

CINEMA ON A CHIP
Dawn of the computer
supermemory

MIND MELD
When two brains
become one

SPYING FOR A DRINK
The alcohol police are
watching you

NewScientist

WEEKLY December 5-11, 2009

Extreme oil

How we'll squeeze out every last drop



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COVER STORY

Extreme oil

Extraordinary measures to keep the black stuff flowing

Cover image
Jon Raine



TUI DE ROY/ANDEV/FLPA

Homosexual selection

Why same-sex liaisons are not an evolutionary dead end



CORBIS

The price of going green

If your country turns eco-friendly, how hard will it hit your wallet?

Coming next week

Cats versus dogs

We declare the winner in the great pet showdown

PLUS

How to slice a pizza

Plenty more oil, but use it wisely

Our dependence on the black stuff has placed us squarely on the horns of a dilemma

CHEAP oil has been the driving force behind the phenomenal economic growth of the past century, at least in the west. Oil is the lifeblood of the modern world. If we were to remove it tomorrow, it is no exaggeration to say that civilisation would collapse.

But the days of abundant, easy-to-extract oil are numbered. It's a mantra we've all heard before. Oil production is poised to enter terminal decline: if "peak oil" hasn't already arrived, it is imminent.

Make no mistake, peak oil is a threat to our way of life. However much we despair at the long-term consequences of pumping carbon dioxide into the atmosphere, the prospect of an oil crisis is just as bad, if not worse, and more immediate.

For that reason, the fact that the earth is still dripping with oil is something of a blessing. Conventional oil – liquid hydrocarbons trapped deep underground – may be running short, but reserves like this are a drop in the ocean. Other sources of oil, including tar sands and oil shales, contain about nine times as much oil as we have consumed so far.

Energy companies are already digging for these unconventional resources, driven by our collective thirst (yes, that means you) for oil. Tar sands and the like will soon make a

significant contribution to the global oil supply (see page 34). Unfortunately, they are more polluting and more expensive to extract than conventional oil, which is why most of them are still in the ground.

So unconventional oil is both an opportunity and a threat. It could allow us to complacently carry on as normal, delaying the hard choices we have to make, but all the while pushing us ever deeper into climate crisis. Managed properly, however, unconventional oil could be used to smooth out peak oil and make a gentler transition to a post-oil economy.

"Unconventional oil could be used to smooth out 'peak oil' and ease the transition to a post-oil economy"

Option two won't happen by default. It will require a massive new push for alternatives to fossil fuels. We already know what we need: renewable electricity, a revamped grid and a network of charging stations to power the next generation of electric cars. That's the bare minimum. In all likelihood, we'll need carbon capture and storage, too, to mop up the emissions from that dirty unconventional oil.

All of this costs money – but the source is staring us in the face. Now, more than ever, we need a universal carbon tax which taxes fossil fuels at source according to how polluting they are. Vested interests don't like this idea, but let's not forget that oil companies turn vast profits: Exxon Mobil alone made \$45 billion in 2008. In a sane world, we would surely find a way to divert some of this money to solve the dilemma that oil itself has created. The question is, do we live in a sane world? ■

Nature is no guide to human morality

WHEN the documentary film *March of the Penguins* came out in 2005, some Christians tried to exploit it to promote a conservative social agenda. To them, the penguins' apparent monogamy and selfless parenting affirmed the rightness of traditional family values.

This is a logical error sometimes called the "naturalistic fallacy": you cannot draw inferences about what is right from what happens in nature. Penguin behaviour tells you nothing about human morality.

The same applies to same-sex sexual behaviour in animals (see page 48). It might be tempting to use animal examples to refute claims that homosexuality is unnatural and therefore wrong. That would be a mistake. We have no need for fallacious arguments to support basic human rights. ■

Writ small, huge recall

FIFTY years ago this month, the physicist Richard Feynman wondered when we would be able to write the *Encyclopaedia Britannica* on a pinhead. Soon, probably, thanks to terabyte chips (see page 40). Today, an encyclopaedia writ small won't be high on most people's wish list, but even mp3 addicts might struggle to fill a chip that has room for hundreds of thousands of songs. If history is anything to go by, it won't be hard to find new uses for supermemories. Why not pocket your entire movie collection for starters? ■

What's hot on NewScientist.com

GALLERY The world's fastest computers

See the five machines that top the latest ranking of the planet's most powerful supercomputers. Up to a trillion times more power than a pocket calculator, they are used to simulate everything from nuclear blasts to earthquakes

VIDEO Our latest podcast

See how videoconferences could go 3D, explore human interactions with animals and zoom in on an ultra-realistic 3D map

TECHNOLOGY The future of social networking

Founders and inventors of the world's leading online social networks met recently to discuss the future of their services, which have changed the web. Opinions aired included a suggestion that social networks will replace email as the dominant form of e-communication

INTERVIEW Steven Laureys: How I know 'coma man' is conscious

The physician who diagnosed Rom Houben as conscious after 20 years

as a coma patient has no time for those who doubt Houben's abilities

BLOG Fresh claim for fossil life in Mars rock

It is arguably the most scrutinised piece of rock in history. Now an even closer look at a meteorite from Mars suggests it may show traces of life after all

SLEEP SCIENCE How to turn ZZZs into memory

From playing sounds to sniffing roses to dreaming of computer games, we are learning

how to optimise sleep for better learning and memory. Before you nod off, check our guide to getting the most from your shut-eye

GALLERY From antibubbles to magma ketchup

The best experimental images shown at the Division of Fluid Dynamics meeting

If you would like to comment online about any of the articles in this issue, please do so by visiting the article at newscientist.com



I will if you will

Emissions pledges will still bust the 2 °C limit

SOMETIMES politicians do deliver on their promises – and so it was with US and Chinese presidents Barack Obama and Hu Jintao last week, when they both put numbers to their pledges to cut their nations' carbon footprints. Unfortunately, the latest modelling exercises suggest these cuts will not be enough to head off dangerous climate change. Europe may have to take up the slack.

Just two weeks ago, there were widespread fears that the Copenhagen climate conference, which kicks off next week, would fail. The Danish prime minister, who is hosting the talks, pleaded that the negotiators should at the very least offer quantitative promises to cut their countries' emissions.

The leaders of the US and China have now done so. On 26 November, Obama said the US would cut emissions by 17 per cent from 2005 levels by 2020 and by 83 per cent by

2050. The following day China – which has long insisted it would not budge until the US did – pledged to cut the amount of carbon it releases per unit of GDP to 40 to 45 per cent below 2005 levels by 2020.

With pledges from most major emitters now on the table, the

"The impact of the recession on Europe has given it space for far more ambitious targets for 2020"

question is: will they be enough to limit the increase in global temperatures to 2 °C? Many scientists predict that warming beyond this level will result in severe, and sometimes irreversible, environmental changes.

The indications are not promising. The pledges made so far translate into around 3 °C warming by 2100, an international team of climate modellers told *New Scientist*.

Domestic politics in both China and the US make it difficult for either country's government to commit to bigger cuts. Republicans in the US Congress have said that they will fight hard to defeat emissions cuts. This makes it uncertain whether Obama will be able to deliver even on the pledge he will take to Copenhagen.

Chinese leaders are reluctant to commit to bigger emission savings for fear that this would slow the country's recent rapid increase in living standards.

These obstacles have led some climate campaigners to turn their attention to Europe, which has committed to a 20 per cent cut from 1990 levels by 2020. "The impact of the recession now means that the European Union's 2020 goal is so unambitious that Europe would need to deliberately slow its reductions not to meet it," says Joss Garman, a climate campaigner with Greenpeace UK. "There's a huge space for increased ambition that would move the world closer to what the science says is necessary."

Beware pirates

WRAPPED in barbed wire and blanket CCTV coverage is not how most scientists go about their business. But that's how the South African research ship FRS Algoa plans to brave the pirate-infested waters of the Indian Ocean.

Even with such precautions, its mission – to deploy a network of 10 climate-monitoring buoys as part of a monsoon early-

"Concerns over possible raids by Somali pirates will stop the Algoa deploying more than half its buoys"

warning system – seems to have been scuppered from the outset.

Although it will have an armed escort, concerns over possible raids by pirates from Somalia will prevent it from deploying more than half of its buoys.

The buoys are intended as part of a larger network set up by the US National Oceanic and Atmospheric Administration to observe and predict seasonal risks of floods and drought induced by monsoons, says NOAA oceanographer Michael McPhaden. "If we are missing part of the basin, that will reduce our ability to advise countries on how to prepare for impending seasonal disasters," he says.

Nuclear censure

YOU'D think it would be the one thing nuclear companies want to be sure about: that their reactors can withstand freak weather or a plane crash.

Yet US firm Westinghouse has so far failed to convince regulators that its AP1000 reactors can withstand such events. "At this stage Westinghouse has not presented an adequate safety case for external hazards," concluded the UK's Health and Safety Executive (HSE) last week. This echoes comments from the US Nuclear Regulatory Commission

in October, which said the firm must rethink the "fundamental engineering standards" of the reactor housing. The US plans to build 14 AP1000s; China four.

For its nuclear programme, the UK is considering the AP1000 and the European pressurised water reactor (EPR), developed by Areva and EDF. The EPR is the front runner, but its design was also criticised by the HSE.

Kevin Allars of the HSE adds that neither reactor is unsafe and that the criticisms are a normal part of the regulatory process. The nuclear companies say they are addressing the problems.

New HIV advice

GOOD news on the HIV front. The World Health Organization now advises giving antiretroviral therapy (ART) to people with HIV earlier in the infection cycle, which should slow progression of the disease in individuals and also put a brake on its spread.

The WHO previously advised starting ART only when levels of the CD4 immune cells attacked by HIV dip below 200 per cubic millimetre of blood, which is typically when symptoms appear. But recent studies have shown that people survive for longer if

treated earlier, and that they are less likely to pass on the virus.

Now the WHO has adopted the higher CD4 threshold of 350 cells. This will have its biggest impact in poorer countries served by the WHO's HIV treatment programme.

"People who are treated early survive for longer and are less likely to pass on the virus"

The WHO also changed advice to breastfeeding women with HIV. It now recommends ART for them due to evidence that this helps stop transmission of HIV to the infant.

Collider smashes energy record

2028 GMT, 29 November 2009. That's when the Large Hadron Collider became the highest-energy particle accelerator ever.

Researchers at CERN accelerated a beam of protons in the LHC to energies of 1.05 teraelectronvolts (TeV), breaking the previous record of 0.98 TeV held by the Tevatron accelerator at Fermilab in Batavia, Illinois. "Everything is going much faster than even the most optimistic of us dreamed," says Steve Myers, director for research and technology.

Within hours of snatching the title, both the LHC's beams, one travelling clockwise and the other counter-clockwise, were accelerated to still higher energies of 1.18 TeV. The beams will have collided, although

no data was collected as the detectors weren't switched on.

CERN plans to run the LHC at 1.18 TeV until 17 December in order to get the first set of data from the detectors, says Myers. Then it will shut down for a two-week break.

Engineers are also testing the "beam dump" mechanism, an emergency break for a beam that can no longer be controlled by the LHC's superconducting magnets. In such a situation, each beam would be steered into a tunnel where it would crash into a 7-metre-long block of composite graphite lined with stainless steel and concrete. Each block is designed to absorb 7 TeV - the expected energy per beam when the LHC is running at full tilt.

Treat autism early

TODDLERS with symptoms of autism can show dramatic improvement if they are given early, intensive therapy. The finding, from the first randomised controlled trial in such young children, should settle the question of whether early screening and treatment of autism are worthwhile.

Sally Rogers, a psychologist at the Mind Institute of the University of California, Davis, and colleagues randomly assigned autistic toddlers aged 18 to 30 months to receive either conventional care or an intensive programme of behavioural therapy known as the Early Start Denver Model. This emphasises fun, child-directed activities rather than the repetitive exercises used in conventional autism therapies.

After two years, the 24 children in the ESDM programme achieved higher scores in IQ tests and in several measures of language use and social interaction than the children given conventional care. Psychologists who had not encountered the children before the treatment considered that seven of them no longer met the diagnostic criteria for autism, as compared with just one of the 21 given conventional care (*Pediatrics*, DOI: 10.1542/peds.2009.0958).

60 SECONDS

Smallest flower

You'd have to be a very light-fingered thief to steal this orchid. Discovered hidden in the roots of a larger plant in Cerro Candelaria nature reserve in the eastern Andes, Ecuador, *Platystele* is the world's smallest orchid. The flower is 2.1 millimetres wide and has transparent petals a mere one cell thick.

Black hole at work

A supermassive black hole has been spied forging its future home. The black hole is spewing out a stream of energetic particles and gas that is forming stars in a neighbouring galaxy. The two will eventually merge. The finding hints that such black holes are born before their host galaxies (*Astronomy and Astrophysics*, vol 507, p 1359)

How Jane Austen died

Jane Austen has long been thought to have died of Addison's disease, which disrupts the adrenal gland. But Katherine White of the Addison's Disease Self-Help Group in the UK disagrees. Addison's causes confusion, but Austen wrote that she had a "clear head" and dictated comic verse before she died. Instead, she died of tuberculosis, says White (*BMJ*, DOI: 10.1136/jmh.2009.001453).

Sweet panda music

If you're a giant panda looking to get jiggy it helps to say so. Female pandas make different noises when fertile, researchers have shown in playback experiments. Males were twice as likely to approach and loiter near a speaker playing fertile rather than "pre-fertile" chirps (*Proceedings of the Royal Society B*, DOI: 10.1098/rspb.2009.1431).

Contagious loner

You may feel you have none, but you can still pass loneliness on to your friends - and their friends, say Nicholas Kristakis of Harvard University and colleagues. They used surveys of Massachusetts residents to trace loneliness in social networks.



Beam comes true

Your vaccine might not work for me

CHILDREN whose genetic make-up means they may not be protected by the standard form of a vaccine could in future be given a personalised shot. This is the prospect raised by the discovery of gene variants that seem to predict whether an individual will produce enough antibodies in response to a vaccine to protect them against disease.

Vaccines expose the immune system to a deactivated version of a disease agent. This prompts the production of specific antibodies, which will bind to the real disease-causing agent if the vaccinated person is later exposed to it. Though all of us usually get the same vaccines in the same doses, not everyone produces enough disease-specific antibodies in response. As a result, between 5 and 20 per cent of people vaccinated against hepatitis B, and between 2 and 10 per cent of those vaccinated against measles, will not be protected if they ever encounter these viruses.

Various factors determine who goes unprotected, but it is clear that

produce antibodies and recruit infection-fighting cells.

Yucesoy's team analysed the DNA of 141 healthy babies aged between 11.5 and 14 months, searching for variations in 11 cytokine genes. They then gave the babies routine vaccines for hepatitis B and pneumococcus and a standard diphtheria-tetanus-whooping cough combination vaccine, and measured the levels of antibodies in their blood.

When the team analysed their results, they found single-letter variations in seven of the cytokine genes that were more common in infants who produced low levels of antibodies in response to certain vaccines. Most variants were associated with antibodies to just one disease, although in one case, the same variant was associated with fewer antibodies to tetanus and more to pneumococcus (*Vaccine*, DOI: 10.1016/j.vaccine.2009.09.076).

The researchers still have to confirm their results in a larger population of children, and to demonstrate that these gene variants translate into a lack of disease protection. But if the results stand up, infants' genes could be routinely screened for these variants before vaccination. If a child has some of the variants, the missing cytokines could be added to the vaccine formulation. Another option would be to add immune stimulants or give a higher dose of vaccine, to increase the response from the intact cytokine genes.

"Although the findings of the paper need confirming, it is possible that, in future, knowledge of an individual's genetic background might allow doctors to use vaccinations especially designed to get the optimum response for someone with that particular genetic background," says Hilary Longhurst, an immunologist at St Bartholomew's Hospital in London. **Charlotte King** ■

"An individual's genes might allow doctors to design vaccines that get the optimum response"

genes play a major role. Finding out which gene variants lead to an abnormally weak vaccine response could allow people with these variants to be given alternative immunisations. These might take the form of higher doses of the standard vaccine, or a modified version of it.

To work out which genes help determine the immune response to common childhood vaccines, Berran Yucesoy of the US National Institute for Occupational Safety and Health in Morgantown, West Virginia, and her colleagues focused on genes that code for cytokines. These cell-signalling molecules help to



PATRICK ALLARD/REA

Time for your personalised shot



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INSIGHT

Fresh doubts emerge over DNA evidence in high-profile Italian murder trial

ON THE eve of the verdict of the high-profile trial in Perugia, Italy, in which Amanda Knox and Raffaele Sollecito are charged with the murder of British student Meredith Kercher, DNA evidence brought by the prosecution is being questioned by nine US specialists in DNA forensics.

The trial is in its final stages, with a verdict expected on 7 December. Knox and Sollecito are pleading not guilty. In an open letter, the US specialists outline their concerns with two pieces of DNA evidence that are central to the case against Knox and Sollecito. The defence has already suggested that the amount of DNA allegedly linking the pair to the crime is too small to be definitive. The letter raises the possibility that this DNA was introduced through contamination of the evidence and concludes that the DNA test results "could have been obtained even if no crime had occurred".

Two years ago, Kercher was found dead, with cuts to her throat, in the accommodation she shared with Knox in Perugia. Although a third suspect, Rudy Guede, has been convicted of her murder, the prosecution claims that Knox and Sollecito helped. The case against them largely hinges on two pieces of DNA evidence. One is

from a knife recovered from the kitchen drawer at Sollecito's apartment. The other comes from a portion of a clasp that was cut away from the bra Kercher was wearing. The forensic specialists question both.

In respect of the knife, the letter says contamination from other DNA present in the lab that did the analysis cannot be ruled out. The initial method used was standard: the DNA was amplified, then analysed using electrophoresis. This generates a graph consisting of a series of peaks, whose heights represent how

much of certain DNA snippets are present. Taken together the peaks create a DNA "fingerprint" unique to an individual.

The lab says that DNA taken from the knife's blade produced a series of peaks that matched Kercher's DNA, while DNA from the handle produced peaks that matched Knox's.

To minimise the risk that some peaks arise from contamination, most US labs only count peaks above a height threshold of 150 relative fluorescence units (RFUs) and all dismiss those below 50. The trouble with the DNA found on the knife is that "most of the peaks are below 50", says Greg Hampikian of Boise State University in Idaho, who signed the letter and reviewed the DNA evidence.

When this happens, samples can be rerun, but this doesn't appear to

have been done in the Knox and Sollecito case. This means contamination cannot be ruled out, the open letter claims. The same lab may also have been running DNA profiles from other evidence in the case at the same time, it says, and tiny amounts of this could have contaminated the knife samples.

What's more, a sensitive chemical test for blood on the knife was negative, and it is unlikely that all chemically detectable traces of blood could be removed from the knife while retaining sufficient cells to produce a DNA profile. "No credible scientific evidence has been presented to associate this kitchen knife with the murder of Meredith Kercher," the letter concludes.

Evidence from the clasp is equally inconclusive, according to the letter. What looks like a mixture of different people's DNA was found on it, and Sollecito could not be excluded. However, because Sollecito had visited the women's home several times before the murder, his DNA could have made its way onto the clasp "through several innocent means", the letter says. Neither Sollecito's nor Knox's DNA was found on the remainder of the bra, other items of Kercher's clothing, objects collected from Kercher's room, or in samples from her body. Guede's DNA was found everywhere, the letter points out. **Linda Geddes ■**



ALESSANDRO BIANCHI / REUTERS

Watery niche may foster Martian life

Could snow on Mars harbour life? Perhaps, thanks to a form of greenhouse effect that creates liquid water beneath an icy crust.

As far as anyone can tell, liquid water is rare on Mars. At the equator, temperatures can rise above freezing, but any snow or ice that melts would quickly evaporate due to the low atmospheric pressure.

Near the poles, water is abundant but permanently frozen.

New calculations by Diedrich Möhlmann of the German Aerospace Center in Berlin suggest that these frozen deposits could contain liquid water, at least during the day. According to Möhlmann, the heat from sunlight penetrating into ice or snow should get absorbed by any embedded dust grains, warming the dust and the surrounding ice. This heat mostly gets trapped because ice absorbs infrared radiation.

This effect melts the interior of ice and snow deposits in Antarctica, and

so may do the same on Mars, an idea first proposed by Gary Clow of the US Geological Survey in 1987. But Clow assumed the liquid water would form within porous snow. On Mars, such water would still be subject to the low pressure of the atmosphere and so prone to evaporation.

Möhlmann's calculations assumed an impermeable upper crust of solid ice, which would form as water

"Martian snow might melt in a zone that begins a few centimetres below the icy surface"

vapour diffused into pores and refroze. Such a seal would prevent evaporation and trap heat more effectively inside a snow bank, causing it to start melting in a zone that begins a few centimetres below the icy surface and extends a further 10 metres down, he says (*Icarus*, DOI: 10.1016/j.icarus.2009.11.013).

Phil Christensen of Arizona State University in Tempe says the idea has merit. "If I was going to search for life on Mars I would certainly include landing and looking at some of these potential snow deposits," he says. **David Shiga ■**

Rays pierce foggy fabric of universe

Rachel Courtland

THE universe is far more transparent at high energies than we thought. This discovery – based on sightings of unexpectedly bright objects that should be too far away to see so clearly – may call into question our understanding of how galaxies are born and evolve.

Most light travels through the cosmos unimpeded. But photons with very high energies of more than 100 gigaelectronvolts can collide with intergalactic infrared light. The longer these photons have to travel, the greater their chances of colliding and the less likely they are to reach Earth. As a result, distant blazars – galaxies with gluttonous black holes at their centres whose flares are pointing directly at Earth – are supposed to be much dimmer at higher energies than those that are not so far off.

Based on estimates of the amount of infrared light pervading the universe, blazars more than a billion years old were

expected to be mostly invisible to telescopes looking for very high-energy gamma rays, says astrophysicist Simon Swordy of the University of Chicago.

But in 2006, the HESS telescope in Namibia reported the discovery of two unexpectedly bright blazars that are more than 2 billion years old. What's more, bright light from a blazar called 3C279, spotted one night in

"The universe is more transparent than expected, questioning what we know of galaxy formation"

2007 by the MAGIC telescope on La Palma in Spain's Canary Islands, survived some 5 billion years of travel. "We can see significantly further than we thought we could," says Swordy.

The mystery grew last month, when the VERITAS telescope in southern Arizona, following up on observations made by NASA's orbiting FERMI telescope, reported the discovery of yet

another blazar that glows unusually brightly with very high-energy gamma rays. The new source, named 1ES 0502+675, is 4 billion years old. While it is not as distant as the one discovered by MAGIC, it could provide more useful information as it is bright, sits at a well-established distance and has been observed steadily for more than a month.

These blazars suggest that the amount of infrared light between galaxies must be quite low. This infrared background is light left over from star formation processes that occur early in the life of galaxies. We can estimate the background by counting galaxies in deep space, but now astrophysicists are beginning to question these estimates. "The amount of infrared is really right at the minimum you would expect from what we know about star formation and evolution," says Rene Ong of the University of California, Los Angeles, and spokesperson for VERITAS. "It's becoming a problem."

Continued observation of 1ES 0502+675 could help solve the puzzle. "This source could produce better and more reliable constraints on the extragalactic background than any source that has come before," says Ong. ■

SOUNDBITES

"It is possible that climate science has become too partisan, too centralised."

Climate researcher **Mike Hulme** at the University of East Anglia, UK, responds to the leaking of emails from UEA last month with the suggestion that the Intergovernmental Panel on Climate Change may have outlived its purpose (Dot Earth blog, 27 November)

"What we have at the moment is rather like wasted muscle tissue."

Mark Post of Eindhoven University of Technology, the Netherlands, on his team's attempt to make "artificial meat" from pig cells (*The Sydney Morning Herald*, Australia, 1 December)

"If this project was offered in any state in the US, they wouldn't allow it."

Roberto Cintron, a resident of Guayama in Puerto Rico, protests against plans by a local firm to breed thousands of macaque monkeys to sell for scientific research. The island is already plagued by patas monkeys descended from lab escapees (Associated Press, 30 November)

"We had no intention of building many facilities, but apparently the west doesn't want to understand Iran's peaceful message."

