a large number of other potential causes?”

Wessely says his study showed that screening soldiers for PCS when they get home cannot distinguish between those whose problems were caused by concussion and those who have anxiety, depression or PTSD. “It’s fraught with danger,” he says. “Caution is needed before labelling mTBI as an epidemic because this might become self-fulfilling.”

But Barth insists some kind of screening is needed. “At least the military is making an attempt to look at these issues,” he says.

When it comes to combat trauma, unpicking the physical from the psychological is bound to be highly complex. As Barth says, perhaps the greatest danger could be in trying to simplify the picture too much. “I recommend that we get comfortable with the complexity,” he says, “and treat it as a challenge.” ■

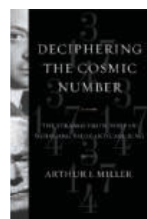
Michael Bond is a consultant for *New Scientist*

A magnificent obsession

Two of history's most profound thinkers were brought together by dreams and strange coincidences

Deciphering the Cosmic Number: The strange friendship of Wolfgang Pauli and Carl Jung by Arthur I. Miller, W. W. Norton, \$27.95/£18.99 (published in the UK in June)

Reviewed by Dan Falk



ON THE surface, Arthur I. Miller's latest book is a joint biography of two great minds of the 20th century: quantum physics pioneer Wolfgang

Pauli and psychoanalysis master Carl Jung. This two-in-one approach has served Miller well; his 2001 book *Einstein, Picasso* attracted wide acclaim. But whereas Einstein and Picasso never actually met, Pauli, we learn, met Jung on numerous occasions. They grew to be close friends, and Pauli became one of Jung's regular clients.

The two shared similar obsessions. Both were scientists, but each feared that physics would always be missing something if it neglected the inner workings of the mind.

Jung obsessed over mental archetypes – primitive, subconscious symbols hard-wired into our perception of the world – and was fascinated by the Kabbalah, a fiendishly complex branch of Jewish mysticism.

Pauli, for his part, was enamoured by Johannes Kepler, who tried (unsuccessfully) to explain the structure of the solar system in terms of geometry alone. He was also intrigued by a lesser known contemporary of Kepler – Robert Fludd, a member of the Rosicrucian secret society, who believed that simple geometrical forms held the key to



Carl Jung saw deep cosmic significance in dreams and mysticism

unlocking the cosmos. As Pauli struggled with problems in quantum physics, Miller explains, he felt “the need for a fusion of physics with Jung’s analytical psychology in order to understand first the unconscious and then the conscious”.

Pauli began experiencing bizarre dreams and turned to Jung for help in making sense of them. The dreams featured a startling mix of geometrical figures, motifs from physics (clocks and pendulums) and mysterious figures reminiscent of Jung’s

archetypes (the serpent eating its tail, a veiled woman and an ape-man, to name a few). Although Pauli described 400 dreams to Jung, these visits were kept a secret; when Jung wrote about them, he referred to his famous patient only as a “great scientist”.

Numerology is never far beneath the surface of Miller’s story. Pauli was troubled by the number 137. As physicists pored over the equations that determine the spectra of the chemical elements, a particular combination of physical constants kept cropping up. Referred to as the “fine structure constant”, it combined the speed

of light (crucial in Einstein’s relativity) and Planck’s constant (the heart of quantum theory), along with the magnitude of the charge of an electron. By themselves, each of these has to be expressed in some particular units (say, metres per second for the speed of light), but combined, the result is a unitless “pure number”. Arnold Sommerfeld first worked out its value as 0.00729, equivalent to (roughly) 1/137.

Why 137? Pauli obsessed over it,

“As Pauli struggled with quantum physics, he felt the need to fuse physics with Jung’s psychology”

and he wasn’t the only great physicist to do so: Arthur Eddington, Enrico Fermi and Richard Feynman all took stabs at it over the years. Meanwhile Jung, with his knowledge of Kabbalah, also found enormous significance in 137. Every letter in the Hebrew alphabet has a number associated with it, and – lo and behold – the letters in the word “Kabbalah” add up to 137. Remarkable – or a meaningless coincidence.