Iran's nuclear chief **Ali Akbar Salehi** says the country was provoked into its plans for 10 new uranium enrichment plants after the UN demanded it stop work on a plant it revealed in September (BBC Online, 30 November)

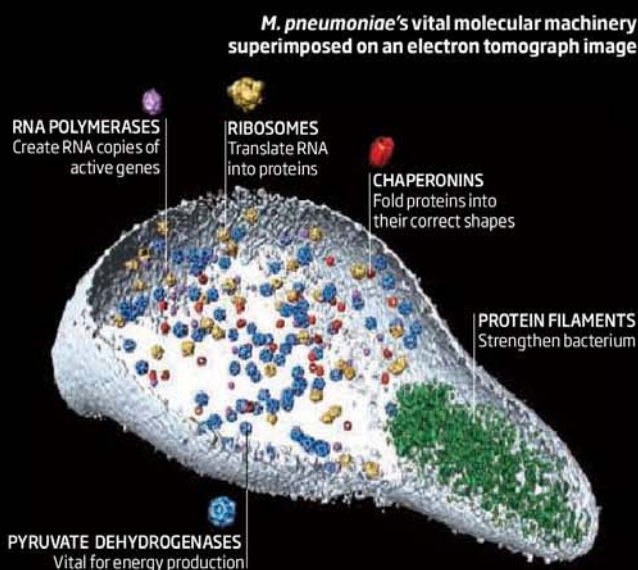
"A lot of people think of this as a tax on rich Republican housewives. That's not the case."

A 5 per cent "bo-tax" on cosmetic surgery being debated in the US Senate as part of the healthcare bill would penalise those on average incomes, says plastic surgeon

Phil Haeck (*The New York Times*, 29 November)

A 'simple' bug springs complex surprise

A HUMBLE bacterium has challenged our ideas about how genes operate. *Mycoplasma pneumoniae* has just 689 genes, but it gets by with only eight "transcription factors" or protein switches – compared with *E. coli*'s 50. This suggests that its limited number of proteins interact in complex, unknown ways to influence gene activity. The team behind the analysis also produced the first image of a bacterium's "molecular motors" (right). **Andy Coghlan** ■



SOURCE: PLoS ONE/SCIENCE. DOI:10.1371/journal.pone.0176343



Dear God, please confirm what I already believe

GOD may have created man in his image, but it seems we return the favour. Christians subconsciously endow God with their own beliefs on controversial issues.

"Intuiting God's beliefs on important issues may not produce an independent guide, but may instead serve as an echo chamber to validate and justify one's own beliefs," writes a team led by Nicholas Epley of the University of Chicago in *Proceedings of the National Academy of Sciences* (DOI: 10.1073/pnas.0908374106).

The researchers started by asking Christian volunteers to give their own views on controversial topics, such as

abortion, followed by what they thought were the views of God, average Americans and public figures such as Bill Gates. Volunteers' own beliefs corresponded the most with those they attributed to God.

Next, the team asked another group of volunteers to undertake tasks designed to soften their existing views, such as preparing speeches on the death penalty in which they had to take the opposite view to their own. They found that this led to shifts in the beliefs attributed to God, but not in those attributed to other people.

Finally, the team used functional MRI scans of subjects' brains to show that contemplating God's beliefs activates the same brain areas as thinking about one's own views, while thoughts about other Americans' views activate a brain area used for inferring other people's mental states.

French immigrants founded British farms

THE British may owe the French more than they care to admit. Archaeological finds from Britain show that farming was introduced 6000 years ago by immigrants from France, and that the ancient Brits might have continued as hunter-gatherers had it not been for innovations introduced by the Gallic newcomers.

Mark Collard, from Simon Fraser University in British Columbia,

Canada, and his colleagues studied carbon-14 dates for ancient bones, wood and cereal grains from locations across Great Britain. From this they were able to assess how population density changed with time, indicating that around 6000 years ago the population quadrupled in just 400 years (*Journal of Archaeological Science*, DOI: 10.1016/j.jas.2009.11.016). This

coincides with the emergence of farming in Britain.

Such a population explosion almost rules out the idea that farming was adopted independently by indigenous hunter-gatherers, says Collard. Pottery remains and tomb types suggest the first immigrants came from Brittany in north-west France to southern England, followed around 100 years later by a second wave from north-eastern France who settled in Scotland.

Who knew stars came this big?

A SUPERNOVA that burst onto the cosmic scene in April 2007 was probably the death throes of the most massive star yet discovered.

So say Avishay Gal-Yam of the Weizmann Institute of Science in Rehovot, Israel, and his colleagues, who followed the afterglow of the explosion in a nearby dwarf galaxy over 18 months (*Nature*, DOI: 10.1038/nature08579).

Their observations point to the explosion of a hypergiant star with a mass 200 times that of the sun. That would blow apart the idea that stars bigger than about 150 solar masses do not exist in our mature universe.

Gal-Yam thinks the conditions in the host galaxy could be like those in the early universe, when theory says such giant stars were born and died in great numbers, seeding the universe with heavy elements. "These galaxies could be fossil labs to teach us about the first stars," he says.

Unravelling secrets of giant black holes

IT WOULD be like watching a supermassive black hole in "fast forward". Studying the gamma-ray source Cygnus X-3 could reveal how these objects evolve.

Cygnus X-3 is thought to be the remnant of a star in our galaxy – either a black hole or a neutron star – feeding on a disc of material. Now two sets of observations have shown that it is emitting high-energy gamma rays. Supermassive black holes do the same, and if similar processes are behind the bursts, watching Cygnus X-3 could tell us how they develop as they gobble up matter from their surroundings. Cygnus X-3 is smaller, and so will evolve faster (*Science*, DOI: 10.1126/science.1182174; *Nature*, DOI: 10.1038/nature08578).

Trapped rainbow has a golden lining

OH, TO catch a rainbow. Well, it has been done for the first time ever.

In theory, light can be split into its constituent wavelengths inside a tapering waveguide – a structure that guides light waves down its length. As the waveguide thins, the components of the light are made to stop in turn at ever narrower points. That's because any given component of the light cannot pass through an opening smaller than its wavelength. This leads to a "trapped rainbow".

Vera Smolyaninova of Towson University in Baltimore, Maryland, and colleagues performed the feat using just a convex lens and a plate of glass. They coated one side of a 4.5-millimetre-diameter lens with a gold film 30 nanometres thick, and laid the lens gold-side down on a flat glass slide also coated with gold film. Viewed side-on, the space between the curved lens and the flat slide was a layer of air that narrowed to zero thickness where the lens touched the slide – essentially a tapered waveguide.

When they shone a multi-wavelength laser beam at the open end of this waveguide, a trapped rainbow formed inside. This could be seen as a series of coloured rings when the lens was viewed from above with a microscope: the visible light leaked through the thin gold film (arxiv.org/abs/0911.4464).



Autism and schizophrenia could be polar opposites

AUTISM and schizophrenia may be two sides of the same coin, suggests a review of genetic data associated with the conditions. The finding could help design complementary treatments for the two disorders.

Though autism was originally described as a form of schizophrenia a century ago, evidence for a link has remained equivocal. One theory puts the conditions at opposite ends of a developmental spectrum.

To investigate, Bernard Crespi, an evolutionary biologist at

Simon Fraser University in Vancouver, Canada, and colleagues gathered data on all known genetic variants associated with each condition, then looked for patterns of co-occurrence.

The researchers found four regions in the genome which dramatically affect the risk of autism or schizophrenia. Called "copy-number variants", these are stretches of DNA with seemingly accidental duplications or deletions. Crespi's team found that the presence of a particular variant – a duplication, say – was

often associated with autism while the opposite variation – a deletion of the genetic material – was linked to schizophrenia (*Proceedings of the National Academy of Sciences*, DOI: [10.1073/pnas.0906080106](https://doi.org/10.1073/pnas.0906080106)).

The results fit with other evidence that autism may be caused by overdevelopment of specific brain regions and schizophrenia by underdevelopment, says Crespi.

If they are indeed opposites, work on one disorder may inform work on its counterpart, he says.

Did rich pickings create bird split?

THE friendly bird-feeder could be an evolutionary force to be reckoned with. British people who feed birds are contributing to the evolution of a whole new species of blackcap, new research suggests.

Martin Schaefer at the University of Freiburg in Germany and colleagues measured genetic variation between blackcaps in two German sites 800 kilometres apart just after the birds had returned from their winter grounds on the Iberian peninsula and in the UK.

To their surprise, the team found that blackcaps that spend winter in Spain share more genes with those that live 800 kilometres away but also overwinter in Spain than they do with blackcaps that live in the same forests but overwinter in the UK (*Current Biology*: DOI [10.1016/j.cub.2009.10.061](https://doi.org/10.1016/j.cub.2009.10.061)). This suggests that despite living side-by-side for half of the year, the birds no longer breed together.

"After world war two, the British started to put out far more food for the birds than they did before," Schaefer says. "As a result, those that accidentally migrated north thrived rather than being killed off, leading to the evolution of a whole new lineage."



You can swim but you can't hide

IT IS one of evolution's most eccentric creations: a head shaped like a hammer. Now, a study suggests that the hammerhead shark may have evolved its weird snout to boost its vision and hunting prowess.

Whether having eyes so far apart enhances the sharks' vision has been debated for over a century. Now their first eye examination has laid the debate to rest.

Michelle McComb of Florida Atlantic University in Boca Raton and colleagues implanted electrodes into the eyes of three species of hammerhead – the winghead, the

bonnethead and the scalloped hammerhead – and two other shark species to measure their field of vision. They found that the further apart the eyes were set, the better their binocular vision. Hammerheads therefore perceive depth better and can track fast-moving prey like squid more accurately than sharks with close-set eyes.

The team also found that all the sharks studied have a 360-degree view in the vertical plane, so they can simultaneously see prey above and below them (*Journal of Experimental Biology*, vol 212, p 4010).



Covered in solar panels

Solar plane spreads its wings

IT DOESN'T look like a flea, but the owners of this solar-powered aircraft hope it will mimic one next week.

Should it perform the gentle "flea hop" planned it will be the first crewed solar-powered aircraft to take off under its own power.

Runway tests planned as *New Scientist* went to press should have taken Solar Impulse, driven by four electric propellers and 400 kilograms of batteries, to a speed of 37 kilometres per hour, just shy of the 45 needed for it to take off. A flea hop is the next step.

It seats only one person, but Solar Impulse has a wingspan of more than 60 metres, comparable to a long-haul jet. Yet at just 1600 kilograms it weighs about as much as a midsize car.

The upper surfaces of the aircraft's wings and tailplane are covered in solar panels, intended to allow the craft to stay aloft for long periods by

charging its batteries while airborne.

"I hope the first solar-powered flights will take place in March or April of next year," says André Borschberg, who leads the project team and will pilot Solar Impulse once tests are complete.

"I hope the first solar-powered flights will take place in March or April of next year"

By 2011 he hopes to be flying the craft long-haul, with circumnavigation of the globe the ultimate goal.

The take-off trials are dependent on favourable weather, but it is the strength of the wind, not sunshine, that is critical. To ensure the most is made of good conditions, the batteries are being charged from the mains before each test.

Threat hidden in plain text

HACKERS could evade most existing antivirus protection by hiding malicious code within ordinary text, according to security researchers.

A common way of hijacking computers is to deliver malicious code to them and then run it. Current security works on the assumption that the code used has a different structure to plain text such as English prose.

To highlight the weakness and encourage the development of new security measures, Josh Mason of Johns Hopkins University in Baltimore, Maryland, developed a way to search a large set of English text for combinations of words that could be used in code. The program highlighted the text to be used in the instruction set in bold, while leaving the sections to be skipped in normal text.

26

Percentage of US teenagers who admit to writing text messages while driving, according to a Pew Internet survey

I'm sensitive to your touch, user

WHY are the latest touch-screen devices often larger than the push-button versions they replace? It has long been assumed the culprit is the "fat finger" problem of fingertips being too wide to hit closely packed targets.

It turns out the real reasons for touch-screen mishits are finger orientation and variation between users, according to Christian Holz and Patrick Baudisch at the Hasso Plattner Institute in Potsdam, Germany. More importantly, these errors can be corrected.

In tests, volunteers told to repeatedly touch screens at

specific angles registered distinct clusters of touch points. With different participants and an eight-camera rig to capture finger orientation in three dimensions, the precision of the touch interaction tripled.

The researchers then adapted a type of fingerprint scanner used at international borders to identify finger orientation without cameras. Their system – dubbed Ridgepad – finds the centre of the fingerprint for each screen touch, and compares it with a database to calculate orientation, giving twice normal accuracy. At present, however, the technology cannot be built into smartphones because its components are too big.



"Sometimes our search results can be offensive"

Explanation added by Google to results of image searches for "Michelle Obama", after complaints that the top result showed a racial slur. The offending image no longer appears in Google search results since the site hosting it has removed it from its web pages

The people vs the entertainment industry

Intrusive new laws are being laid down across the world to tackle digital piracy – and it's not just web users who are unhappy

Paul Marks

"THIS is the kind of snooping you'd expect in China, not a modern western democracy. It raises huge questions over privacy invasion and freedom of expression." So says Andrew Heaney – who is not, as you might imagine, a civil liberties campaigner, but a senior executive at TalkTalk, one of the UK's largest internet service providers. Along with other ISPs, his company faces the prospect of being forced to spy on its customers' downloads for signs of potential copyright infringement.

Heaney's disquiet is shared by web campaigners worldwide, as

the measures contained in a controversial international copyright treaty (*New Scientist*, 5 July 2008, p 24) are slowly being translated into national laws variously tipped to bridge, distract from or widen the gulf between the entertainment industry's desires and those of the millions who share copyrighted material over the internet.

The Anti-Counterfeiting Trade Agreement (ACTA), suggested by the US administration in 2007, aims to redefine global trade rules. The intention is to stem losses from counterfeiting and internet-mediated piracy of content like music and movies.

It will do that by penalising internet service providers and websites that carry, or help people to find, pirated content. ACTA has quickly proved a hit with G8 nations, the European Union, South Korea and Australia, who are all using it as a basis for future national laws.

ACTA is still being worked up in secret by trade delegations from the many nations involved. But a series of leaks to the Wikileaks website reveal that it will require ISPs to become technological sleuths who monitor their customers' internet use to "deter unauthorised storage and transmission of infringing content". Infringers will face a "graduated response", with disconnection as the ultimate sanction.

The Obama administration's plans to implement ACTA are still hidden in a thicket of non-disclosure agreements with

movie studios and record labels. The UK's Digital Economy Bill, unveiled in last month, is clearly inspired by ACTA.

The bill stipulates that people who share copyright-infringing content should receive two warnings by post, after which they will face punitive "technical measures". These may include having their internet connection filtered to block attempts to download copyrighted material, "throttled" to slow downloads to a crawl, or even cut off entirely. Spain, Ireland and France have similar plans.

ISPs are wary of being seen to invade customers' privacy by sifting through their personal data – and of the potential costs involved – though Nicholas Lansman, head of the European ISP Association, insists that they oppose illicit file sharing.

"Monitoring every single packet going across our network for the fingerprints of hundreds

"ISPs would have to scan every chunk of data with the sort of software now used by China and Iran"

of copyrighted files will require tens of millions of pounds' worth of computer systems," Heaney warns. Without that extra computing power, internet access will slow to a crawl.

ISPs would have to scan the contents of every chunk of data, using what is known as "deep packet inspection" technology, which is used by China and Iran to monitor and censor internet



MARKUS SCHRIEBER/AP PHOTOS

communications. But even if ISPs install such technology, identifying infringers will be far from straightforward. The EU has ruled that before anyone can be sent a warning letter, rights holders must take an ISP to court to get the name and address of an alleged culprit.

There is evidence that such threats will deter some people from illicitly sharing content (see "Copyright conundrum"). Others, though, will simply seek ways of carrying on regardless.

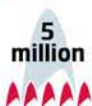
Freeloading on an unsuspecting neighbour's Wi-Fi connection is one option – and is possible even if the connection is secured. YouTube carries videos on how to use free software to "sniff" the passwords of protected connections. The ease with which people can "borrow" Wi-Fi in this way undermines the assumption that the owner of a connection can be blamed for everything downloaded by it. "The government knows there is a wireless hijacking risk but they

Copyright conundrum

Large numbers of people may be targeted by new strategies to protect copyright, but there is evidence the measures can work



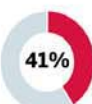
Proportion of US residential broadband traffic used by file-sharing programs



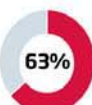
Number of illegal downloads of the latest *Star Trek* movie within the first four months after its cinema release



Proportion of UK internet users who use "unofficial" online sources of music (file sharing and websites)



Proportion of file-sharing users in a UK/US/France sample who would stop sharing if they received a warning letter



Proportion of file-sharing users in a UK/US/France sample who would stop sharing if threatened with disconnection

SOURCE: CADAVIDENS/PARAMOUNT/THE LEADING QUESTION



Public attitudes to file sharing will be crucial

haven't proposed a process by which people can be assumed innocent until proven guilty," says Heaney.

The mobile broadband connections provided via cellphones or computer USB sticks offer another loophole to the disconnected. Mobile providers do not assign IP addresses to users as fixed line providers do, so it's not possible to track file sharing to individuals.

These problems are exacerbated by changes in sharing technology. BitTorrent, the most popular file-sharing protocol, used to depend on central websites to host "trackers" – small files that tell software where to find particular files. The Pirate Bay site in Sweden was the most popular tracker host, but it recently shut down after a refinement to the BitTorrent protocol allowed tracking tasks to be shared out among users.

With the disappearance of tracker hosts, ACTA has lost one of its main targets, although rights

holders can still track alleged infringers, says Danny O'Brien of the Electronic Frontier Foundation in San Francisco. Investigators can join a network and spy on its users from the inside, he says.

Heaney notes that software used to record music from legitimate internet streaming services, and that can automatically label all tracks in a handy library, is impossible to detect. Meanwhile, O'Brien predicts offline sharing will become more common, as ultra-high-capacity hard drives get cheaper. By this time next year a terabyte of storage – enough for more than 1000 movies – is expected to cost as little as \$50.

Public attitudes and the nature of digital information mean that large numbers of people will continue to breach copyright, O'Brien says. "The fact they can do it so casually is a side-effect of how easy it is to copy digital data, and how difficult it is to stop that. That ease of copying isn't going to go away." ■

Take control of your personal office environment

WE'RE used to taking command of our personal climate in planes and cars by using simple controls. Why not in buildings too?

A study of the effect of installing individual air-conditioning vents at office desks, and putting controls at each worker's fingertips, suggests it can cut a building's energy use in half.

The approach costs more to install than a conventional system, and has never taken off commercially. But engineer Stefano Schiavon and colleagues at the University of California, Berkeley, say their research shows the idea is worth revisiting, as companies and countries seek to cut emissions.

They simulated an office building in a hot, humid climate like that of Singapore, where air conditioning is relied on throughout the year. Results showed the building's energy use was cut by 50 per cent.

Personalised ventilation means less air needs to be cooled and pumped through a building because air needs only to be blown at desks, and not throughout entire rooms. Individual vents can also switch off automatically when a desk is vacant.

The result is that a room's temperature can increase while keeping people comfortable at work.

Raising a building's temperature

even a little can save large amounts of energy. The Japanese government is campaigning to convince offices to discourage suits and ties, to allow office thermostats to be turned up slightly and save power.

"In an environment like Singapore, it's pretty clear that these systems would pay for themselves in energy savings," Schiavon says.

Air conditioning is a major driver of south-east Asia's electricity use, and accounts for the bulk of electricity used by buildings in Singapore.

Past research has shown personal ventilation can also make people more comfortable, and hinted it can limit the spread of airborne diseases.

The personalised approach isn't always suitable, though. Only workplaces where people tend

"In Singapore it's pretty clear that these systems would pay for themselves in energy savings"

to stay in one place would benefit, points out environmental engineer Peter Nielsen of Aalborg University in Denmark. Savings are also smaller in cooler climates, where on cold days the number of people directing warm air onto themselves causes the room to overheat. Mason Inman ■



Devouring electricity

Dual-use modems will let users own a piece of the internet

STORING internet data in users' homes could save energy equivalent to the output of five large power plants in the US alone.

When you watch a video online it streams to your computer from a distant data centre, likely a giant warehouse full of servers. But if a new proposal is implemented, some data would reside on the modems of domestic broadband users. Press play and your video would come from the homes of other people in your city.

Vytautas Valancius at the Georgia Institute of Technology in Atlanta worked with Spanish telecoms firm Telefonica and modem manufacturer Thomson on this "Nano Data" project to cut

the inefficient way even state-of-the-art data centres use energy.

Data centres consume much the same energy regardless of how hard they are working, since idle servers can use up to 80 per cent of their maximum power. In 2007, US data centres used almost as much energy as 6 million homes.

Modems under the new system would have split personalities. One part provides internet access as usual, another acts as a scaled-down data centre controlled by the network operator. That half would download and store web data without affecting the owner's connection. When someone tries to access a website, their computer may be directed to download it



Your friendly neighbourhood web

from a nearby user's device.

Because home modems are typically left on all day and do not need cooling, energy use can be cut by up to 60 per cent, Valancius's simulations suggest. Christophe Diot, chief scientist at Thomson, says prototype Nano Data devices are being built and will be ready

for deployment in two years.

"This has significant potential," says Sergiu Nedevschi, a computer scientist at the University of California, Berkeley, but he notes that data centres will still be needed for busy periods and to provide rarely requested data. **Jim Giles** ■

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Seawater plus fresh water equals non-stop electricity

THE world's first prototype osmotic power station came on stream last week. Sited on the banks of the Oslo fjord at Tofte in southern Norway, it generates electricity by exploiting the process that keeps plants standing upright and the cells of our own bodies swollen, rigid and hydrated.

Osmosis occurs wherever two solutions of different concentrations meet at a semipermeable membrane. The spontaneous passage of water through the membrane from dilute to concentrated solutions generates a pressure difference. This can be used to drive a turbine and generate electricity.

"The potential is huge," Terje Riis-Johansen, the Norwegian minister for petroleum and energy, said at the new plant's opening ceremony.

Statkraft, the renewable energy giant running the project, estimates the global potential of osmotic power to be around 1700-terawatt-hours per year - about 10 per cent of the world's current electricity consumption.

The two solutions used at the Tofte plant are fresh and salt water extracted from the area where water from the fjord flows into the sea. Discounting the power used to pump the water into the facility, the prototype is able to produce just 4 kilowatts - enough to keep two or three kettles boiling.

Scaling up the technology could prove difficult. Some major problems

"Many of the world's major cities are on estuaries that could be ideal for osmotic power generation"

remain unsolved, including the long-term effect of silt and bacteria on the membrane's performance.

Many of the world's major cities are on estuaries that could be ideal for osmotic power generation if these problems can be overcome. And unlike wind and solar power, it offers a continuous source of electricity. **Richard Webb** ■

Computers rule OK

The microprocessor has been voted the greatest discovery. Rightly so, says **Federico Faggin**

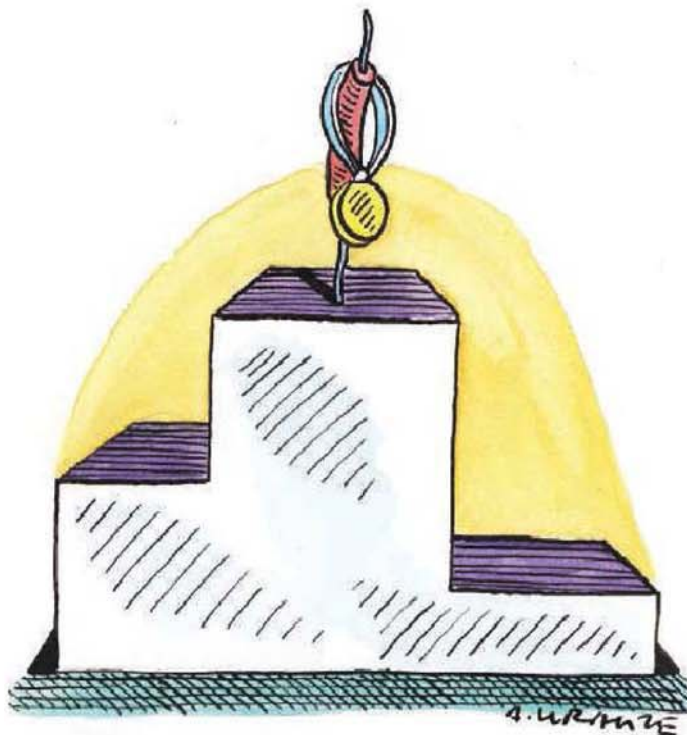
TWO inventions have shaped our modern world more than any other: the engine and the computer. Where the engine captured and extended the human capacity to do physical work, the computer did the same for the capacity of the human brain to think, organise and control. This power has now pervaded not just homes and offices but also tens of thousands of products where it once didn't seem to fit, thanks to a small and beautiful device called the microprocessor.