The history is fascinating, as are the insights into the personalities of these great thinkers. Miller, however, seems oddly accepting of Pauli and Jung’s musings, which these days we would label pseudoscience. And Miller’s thesis that their ideas are bearing fruit today, with the study of consciousness “a burgeoning field of research using concepts from quantum mechanics”, is somewhat exaggerated. ■

Dan Falk’s latest book, *In Search of Time*, was published by McClelland & Stewart in October

PAPERBACK PICKS

Compiled by Eleanor Harris

1 Bad Science

by Ben Goldacre,
Harper Perennial, £8.99

An updated edition of "one of the essential reads of the year" according to reviewer Michael Bond

2 Head Trip

by Jeff Warren,
Oneworld, £10.99

An endearing first-person account of the various states of consciousness

3 Physics of the Impossible

by Michio Kaku,
Anchor Books, \$15.95

"An easy-to-read physics primer in disguise" said our reviewer Michael Brooks

4 My Stroke of Insight

by Jill Bolte Taylor,
Hodder, £8.99

The incredible story of the neuroscientist who rebuilt her own mind after suffering a severe stroke

5 ID

by Susan Greenfield,
Sceptre, £8.99

How 21st century technologies might alter the minds of future generations

6 Quantum

by Manjit Kumar,
Icon Books, £9.99

A vivid account of the people behind the debate over the nature of reality

7 The Drunkard's Walk

by Leonard Mlodinow,
Penguin, £9.99

An engaging guide to the randomness of our everyday lives

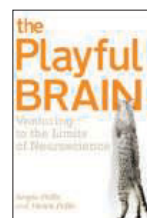
For these reviews and more, check out Books & Arts online at www.newscientist.com/books-art

Just for the fun of it

What is play actually for? Two books take a stab at explaining why it is so important

The Playful Brain by Sergio Pellis and Vivien Pellis, Oneworld, £19.99

Reviewed by Rowan Hooper



PERHAPS because of its non-serious nature, play has been a neglected, even embarrassing subject for serious scientists. Little work has been done on what it's for – that is, its evolutionary function. *The Playful Brain* has a stab at rectifying this, with some success.

Play is so complicated, say the authors, that to understand it we need to build up a towering "layer cake" of information about neurology, physiology and juvenile development. Primates are difficult to experiment on – for this reason, and because of the authors' area of expertise, we are plunged straight into a detailed analysis of play fighting in rats.

We have to wade through a lot of technical reading to get to the good stuff – and here I'm going to

be shamelessly pro-ape – the parts about primates in general, and humans in particular.

I enjoyed an anecdote about two juvenile gorillas play fighting, bashing into each other's shoulders. One abruptly changes his attack, and grabs the other's genitals, making him leap into the air in surprise.

So what is play actually for? Pellis and Pellis show that play improves social competence by honing the emotional and intellectual skills necessary to thrive in society. This explains why males play more than females: females are more socially competent to start with, while males by their nature are more aggressive and competitive.

The social competence theory prompts the authors to suggest that banning roughhouse play among children in many countries is not doing them any good. Preventing unstructured play is damaging – if you prevent an animal from playing when it is young, it will have serious social

problems later. Yet extracting these nuggets was not the most fun I've ever had, and I'm left waiting for a really enlightening and engaging book on play.

Another attempt is Stuart Brown's *Play: How it shapes the brain, opens the imagination, and invigorates the soul* (Penguin, \$24.95). Like the Pellis's book, there are some good anecdotes, but it seems to avoid the uncomfortable yet important area of childhood sexual play, barely mentions the evolutionary value of play, while seeming leaden and laboured.

In summary: all work and no play makes Jack a dull (and dysfunctional) boy.

Packing a punch

Horizon: How Violent Are You?
Documentary on BBC2 in the UK, currently scheduled for 5 May

Reviewed by Liz Else



AFTER 60 hours of little sleep, tending crying twins and trying to hold down a job, Michael is tense and becoming a bit paranoid.

Luckily for this seemingly unenviable fellow, he is in fact taking part in a TV experiment. He is Michael Portillo, a former UK government minister, and the twins are lifelike dolls, built to be as inconsolable as real-life babies.

The programme is part of a BBC2 season on that perennially fascinating subject, violence. Portillo explores the extent to which each of us has the capacity for violent behaviour, by way of a Bolivian "mutual conflict festival", interviews with a football thug and a boy soldier, and a restaging of Stanley Milgram's "obedience" experiments of the 1960s.

It's gripping, based on sound science, and for many viewers will be quite shocking. However, anyone acquainted with their own dark side will be left with more questions than answers.



HOLLY HARRIS/GETTY



Photography: Munem Wasif

Water, water, nowhere

Bangladesh has a complex and increasingly difficult relationship with water. Among the factors contributing to this are climate change, catastrophic flooding, coastal erosion and the pollution of drinking wells by natural arsenic.