Early computers were huge machines constructed from heterogeneous technologies and were very costly and wasteful of energy. Fifty years ago, a computer was an end in itself – it was inconceivable to put a computer inside, say, a toy or an electric toothbrush.

Semiconductor technology changed all that. Semiconductors made it possible to shrink computing components down

to previously unimaginable sizes, enabling the invention of the microprocessor. This extended the idea of what a computer could be and provided a conceptual framework for delivering the immense power of computing technology into practical components that could be manufactured in volume, and therefore at low cost.

The microprocessor led naturally to the microcontroller, an entire computer on a single integrated circuit: very small,



THE GREATEST DISCOVERY OF THE PAST 50 YEARS

We invited computing pioneer Federico Faggin to write this piece to celebrate the microprocessor's victory in a poll to find the discovery that has had the greatest impact on the world in the past 50 years.

To mark the launch of the website ImpactWorld! we teamed up with the Engineering and Physical Sciences Research Council (EPSRC), one of the

UK government's main science funding agencies. The EPSRC came up with a list of 10 discoveries and nominated an eminent scientist to make the case for each one.

The discoveries were: the mobile phone; space exploration; magnetic resonance imaging; the World Wide Web; the global optical fibre network; error-correcting codes; lasers; public

key encryption; green chemistry; and the microprocessor.

The microprocessor won hands down with 48 per cent of the vote, followed by the World Wide Web (31 per cent). Everything else was languishing in single figures. For the nominations and poll results, visit newscientist.com/special/big-impact.

Too much information

We must not squander the riches left over from the big bang, says **Stuart Clark**

COSMOLOGISTS are doing the happy dance. The European Space Agency's Planck mission is busy surveying the cosmic microwave background, aka the "echo" of the big bang, and in 2013 will release a feast of data that promises to deliver profound new insights into the origin of the universe.

Surely a victory for science?

Only, it seems, if cosmologists can resist the temptation to gorge themselves on all those goodies.

A trio of astronomers have warned that, unless we use the information sparingly, we risk squandering a once-in-eternity opportunity (see arxiv.org/abs/0909.2649). If the whole data set is released at once, as is

planned, any new ideas that cosmologists come up with may have to remain untested because they will have no further data to test them with.

This is a problem unique to cosmology. In other sciences, additional information is always available: you can always reset and rerun an experiment, or go out into the field to collect more data. Because of our fixed location in the universe, however, cosmology doesn't have that luxury. There is only a finite amount of information we can gather about the universe, and once we gather all there is to know about one aspect of it – in this

case the temperature fluctuations in the cosmic microwave background – the well runs dry.

In 2005, astronomers discovered a mysterious alignment of hot and cold spots in the CMB, which they dubbed the "axis of evil". If the phenomenon is real, it has important implications for our understanding of the universe. The Planck data will be used to test it. But imagine if cosmologists find another, similar, mystery buried in the data. What will they

"There is only a finite amount of information we can gather about the universe"

inexpensive and energy efficient. Today there is no industry and no human endeavour that hasn't been touched by microprocessors or microcontrollers.

Microprocessors and semiconductor technology are co-evolving, one feeding the other in a cycle of growth limited only

"The microprocessor is arguably the greatest of all the machines created in our image"

by the "food" supply – the ability to make ever smaller transistors. This process is not only delivering ever smaller, faster and cheaper microprocessors, but also adding capabilities such as sensors and motors. We can now routinely make digital video and still cameras smaller than a grain of rice, optics included, costing less than a dollar. As time goes on, we will be able to mass-produce ever more complex and complete systems.

We are fascinated with creating machines built in our image. The microprocessor is arguably the greatest of them all. ■

Federico Faggin was part of the team that developed the Intel 4004, the world's first commercial microprocessor, released in 1971

use to test that one?

The answer, according to Roberto Trotta of Imperial College London, is to be frugal with what you let the cosmologists see. Instead of giving out all the data at once, the supply should be rationed. Drip-feeding will allow the development of new hypotheses which can be tested as more of the Planck information is released. If we don't adopt this approach, we risk wasting the finest cosmology data set we have ever had, and remaining forever in the dark. ■

Stuart Clark is the author of *Galaxy and Deep Space*, both published by Quercus

One minute with... Brooke Magnanti

"Belle de Jour", author of *The Intimate Adventures of a London Call Girl*, turns out to be based at the University of Bristol, UK

In one of your early papers you established a possible link between thyroid cancer in women in Cumbria and fallout from Chernobyl.

The trends in thyroid carcinomas in young women in north-west England show a consistent rise since the late 1980s. But our research also shows an increase in areas that didn't receive fallout from Chernobyl, so there may be other causes at work.

You've also looked at policy for assessment of risks from organophosphates.

There are pesticides that have been banned from indoor use in the US but are legal in the European Union which may cause developmental, emotional and possibly autistic spectrum disorders. We're collating the evidence and consulting experts to put forward a case to policy-makers to implement a similar ban to the one in North America.

What do you say to the charge that you have glamorised prostitution?

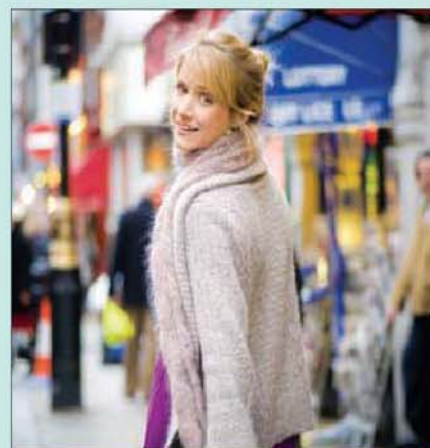
Call girls existed long before I got into the game and details of what that life is like were well established before I started writing about it. Implying I single-handedly turned the business around is flattering, but doesn't stand much scrutiny.

Do the dangers of prostitution outweigh the benefits of not being in debt?

The particular situation I was in was far less dangerous than streetwalking and paid sufficiently well that I didn't have to do it for very long. Also I met fewer men than a streetwalker would in the same period and again that decreased the chances of a bad experience. I trusted my instincts and the agency was very good about vetting clients as well. Let's be frank, postdocs are not well paid – being debt-free enabled me to continue to choose science jobs I love rather than changing career.

Would you support the legalisation of prostitution?

In the UK prostitution is legal – pimping, soliciting



PROFILE

Brooke Magnanti has a PhD in forensic pathology. She studied cancer epidemiology and currently works in the UK at the Bristol Initiative for Research of Child Health

and brothels are not. This results in a huge safety gap between call girls and streetwalkers. Doesn't it make sense for women at all price points in the sex business to have the same protection I did, and in doing so, possibly gain the leverage they need over traffickers and clients to protect their personal and sexual health?

How were you able to conceal your identity as Belle de Jour for so long?

My anonymity was maintained the old-fashioned way: a confusing paper trail. We set up a corporation with other people on the board. The papers didn't find me because they assumed I would be a writer, not a small-time blogger.

Your colleagues have reportedly been very supportive, but do you worry that the publicity will hinder your career?

Yes. That was the main reason for my anonymity. If I just wanted to be a writer it probably would have been more profitable to come out sooner, but working in science is important to me.

Interview by Rowan Hooper

Nutt controversy

Our guest editorial by David Nutt (7 November, p 5) elicited a great deal of response. A representative selection appears here, followed by a response from Nutt on page 30. Professor of neuropsychopharmacology at Imperial College London, Nutt was controversially dismissed from his post as chairman of the UK government's Advisory Council on the Misuse of Drugs after publicly airing views that ran contrary to government policy.

From Melford Bramble

David Nutt reiterated the "two bowls scenario", which illustrates the point that it is safer to give a stranger MDMA (ecstasy) than it is to give them a peanut. However, the two-bowls example assumes that the only indicator of a drug's harm is its toxicity; it takes no account of the social effects of drugs. If you wanted to persuade a young person to indulge in risky sexual behaviour, which would you give them: peanuts or ecstasy? Even alcohol would

get left on the shelf.

When it comes to law-making, clarity is just as important as scientific accuracy. Unclear laws cannot be enforced fairly – if they can be enforced at all. Nutt's contributions to the debate were eroding the clarity of the government's stance on drugs and he was beginning to look silly. The politicians were afraid of looking silly by association.

Politics and legislation are not scientific disciplines. If a scientist strays into either solely on the basis of their test tubes then they will be eaten alive by people who are experts in those fields. If speaking scientifically, it is understood that you are merely illustrating a point when you say that giving ecstasy to a stranger is safer than giving them a peanut. But in politics, and the world in general, by making that statement you will likely be encouraging people to take drugs.

Southsea, Hampshire, UK

From Munjed Farid Al Qutob

Nutt asks: "Why would any scientist take up some future

offer of a government advisory post when their advice can be treated with such disdain?"

Of course, the UK's home secretary Alan Johnson has erred in sacking such a distinguished academic and has unintentionally stifled a public debate on the dangers of legal and illegal drugs,



and whether ecstasy and cannabis are less dangerous than nicotine, alcohol or horse-riding. Indeed, smoking has a litany of appalling effects on health, and alcohol abuse has blighted the lives of thousands of people.

However, it should not be taken for granted that the government will act according to the opinion of even such a distinguished scientist as Nutt. He must be aware that the present government has an excellent track record of introducing an outright ban on smoking in enclosed public spaces and in debating publicly the dangers of binge drinking.

Isn't it unfair to deride the government's policies when they aim at ridding our society of the spectre of another drug?

London, UK

From Andrew Broadbent

Contrary to common assumptions, Nutt's article in *The Lancet* (vol 369, p 1047) did not measure the physical, social or economic harm of different drugs; it combined the opinions of professionals, ranked on an arbitrary 0 to 4 scale, into an overall index of harm, but provided no range of errors.

The overall result that heroin is only about 50 per cent more harmful than alcohol would seem to provide little basis for policy. In fact, Nutt's ranking of harm indicates so little difference between drugs that an equally valid conclusion regarding the classification of cannabis, which has caused such a furore in the UK recently, could have been that it did not really matter whether the drug is deemed to be class B or C. *London, UK*

From Philip Bowles

Nutt is unquestionably correct to call for a rational drugs policy in his editorial, but perhaps not in his plea for a consistent policy on drug legalisation.

Both politics and science are fundamentally concerned with setting objectives and identifying how best to achieve them – in science through experimental design, in politics through drafting appropriate legislation.

The most suitable policy on any given substance will be contingent both on the politicians' objectives for that policy and the particular problems associated with that drug. So it is not at all obvious that striving for consistency for the sake of consistency is either politically sound or scientifically defensible.

For instance, policies targeting substances such as alcohol, which inflict damage primarily through their effects on violent crime, are plainly going to require different approaches from reducing health risks associated with tobacco or cannabis. There are also different types of drug-related crime: substance abuse can lead to individual criminal activity, but there are also the wider issues of drug smuggling and dealing.

We need to recognise how unsuccessful it has been to apply a single standard to varied subsets of substances. A rational approach to drug legislation demands a policy that aims to

Enigma Number 1574

Doubly square dates

RICHARD ENGLAND

4 April 2001 was the first doubly square date of the century because whether written in the order *day.month.year* or in the order *month.day.year* (in each instance with two digits for each element) it comes out as 04.04.01, and 40401 is 201².

Still with two digits for each

element, there are some doubly square dates for which the square that comes from the order *day.month.year* is not the same as the square that comes from the order *month.day.year*. This is the case for each of the next two doubly square dates after 4 April 2001. What are those two dates (in the same form as 4 April 2001)?

WIN £15 will be awarded to the sender of the first correct answer opened on Wednesday 20 January. The Editor's decision is final. Please send entries to Enigma 1574, New Scientist, Lacon House, 84 Theobald's Road, London WC1X 8NS, or to enigma@newscientist.com (please include your postal address).

Answer to 1568 Odd puzzle: PUZZLE is 102235

The winner Richard Ford of Abingdon, Oxfordshire, UK

approach the diverse political issues raised by different substances on a reasoned, case-by-case basis.

A one-size-fits-all war on drugs got us into this mess. The same logic, even if more rationally applied, won't get us out of it.
High Wycombe, Buckinghamshire, UK

From Douglas Cross

Home secretary Alan Johnson's dismissal of David Nutt, who he says strayed into the exclusive field of politics, highlights the profound divide that now exists between science and politics. But this is no isolated event – entrenched policies are protected regardless of scientific evidence of their inappropriateness, and dissenters can have their reputations sullied by innuendo.

Nutt's treatment by the government has drawn attention to the contempt with which science and scientists are regarded by politicians. Public debate over health issues cannot be the sole prerogative of politicians: where expert opinion indicates that policies are wrong, then scientists qualified to advise have a duty to the public to ensure that their dissenting views are heard.

Senior scientists are now predicting the collapse of the support of independent scientists in advising the UK government on policy-making.

This is a dangerous development. If independent scientists withdraw from the arena, this will leave only publicly employed scientists to challenge their political masters.
Lowick Bridge, Cumbria, UK

From John Champion

Johnson did not dismiss Nutt because of his views, but because he aired them in public and because they ran contrary to government policy. Nutt's own actions made his position untenable.

Liphook, Hampshire, UK

From Chris Adams

It seems to me that government advisers are de facto consultants, and that the Advisory Council on the Misuse of Drugs (ACMD) has not followed the basic rules of effective consultancy. Most importantly, both the consultant and the client need to understand the question that the consultant is being asked, ensure that the question is the most relevant and pertinent to the situation, and then agree on the likely form the answer will take.

In this light, the failure of the ACMD was its concentration on the short-term strategic issues of drug categorisation, rather than getting ministers to think more broadly in terms of the various issues that lead to drug taking. The problems encountered in considering human interaction with intoxicants are deep and complex.

The difficulties are that the government does not have clear policy objectives, and the first task



of a consultant should be to sketch out options of what those policy objectives might be – clearly not an easy task in this situation.

For much of society, it is the adverse effects of drug taking that count most and it is for this reason legislation is desired. However, the human animal seems to enjoy being intoxicated. Policy should strive for an acceptable way of coping with this facet of human nature in an overpopulated and wealthy industrial society.

Llangollen, Clywd, UK

David Nutt replies:

I am pleased to be able to reply, and to thank those who support my stance. The other letters raise a number of issues. Those that think there is a chance that the government will engage in sensible dialogue regarding drugs or alcohol are sadly mistaken: political expediency has been the order of the day for many years.

The issue of the utility and rigour of the "harm matrix" is that, though far from ideal, it does represent the first attempt to articulate and estimate the various forms of drug harms, and represents the views of more than 20 experts from the Advisory Council on the Misuse of Drugs – not just me. It would be perverse to suggest that all classified drugs should be in the same category simply because the highest drug-harm score is little more than double the lowest. Would you want to see the same penalty for speeding at 100 mph as at 50 mph in a built-up area?

With regard to the "two bowls scenario": as peanut-related deaths are mostly allergic in origin they are not dose-related. There is some dose-effect relationship with MDMA deaths, which can be mitigated by education and drug testing. However, if harm reduction is the reason for making drugs illegal, then why not ban peanuts when this would also save lives?

By extension, the failure of the government to tackle the deaths from alcohol – indeed to encourage them by its policy of decreasing relative taxation – does serious discredit to what has otherwise been a good track record in harm reduction in drug treatment.

London, UK

Extrapolation nation

From Mike Keating

Angela Saini's article about misunderstanding probability in courts makes me wonder how it's possible to verify assertions such

as the probability of having DNA matching that found at the crime scene being "1 in 200 million" (24 October, p 42). I doubt that 2 billion cases have been examined for this purpose. With DNA, I gather that the samples are



compared in 20 or so places on the genome. A figure is then given for the chance of a match at any one place, and raised to the power of 20 to give the chance of 20 matches. This assumes that matches in different places are independent of one another.

As we derive our DNA from a small pool of ancestors, not all possibilities will be realised in the population, so 20 matches will occur more frequently than the independence hypothesis suggests.

Cornhill-on-Tweed, Northumberland, UK

For the record

■ When discussing the effects of travelling at close to the speed of sound we said that this liquefies the ground beneath a vehicle's wheels (21 November, p 38). We should have said that the ground is fluidised.

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How our brains build social worlds

Unravelling the neurology of human interaction may also help explain strange beliefs such as creationism, say **Andreas Roepstorff**, **Chris Frith** and **Uta Frith**

YOU know how it works. A student volunteer sits alone in a soundproof booth, watching a computer screen and waiting for moving dots to appear. When they do, he or she has to decide whether there is a walking man hidden somewhere in those dots. If there is, and he is walking left, the volunteer has to press the left button. It's a tricky task, and most of the time people end up guessing.

In our view, this kind of traditional experiment has a serious limitation: it does not take into account the influence of social interaction. On the surface, of course, no social communication is involved, as the volunteer is alone in a room. But dig deeper, and you'll find plenty. For one thing, the man hidden in the dots is a social stimulus, although not one that can interact. Such experiments involve social communication at another level, too. Any participant brings his or her baggage about what psychologists are like and how volunteers should behave.

The problem is that these hidden social interactions remain out of focus in the experiment. Our aim at the Interacting Minds project at the Danish Neuroscience Centre in Aarhus is to develop a new kind of experiment that is focused on such interactions.

In the past decade, the neuroscience of social behaviour has blossomed. A major catalyst for this has been the discovery of what seems to be a physiological mechanism for social interaction, located in the brain's "mirror

neurons". These have been seen to fire not only as a monkey, say, grabs a peanut, but also when the monkey sees an experimenter do the same thing. Imaging experiments in humans have similarly revealed parts of our brains becoming active when we see someone moving, or even when watching a walker hidden among moving dots. It seems we are not just observers of the social scene but that we automatically share the experiences and emotions of the people we are observing.

This is only half the story, though, as interaction between people extends far beyond this. When I see you in pain, I feel your pain and my face automatically expresses this pain. What's more, you can see by my expression that I share your pain, and you are comforted by the knowledge someone else shares your pain. You are responding to my response to you.

Such interactions are a feature of many aspects of everyday life. They come to the fore when people play music, so in one of our experiments we got two people to tap a simple beat together. You might expect a leader and a follower to emerge, with the leader trying to maintain the beat, while the follower synchronises with the leader. Our twist was to also study what happened when each person could only hear the other, but not him or herself. No leader emerged: both players became followers, continually and mutually adjusting their taps to each other.

How can such behaviour be explained in terms of neuroscience? We think that two people performing together in this way are best described as a single, complex system rather than as two systems interacting. We also believe the same kinds of description should be applied generally to the brain activity that occurs when two people interact, because their brains also become a single complex system.

During any kind of social interaction people



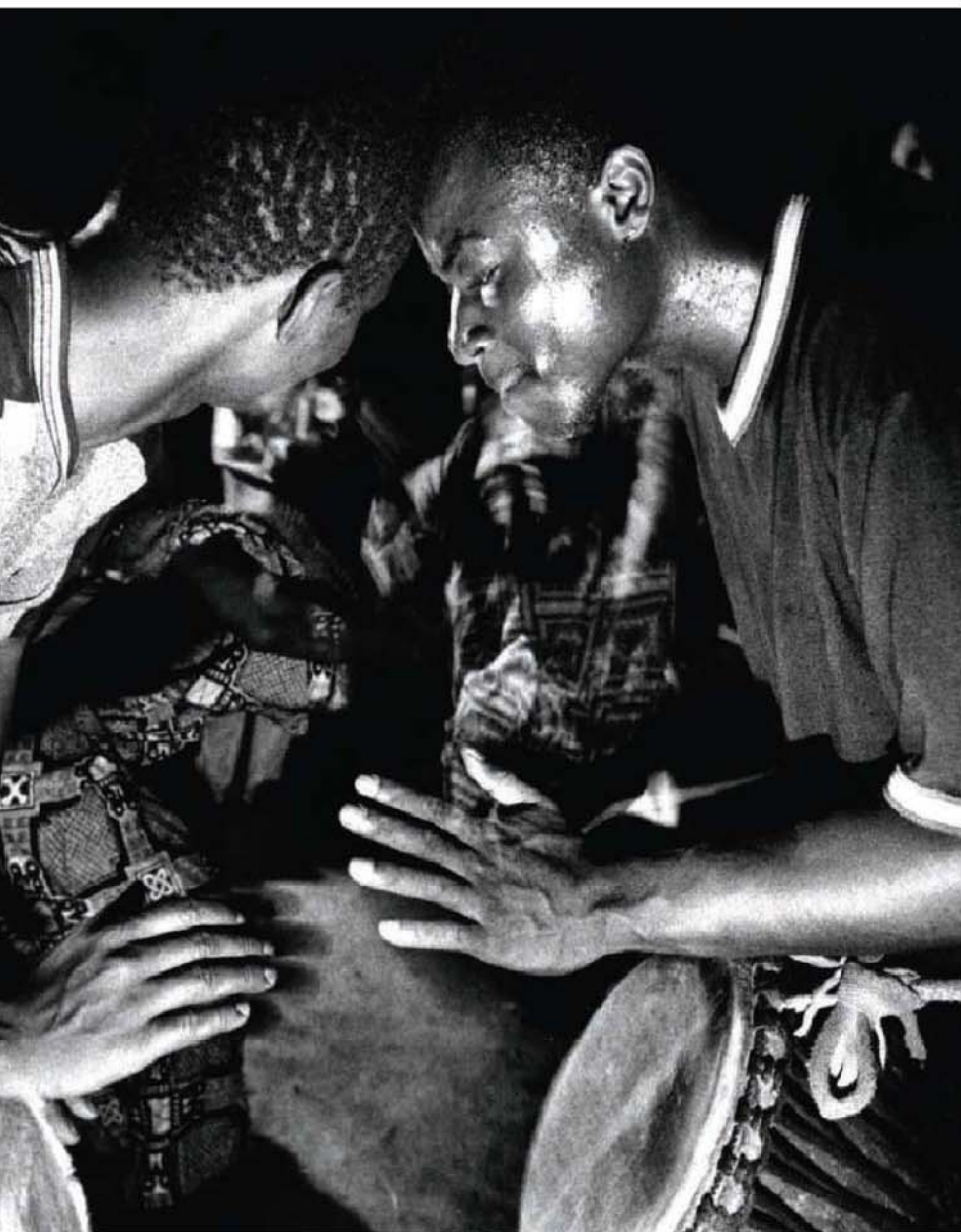
"We need to know how the brain models other people's models of the world"

unconsciously imitate each other, or else show the appropriate complementary action and reaction. When this happens, the parts of the brain that unconsciously respond to the actions of others create a form of resonance. We are not usually aware of this, but when it occurs we feel "on the same wavelength" as the person with whom we are interacting.

This feeling of similarity is an essential aspect of communication, and it is generally easier to communicate with someone who we feel is similar to ourselves because of the

PROFILE

Andreas Roepstorff leads the Interacting Minds project at the Danish Neuroscience Centre, Aarhus. Chris Frith and Uta Frith, both based at University College London and the DNC, have been awarded the European Latsis prize for their contribution to understanding the human mind and brain



Strange things happen when people play music together and can only hear each other

and divert attention from where the trick is really happening.

This raises the interesting question of how our brains deal with deception. Somehow, a balance has to be struck: it would be too costly to question the motive behind every interaction, but taking everything at face value makes us vulnerable. Neuroscientists have become very interested in the differences in brain activity between interacting with a person considered trustworthy and one perceived as dangerous and deceptive.

One key difference may be a shift in the balance between unconscious mirroring of another person's actions and expressions and conscious attempts to grasp the other's motives. This may lead to a decoupling from the other, a kind of separation within the interaction, as activity diminishes in areas that mirror experiences, while higher-order, cognitive frontal functions kick in.

A major aim of the Interacting Minds project is to understand the ability to compare, exchange and jointly create models of the world. Our group has forged strong collaborations with humanities departments at the University of Aarhus because we need their expertise on the shared worlds of human culture. It is these models that create the common knowledge that makes communication possible, including between experimenter and volunteer in experiments.

These shared models are often more robust and longer-lasting than the individual models. We experience them through symbols and words, which work precisely because there is general agreement about their meaning. This is how the paper and base metal we call money, for example, lets us communicate a value that can be applied to any commodity. In the right context, any object can become imbued with meaning. Just think of the collection of graphics now universally understood to indicate good humour (;-)!

The internet has dramatically increased both the possibilities for interactions and the size of the interacting groups. Undoubtedly, new shared models will emerge. But there are also greater possibilities for false models, in the shape of deception, propaganda, or genuinely held but dangerously wrong-headed ideas – creationism, the denial of global warming, take your pick. The possibility that neuroscience can help us understand the spread through society of true or false models of the world surely gives our work particular urgency. ■

knowledge we share. There is, however, another important part of communication, and that is to learn new things. So, as well as bearing in mind our similarities, we must also keep track of our differences and, in particular, the things that we know and that other people don't know. Think of the appeal of gossip.

There is nothing specifically social about building models of the world. The brain does this when we are alone and unobserved, as it learns about the world and creates perceptions and beliefs. On the basis of those beliefs, our brain predicts what should happen next and decides if the sensory signals it then receives provide evidence for or against that belief. When it finds errors in its predictions, the brain acts as a hypothesis engine, continually

updating our beliefs about the world. Think of the unexpected sensations when you lift a coffee pot you thought was full and it turns out to be empty.

But what makes human social interactions so fruitful in daily life – and as a subject of study – is our ability to compare our model of the world with other people's. We know something about how the brain models the world, but we need to know a great deal more about how our brains model other people's models of the world. People continuously put this kind of modelling to use when doing things with others: when we talk, teach, listen or learn. Good teachers know that and tailor their teaching accordingly. So do stage magicians as they play with our expectations

DIETER TELBANKS/PANOS



Scraping the bottom of the barrel

We'll have to go to extraordinary lengths, says **David Strahan**, if we are to stand any chance at all of keeping the oil flowing

EIGHTY-FIVE million barrels. That's how much oil we consume every day. It's a staggering amount – enough to fill over 5400 Olympic swimming pools – and demand is expected to keep on rising, despite the impending supply crunch.

The International Energy Agency forecasts that by 2030 it will rise to about 105 million barrels per day with a commensurate increase in production (see graph below), although whistle-blowers recently told *The Guardian* newspaper in London that insiders at the IEA believe the agency vastly over-estimates our chances of plugging that gap. The agency officially denies this.

Wherever the truth lies, it is widely expected that by 2030 we will have passed the peak of conventional oil production – the moment that output from conventional oil reserves goes into terminal decline. A report from the UK Energy Research Centre (UKERC) published in August said there was a “significant risk” it would happen before 2020. And that means we will soon be staring down the barrel of the ultimate oil crisis.

Some governments and corporations are waking up to the idea and beginning to develop alternatives to keep the world's transport systems moving when cheap oil runs out. These include biofuels, more energy-efficient – or electric – cars, and hydrogen. But none of these is likely to make up the global shortfall in time. The pressure is on to keep the black stuff flowing and so the next two decades will see an unprecedented effort to exploit increasingly exotic and unconventional sources of oil. They include tar sands (a mixture of sand or clay and a viscous, black,

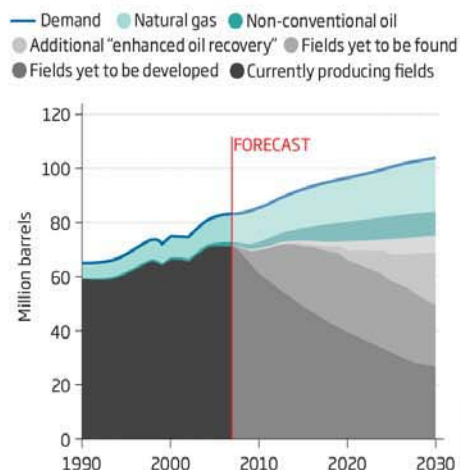
sticky petroleum deposit called bitumen), oil shale (a sedimentary rock containing kerogen, a precursor to petroleum) and synthetic liquid fuels made from coal or gas.

Purely in terms of geological abundance, these sources look more than sufficient to meet global demand. According to the IEA, taken together, they raise the remaining global oil resource to about 9 trillion barrels (see map, page 39) – almost nine times the amount of oil humanity has consumed to date. The trouble is that the name “non-conventional oil” hides several dirty little secrets and a whole host of huge challenges.

Conventional oil refers to liquid hydrocarbons trapped in deep, highly pressurised reservoirs, which means that when the wells are drilled, the oil usually gushes to the surface of its own accord. Non-conventional oils are not so forthcoming, and need large ➤

Trouble ahead

Easy-to-produce oil will soon start running out. This is how the International Energy Agency predicts we'll plug the gap



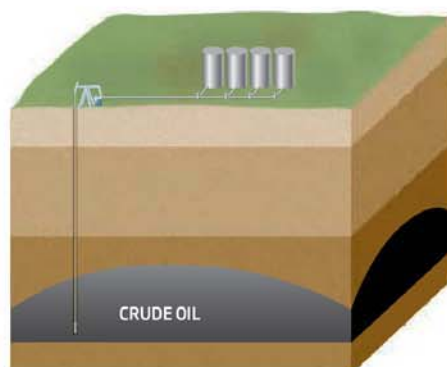
Excavating the tar sands in Fort McMurray, Canada

ORIAN FELLINGWAG/DAGENS NARINGS/VICORBS

Putting the squeeze on

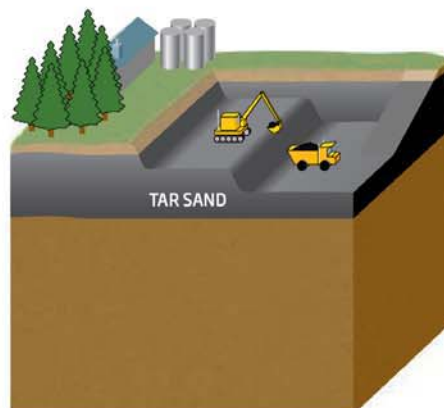
How the new techniques to extract oil from unconventional sources compare with established oil drilling. Figures do not include refining

CONVENTIONAL DRILLING



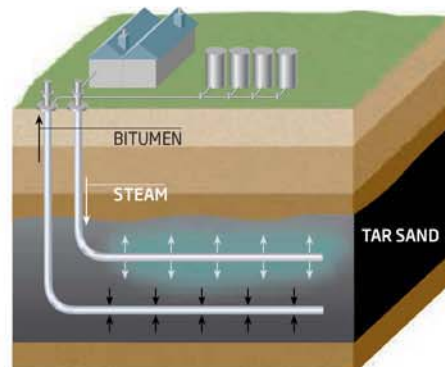
A well is drilled down to an oil reservoir. The oil is usually under high pressure, so it bursts back up the bore as soon as the reservoir is tapped

MINING



The tar sand is dug up, rinsed in a cocktail of hot water and chemicals to separate the bitumen from the sand. The bitumen is then sent for further processing and refining

STEAM ASSISTED GRAVITY DRAINAGE (SAGD)



Steam is pumped into the reservoir. This melts the bitumen which is collected and pumped to the surface. An advanced version uses some energy of the bitumen to produce steam, making the process more self-sufficient

Barrel production per day	85 million
Barrels produced per barrel invested	18
CO ₂ per barrel produced	50kg (estimate)
Fresh water per barrel of oil produced	Negligible
Percentage of oil recovered	35%
Oil price to make extraction viable	\$10 - 80

630,000
8
69kg
4 barrels of water
80 - 90%
\$70 - 80

580,000
4 - 12
100 - 200kg
0.9 barrels of water
25 - 60%
\$50 - \$75

amounts of energy, water and money to coax them from the ground and turn them into anything useful, like diesel or jet fuel.

As a result, non-conventional oil production to date has been slow to expand – with current output of just 1.5 million barrels per day. Not only that, because they take so much energy to produce, they are responsible for higher carbon emissions per barrel than conventional oil.

But, slowly, things are beginning to change. Growing awareness of the impending oil shortage and its ramifications – Deutsche Bank predicts a barrel price of \$175 by 2016, for example – has driven a surge of investment in new technologies to recover non-conventional oil more effectively. “Canada could eclipse Saudi Arabia,” says Julie Chan, vice-president of finance at E-T Energy, a Canadian company developing a new technique to extract oil from tar sands. So are non-conventionals poised to swoop in and confound the peak-oil doomsayers? Can we expect a new era of expensive, technologically demanding and environmentally damaging oil?

The most famous of the non-conventional resources are the Canadian tar sands, where proven reserves are second only in size to Saudi Arabia’s conventional crude. Today, production stands at 1.2 million barrels per

day. Tar sands containing bitumen are extracted from huge opencast mines and processed to produce oil. But mining and processing the raw bitumen is expensive and requires huge volumes of water (see diagram above). In Canada, the industry is already reaching the legal limits of what can be drawn from the Athabasca river in winter. Worse, mining is only possible for deposits less than about 75 metres deep, and that’s just 20 per cent of the total resource. So a whole range of new technologies is now being explored to extract the deeper bitumen.

Steamy business

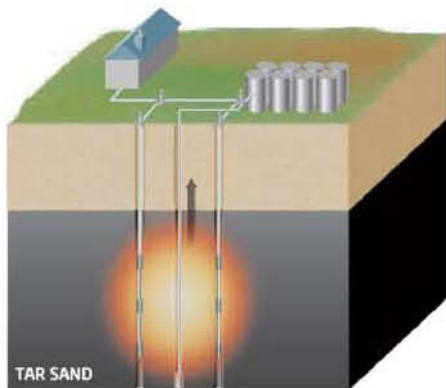
Steam-assisted gravity drainage (SAGD) is one of the most established processes, accounting for almost half of tar sands production. Steam is injected into a well to melt the bitumen, which drains into a secondary shaft from where it is pumped out (see diagram above). This is cheaper and uses much less water than mining, but more energy – usually from natural gas – to produce the required steam. An industry-sponsored report published by Alberta Chamber of Resources in 2005 found that if tar sands oil production rose to 5 million barrels per day by 2030, it would need

60 per cent of the gas consumed by western Canada, which it said would be “unthinkable”.

But this brand of SAGD is not the only game in town. Nexen, a Canadian oil company, has developed a new twist on SAGD by dispensing with natural gas as fuel and using some of the bitumen to generate the energy needed to produce the steam. At its site in Long Lake, Alberta, the company gasifies asphaltenes – the heaviest fraction of bitumen. This synthetic gas is burned to generate steam for SAGD, and is also used to produce hydrogen which in turn is used to upgrade the bitumen on-site into high quality synthetic crude oil. This makes the process cheaper and energy self-sufficient – it even generates surplus power to export to the grid. The downside is that carbon dioxide emissions are higher than for mining or standard SAGD. The company aims to expand production from its current 14,000 barrels per day to 60,000 by 2013.

A method called “toe to heel air injection” takes a similar approach to SAGD, but does its burning underground. THAI involves a pair of wells. A vertical air-injecting well is drilled close to the “toe” of a horizontal production well (see THAI, page 37). Steam is pumped into both wells to heat the bitumen until it is hot enough to combust spontaneously when

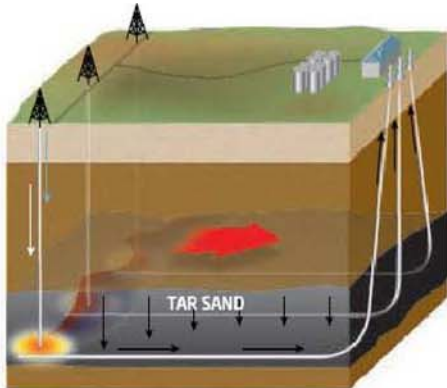
ELECTRO-THERMAL DYNAMIC STRIPPING PROCESS (ET-DSP)



Electrodes are placed in wells, and a current is passed through groundwater in the reservoir to heat the bitumen. Molten product flows into a production well and is pumped to the surface

110,000 (estimate for 2014)
Unknown
70 - 100kg (estimate)
Unknown
65%
\$26 (estimate)

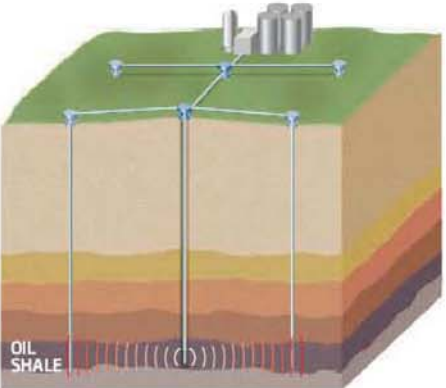
TOE-TO-HEEL AIR INJECTION (THAI)



Steam is injected until the bitumen is hot enough to ignite when exposed to air. Air is pumped in to create a 500°C fire front, melting the bitumen which is pumped to the surface

10,000 (estimate for 2012)
Unknown
60 - 100kg (estimate)
Unknown
70 - 75%
\$45

IN-SITU SHALE OIL EXTRACTION



Shale is heated with microwaves, electricity, or critical fluids – to very high temperature so that it converts to a liquid hydrocarbon while still underground and can then be pumped out

Negligible today
3 - 4
Unknown
Unknown
Unknown
\$50 - 110

SOURCE: IEA, ALBERTA CHAMBER OF RESOURCES, CANADIAN ASSOCIATION OF PETROLEUM PRODUCERS, IHS CERA, LENEF CONSULTING, NEXEN, PETROBANK ENERGY & RESOURCES, E-T ENERGY



The bitumen in the tar sands gives the earth a thick mushy feel

called electro-thermal dynamic stripping process (ET-DSP). A grid of vertical wells is drilled into the tar sands, each containing three large electrodes (see ET-DSP, above). Current is conducted between the wells via groundwater. The electrical resistance of the earth generates heat which liquefies the bitumen and allows it to flow into a central production well. Changing the voltage gradient between the electrodes allows the operators to direct the electric field to heat the richest parts of the bitumen deposit. Any water that comes up with the liquefied bitumen is re-injected to maintain conductivity. Since the process runs on grid electricity, there's no need for natural gas.

However, on the basis of Alberta's largely coal-fired power supply, the electricity used in ET-DSP means the production process is responsible for more carbon emissions than either mining or conventional crude production. E-T Energy, the company developing the technology, insists that emissions could be slashed if it were powered using hydro, wind or even gas-fired power. In a separate development, Bruce Power, an Alberta-based nuclear power generation company, has drawn up plans for new reactors sited near Canadian tar sands deposits to

exposed to air. Then the steam is turned off, and air is pumped down the injector well to feed a horizontal fire front that moves slowly through the reservoir from the toe of the production well towards the heel, generating temperatures of up to 500 °C. The intense heat separates the bitumen into heavier and lighter fractions, with the heavier one (asphaltenes) fuelling the fire while the lighter ones melt, flow to the production well and get pumped to the surface. That's a neat trick, because it means part of the refinery's job is done

underground. This process uses between 10 and 30 per cent of the natural gas consumed by SAGD processes. It is even self-sufficient for its water needs, because groundwater is pumped up the production well along with the bitumen and recycled. A third approach sounds a little more "out there", but in theory has the potential to be the least polluting of all the new bitumen-extraction techniques. Instead of heating the bitumen in a conventional fashion, the idea is to zap it with electricity, using a technique

Extracting oil from tar sands means using totally new machinery

provide CO₂-free electricity to the oil-extraction industry.

Although THAI and ET-DSP seem to have solved some of the practical problems of tar sands oil production, and the costs may fall in the future, they are still in their infancy. IHS CERA, an oil consultancy that recently produced a report on the growth prospects for tar sands production, estimates it will take between 5 and 15 years to commercialise the new technology. "It could be a decade before it is used in enough [tar sands] reservoirs to contribute meaningfully to production," says Jackie Forrest, one of the report's authors.

Tar sands

In a scenario most favourable to tar sands – high oil prices, growth in demand and a supportive regulatory framework – IHS CERA predicts output from the Canadian tar sands could reach 6.3 million barrels per day by 2035. That's a small fraction of forecast global demand, but to achieve even this, production would have to grow twice as fast as it ever has. That, says Forrest, "is really pushing it". So what of the other alternatives?

Oil shale is the next large unconventional resource under consideration, with around 2.5 trillion barrels of "oil equivalent" identified. It was used to produce oil before the oil industry took off in the late 19th century. To produce oil from it, you essentially need to speed up a geological process that takes millions of years.

This is done by heating the rock to 500 °C until the kerogen decomposes into a synthetic crude oil and a solid residue. Traditionally that has meant digging up the shale and baking it in a huge oven. An expensive, energy-intensive process. It also leaves a greater volume of waste than the original shale, as testified by the hills of shale slag called "bings" that dot the West Lothian region of Scotland, where a century of shale oil production ended in the 1960s. What's needed is an in-situ production method similar to those developed for tar sands. Three-quarters of the global shale resource (see map, page 39) lies in Colorado, Utah and Wyoming, and Barack Obama's administration has recently restarted the process of leasing federal land for shale oil R&D. A number of technologies are being developed to heat the shale underground.



These utilise microwaves, high-temperature gas injection, and radio waves combined with supercritical CO₂. Such heating creates an oil reservoir that can then be extracted using conventional drilling (see diagram, page 37).

Oil multinational Shell has experimented with in-situ shale oil extraction at its development site in Cathedral Bluffs, Colorado. The company drilled bore holes 650 metres deep and inserted electrodes to heat the shale to between 340 °C and 370 °C over a period of months. However, the process is extremely power hungry, requiring energy to both heat the shale and to freeze the perimeter of the reservoir to block the flow of groundwater.

The company says it is unlikely to commercialise the process for at least another five years. The IEA estimates shale oil would cost between \$50 and \$100 per barrel to produce, without taking into account any carbon-emissions pricing that may come into force. It expects no significant shale oil production this side of 2030.

There's yet another old-school production method that may experience something of a renaissance in the coming decades. Just as

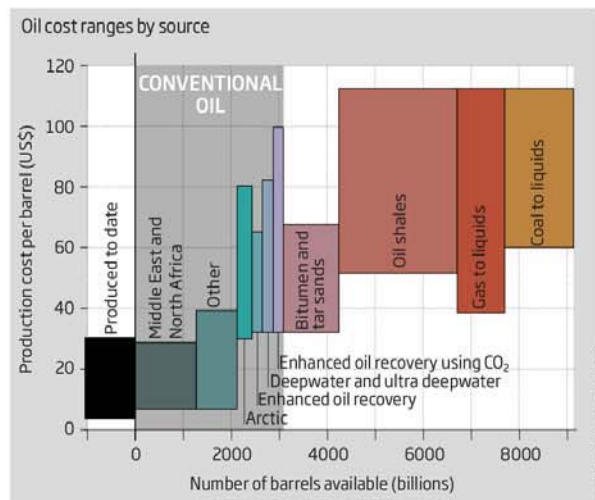
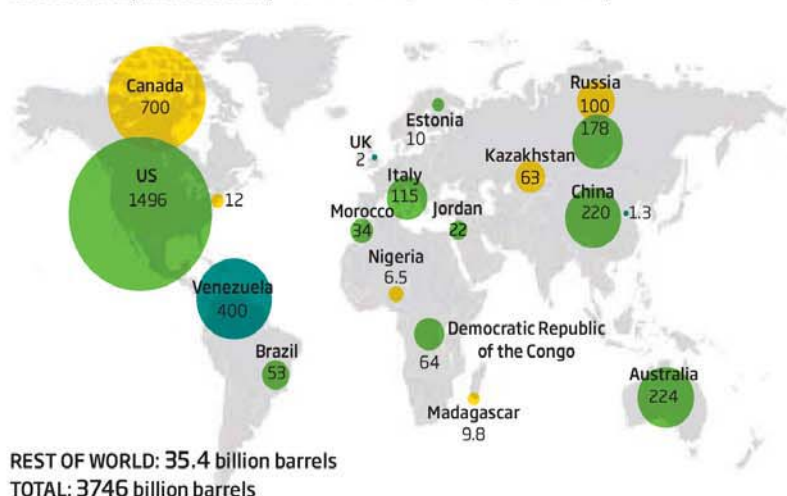
shale oil is nothing new, neither is making liquid fuels from coal. Two German researchers developed the eponymous Fischer-Tropsch process in the 1920s, heating coal to produce a gas of carbon monoxide and hydrogen, which is then catalysed to produce diesel and kerosene. The technology was exploited by oil-strapped, coal-rich Germany during the second world war, and by South Africa in the 1980s and early 1990s to beat sanctions imposed during apartheid. South Africa has the world's only major coal-to-liquids (CTL) plant operating today and China has recently built a demonstration plant in Inner Mongolia.

So, could coal be the answer? Few doubt there is enough of the stuff to support a major expansion of CTL (*New Scientist*, 19 Jan 2008, p 38), and the fuels produced are of a high quality. The drawbacks are formidable: it takes about two tonnes of coal and up to 15 barrels of water to produce a single barrel of synthetic fuels. That makes it expensive. The IEA says that when it comes to US coal, to supply just 10 per cent of US transport fuel consumption would mean investing \$70 billion, and raising coal production by 25 per cent – an

More than enough?

There are more sources of unconventional oil left to extract than we have consumed in all history. But at what cost?

Recoverable oil (billions of barrels) ● Tar sands ● Oil shale ● Extra-heavy oil



“Microwaves, high-temperature gas injection, and radio waves combined with supercritical CO₂ could all be used to extract oil from shale deposits”

additional 250 million tonnes per year.

Worse, because of the feedstock and energy demands of the production process, CTL fuels have roughly double the carbon emissions of conventional crude on a well-to-tank – or “mine-to-tank” – basis. Carbon capture and storage could be applied to the production plant, but the process is likely to be 90 per cent efficient at best. Then there are still the same emissions as petrol derived from oil when burning it in your car engine. So even with CCS, CTL is always likely to emit more carbon than conventional crude.

The Fischer-Tropsch process can also be used to make liquid fuels from natural gas. As with coal, there is no immediate shortage of feedstock. In fact, prices have slumped as rising gas production in the US and falling global demand combine to produce a worldwide glut which should last for at least the next few years. But, as with coal, there are major drawbacks.

The gas-to-liquids process (GTL) emits much less carbon than CTL, because the feedstock is cleaner, but still more than conventional crude. That’s because almost half of the 280 cubic metres of gas it takes to produce a barrel

of GTL fuel is burnt during the conversion process. Three small plants account for global production of 50,000 barrels of synthetic fuels per day. That should quadruple in the next few years with the opening of two larger plants in Qatar and Nigeria.

So with huge reserves and up-and-coming technologies, what are the prospects for unconventional sources? Will the non-conventionals be able to fill the gap left by diminishing crude oil, are we doomed to soaring emissions from ever dirtier oil?

Most analysts agree on one thing: despite the enormous size of the non-conventional resource, it will be decades before the new technologies can have a significant impact. In the meantime, any attempt to grow output quickly will have major regulatory and financial hurdles to overcome. In the US, federal bodies are effectively banned from buying non-conventional fuels because of their high CO₂ emissions.