Now photographer Munem Wasif has brought to light another growing problem that is already affecting hundreds of thousands of people in the Satkhira region of south-west Bangladesh: increasingly salty groundwater.

This rise in salinity has been caused by a shift from traditional

agriculture to commercial shrimp farming. The latter can generate a lot of money for a fortunate few, but for most its consequences are disastrous. Once-fertile land turns to brackish water and local people lose access to drinking water and their livelihoods.

Wasif, who is Bangladeshi-born, has created a striking set of photographs that give insights into the resulting hardships faced by the people of Satkhira. This image captures the daily routine of Shajhan Shiraj and his brothers as they drag their boats across the mud in a three-

hour journey to collect their cargo of fresh water. Similar journeys are becoming more frequent across the region as accessible drinking water becomes increasingly hard to obtain.

Wasif's photographs are the result of a commission awarded by Prix Pictet 2008, the world's first photography prize dedicated to sustainability. Its aim is to use the power of photographs to convey messages about pressing social environmental issues.

The theme for 2008 was "water", and the competition supported the UK-based charity Water Aid,

which helps the world's poorest people gain access to safe water, sanitation and hygiene education. Water Aid is now working with the people of Satkhira to introduce much-needed water and sanitation facilities. The theme of the 2009 Prix Pictet is "earth", and the winner will be announced in October. **Adam Goff** ■

You can find this and other photographs by Munem Wasif in *Salt Water Tears: Lives left behind in Satkhira, Bangladesh* by Prix Pictet Ltd, Candlestar



DOES it matter where you park old documents on your website that you are no longer interested in? Yes, it does matter, especially if the website bears the name of a major government department and the documents are accessible to the public.

Back in April 2008, columnist Melanie Phillips wrote in the UK's weekly *Spectator*: "HM Treasury has posted on its website a paper about solar cycles, which says: 'Based on solar maxima of approximately 50 for solar cycles 24 and 25, a global temperature decline of 1.5 °C is predicted to 2020, equating to the experience of the Dalton Minimum'."

Many readers with an active interest in the future of the planet will recognise this argument. A moment with a famous web search engine (FWSE) reveals that it is an article by one David C. Archibald, who gives his academic affiliation as "Summa Development Limited, Perth, WA, Australia". We can find no trace of this organisation online, apart from an entry in the Australian trade marks

registry and various discussions of Archibald's claim that global temperatures will decline until 2020.

So why did Her Majesty's Treasury, the UK's finance ministry, post this stuff on its website? They didn't think they had, it seems. The person who responded to a query from Feedback reader Martin Brown appeared not to understand what was going on: "Once [documents] have been hosted on our site, we have no control over the way in which other sites link to them," they wrote, and suggested that Martin should instead have followed the officially published responses to the government's *Stern Review on the Economics of Climate Change*.

So Feedback had an unofficial look. Another moment's FWSEing revealed the existence of a folder on the Treasury web server computer containing some 10,000 random documents that appear – and we're guessing here – to have been put there in case officials might like to look at

them, if only for amusement. To give an example, one we looked at with amusement was a diplomatic telegram, marked "secret", that warned British embassies of the UK's impending emergency approach to the International Monetary Fund in 1976 – which led to severe cuts in government-funded science and social spending.

Phillips isn't the only person to have been given the impression that these documents' visible existence on the Treasury's website implies approval of their content. Archibald has referred to updating "that paper hosted on the HM Treasury website".

Feedback offers the Treasury a simple solution to this problem. Based on the contents of the offending folder, which is named "www.hm-treasury.gov.uk/d" – but which can only be accessed via the FWSE (use the URL www.slashd.notlong.com) – they should rename it "www.hm-treasury.gov.uk/random-rubbish".

Alternatively, for a reasonable fee, we will show them how to make it genuinely private, as we assume it is supposed to be.

ALWAYS pleased to encourage children to take an interest in science, Owen Healy was happy to be given a script to read from when he was giving tours of Rutgers University School of Engineering



at New Brunswick, New Jersey, to schoolchildren aged 11 to 14.

He was less happy when he started reading it: "The Fibre Optics and Materials Research Program was

established in 1985 under the auspices of the New Jersey Commission on Science and Technology to conduct collaborative research and provide technical support to industrial, government and national laboratories on newly emerging fibre optic materials, waveguides, devices and their applications..."

We can only imagine how excited the kids were by this vibrant text.

FINALLY, don't forget to send in your entries to our competition for all the family in celebration of the Wallace and Gromit exhibition at the Science Museum in London.