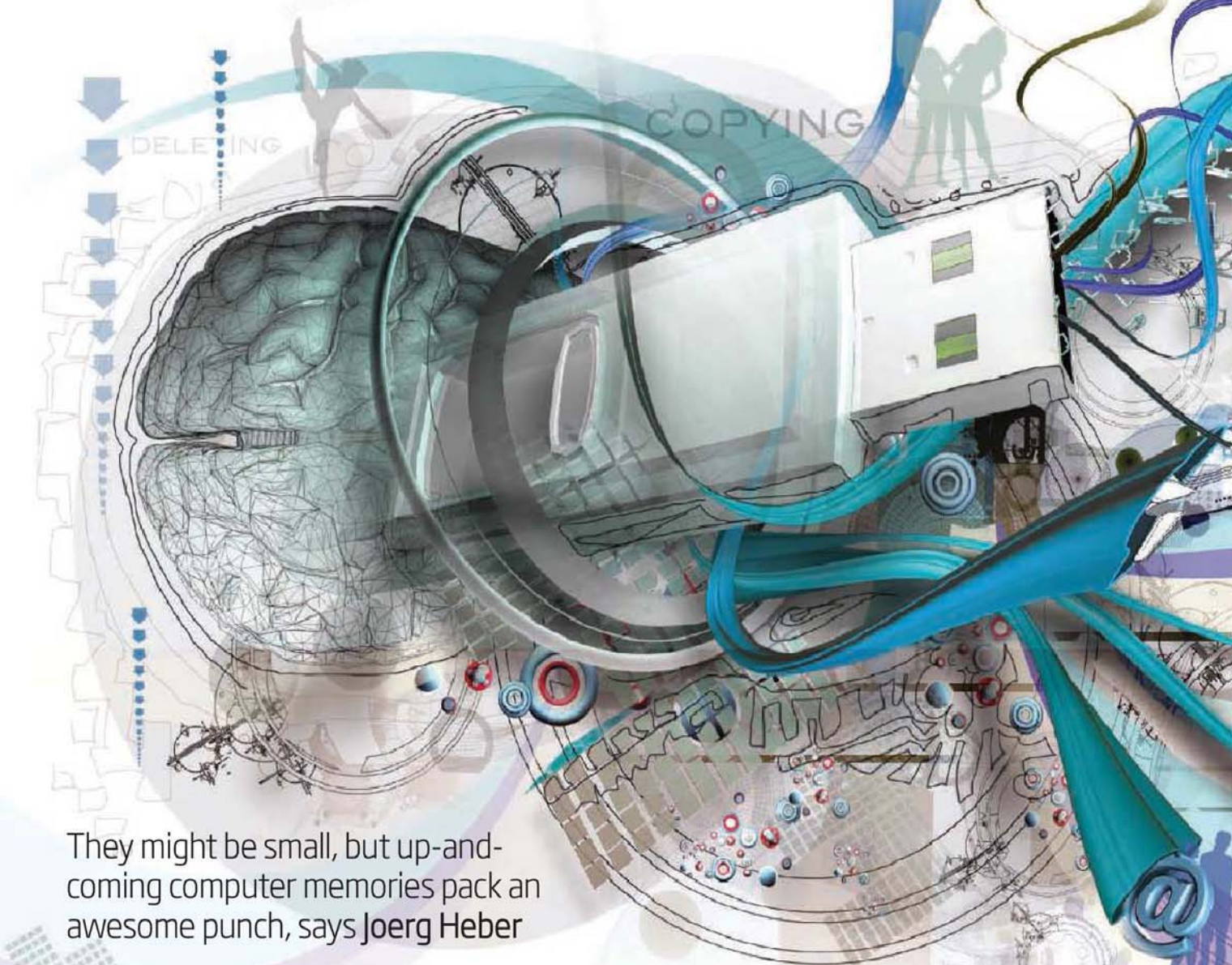
Furthermore, Obama has pledged to introduce a nationwide Low Carbon Fuel Standard (LCFS), requiring American fuel suppliers to cut carbon emissions from burning their fuels by 10 per cent between

2010 and 2020. Globally, non-conventionals would be penalised by any carbon-pricing regime that may result from the UN’s climate change conference in Copenhagen, Denmark, next week. The IEA is pushing for a carbon-emissions price of \$50 per tonne, which it says would add \$5 to a barrel of fuel derived from tar sands, \$12.50 to a barrel of GTL fuels and \$30 to CTL ones.

Oil-price volatility is perhaps of even greater significance. Since the price slumped from its peak of \$147 last year, tar sands projects aiming to deliver a total of 1.7 million barrels per day have been cancelled or delayed indefinitely, says the IEA. If price volatility persists – with oil shortages leading to a price spike, leading in turn to recession and a resumption of low oil prices – the halting investment in non-conventional oil development could become chronic.

The IEA’s chief economist Fatih Birol says non-conventionals can defer global peak oil to “around 2030”. Others are not convinced. “If everything goes well,” says Steven Sorrel, the lead author of the UKERC report, “oil sands might produce 6 million barrels per day in 20 years’ time, but by then we’ll need to add at least 10 times that much capacity – without allowing for any growth in demand. It’s very hard to see non-conventionals riding to the rescue.” ■

David Strahan is the author of *The Last Oil Shock: A survival guide to the imminent extinction of petroleum man* (John Murray, 2007)



They might be small, but up-and-coming computer memories pack an awesome punch, says Joerg Heber

Supermemories

Once upon a time, not so long ago, the idea that you might store your entire music collection on a single hand-held device would have been greeted with disbelief. Ditto backing up all your essential computer files using a memory stick key ring, or storing thousands of high-resolution holiday snaps in one pocket-sized camera.

What a difference a decade makes. The impossible has become possible thanks to the lightning rise of a memory technology with the snazzy name of "flash".

So where is the technology that can store our high-definition home cinema collection on a single chip? Or every book we would ever want to read or refer to? Flash can't do that. In labs across the world, though, an impressive array of technologies is lining up that could make such dreams achievable.

These "supermemories" are close to realising a vision set out by revered physicist Richard Feynman 50 years ago this month. In a lecture

to the American Physical Society entitled "There's plenty of room at the bottom", he asked whether it might ever be possible to write all 24 volumes of the Encyclopaedia Britannica on a pin head. Each tiny ink dot used to print each letter would have to be reduced to the size of just 1000 atoms, he calculated – a square with sides of just 9 nanometres.

Feynman speculated that people looking back from the year 2000 would wonder why it took till 1960 before we began to explore this "room at the bottom" – what we now know as the nanoscale. Late start or not, the progress in miniaturising information storage in the decades since has been stunning. Today, the smallest feature that can store a bit of information is some 40 nanometres across in commercial flash devices. The first flash chips capable of storing 64 gigabits of information were shipped just a couple of months ago.

The kinds of technologies Feynman was talking about, though, would fit terabytes of

data on a single chip. That requires a design simpler even than the already admirably straightforward flash architecture (see "Flash: memory hero", opposite). The mechanism for reading and writing the memory would also have to be reliable and, above all, fast, taking just nanoseconds. And the memory should be stable: once written, it should not degrade for at least a decade.

That is quite a shopping list. Whatever technology fits the bill will not be flash, but it will be mightily impressive. It won't be easy establishing it, with flash already so well entrenched, but with the market for memory chips worth something between \$20 billion and \$30 billion, you can bet it won't be too long before one or more of the technologies described in this feature is sitting inside devices in our pockets. Before that happens, though, the runners and riders in the supermemory steeplechase have just a few hurdles to clear.



MRAM

The longest-standing pretender to flash's crown is magnetoresistive random access memory, or MRAM. Under development by several companies since the 1990s, MRAM chips store information within two thin layers of magnetic material, each divided into a grid of cells. One layer is a permanent magnet whose direction of magnetisation does not change. The other is a temporary magnet whose magnetisation can be flipped 180 degrees by applying a small magnetic field or electrical current. The relative alignment of the two layers' magnetisations determines whether a bit is set to 1 or 0 (*Science*, vol 308, p 508).

MRAM's use of magnetisation is both its strength and its weakness: its strength because magnetisation is fast and easy to control, allowing memory to be written and read in as little as a nanosecond; its weakness because changing the magnetisation of one cell tends to affect its neighbours too.

This "cross-talk" is a tough nut for MRAM

FLASH: MEMORY HERO

Conventional computer hard drives, with their mechanical arms that read information from spinning magnetic discs, are power-hungry, comparatively bulky and prone to failure. Flash memory, developed by researchers at Toshiba in Japan in 1980, is compact and demands little power. That's why it has rapidly come to dominate the market for small-scale permanent computer memories, despite its higher price tag.

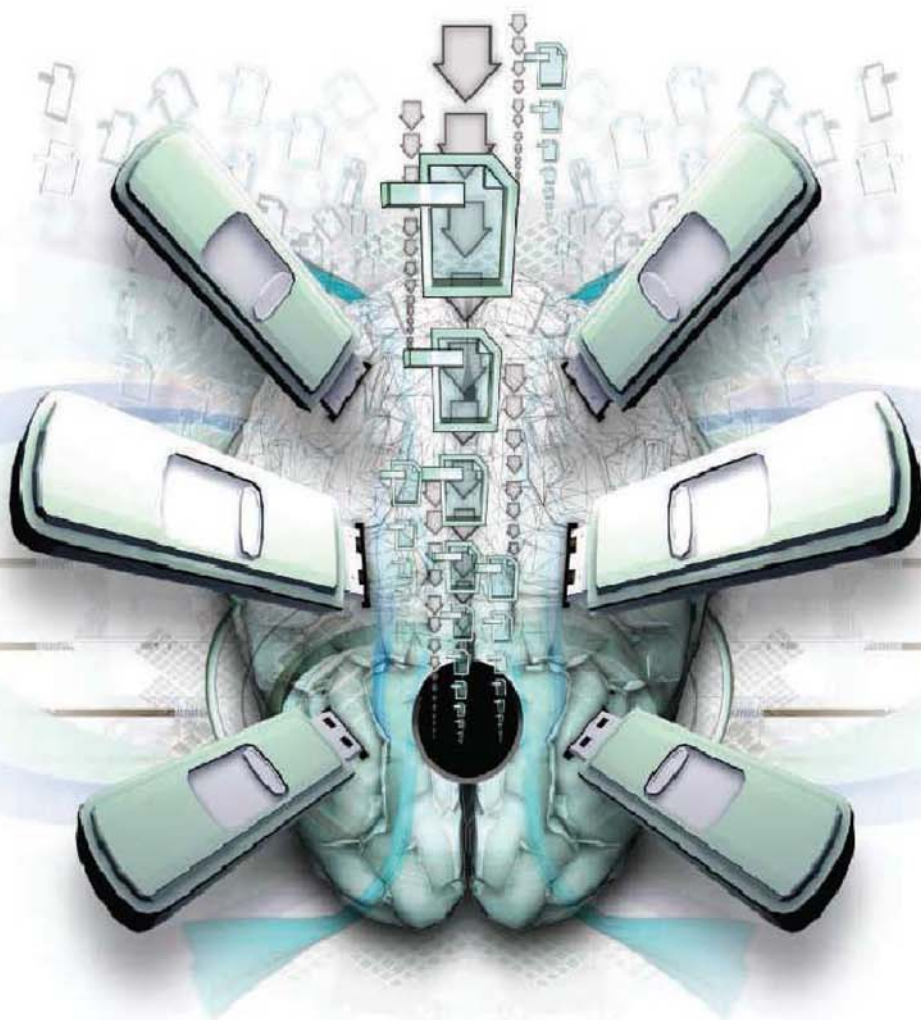
Flash memory bits work in a similar way to the transistors that toggle currents in a computer's processor chips. In a transistor, a tiny electron-

conducting channel is topped off by a metallic strip known as the gate. A voltage applied to the gate creates fields that determine whether electrons can flow through the transistor channel, producing controllable on and off states - the binary 1 and 0. In flash, the only difference is that the electrons are trapped at the gate by a surrounding layer of a highly insulating oxide, making the on and off states permanent.

The memory state can only be changed by applying a large voltage that allows the electrons to escape through the oxide. This makes flash drives slower

than hard drives, and the passage of electrons also slowly degrades the oxide's insulating capabilities. Flash memory can be rewritten only so often - generally between 10,000 and 100,000 times - before failing.

Flash's main limitation is storage density, however. The best flash chips currently have a storage density comparable to that of magnetic hard drives, but in both cases significant further miniaturisation will be difficult. For flash, quantum effects such as electron tunnelling will make the memory patchy if the bit-storage size dips below about 20 nanometres.



researchers to crack. "They haven't really been able to solve the problem yet," says James Scott, a physicist at the University of Cambridge. At the moment it limits the size of MRAM chips to 32 megabytes, less than one-thousandth of the capacity of the best flash devices. Electronics companies such as Hitachi and Toshiba continue to work on improved designs, maintaining faith in the potential of electrically controlled MRAM for fast, high-density memory.

Size: ?
Speed: ✓
Stability: ✓
Power consumption: ?

FeRAM

Ferroelectric random access memory, or FeRAM, is a close relative of flash. Like flash, it uses electrical effects to control a transistor-like structure. But rather than controlling flows of free electrons, it takes advantage of the strange distribution of electric charges found in complex crystals known as ferroelectrics.

In a ferroelectric, small external electrical fields can induce positively and negatively charged ions in the crystal to shift in position, creating a stable electrical polarisation not unlike the field between a magnet's north and south poles. Upwards and

downwards polarisations are the 0s and 1s of the ferroelectric bits (*Science*, vol 315, p 954). A small voltage applied to the crystal can be used to send in additional charges, changing the polarisation and causing the bits to flip. This process is fast – it takes less than a nanosecond in principle – and requires little power, two of the advantages of FeRAM.

As with MRAM, though, FeRAM's strength is also its Achilles' heel. "The problem is that FeRAMs are charge-based," says Rainer Waser, a physicist at RWTH Aachen University in Germany. To switch the ferroelectric with sufficient speed, the additional charge needs to be stored somewhere close by, so every FeRAM memory cell comes with a capacitor attached, eating up valuable space. "The capacitor footprint limits storage density," admits Scott, who has studied ferroelectric materials for three decades. "I can't see FeRAMs going to gigabyte devices like flash."

It could still have its uses, though: FeRAM's low power demands and straightforward design could make it the memory of choice where economy is more important than capacity. Toshiba is convinced, and announced a prototype 128 MB FeRAM chip in February 2009.

Size: ?
Speed: ✓
Stability: ✓
Power consumption: ✓

PCRAM

When it comes to downsizing to the tiny scales needed to replace flash, a chameleon technology known as phase-change random access memory, or PCRAM, looks a promising bet.

It exploits the same sort of technology used in rewritable CDs and DVDs. These store information in the atomic structure of materials with two distinct solid phases: an amorphous phase similar to that in window glass, in which the atoms are arranged in no particular order, and an ordered, crystalline phase such as that found in metals. The crystalline state is electrically conducting, and the amorphous state is an insulator (*Nature Materials*, vol 6, p 824).

In PCRAM, this material is held between two electrodes. All that is needed to flip it between its two phases is a pulse of laser light or electric current applied to the electrodes to melt the material. If the current pulse is long, the material orders itself into its crystalline state. If the pulse is short, the material cools abruptly into the amorphous state (see diagram, opposite).

The approach is not without its problems. Heating memory elements to the few hundred degrees Celsius necessary to change the state dissipates a lot of power – although that power requirement will sink as the devices shrink.

With PCRAM there could be a lot of room at the bottom. Only a few atoms are needed to create a memory unit capable of distinct amorphous and crystalline states. Luping Shi of the Agency for Science, Technology and Research (A*STAR) in Singapore reckons that memory-unit sizes of just 5 nanometres across should be possible – about one-tenth the size that flash memory has so far attained.

What's more, PCRAM's switching times can be blisteringly fast. "Speeds of 1 nanosecond are feasible," says Matthias Wuttig of RWTH Aachen. The problem is that the faster a material is switched, the less stable its crystalline phase tends to be, so PCRAM speeds are still 10 to 100 times slower than that. With individual bits already being imprinted on just a few dozen atoms, the challenge now is to work out what particular combination of different atoms provides the optimal trade-off between speed and stability. Many companies are working on that, and Samsung has recently brought out a 512 MB PCRAM memory chip.

Size: ✓
Speed: ✓
Stability: ✓
Power consumption: ?

RRAM

PCRAM is not alone in its potential to work at the tiniest of scales. A rival technology called resistive random access memory, or RRAM, makes that claim

"We can switch our devices in a nanosecond, and the energy required is in the order of a picojoule"

too. Whereas PCRAM relies on heat-induced changes in a material's atomic structure, RRAM exploits electrochemical reactions that change the bond structure of certain crystalline solids.

RRAM's raw material is a naturally insulating oxide, such as that of titanium and oxygen. When a large voltage is applied to such a crystal, the electron bonds that moor the oxygen atoms to the crystal start to break. As the oxygen floats off, it leaves behind it both holes in the crystal and excess electrons that are available for conduction.

The holes tend to be aligned in rows, creating extremely narrow, electrically conducting channels in the crystal. Reverse the voltage and the oxygen atoms move back towards the channel, cutting electrical conduction and returning the crystal to an insulating state.

This reversible transition creates stable memory states that only a high voltage of the right polarity can switch. Once this voltage is applied, just a few oxygen vacancies moving in and out of the channel

are enough to toggle between conduction on and conduction off, making RRAM a fast, low-power technology (*Nature Materials*, vol 6, p 833).

"We can switch our devices in a nanosecond or less, and the energy required is in the order of a picojoule," says Stan Williams, who works on RRAM at Hewlett-Packard Laboratories in Palo Alto, California. That's about one-hundredth of the energy required by flash. And because the conducting filaments are so small, the switching process could potentially happen on a scale of just a nanometre or so, giving RRAM truly tiny potential.

Stability is a growing challenge at smaller scales, though. If a high-resistance bit is set right next to a low-resistance one, electrical current tends to bypass the high-resistance region and take an undesirable detour through the neighbouring element. This is a problem that Hewlett-Packard and other companies are now trying hard to solve.

RRAM is not just exciting for its conventional memory capabilities. In 2008, Williams and his colleagues realised that RRAM devices have all the characteristics of a memristor – a fabled fourth basic electronic element to join the ranks of resistor, capacitor and inductor. Memristors differ from ordinary resistors in being able to adopt any number of values for their resistance, according to the current that flowed through them in the past. That

could make them models for the analogue computational elements inside the human brain – but with a twist. "These electronic synapses are much smaller and faster than the synapses in the brain, and use less energy," says Williams.

Size: ✓
Speed: ✓
Stability: ?
Power consumption: ✓

RACETRACK MEMORY

Most routes to supermemories involve finding new ways to manipulate atoms and their properties on the nanometre scale. Stuart Parkin of IBM's Almaden Research Center in San Jose, California, believes we should instead rethink memory design. "Maybe considering entirely new, three-dimensional architectures will enable us to improve memory devices further," he says. He and his IBM colleagues have got just such a suggestion: racetrack memory (*Science*, vol 320, p 190).

With racetrack memory, bits are stored as tiny domains of opposing magnetisation, rather as they are in a conventional hard drive. The difference is that the memory units, or domains, are not carved on a monolithic block, but strung out like pearls along a nanoscale magnetic wire. An electric current shunts these domains along the wire and past special reading and writing heads, where the information stored in the pattern of bits can be retrieved or modified (see diagram, left). This can be done at speeds of up to 200 metres per second, resulting in read times of tens of nanoseconds.

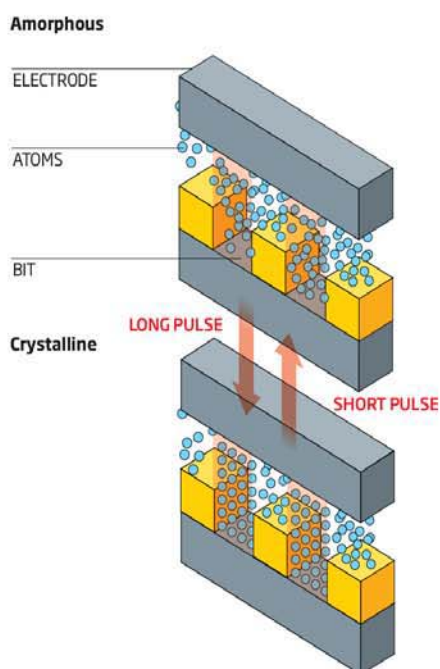
The big potential benefit of the racetrack is its storage capacity. Even just a flat micrometre-sized wire could store information with a density comparable to that of flash, says Parkin. The real deal comes, though, if the nanowires deviate from a standard two-dimensional configuration and are instead coiled into a three-dimensional arrangement of mini-skyscrapers. Then, hundreds of times more bits can be stored than in flash memory covering the same area.

So far, only two-dimensional prototypes are in development, which can match the storage density of flash. For 3D racetracks, Parkin admits his team will need a little longer. If the skyscrapers get off the ground, though, computer memory might have a very different face before too long. ■

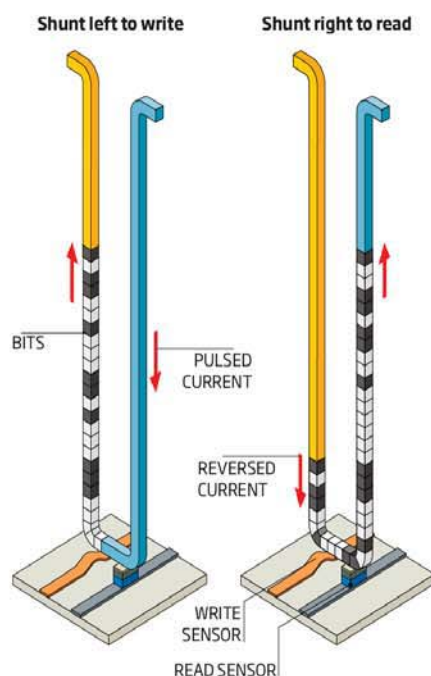
Size: ✓
Speed: ?
Stability: ✓
Power consumption: ✓

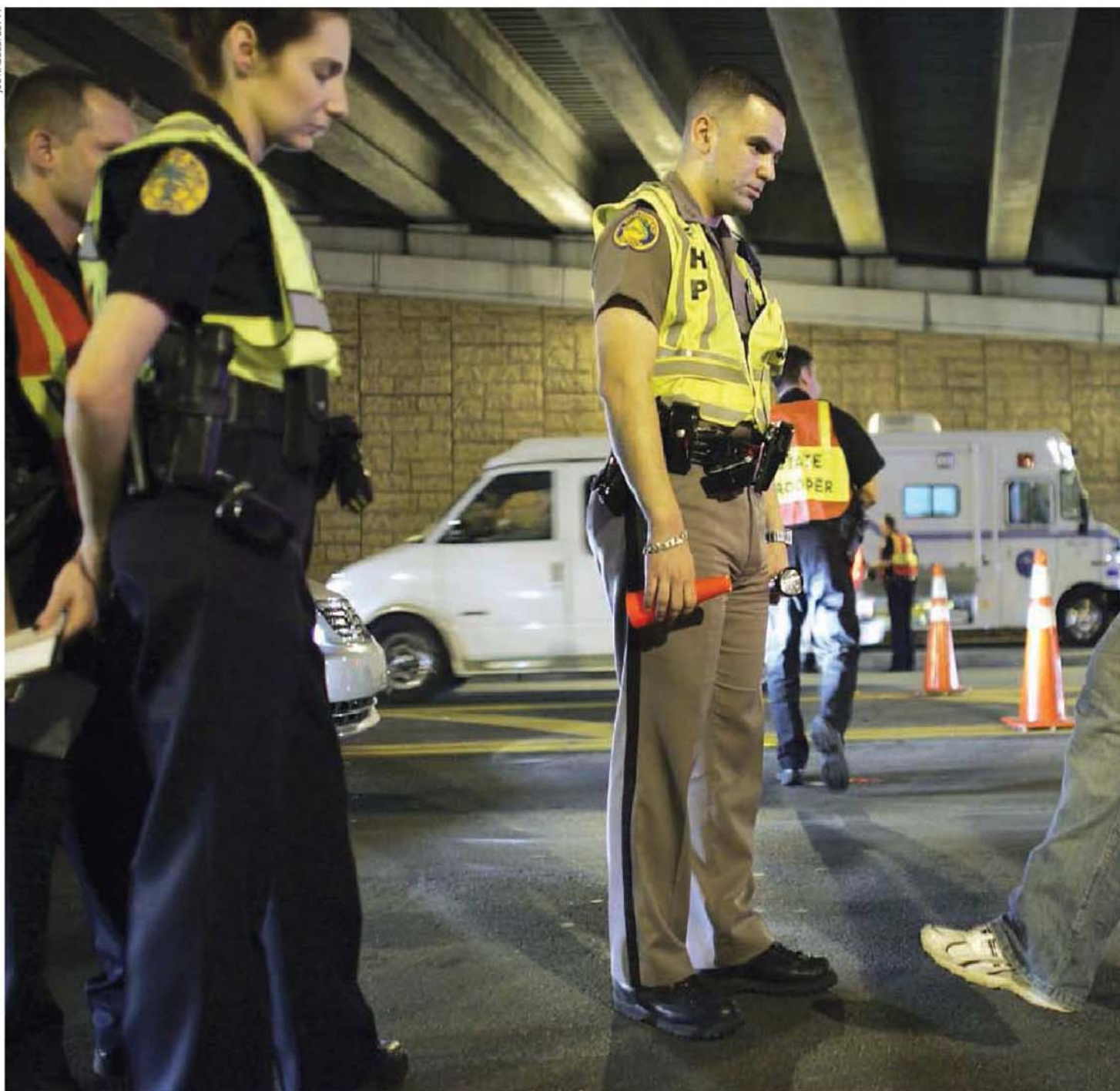
Memories of the future

In **phase-change memory**, 0s and 1s are represented by areas of amorphous or crystalline atomic arrangements. Current pulses of different lengths switch between the two



The information stored in a **racetrack memory** is written and read by shunting magnetically encoded bits to and fro using current pulses





Misbehave under the influence in the US, and you could end up wearing a device that measures your alcohol level 24 hours a day. Jim Giles reports on the next generation of electronic monitors

The drink fink



Driving while drunk could earn you an anklet like the one previously worn by actor Michelle Rodriguez (right)



JENNIFER GRAYLOCK/AP

"In the past we've said that if you don't stop drinking and driving, we'll stop you from driving," says Bill Mickelson, who has worked with the devices as part of a sobriety programme in South Dakota. "That never got to the heart of the problem. So we've developed a way to stop you drinking."

Lohan wore her anklet voluntarily, but most wearers have no choice if they wish to avoid jail. So in the not-too-distant future, could you find yourself wearing such a device if you misbehave after having a few too many? Is this the first step towards a Big Brother age even more intrusive than that envisaged by George Orwell, where the authorities are automatically alerted whenever you consume any substance deemed undesirable? And is this kind of monitoring reliable?

Traces of most drugs linger in our bodies for days or weeks, so random tests every few days can detect most use. Alcohol, however, leaves the body so quickly that tests would have to be done more than once a day to be sure of detecting any drinking. Hence the need for the device Lohan wore, called a secure continuous remote alcohol monitor, or SCRAM.

It relies on the fact that about 1 per cent of any alcohol we consume leaves the body through the skin. Once an hour, it fires a soft jet of air at the skin, vaporising any alcohol present and measuring its concentration. Every night, the day's readings are relayed to the company that makes the anklets, Alcohol Monitoring Systems of Littleton, Colorado, via a modem installed in the wearer's home. If it

appears that an individual has been drinking, AMS notifies the relevant official.

Over the past six years, use of the anklets has spread to almost every part of the US. The courts there have the power to place someone convicted of drunk-driving or alcohol-related violence on probation and require that they abstain from drinking, rather than send them to jail. Judges can also make SCRAM use a condition of bail.

Wearing a monitor is a small price to pay for being able to stay at home with your family and go to work as usual, rather than go to jail. It is also cheaper: SCRAM costs about \$12 per person per day, compared with about \$60 to keep someone locked up.

These advantages have led to the rapid adoption of SCRAM across the US since its introduction in 2003: over 110,000 people have worn the anklets and about 10,000 are currently being monitored.

Some wearers try to beat the system by placing a barrier between the anklet and their skin, or by removing it altogether, but tampering can be detected. The monitor is fitted with an infrared sensor whose readings change abruptly if objects are placed underneath it, while a temperature sensor triggers an alert if it appears the anklet has been removed from the skin.

Wearers often complain that the device is uncomfortable and looks embarrassing. But beyond that the ankle monitors do not cause any serious problems, says AMS spokesperson Kathleen Brown. They can be worn in the ➤

MEMORIAL day weekend 2007 is one that Lindsay Lohan might rather forget. An actor better known for her off-screen antics than her starring roles, Lohan crashed her Mercedes in Santa Monica, California, while over the legal alcohol limit. She checked into rehab. A month-and-a-half later, in July, Lohan emerged and declared that she would clean up her act. Within days she was again caught driving while over the limit.

This celebrity story has a twist, however. As part of her efforts to stay sober, Lohan wore an alcohol-monitoring anklet. When photos of her wearing the anklet hit the press, it was the first time many people had heard of such a thing. Yet devices like these are transforming the way alcohol offenders are dealt with in the US.

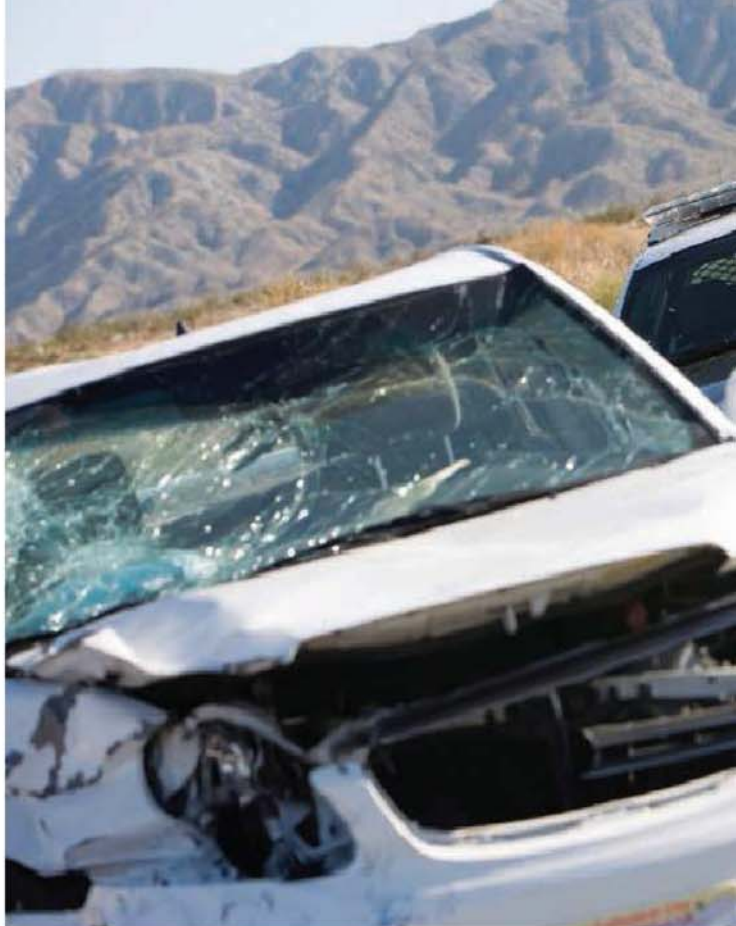
HOW WRONG IS TOO WRONG?

In the film *Minority Report*, a rather implausible method of preventing murders is abandoned as soon as it is shown it occasionally lands innocent people in jail. Real life is very different.

In the US, as in the UK, prosecutors have to prove that evidence of guilt is "beyond reasonable doubt". This standard is rarely quantified, but legal scholars have debated it and judges in the US have been surveyed on the issue. Most put the figure at between 85 and 95 per cent likelihood of guilt. For US probation hearings, the standard is much lower: they usually operate on a standard of "preponderance of the evidence", or greater than 50 per cent.

For these reasons, courts are happy to rely on monitoring devices and tests - even when they are not very accurate. People want complete accuracy, says Leo Kadehjian, a biomedical consultant based in Palo Alto, California, who has advised judges on drug-testing technology. "But that's not what we're entitled to under the constitution," he says. "We have to accept that some guilty people will go free and that some innocent people will be convicted."

If high-risk drinkers are curbed, so are incidents like this



bath and while running or driving, though they can interfere with sports such as soccer.

AMS says that over 70 per cent of SCRAM users do not violate the terms of their probation or bail, which suggests that the device is helping to reduce drinking and by extension alcohol-related crimes. No rigorous, randomised trials have been carried out to confirm this, but what evidence there is appears positive. In 2005, for instance, South Dakota launched its 24/7 sobriety programme, under which judges can order offenders or those on bail not to drink or take drugs. While other states have similar programmes, South Dakota broke new ground by forcing those on the scheme to submit to round-the-clock monitoring using, among others, SCRAM, breath and urine tests. Although it is not possible to separate the effect of SCRAM from the other forms of testing used, the overall impact has been impressive: alcohol-related accidents and injuries have fallen by 43 per cent in the state over the last three years.

False positives

Amid the chorus of approval, however, there are a few dissenting voices. Ever since the anklet was introduced, a few wearers have claimed that the device produces false positives: alerts for drinking sessions that never happened.

The SCRAM's sensor detects the pair of oxygen and hydrogen atoms, called a hydroxyl group, characteristic of all alcohols. This means it cannot discriminate between ethanol and other forms of alcohol. Many common

household substances, such as cleaning fluids and perfume, contain alcohol, which can get into the gap between the detector and skin to produce a false reading.

AMS, however, insists that it can differentiate between external contamination and drinking. Suspicious readings are automatically flagged up by computer at the AMS offices. The company's customer service team takes a look and, if the readings seem ambiguous, sends them to Jeffrey Hawthorne, co-founder of AMS, and a colleague of his for confirmation. Hawthorne would not tell *New Scientist* exactly how they make that call, but says the process is based on the fact that external contaminants, such as perfume, build up on and evaporate from the skin more rapidly than ethanol from drinking.

When someone wearing a SCRAM starts drinking, Hawthorne says, the estimated blood alcohol concentration readings will rise by less than 0.05 percentage points per hour (see graph). When the wearer stops drinking, readings fall at less than 0.025 percentage points per hour. More rapid changes must be due to a contaminant, he claims.

Paige Lustig is just one of several people to disagree. One morning in February 2006, Lustig arrived for a modelling assignment at a hair salon in Birmingham, Alabama. She was on probation for drunk-driving and was wearing a SCRAM. Just after 1 pm, when she left the salon to go home, the device recorded a build-up of alcohol. Lustig found herself back in court facing a jail term.

Alcohol does not appear on the skin until

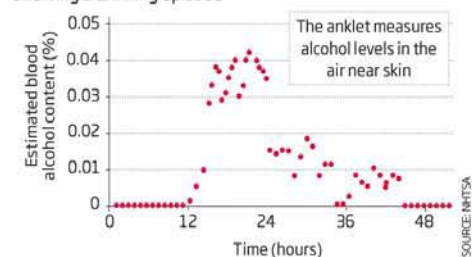
1 to 2 hours after consumption begins, so the readings suggested that Lustig started drinking in the middle of her modelling job. Lustig insists this did not happen. Salvatore Rino Marra, the salon's owner, told the probation hearing that he never allows alcohol in his salon. His wife, and one of the other stylists present that morning, also said that Lustig had not been drinking.

Marra and his wife had applied shampoo, gel, conditioner and large amounts of hair spray to Lustig's hair, compounds that often contain alcohol. Lustig's hair was also blown dry. It is possible that the air in the salon that morning contained enough alcohol to trigger the SCRAM, Michael Hlastala, an expert in the physiology of alcohol at the University of Washington in Seattle, told the court.

Hlastala is a critic of the SCRAM and has testified in around a dozen cases involving the device. He accepts that contaminants generally build up and decay more rapidly than alcohol from drinking, but claims SCRAM

Gotcha

Readings from an alcohol monitor showing a drinking episode





"Stopping drink-drivers from driving didn't always work. Now we have a way to stop them drinking"

MOOREBOARD/ALAMY

data is often so noisy that it is not always possible to distinguish between the two. "It's very hard to identify curves caused by these chemicals," he warns.

Lustig's probation violation was dismissed by the judge, largely on the basis of the eyewitness accounts. AMS would not comment on the case, but the company acknowledges that mistakes are possible, if rare. Brown says that AMS runs internal monthly tests using at least 10 volunteers. Each wears a SCRAM anklet and keeps a log of their activities, including drinking. "We recruit people from hair salons, auto shops, construction sites, bars," she says. Over 12 years of testing, the false positive rate is running at 0.12 per cent. This figure suggests about 1 in 800 of the alerts issued to authorities by AMS is incorrect.

There is little independent research on the SCRAM, but what there is does not contradict AMS's internal findings. In one study, Paul Marques and Scott McKnight of the Pacific Institute for Research and Evaluation in Calverton, Maryland, checked the readings produced when 22 volunteers wearing SCRAMs drank, both in the lab and at home and in bars, over two to four weeks. The device detected 88 per cent of drinking episodes that raised blood-alcohol concentrations above 0.08 per cent – the limit for driving in many countries including the US and UK – with zero false positives (*Alcoholism: Clinical and Experimental Research*, vol 33, p 703).

Despite the small size of the study, its results have been used with great success

WE ARE MONITORING YOU

Electronic monitoring of offenders was pioneered in the US in the 1980s by a judge inspired by a Spider-Man comic. The first generation of tags, designed to enforce house arrests or curfews, simply reveal if someone is in the range of a base station. Now companies are starting to produce far more sophisticated devices, such as alcohol monitors.

GPS-based monitors are already being used to track people 24 hours a day and sound an alarm if they approach areas from which they have been banned. Next up will be devices containing accelerometers, which can reveal what people are doing, such as driving (see main story).

If these prove successful, companies could produce monitors that record far more, from heart rate and muscle movement to sound and video, to reveal exactly what people are up to. Inventors have even patented devices that would make it possible to apply electric shocks or immobilise wearers from afar.

A few people already choose to have RFID chips implanted to allow them to be identified by doctors or help locate them if kidnapped, and enforced implantation in prisoners and mentally impaired people has been considered. Some companies are trying to develop GPS-capable implants, as well as implantable insulin sensors, which might one day be adapted to monitor such things as drug use or stress hormones. More sophisticated implants will require better power sources than currently exist, however. Michael Le Page

to defend against court challenges to the SCRAM. Only a handful of alerts appear to have been overturned in court, *New Scientist's* research suggests, despite the fact that at least several tens of alerts must have been false positives.

Second opinion

Marques thinks AMS should notify SCRAM wearers immediately if a positive result is registered. That way, anyone who thinks the alert is a false positive might have time to take a breath or urine test. "If it's going to affect someone's freedom then we need confirmation," Marques says. In practice this could be difficult, as readings can only be sent to AMS when people are within range of the modem in their home. AMS, for its part, says it is up to the courts to decide if people should have the right to a back-up test.

For now, the company is focusing on the US market, and *New Scientist* found that few officials in other countries knew much about its alcohol monitors. The UK's Department of Transport says it has not looked at this kind of device, for instance. Introducing them could be tricky in many countries, because few have the legal power to stop people drinking altogether. In Australia, for instance, offenders can be banned from entering bars but not from drinking elsewhere.

Future monitors, however, could make it possible to detect more specific activities, such as driving while under the influence. L3 Communications of Canton, Massachusetts, has developed an anklet that can detect the characteristic patterns of acceleration and deceleration generated by the motion of a car, and the movement of a driver's foot on and off the pedals.

The anklet identified when people were driving with 100 per cent accuracy during internal testing, says Leroy Collins, a member of the development team. L3 designed the device for use with people who have had their driving licence suspended, but several companies are now developing rival alcohol monitors after AMS's success and some are interested in incorporating L3's technology.

Some people will think that this kind of monitoring is a step too far. But as long as it helps keep people off drink or off the road, and out of jail, it is likely to attract more supporters than critics. Even researchers concerned about the lack of rigorous, large-scale studies say the benefits of AMS's device justify its use. "I'm sceptical about the science," says Arthur Lurigio, who studies criminal justice and health at Loyola University in Chicago. "But I welcome the SCRAM because it helps people avoid jail and the stigma of jail." ■

Jim Giles is a correspondent in *New Scientist's* San Francisco office. He posts at twitter.com/jimgiles



TUI DE ROYINDEWIJPA

Evolutionary puzzle or force for change? Biologists are reassessing same-sex liaisons, says **Kate Douglas**

Homosexual selection

NOT long ago, the news was full of reports about two male Humboldt penguins at a zoo in Germany that adopted an egg, hatched it and reared the chick together. It seems like every time you turn around, the media spotlight has fallen on another example of same-sex liaisons in the animal kingdom.

In the past few years, the ubiquity of such behaviour has become apparent. This summer evolutionary biologists Marlene Zuk and Nathan Bailey from the University of California, Riverside, published a paper on the subject that included examples from dozens of species ranging from dung flies and woodpeckers to bison and macaques.

That is just the beginning of the story. The burning question is why same-sex behaviour would evolve at all when it runs counter to evolutionary principles. But does it? In fact there are many good reasons for same-sex sexual behaviour. What's more, Zuk and Bailey suggest that in a species where it is common, it is an important driving force in evolution.

Although terms such as homosexual, gay and transgender are commonly used by the mass media, and even by some ethologists, Bailey and Zuk believe you shouldn't extend these descriptors of human sexuality to animals. "It's not simply that they are burdened with the weight of social, moral and political implications, which can obscure objective scientific study," says Bailey. "The problem is that while we can observe the sexual behaviour of animals, we often have little inkling about what motivates it." Besides, as far as we know animals do not form sexual self-identities in the way humans do, he adds. That is why he and Zuk prefer to use the more objective term "same-sex sexual behaviour",



Birds that form same-sex pairings include Laysan albatrosses (left) and Humboldt penguins

which they define as behaviours found in two animals of the same sex that you would find in opposite-sex pairs during courtship, copulation or parenting.

Same-sex behaviour is not necessarily synonymous with same-sex preferences, which have been observed in only a handful of animals. In 2005, for example, Hans Van

"Why expend time and energy in activities that fail to increase reproductive success?"

Gossum from the University of Antwerp in Belgium and colleagues found that damselflies kept in all-male groups subsequently preferred to court other males rather than females, though this preference could be reversed simply by housing them with females (*Biological Letters*, vol 1, p 268).

Neither can you necessarily infer anything about sexual orientation from same-sex behaviour. Orientation is tricky to establish because it requires information about the consistency of partner preferences over a long

period of time. Examples are thin on the ground, either because they do not exist or because they have yet to be discovered. The most notable include some male bighorn sheep that have been observed to predominantly mount other males throughout their lives, and female Laysan albatrosses – more of which later.

Nevertheless, even narrowing the scope to sexual behaviours rather than preferences or orientation leaves a huge evolutionary puzzle. Why would individuals expend time and energy in activities that fail to increase reproductive success? Could the sheer numbers engaging in same-sex behaviour mean that it has survival benefits after all?

In 2008, Sara Lewis at Tufts University in Medford, Massachusetts, and colleagues decided to address this question (*Journal of Evolutionary Biology*, vol 22, p 60). Red flour beetles are a scourge of the pantry, but they are up to more in there than just infesting your food. Sexually receptive females locate

males by homing in on airborne pheromones released by the males, but these same signals also occasionally attract other males. The mounting male clambers on top of his quarry and extrudes his genitals, sometimes transferring sperm to the hind end of his partner. Might these male-male copulations provide some benefit to the participants? The researchers designed an experiment to test three possibilities: that males establish social dominance by mounting other males, that males who mount other males gain practice ➤

for later sexual encounters with females, and finally, that mounting males transfer sperm onto the other males, who then inadvertently inseminate a female with it later on. Only this last idea stood up: they found that a small proportion of offspring were fathered by males who had never mated with the mothers but had mounted another male that had subsequently copulated with the female.

Other research groups have tested the evolutionary underpinnings of same-sex behaviour in different species and come up with a variety of explanations. Zuk and Bailey were intrigued by the idea that there might be common factors in these various theories. Their paper brings all the evidence together for the first time and concludes that there are many evolutionary origins of same-sex sexual behaviour (*Trends in*



JASPER VAN HEUSDEN

Damselflies exhibit the prison effect, while some bighorn sheep form committed male-male pairs

insemination, as in the flour beetle, provides a third possible adaptive advantage. Then there is the practice hypothesis, that individuals are honing their skills for mating, which seems to hold good for male fruit flies at least.

Several other adaptive explanations have been invoked to explain same-sex behaviour in humans, including kin selection – helping to further the genes you share with close

There are also various non-adaptive explanations. Mistaken identity could indeed be one cause. Van Gossum's damselflies exemplify another idea, known as the prisoner effect, in which depriving individuals of interaction with the opposite sex prompts them to mate with members of their own sex. Then there is the evolutionary by-product hypothesis – selection for some other independent trait, such as high sexual responsiveness, might make individuals more likely to participate in same-sex sexual behaviour. It has also been suggested that same-sex behaviours appear when organisms are imperfectly adapted to their environment.

Even without further investigation of these hypotheses there is enough evidence to conclude that same-sex sexual behaviour has a wide variety of origins. Zuk and Bailey were also struck by the idea that evolutionary biologists have been missing an important piece of the puzzle. Regardless of why same-sex behaviour exists, if it is common enough, it is likely to affect social interactions within a population, change the behaviour of other individuals, and even nudge the evolution of other traits in a different direction. "Researchers have not studied the evolutionary consequences of same-sex behaviour, but we found some tantalising examples that suggest it might be worthwhile to do so," says Bailey.

Take the desert locust, famous for forming dense, apocalyptic swarms. In the midst of this orgiastic chaos, males are sometimes mounted by other males, and so miss the opportunity to copulate with females or simply to feed. However, they can minimise the chances of this happening by releasing large amounts of a pheromone called phenylacetone. The mere possibility of same-sex sexual behaviour, for whatever reason, might have favoured the evolution of males that release lots of phenylacetone at just the right moment to ward off other males and prevent same-sex mounting. Then there is the example of the common toad. A male toad has to be persuasive to get a female to mate with him – in fact, he has to

"Evolutionary biologists have been missing an important piece of the puzzle"

Evolution and Ecology, vol 24, p 439).

First, there are the adaptive hypotheses, which provide an explanation for same-sex behaviour that would boost the biological fitness of one or more of the individuals involved (see chart, below). For example, several species, including bottlenose dolphins, seem to use same-sex behaviours to promote social bonding. Others may have evolved them as a form of intrasexual conflict. Indirect

family members – and "over-dominance" – the idea that certain genes somehow increase fitness in individuals who possess a single copy of them but are associated with same-sex behaviour in people with two copies. Then there is "sexually antagonistic selection" – the idea that alleles promoting same-sex behaviour in men are favoured by selection because they increase the reproductive chances of their daughters.

Explicable liaisons

Same-sex sexual behaviour is remarkably common among animals, and studies suggest a host of reasons to explain its evolution

Adaptive explanations – improve survival of individuals involved

Social glue	To form and maintain bonds and alliances	Bottlenose dolphins	
	To reduce tension and prevent future conflict	Acorn woodpeckers	
	To facilitate reconciliation after conflict	Japanese macaques	
Intrasexual conflict	To establish and reinforce dominance hierarchies	American bison	
	To reduce reproductive success of competitors	Dung flies	
Practice	To improve courtship or mating skills	Fruit flies	
Kin selection	To provide resources to siblings	Humans	
Indirect insemination	To inseminate a female via another male	Flour beetles	
Over-dominance	When a single copy of a gene promotes survival, but two promote homosexuality	Humans	
Sexually antagonistic selection	When alleles promoting homosexuality in one sex increase fitness in the other	Humans	

Non-adaptive explanations – no associated survival benefit

Mistaken identity	Due to weak sex discrimination	Orange chromide cichlids	
Prison effect	In a single-sex environment	Damselflies	
Evolutionary by-product	As a result of selection for another trait, such as high sexual responsiveness	Japanese macaques	
Maladaptation	When organisms are imperfectly adapted to their environment	Many species	

SOURCE: DANIELA VERGARA



DONALD H. JONES/MINDEN PAPER

squeeze the eggs right out of her before he can fertilise them. Males accomplish this feat by embracing the object of their affection in a tight mating “hug” called amplexus. They are evidently not very good at telling females apart from males since they sometimes mistakenly climb onto other males. When this happens, the hapless victim pipes up with a special chirp, only used in this context, which prompts the clasping male to release his vice-like grip. “It would be worth investigating further whether this special ‘get off me’ chirp owes its existence to the presence of same-sex mounting in this species,” says Bailey.

Here are two small examples of physical traits that may have been shaped by same-sex behaviour. If Bailey and Zuk are correct, this could be the tip of the iceberg. They point out that in theory, there are many ways in which same-sex sexual behaviour could affect the evolutionary trajectory of a species. By definition it alters the social environment of a population of animals. Since an individual’s social environment affects its success in terms of survival and reproduction, you might expect such changes to influence the speed or direction of evolutionary change.