Feedback has teamed up with Carlton Books to offer you the chance to win a copy of *Grand Adventures and Glorious Inventions: The scrapbook of an inventor and his dog* by Penny Worms, signed by the characters' creator, Nick Park. This fun hardback is packed with information about Wallace's cracking contraptions and his madcap adventures with Gromit – from *A Grand Day Out* to *A Matter of Loaf and Death*.

All you have to do is write to us describing in no more than 100 words your own Wallace-and-Gromit-style invention. The best entry will receive a copy of the book signed by Park, with four runners-up each receiving an unsigned copy.

You may enter the competition by email (address below; please put "Competition" in the subject field), fax, post or by going to www.newscientist.com/article/dn16888. The competition closes on 4 May 2009 and no entries will be accepted after that date. The results will be published in the 16 May issue of *New Scientist*. The editor's decision is final.

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.

A sign on a building at Durham University in the UK says "No smoking outside these doors". Martin Dehnelt observes that since smoking is banned inside, too, the university is claiming jurisdiction over the universe

Achoo blues

Twice, when donating blood platelets to the Red Cross, I've started sneezing uncontrollably. Assistants respond immediately by giving me Tums, a brand of antacid indigestion tablet. Their explanation is that Tums restores my calcium balance. I understand how my calcium could get out of whack when my blood is being removed, filtered and given back to me without platelets, but what does this have to do with sneezing?

■ Donating platelets involves the use of a plateletpheresis machine, which draws and separates platelets from a donor's blood before returning red cells and plasma to the donor's bloodstream.

A solution called acid citrate dextrose is added to the blood to stop clotting during this process: citrate, in particular, has the effect of lowering blood calcium levels to a point where the blood cannot clot in the machine.

This calcium deficiency, or hypocalcaemia, may cause side effects when blood from the

Sneezing is not a common side effect, but low calcium levels could cause tingling in the nasal passages and hence sneezing.

The treatment for this is first to slow down the rate of platelet collection and then to supply the donor with antacid tablets, a rich source of supplementary calcium. If this is not effective, the procedure may have to be halted until symptoms resolve and a decision made over whether to proceed at a lower rate of platelet collection.

*Richard Benjamin
Chief medical officer
American Red Cross
Washington DC, US*

Wheels of death

I heard the car is the deadliest weapon created by humans and that the number of lives it has claimed exceeds the death toll from atomic weapons, guns or bombing. Is this true? And what are the grisly figures involved? (Continued)

■ By not considering the less developed countries, some of your previous correspondents have neglected nearly 90 per cent of deaths caused by road traffic accidents. The World Health Organization estimates the total is 1.2 million deaths per year, the majority of these probably being pedestrians and cyclists.

It is also necessary to add the deaths from "traffic-related air pollution", as another WHO

report terms it. These have been estimated as between 0.8 times (in New Zealand) and three times (in Switzerland) as high as the accident-related death rate, so perhaps it would be correct to double the estimate

"The current annual death rate due to motor vehicles is at least double those caused by war"

of deaths due to motor vehicles to 2.4 million.

We should also factor in an estimate for deaths due to climate change caused by vehicle and petroleum industry carbon dioxide emissions. A definite value for this number of deaths will presumably remain unknown until it starts to reach tens of millions per year, because it is difficult to attribute individual droughts, storms or floods to climate change.

Even disregarding climate-change deaths, however, the current annual rate of deaths due to motor vehicles is at least double that caused by war.

*Philip Ward
By email, no address supplied*

THIS WEEK'S QUESTIONS

SPEED FREAKS

A single Formula 1 car passing by makes a noise of around 110 decibels. Last year I went to a Formula 1 Grand Prix and sat near the start line, where 20 cars left the grid at once. The noise was

mind-numbing, much louder than a single car, but not 20 times louder (or 2200 decibels, an unachievable figure). Why wasn't it?

*Walter Coppin
Edinburgh, UK*

STICKY PROBLEM

What caused this tree resin, emerging where a branch was sawn off, to flow out at an angle, then vertically downwards, before flowing in an upward curve (see photo)?

*Rupert Ward
Albany, Western Australia*



THE RIGHT PATH

A pathway in my neighbourhood splits at an incline into both steps and a slope. Which option requires more calories to walk up or down?

*Yonatan Silver
Jerusalem, Israel*

"Citrate has the effect of lowering blood calcium levels to the point where the blood cannot clot"

machine is returned to the donor's body. Symptoms include tingling, chills, slight nausea, bruising, fatigue and dizziness; the most frequent one is tingling around the lips.

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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