Take the Laysan albatross. These large, graceful seabirds establish breeding colonies on islands in the Hawaiian archipelago, and recently it emerged that in the Oahu colony over 30 per cent of the nesting pairs consist of two females. Female-female pairings have been observed in other birds, such as California gulls and roseate terns, but never at quite such a high rate. What’s more, Lindsay Young from the University of Hawaii found that many of the albatross female-

female pairs remain faithful over several years. They engage in mutual preening and even occasionally copulation, and, like female-male pairs, each year they raise a single chick. Both females will have laid a fertilised egg and randomly shunted one aside (*Biology Letters*, vol 4, p 323).

Changing evolution

The fact that female same-sex bonds accounted for nearly a third of the breeding pairs in the Oahu colony makes for interesting population dynamics, according to Bailey and Zuk, and it prompts the question of what evolutionary consequences the colony might experience as a result. For instance, in colonies where females without a mate remain single, the male gains little by straying from his female partner. Even if he did fertilise the egg of a non-paired female it would not survive as it takes two adults to raise a single chick. In the Oahu colony, though, males that mate with

females outside their long-term pair bond might gain an edge over those that do not. “So one evolutionary consequence to keep an eye out for in Laysan albatross populations that have high rates of female-female pairs is the evolution of males that spend more time copulating with females to whom they are not permanently bonded,” says Bailey.

From the female perspective there are possible evolutionary consequences too. Consider the procedure for deciding which of the two eggs in a female-female partnership is incubated. It appears to be random: in a population with only opposite-sex pairs, females never need to distinguish their own eggs, so the ability to do so is unlikely to have evolved. But imagine if a genetic mutation arose in one member of a female-female pair that enabled her to distinguish her egg from that laid by her partner, says Bailey. “The mutation would probably spread through the population and tip the dynamics of female-female relationships more towards conflict rather than cooperation.”

All this is hypothetical since same-sex behaviour has not been studied from this angle before. Nevertheless, there is no doubt that the prevalence of female-female pairs in the Oahu colony changes the costs and benefits of traits such as extra-pair copulations for males and egg recognition for females. What’s more, Bailey points out that the evolutionary consequences might reverberate way beyond this colony. That is because the excess of females in Oahu is a consequence of females having migrated in from elsewhere. By adopting same-sex parenting behaviour, female Laysan albatrosses could escape colonies with dwindling resources and reproduce even when the sex ratio in their adoptive colony is biased against them.

Whether or not same-sex behaviour is an important factor in evolution remains to be seen. “Given its persistence in species in many different animal groups, including humans, viewing it as an evolutionary force in its own right promises to provide a much richer understanding of the evolution of reproductive behaviour,” Bailey says. He suggests we could make some fascinating comparisons. Might male-male copulation in species as diverse as flour beetles and dolphins have similar, even predictable, evolutionary consequences? More daringly, could understanding the evolutionary consequences of same-sex interactions in animals help us understand our own evolution? ■



R. D. SCHNEIDER/FLPA

Male common toads have a special chirp to discourage advances from other males

Kate Douglas is a feature editor at *New Scientist*

Fantastic journeys

Find the perfect gift from our selection of books, computer games and e-readers. First up, the best of the picture books

PICTURE books make fabulous gifts – especially when they are both informative and fun to look at. Our choices combine aesthetic appeal with quality content.

The Art of Nature by Judith Magee, Natural History Museum, (£25) is a visual celebration of European natural history illustrations. Continent by continent, the stories of the collectors and artists are told, accompanied by sumptuous watercolours, detailed maps, beguiling animal sketches and botanical drawings. As the introduction notes, the drawings and observations were heavily influenced by the mores of the time so this book is an insight into how Europeans perceived the natural world.

A coffee table book in the truest sense, photographer Michael Poliza's new tome *AntArctic* (teNeues, £85/\$125) is stuffed with 135 large-scale photographs. There are plenty of striking images – from those so close you can make out the individual water droplets on a penguin's face to the sweeping glacial landscapes complete with perfect sunsets.

A journalist's description of Poliza's expeditions to both poles (hence the title) is interesting, but anecdotes would have been better in the man's own words, such as the tale of the time Poliza came across the perfect polar bear shot whilst nipping out for a midnight pee. The book would make an impressive gift on size alone, but the editor seems to have gone for quantity over quality. I would have preferred fewer photos but have every single one take my breath away.

I found exactly that in *Surviving* by Alessandro Minelli and Maria Pia Mannucci, (Firefly Books, £30/\$45), a whistle-stop tour of the survival secrets of the planet's most exquisitely adapted creatures. The colours are wonderfully vibrant, and, set against black backgrounds, the subjects seem to leap off the page.

The Heart of the Great Alone by David Hempleman-Adams, Sophie Gordon and Emma Stuart, (Bloomsbury, £29.95/\$47.50) tells the epic tales of Ernest Shackleton's attempt to cross Antarctica and Captain Scott's ill-fated polar voyage through the lenses of their photographers. Although some of

Final journey: Herbert Ponting's *Grotto in an iceberg*

the photographs have been seen before, they are truly excellent and capture the utter desolation of the frozen wastes.

When we look at pictures of distant stars and galaxies we are staring into the past since the light has taken so long to reach us. *Far Out: A space-time chronicle* (Michael Benson, Abrams, £30/\$55) takes advantage of this fact to make the book much more than just a beautiful photographic record of our universe. You start with images of the youngest light from nearby stars and galaxies, and move further into space and back through time with each turn of the page. Accompanying the images are explanations of significant events in Earth's history at the time the light left the star, for example, light from the nearby Corona Australis constellation was emitted around the time Columbus came upon the Bahamas, while that from the more distant galaxies has been travelling towards us since the Earth's continents were one.

60: Innovators shaping our creative future (Thames & Hudson, £35/\$75) will appeal to anyone with an interest in popular culture and design. A slick book with high-quality photographs, it showcases the most creative minds in fashion, architecture, photography, green technology and science – including biomimicry populariser Janine Benyus and eco-warrior and leader of the "Transition movement" Rob Hopkins. Reviewed by Jessica Griggs

The best of the rest

The Metamorphosis of Plants by Johann Wolfgang von Goethe and Gordon Miller, (MIT Press, £16.95/\$21.95)

The latest translation of the 1790 classic is brought to life with stunning botanical photos. Perfect for a Goethe enthusiast or a green-fingered history buff.

The Elements by Theodore Gray, (Black Dog and Leventhal, £22.95/\$29.95)

A visual periodic table is book I'd have liked when I was young.

Life (BBC Books, £25)

The book to accompany the BBC television series, full of great pictures and intriguing text.

Wildlife Photographer of the Year (BBC Books, £25)

The 19th incarnation of a wildlife favourite never disappoints.



Now read on...

Out-of-the-ordinary books to satisfy all tastes

Hands-on Einstein

Einstein: The life of a genius by
Walter Isaacson, Andre Deutsch, £30

Reviewed by Andrew Robinson



IF YOU hanker after rare Einstein-related facsimiles, such as his 1896 school-leaving certificate (physics grade: 6/6), his 1940 American certificate of naturalisation, or his handwritten lecture notes on relativity in Berlin and Zurich from 1918-19, then this superbly illustrated book on his life and work, all packed in a sturdy box, is for you.

The intelligent text by Einstein biographer Walter Isaacson is surprisingly serious, with German documents translated. There are slips – for example, nothing on Einstein's powerful opposition to the hydrogen bomb. Nonetheless, this elaborate production makes for a pleasurable distracting read. **Perfect for: Einstein aficionados who think they have everything**

What's on your mind?

This Will Change Everything edited by
John Brockman, HarperCollins, \$14.99

Reviewed by Michael Bond



LITERARY agent John Brockman assembles a stellar cast of intellectuals each year to answer a boundary-pushing question. His latest poser – “What game-changing scientific ideas and developments do you expect to live to see?” – has drawn a stunning array of responses, from nuclear terrorism to in-vitro meat.

Some ideas are predictable (immortality, intelligent robots, designer children), some world-saving if they happened (oil we can grow) and some we'd be better off without (neuro-cosmetics). Many are self-indulgent technological fantasies. With contributions from Ian McEwan, Steven Pinker, Lee Smolin, Craig Venter, Richard Dawkins and 130 others of their ilk, the book is like an intellectual lucky dip. **Perfect for: anyone who wants to know what the big thinkers will be chewing on in 2010**

Proof's in the picture

Logicomix by Apostolos Doxiadis and
Christos Papadimitriou, Bloomsbury,
£16.99/\$22.95

Reviewed by Mike Holderness



IN THIS graphic-novel biography of philosopher and mathematician Bertrand Russell, the book's artists draw themselves and their debates with the authors about how, say, to illustrate the concept “proof”. Such self-reference is at the heart of the story, from Russell's despair at the paradox that halted his effort to put mathematics on a rigorous footing, to Kurt Gödel's incompleteness theorems nailing down that project's coffin.

Logicomix grippingly recounts the turmoil of the 20th-century logical world. As Russell searches for certainties we ask with him: does formal logic drive people mad, or does madness drive them to formal logic?

Perfect for: those working on a formal proof that it is possible to be both strange and happy ➤

Pop-up physics

Voyage to the Heart of Matter
by Anton Radevsky and Emma Sanders,
Papadakis, £20

Reviewed by Valerie Jamieson



AMONG popular books about particle physics, this one stands out – quite literally. It is the world's first pop-up book about the Large

Hadron Collider, the atom-smashing behemoth under the French-Swiss border.

Renowned paper engineer Anton Radevsky uses every trick in the pop-up book to recreate the universe, the LHC and the biggest of its four experiments, ATLAS, and he does so to wonderful effect (see picture, right). It is fitting that complex paper engineering is used to reflect the LHC's engineering achievements.

Voyage to the Heart of Matter is not without its flaws. Some of the pop-ups need a helping hand and at times the book is hard to navigate. Yet there's a lot packed into its eight pages, and the level of detail in the illustrations guarantees you'll spot something new each time you read it. **Perfect for: teenagers who have studied the LHC at school or been lucky enough to visit CERN**

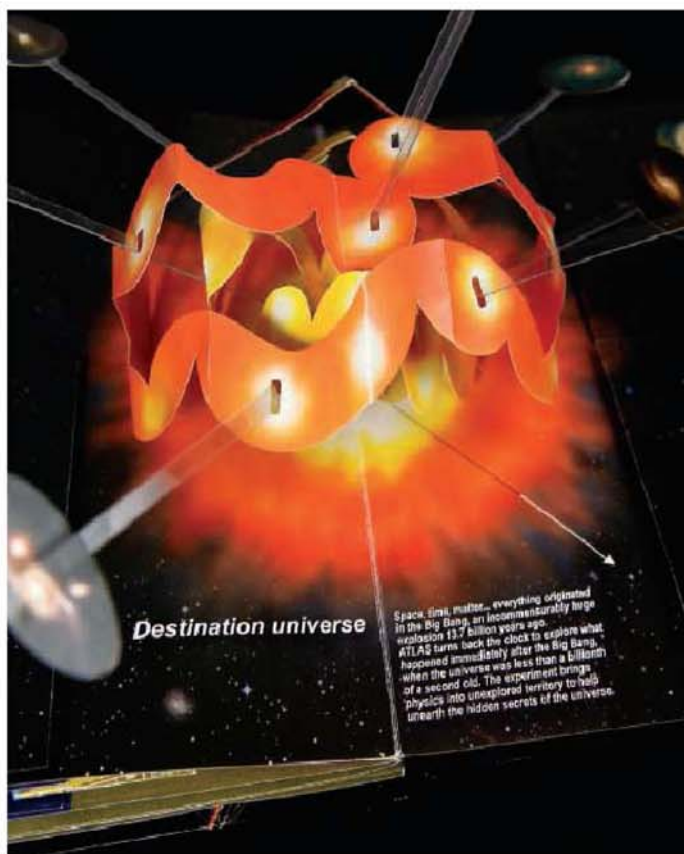
A dazzling partnership

When It Changed edited by Geoff Ryman, Comma Press, £7.99

Reviewed by Michael Brooks



WRITING science into fiction is often a hit-and-miss affair. Some ideas work beautifully for inexplicable reasons; other ideas never seem to find what it is they are looking for, for equally inexplicable reasons. The anthology *When It Changed*, though, is all hit, no



miss. It is thought-provoking at worst, and stunning at best.

Sara Maitland's "Moss Witch", a cautionary tale for eager botanists, is simply dazzling; my woodland walks will never be the same. Editor Geoff Ryman's story, "You", a snapshot of a world where everybody's lives are accessible through searchable video blogs, is a complex and insightful exploration of seeing the world through someone else's eyes.

The idea behind the book is just as good: each piece of fiction is partnered with a note from the scientist whose input inspired it, allowing us a rare glimpse into their world. Simon Ings's story, "Zoology", for example, gets inside the restless, curious (some might say troubled) mind of a scientist; the note accompanying Ings's piece, by biologist Matthew Cobb, is equally revelatory about the processes behind science. The book shows that science can inspire anyone and everyone. **Perfect for: that special someone who doesn't yet "get" science**

Breath of fresh air

The Invention of Air by Steven Johnson, Penguin, £9.99/\$16

Reviewed by Stephanie Pain



THIS deceptive little book is ostensibly the tale of Joseph Priestley, best known in the UK as the man who discovered oxygen and in the US as a hero of the American revolution. But this isn't just the story of how a provincial minister with radical ideas became one of England's most important scientists and its most hated man, forced to flee to his friends in the US. It is also a compelling inquiry into the nature of scientific discovery.

As Johnson points out in the book, now published for the first time in the UK, Priestley and his fellow dabblers had advantages today's scientists must envy – an enormous range of interests, a vast breadth of knowledge,

the freedom to share everything they learned and the luxury of time to think, experiment and pursue other interests without professors, managers or funding bodies breathing down their necks. Who today could spend 30 years following a hunch? **Perfect for: any scientist in need of inspiration**

Well versed

Song of Two Worlds by Alan Lightman, A K Peters, £18/\$24.95

Reviewed by Liz Else



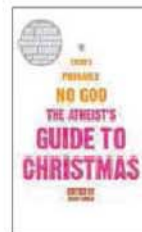
THIS slim volume of narrative verse is a bold move. The point, says arts/science polymath Alan Lightman, is to explore meaning and truth

in science, but in the highly concentrated form only possible in verse. It pays off: "There's no completion in mind/With its unending halls/Or electronic minds that have no belief". **Perfect for: your aesthetic auntie**

Godless Christmas

The Atheist's Guide to Christmas
edited by Ariane Sherine, Friday Books,
£12.99/\$24.95

Reviewed by Amanda Geffer



NON-BELIEVERS this season fear not: there's a Christmas book just for you, by atheist comedians, philosophers and scientists. Among

my favourite stories in the science section are Richard Dawkins's "The great bus mystery" and Nick Doody's history of the scientific discipline Christmasology (which will achieve great breakthroughs as soon as the Yule Hypercollider fires up at the North Pole to discover the Christmas particle). **Perfect for: the godless, good-humoured people on your list**

Red menace

It's the cold war all over again, says **Steven Poole**

THIS season's hottest games are selling geopolitical nostalgia: all the bad guys are Russian. The military pandemonium simulator that is *Call of Duty: Modern warfare 2* (Activision, Xbox360/PS3/PC) features one level, already notorious, in which you play a CIA mole in the team of a mad Russian mastermind, accompanying them as they stroll through an airport massacring civilians. You don't have to kill the civilians yourself – as a protest against global consumerism, I decided to shoot up the duty-free shop instead – but the effect is unsettling. The rest is a Rolls-Royce-quality rehearsal of familiar shooter tropes, with some gorgeously built sets for the mayhem –

Military pandemonium simulator, aka *Call of Duty: Modern warfare 2*

a Brazilian favela stands out – but little thought is required beyond shooting the next guy in the face. The online options, which include dedicated cooperative missions, are state of the art.

A Russian ruffian also features in the other big action game, *Uncharted 2: Among thieves*

"Uncharted 2 crams in every great speeding train action-movie cliché in history"

(Sony, PS3), which resembles a movie starring Indiana Jones's psychopathic kid brother. Your hero flirts, quips and smashes priceless artefacts through snack-sized cinematic clips and *Tomb Raider*-style locations, never forgetting the primary business of shooting a thousand hoodlums

to death. It's just a glittering, linear string of set pieces, but some of them are spectacular. For a deliriously adrenalinised ride, the designers have crammed in every great speeding train action-movie cliché in history, and then thought up some more of their own.

More sedate diversions are offered by *EyePet* (Sony, PS3). With a webcam (supplied) pointed at your floor, you interact with a cute virtual animal, a kind of monkey-dog. Feed it, groom it, wash it, play with it and even show it drawings: they become objects in the game's intriguing space-between-two-worlds. A sure delight for young children, and an impressive experiment in augmented-reality technology.

You can also magic up a monkey, or a dog, but not a hybrid of the two, in *Scribblenauts* (Nintendo, Nintendo DS), a slightly messy but lovably surreal cartoon-style game in which you solve problems by typing in words for things, and watching those things appear in the game's world, complete with physically modelled behaviours. There is a 20,000-word object repertoire: anvils, hot-air balloons or bridges glued to tyrannosaurs can all be yours – if you can figure out how to use them. Refreshingly, I couldn't create a Russian villain.

Steven Poole is the author of *Trigger Happy: The inner life of videogames* (2000)

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E-READERS

Thanks to a growing selection of e-books, innovative new devices, and the notion that trees are just too valuable to waste on print, e-readers are ready for the mainstream. Yet draconian software is a significant barrier, preventing copying, lending or even freely accessing most modern books. Here is our lowdown on the latest devices

Sony Reader Touch Edition PRS-600 (£240)

This has the advantage of a touch screen that allows you to navigate menus, add notes with a stylus and turn pages with a finger swipe. Needs a PC or Mac to download books and articles from the web

Amazon Kindle (\$259)

The Kindle, available only from Amazon.com, automatically connects to a 3G cellphone network for free, so you can buy books, newspapers and magazines direct from Amazon. Slim, light, easy to use: the device to beat

The Nook (\$259)

Not to be outdone by Amazon, Barnes & Noble released its own e-reader with a 3G connection in October. It has a black and white screen for reading and a narrow colour touchscreen for browsing and buying. Only available in the US

iPhone e-readers

Why buy and carry a separate e-reader if your phone can do the job? Small screen aside, the pick of the iPhone e-readers are Stanza, eReader and the Barnes & Noble app, all free to download

Laptop e-readers

Limited battery life and weightiness make reading e-books on a laptop a chore. That could change next year with the arrival of smartbooks – small, light, ultra low-power devices. For software try Adobe's Digital Editions, Microsoft Reader or eReader, all free to download
Justin Mullins



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BIOLOGY

ASSISTANT PROFESSOR AND ASSOCIATE PROFESSOR POSITIONS

Harvard Medical School (HMS)
and Massachusetts General
Hospital (MGH)

MA - Massachusetts

Positions for Assistant Professor
and Associate Professor, are
available at the Cutaneous Biology
Research Center of MGH/Harvard
Medical School/Department of
Dermatology.

For more information visit
NewScientistJobs.com Job ID:
200641020

Assistant Research Scientist - 46685

City of Hope
CA - California

Work involves constructing
vaccines for a collaborative study
in macaques, completion of GLP
development of a multi-antigen
vaccine for human use, and other
collaborative efforts.

For more information visit
NewScientistJobs.com Job ID:
200647740

Assistant Research Scientist - Hematopoietic Stem Cell & Leukemia

City of Hope
CA - California

Our research program is focused on
investigation of regulation of normal
and malignant hematopoiesis.
Specific areas of interest include
study of molecular mechanisms
of stem cell transformation;
development of mechanism based
therapies; and investigation of
hematopoietic development from
pluripotent cells.

For more information visit
NewScientistJobs.com Job ID:
200647746

Assistant, Associate or Full Professor - New York

SUNY Downstate Medical Center

NY - New York

A position is available at the SUNY
Downstate Medical Center to
develop a cutting-edge research
program in proteomics, lipidomics
and metabolomics.

For more information visit
NewScientistJobs.com Job ID:
200644071

Bioinformatics Staff Scientist, RTP North Carolina

The National Institute of
Environmental Health Sciences
NIEHS, NIH

NC - North Carolina

The Laboratory of Neurobiology
is seeking a Staff Scientist with a
strong background in computer
science, bioinformatics and
advanced statistical methodologies
to participate in team research on
the epigenetic regulation of cellular
processes.

For more information visit
NewScientistJobs.com Job ID:
200646826

CANCER RESEARCH - ROCHESTER NY - FACULTY POSITIONS

University of Rochester Medical
Center

NY - New York

Two positions at the Assistant
and/or Associate Professor level
are available in the University
of Rochester Medical Center,
Department of Surgery Tumor
Biology Research Group.

For more information visit
NewScientistJobs.com Job ID:
200646606

Facilitators for pharmaceutical teams curriculum

Novartis Institutes for
BioMedical Research (US)

MA - Massachusetts

Novartis Institutes for BioMedical
Research (NIBR) is looking to
contract with experienced
facilitators familiar with experiential
learning techniques (involving
participants in active participation,

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Fax 415 543 6789

collaboration and interaction) to
deliver pre-established curriculum
for the Creative Teams Program.

For more information visit
NewScientistJobs.com Job ID:
200641138

Faculty Positions: Cancer Biology

Moffitt Cancer Center
FL - Florida

While candidates working on any
cancer type will be considered,
preference will be given to those
with an interest in melanoma
research. An outstanding start-up
package is available, as well as
a highly competitive salary and
excellent lab space.

For more information visit
NewScientistJobs.com Job ID:
200645280

Postdoctoral Fellow - Tufts Medical Center, Boston MA

Tufts Medical Center
MA - Massachusetts

NIH-funded position available in
vascular biology, investigating
the role of innate immunity in
atheroclerosis. Ph.D in physiology,
cell biology, immunology or related
field required.

For more information visit
NewScientistJobs.com Job ID:
200642985

Research Associate I/II

Medimmune US

CA - California

Development and/or optimization
of virus upstream processes (from
cell thaw through viral harvest). This
includes designing experiments,
analyzing data, developing batch
records, SOPs and protocols, and
writing and/or reviewing technical
reports.

For more information visit
NewScientistJobs.com Job ID:
200645870

Research Associate II

City of Hope
CA - California

The majority of the work will consist
of processing of human blood
specimens for flow cytometry to
support development of vaccine
candidates that target tumor
antigens involved in hematologic
malignancies in support of our
institutional stem cell transplant
program.

For more information visit
NewScientistJobs.com Job ID:
200647728

Research Associate II - 50143 - Islet Cells

City of Hope
CA - California

Seeking research associate to work
on our clinical and research islet
isolation team. Be a part of the islet
transplantation program at City of
Hope and the Southern California
Islet Consortium.

For more information visit
NewScientistJobs.com Job ID:
200647733

Research Associate II - Gene Regulation Drug Discovery

City of Hope
CA - California

The laboratory integrates
molecular, cellular and whole
animal approaches to identify novel
pathways of estrogen-related
receptor mediated gene regulation
and to determine their regulatory
effects on target genes and energy
metabolism in cardiac and skeletal
models.

For more information visit
NewScientistJobs.com Job ID:
200647735

Research Faculty Computational and Systems Biology

Memorial Sloan-Kettering
Cancer Center

NY - New York

Pursue basic research, solve
biological problems with major
emphasis on computational
methods, and build active bridges to
experimental and clinical research.
Actively participate in building out

research programs at one of the best clinical-scientific institutions in the world.

For more information visit
NewScientistJobs.com Job ID:
200645874

Research Scientist

Pfizer US
 MA - Massachusetts
 The Advanced Drug Delivery group is seeking a qualified technical scientist to provide technical expertise in development and evaluation of novel biomolecular conjugates, and their application to new candidate drug products.
For more information visit
NewScientistJobs.com Job ID:
200641768

Research Scientist- ImClone Systems- #110490- New York, NY

ImClone Systems
 NY - New York
 A leader in therapeutic antibodies, ImClone Systems is committed to advancing oncology care by developing a portfolio of novel targeted biologic treatments designed to address the medical needs of patients with a variety of cancers.
For more information visit
NewScientistJobs.com Job ID:
200641018

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Vanderbilt University Medical Center
 TN - Tennessee
 Basic biomedical research and clinical research protocols at Vanderbilt have long been recognized for their contributions to the advancement of medicine.
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NewScientistJobs.com Job ID:
200647655

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The Salk Institute
 CA - California
 This symposium brings together leaders who will discuss and

compare the molecular events and higher cognition that occurs in the chemosensory, somatosensory, auditory and the visual systems.
For more information visit
NewScientistJobs.com Job ID:
200645877

Senior Manager of Youth Programs

Project Exploration
 IL - Illinois
 Set and lead the tone of youth programs at Project Exploration
 •Develop, manage, implement, and evaluate all youth development programs, youth activities, and program materials.
For more information visit
NewScientistJobs.com Job ID:
200277977

Associate Scientist II/ Scientist I

Medimmune US
 CA - California
 The essential responsibilities will include planning and executing pre-formulation and formulation studies, developing and performing biophysical, biochemical and biological analyses.
For more information visit
NewScientistJobs.com Job ID:
200645868

Software Engineer II

Dana-Farber Cancer Institute
 MA - Massachusetts
 We cordially invite applications for a one-year Bioinformatics Software Engineer position in computational biology and bioinformatics. The position may be extended contingent on obtaining further funding.
For more information visit
NewScientistJobs.com Job ID:
200641965

Support Scientist - Molecular Medicine - #46332

City of Hope
 CA - California
 The ideal candidate should be highly organized with experience in working with a multi-disciplinary team for handling high throughput sequencing analysis within Bioinformatics Core Facility,

Beckman Research Institute.
For more information visit
NewScientistJobs.com Job ID:
200647743

Technical Delivery Manager

Medimmune US
 MD - Maryland
 Position will be responsible for understanding business problems and working with relationship managers, business analysts and technical teams to develop technology solutions in support of business needs.
For more information visit
NewScientistJobs.com Job ID:
200642313

CHEMISTRY

Formulation Scientist #225337

ImClone Systems
 NJ - New Jersey
 A leader in therapeutic antibodies, ImClone Systems is committed to advancing oncology care by developing a portfolio of novel targeted biologic treatments designed to address the medical needs of patients with a variety of cancers.
For more information visit
NewScientistJobs.com Job ID:
200645875

CLINICAL

Clinical Research Nurse (204951)

Henry M Jackson Foundation
 CA - California
 The Henry M. Jackson Foundation (HJF) is seeking a Clinical Research Nurse to support the Clinical Investigation Department located at the Naval Medical Center in San Diego (NMCSD)
For more information visit
NewScientistJobs.com Job ID:
200645879

MATHS & IT

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New Visions for Public Schools- Hunter College
 NY - New York
 The New Visions-Hunter College Urban Teacher Residency is a 14-month teacher-training program

that fully integrates the graduate coursework of the aspiring teacher (resident) with intensive, hands-on experiences in New York City schools.

For more information visit
NewScientistJobs.com Job ID:
200642973

PHYSICS

Medical Physicist

Brigham and Women's Hospital & Harvard Medical School
 MA - Massachusetts
 The Medical Physics and Biophysics Division is seeking a PhD level Physicist at the Assistant or Associate Professor level to join our dynamic Physics staff of 50 people, including 12 faculty physicists.
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NewScientistJobs.com Job ID:
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Online Tutoring Positions - Statistics, Calculus, Chemistry, Physics and other core academic subjects.
 United States.
 The world's leader in Online Tutoring and Homework Help still has online tutoring positions for the 2009/2010 academic year for anyone who is well versed in Statistics, Calculus, Chemistry or Physics as well as other core academic subjects.
For more information visit
NewScientistJobs.com Job ID:
200649065

McGill University (200647928)

Tenure-Track Faculty Position, Experimental Condensed Matter Physics
 Brigham and Women's Hospital & Harvard Medical School
 QC - Quebec
 The applicant will be expected to become a member of the Centre for the Physics of Materials, which includes faculty members from the departments of Physics and Chemistry as well as research scientists in industrial laboratories.
For more information visit
NewScientistJobs.com Job ID:
200647928

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Global Germplasm Management

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Nutrient and Water Use Efficiency

Plant Breeding and Genetics

Plant Molecular Biology

Plant Pathology/Entomology/Nematology

Plant Physiology

Plant Transformation

Protein Sciences

Regulatory Sciences/Affairs

Statistical/Quantitative Genetics

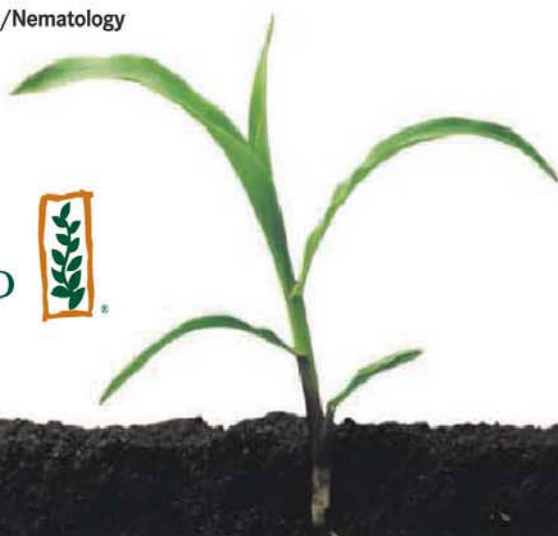
Structural Biology

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NIEHS
National Institute of
Environmental Health Sciences
National Institutes of Health

Bioinformatics Staff Scientist

Research Triangle Park, NC

The Laboratory of Neurobiology is seeking a Staff Scientist with a strong background in computer science, bioinformatics and advanced statistical methodologies to participate in team research on the epigenetic regulation of cellular processes. The position is ideal for a person with proven experience in theoretical sciences interested in applying his or her knowledge to cutting edge biological problems that include control of stem cell lineage, cell differentiation, neuronal development and aging in health and disease. Research by the candidate will be in support of research directed by Dr. Lutz Birnbaumer, a Principal Investigator at the NIEHS in the central-north area of North Carolina. Dr. Birnbaumer's group at the NIEHS has developed methodology to assess genome-wide changes in the methylation status of genomic DNA at single-base-pair resolution. He and his team are using this technology to study the roles of DNA methylation in health and disease. Each experiment generates 40 to 400 million data points that require analysis by investigators familiar with the computer science and statistical tools required to extract understandable associations and differences, including postulation of regulatory networks and mechanisms of cell lineage definition.

Minimum qualifications include a doctoral degree (Ph.D. or equivalent) with a strong background in computer science, bioinformatics, and advanced statistical methodology. Experience or familiarity with modern concepts of epigenetics and regulation of cellular processes will make a candidate particularly suitable. Salary is commensurate with background. For additional information concerning the position, contact Dr. Lutz Birnbaumer at birnbau1@niehs.nih.gov. For additional information concerning the research projects and publications, visit website: <http://www.niehs.nih.gov/research/atniehs/labs/ln/ts/index.cfm>.

Staff scientist positions within the NIH system are equivalent to research assistant professor positions in academia. The appointments are for 5 years, renewable if deemed appropriate. However, the expectation is that the candidate will move on with a new experience and an enriched list of publications.

Applications from women and minorities are particularly encouraged. To apply, submit a cover letter indicating interests, curriculum vitae and 3 letters of recommendation by December 31, 2009 to:

Ms. Barbara Curtis (DIR09-05)
National Institutes of Health • National Institute of Environmental Health Sciences
P.O. Box 12233, Maildrop A2-06 • 111 Alexander Drive, Room A248
Research Triangle Park, NC 27709
E-mail: dir-appls@niehs.nih.gov



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
National Institutes of Health

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Director

NATO Undersea Research Centre, La Spezia, Italy



The NATO Undersea Research Centre (NURC) develops technology that will facilitate the transformation of NATO military capabilities and is a focus for partnering in maritime innovation for NATO Commands and the NATO Nations. The Director NURC is assigned by the North Atlantic Council (NAC) upon the recommendation of the Supreme Allied Commander Transformation (SACT) and with the advice of the Scientific Committee (SC). He/she is responsible to SACT for addressing shortfalls in NATO's maritime operational and transformational capabilities in coordination with the Military Committee (MC), the Conference of National Armaments Directors, and the NATO member states.

Key challenges facing the successful candidate for Director will include requirements to:

- Develop the long term vision for research and technology to establish the scientific foundations underpinning the transformation of the military capabilities of NATO's maritime forces, and to implement NATO's concept of operations for maritime security.
- Develop the strategy to implement the new business plan which foresees the development of a customer funded programme of work to complement the NATO funded effort to transform Alliance maritime capabilities. Key challenges include establishing the financial and business mechanisms, marketing the services, and achieving synergy with and complementing the NATO funded scientific programme.
- Candidates are expected to attach to their application a maximum of four pages summarising their views about these (and possible other) challenges, and how they would address them if selected for the position.

MAIN DUTIES - The Director is the Chief Executive Officer of the NURC, responsible to SACT for the management of the Centre and fulfilment of the NURC's missions in accordance with its approved Charter and Terms of Reference, and in particular to:

- Formulate strategy and policies for the RT&D support of the NATO Commands and the NATO member nations, and the transformation of the Centre and propose these for implementation to the SACT, the MC and the NATO Council (NAC);
- Formulate, plan and conduct the NURC program of work within the Atlantic Alliance framework of NATO Command Structure guidance, and the NATO R&T strategy. Reporting to the NURC Scientific Committee (SC), the NATO Research and Technology Board (RTB), Conference of National Armament Directors (CNAD), and SACT.
- Assess and advise SACT with respect to the practical implications of Military Committee guidance, NATO RT&D policies, and SCNR recommendations.
- Prepare budgets and negotiate the allocation of financial resources with relevant NATO bodies;
- Promote NURC projects and NATO S&T, R&D, and RT&D in the field of expertise of NURC (naval and maritime) with sponsors and customers; working to transition RT&D results to military capability acquisition;
- Develop the Peace Establishment (list of authorized positions), and engage the necessary personnel to fill positions within the approved establishment;
- Develop investment proposals through interaction with host nations, HQ SACT or a NATO member state;
- Liaise with Italian authorities for Host Nation support of the Centre.
- Exercise either personally or through appropriate delegation the legal authority granted to the Centre with respect to contracts, legal and administrative procedures, and the acquisition and disposal of property;
- Work under the direction of SACT and implementing MC policies.

QUALIFICATIONS AND EXPERIENCE

ESSENTIAL - The incumbent must have:

- An advanced university degree (Master's degree or equivalent) preferably in science, engineering or a defence policy or complementary related discipline from an institute of recognised standing;
- Broad and substantial experience in the scientific and technical direction and management of military related research and development in the public or private sector, obtained by holding a position as Director, Chief Operating Officer, Deputy/Associate Director, or equivalent of a research or engineering organization with recognized national and international standing, or similar leadership positions;
- Demonstrated experience in fostering innovation as evidenced by holding a position as a business development officer, filing patents, reports and publications of achievements or recognition by professional organisations;
- Broad and substantial experience in business based project accounting and budgeting as well as with the management of risk;
- Substantial experience of project management for equipment & systems development, production or acquisition;
- Personal qualities, especially verbal and written communication skills, and professional and management stature such that he / she can represent the Centre appropriately in meetings of intergovernmental bodies, or with representatives of NATO member states MoD's;
- Experience in the personal performance of technological research in one or more of the pertinent naval warfare disciplines;
- Fluency, orally and in writing, in one of the official languages of the Organisations is essential and a good working knowledge of the other is desirable. The work of the NURC is conducted primarily in the English language; and
- A NATO COSMIC Top Secret security clearance (if not currently held the incumbent must be eligible for this level of clearance).

DESIRABLE - The following would be considered an advantage:

- Knowledge of quality management systems (e.g. ISO 9000), and of risk management;
- Knowledge of the Organization of NATO;
- Professional education as evidenced by an advanced university degree, preferably including the doctorate or equivalent academic attainment; and
- A qualification in management (Master of Business Administration or equivalent).

CONTRACT

- The successful applicant will be offered a definite duration contract of three years' duration, which may be renewed for an additional period.
- If the successful applicant is seconded from a national administration, public institution or the armed forces of a NATO member state, he or she will be offered a three year definite duration contract which, subject also to the agreement of the national authority concerned, may be renewed for a further period.
- Serving staff members will be offered a contract according to the NATO Civilian Personnel Regulations (NCPR).

HOW TO APPLY

- Complete the HQ SACT application form, (which can be downloaded from www.act.nato.int <click on Career Opportunities - Civilian Employment - Application> and attach a curriculum vitae, and submit to civilianpersonnel@act.nato.int. Applications from citizens of NATO's 28 participating nations are eligible to apply.
- Candidates are expected to attach to their application form a maximum of four pages summarising their views about the strategic challenges facing this post, and how they would address them if selected for the position.
- As part of the selection process, shortlisted candidates may be asked to attend an assessment centre and may be interviewed by members of the NURC Scientific Committee of National Representatives and senior members of HQ SACT.
- Appointment will be subject to approval by the North Atlantic Council, deliverance of a NATO COSMIC Top Secret security clearance by the national Authorities of the selected candidate and certificate of physical fitness.

For more information about this position, or to apply, please email: civilianpersonnel@act.nato.int or see application procedure at NewScientistJobs.com ID# 200633797. Application review will begin January 11th, 2009



Post Doctoral Position in Immunobiology: immunobiology laboratory performing basic and pre-clinical research related to vaccines against disease caused by bacterium *Neisseria meningitidis*. Duties will include performing various immunobiological assays, including assays involving live *N. meningitidis* organisms, processing of human blood samples, and potentially animal work. The successful candidate will have a theoretical and practical understanding of molecular biology and microbiology. A Ph.D. in microbiology, molecular biology, or a related field is essential. Previous experience with transcriptional profiling by quantitative RT-PCR and/or microarrays, gene cloning, protein expression, purification and characterization is preferred.

Post Doctoral Position with interest in protein structure-function, high density lipoproteins (HDL), or lipid metabolism. The focus of our group is on HDL, namely HDL metabolism and the structure-function of HDL's main protein component, apolipoprotein A-I. Projects include examination of cellular and physiological processes that govern HDL biogenesis, characterization of genes involved in HDL formation and cholesterol mobilization, analysis of apolipoprotein structure, functional analysis of structural features of apolipoproteins, and investigation into the effect of incorporation of hydrophobic drugs onto HDL. Experience in cell biology, protein chemistry and/or lipid metabolism is encouraged. Position qualifications: The candidate should have completed a PhD, MD or PhD/MD and be available to relocate to the SF Bay Area. Emphasis will be placed on candidates with a background in protein chemistry, genetic analysis, RNA knockdown, or fluorescence microscopy.

To apply, please send CV and cover letter to : chorihr@chori.org

Children's Hospital Oakland is an EO/AA employer

Postdoctoral Position in Pain Biology University of Wyoming, Laramie

Applications are invited for an NIH-funded postdoctoral position to study the long-term effects of neonatal inflammation on the functional and anatomical properties of skin sensory neurons in mice, with emphasis on potential changes in the central and peripheral terminals of nociceptors. Previous electrophysiological experience is required, and individuals with related experience in intracellular or whole-cell recordings, in vivo physiology, small animal surgery, or histological analysis are especially encouraged to apply. Successful applicants will be expected to communicate their findings effectively in English through publications and professional meetings. Current funding for this position is for up to 4 years with annual reappointment contingent on performance. Salary is dependent on experience.

Interested individuals should send their CV, a statement describing research interests and past accomplishments, and contact information for 3 references to: woodbury@uwyo.edu.

Applications can also be mailed to:
Dr. C. Jeffery Woodbury,
Dept. of Zoology and Physiology,
University of Wyoming, Laramie, WY 82071.



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Assistant Professor – Epilepsy Genetics

The Institute for Integrative Genomics and Departments of Neurology and Medicine, Vanderbilt University are seeking to fill 1-2 new tenure track Assistant Professor positions to help establish a new, inter-departmental Center for Genetic Epilepsy Research. Candidates should have a Ph.D., M.D./Ph.D. or M.D. degree and significant prior research experience in the genetics, genomics, neurophysiology or neuropharmacology of epilepsy. We are especially interested in candidates who 1) study the molecular genetics of human epilepsy including Mendelian seizure disorders and genetically complex epilepsies, 2) utilize mouse or other animal models to map genes responsible for epilepsy susceptibility or genetic/epigenetic modifiers of Mendelian epilepsies; 3) investigate the neurophysiological basis of epilepsy using brain slice electrophysiology or other innovative methods; 4) investigate the pharmacology or pharmacogenomics of anticonvulsant treatments. Successful candidates will be provided well appointed laboratory space and generous start-up funds to initiate their independent research programs in the collegial and collaborative scientific environment of Vanderbilt University. Appropriate secondary academic appointments are anticipated in basic science departments as well as affiliations with other neuroscience research centers (Vanderbilt Brain Institute, Center for Molecular Neuroscience).

Interested candidates should send by email a current C.V., summary of research experience and future plans, and names and addresses of three references as a single PDF file to:



Epilepsy Faculty Selection Committee
Division of Genetic Medicine, 529 Light Hall
Vanderbilt University
Nashville, TN 37232-0275
Deborah.M.Holguin@vanderbilt.edu

Vanderbilt University is an equal opportunity and affirmative action employer



COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

2010 The Louisa Gross Horwitz Prize for Biology or Biochemistry

The Louisa Gross Horwitz Prize was established under the will of the late S. Gross Horwitz through a bequest to Columbia University and is named to honor the donor's mother. Louisa Gross Horwitz was the daughter of Dr. Samuel David Gross (1805-1889), a prominent surgeon of Philadelphia and author of the outstanding *Systems of Surgery* who served as President of the American Medical Association.

Each year since its inception in 1967, the Louisa Gross Horwitz Prize has been awarded by Columbia University for outstanding basic research in the fields of biology or biochemistry. The purpose of this award is to honor a scientific investigator or group of investigators whose contributions to knowledge in either of these fields are deemed worthy of special recognition.

The Prize consists of an honorarium and a citation which are awarded at a special presentation event. Unless otherwise recommended by the Prize Committee, the Prize is awarded annually. Dr. Victor Ambros, University of Massachusetts Medical School, Worcester, MA, and Dr. Gary Ruvkun, Harvard Medical School, Boston, MA, were the 2009 awardees.

Qualifications for the award

The Prize Committee recognizes no geographical limitations. The Prize may be awarded to an individual or a group. When the Prize is awarded to a group, the honorarium will be divided among the recipients, but each member will receive a citation. Preference will be given to work done in the recent past.

Nominations must be submitted electronically at <http://www.cumc.columbia.edu/horwitz/>

Deadline date: January 31, 2010

Nominations should include:

- 1) A summary, preferably less than 500 words, of the research on which this nomination is based.
- 2) A summary, preferably less than 500 words, of the significance of this research in the fields of biology or biochemistry.
- 3) A brief biographical sketch of the nominee, including positions held and awards received by the nominee.
- 4) A listing of up to ten of the nominee's most significant publications relating to the research noted under item 1.
- 5) A copy of the nominee's curriculum vitae.



The CNRM is a collaborative intramural federal research program involving the U.S. Department of Defense and the National Institutes of Health joining clinicians and scientists across disciplines to catalyze innovative approaches to traumatic brain injury (TBI) research. CNRM is supporting new faculty positions at the Uniformed Services University of the Health Sciences, which heads the operations of the CNRM (www.usuhs.mil/cnrm).

TBI Clinical Research Faculty

Professor (tenure track) AD-0602-00 (Neurology/CNRM)

TBI Neuropathology Faculty

Professor (tenure track) AD-0602-00 (Pathology/CNRM)

TBI Nurse Researcher Faculty

**Assistant Professor (tenure track) AD-0610-00
(Graduate School of Nursing/CNRM)**

Information online: http://www.usuhs.mil/chr/vacancies_faculty.htm

The Uniformed Services University is an equal opportunity employer.

The CNRM TBI research programs have an emphasis on aspects of high relevance to the military populations, with a primary focus on patients at Walter Reed and National Naval Medical Centers.



A Catalyst For Brain Injury Research



Research Faculty Computational and Systems Biology

The Computational Biology Program (cbio.mskcc.org) at MSKCC (ski.edu) seeks innovative investigators for tenure-track positions at the Assistant, Associate, or Full Professor level. Pursue basic research, solve biological problems with major emphasis on computational methods, and build active bridges to experimental and clinical research. Actively participate in building out research programs at one of the best clinical-scientific institutions in the world. Work in MSKCC's new Zuckerman Research Center, on Manhattan's Upper East Side, in close proximity to Rockefeller University and the Cornell Weill Medical College. Train graduate students in the Gerstner Sloan-Kettering Graduate School (sloankettering.edu), the Weill Cornell Graduate School of Medical Sciences and in tri-institutional graduate programs.

Areas of special interest include chemical biology, physiology, developmental biology, neurobiology, genetics and cancer biology. Applicants should have a doctoral-level degree and the potential to develop an independent, interdisciplinary research program. MSKCC offers a highly interactive, supportive and dynamic research environment with programs in Computational Biology, Developmental Biology, Molecular Pharmacology & Chemistry, Cancer Biology & Genetics, Structural Biology, Immunology, Cell Biology, Molecular Biology, and Human Oncology and Pathogenesis, as well as unparalleled clinical programs in cancer research, treatment and prevention.

E-mail your application (PDF) to compbio@mskcc.org as soon as possible in December 2009 but no later than January 10, 2010. Detailed instructions at cbio.mskcc.org/faculty-search/. Need more information? E-mail Dwana Agosto: agostod@mskcc.org Department Chair: Chris Sander. MSKCC is an affirmative action, equal opportunity employer.



Memorial Sloan-Kettering
Cancer Center
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WILLIAM of Occam (or Ockham) provided one of the most powerful – or at the very least the most cited – tools in the box of methodological instruments: his famous razor. Feedback last translated this dictum as “Do not introduce entities without necessity” (7 June 2008). As an example of its application: if you see an object moving impossibly rapidly across the sky, it may well be an unidentified flying object – but before introducing aliens or angels into your cosmology, first try cleaning your glasses and/or rinsing your eye.

Digging deeper, we discover that the *Stanford Encyclopedia of Philosophy*’s translation of what the 14th-century theologian and philosopher actually wrote was: “Nothing ought to be posited without a reason given, unless it is self-evident or known by experience or proved by the authority of Sacred Scripture.” That puts a different slant on it.

One of the things that scientists quickly learn is that “entities”

have a way of introducing themselves inconveniently into theory and experiment alike. To make progress, or just to create the appearance of progress, inconvenient results can be quietly swept under the carpet.

Ten years ago the biologist Sydney Brenner, in his collection *Loose Ends from Current Biology* (illustrated by Andrzej Krauze, whose work also graces this magazine’s Opinion pages) gave this useful, if murky, habit a name. Feedback enviously congratulates the *Journal of Biology* for adopting that name a couple of months ago for a new column: “Ockham’s broom”.

READER Eliot Attridge has been reading *The Making of the Fittest* by Sean Carroll, subtitled “DNA and the ultimate forensic record of evolution”.

The book, he says, is “an excellent, highly readable explanation of biogenics... Amongst other things it goes into detail about the evolution of trichromatic vision in humans and

related apes.” It relates these topics to the work of Darwin and Mendel.

So Eliot was quite surprised to read this disclaimer in his edition: “This book is a work of fiction. Names, characters, businesses, organizations, places and events are either the product of the author’s imagination or are used fictitiously. Any resemblance to actual persons, living or dead, events or locales is entirely coincidental”.

Someone at the publisher has, it seems to us, reduced their chances of surviving to reproduce.

IS THE Australian company Liquid Snow Tours, in St Kilda, Victoria, anticipating the effects of climate change on its business, wonders Vanda Hamilton.

Indeed, on checking we find that the folks there “are very aware that we depend heavily on snow and therefore global warming is no friend of ours”.

They go on to trumpet their low paper usage as well as carbon-offsetting for flights from Australia to Japan. Will this be enough, though, to reduce the incidence of liquid snow?

ENTIRELY new threats to the environment are identified in an article entitled “Identity crisis” in the magazine *Conservation*, which has Douglas Fox, also a contributor to *New Scientist*, reporting that researchers at Toho University in Japan “extrapolated from a handful of examples to what they call a universal phenomenon: human activities homogenize natural environments by clouding the water, levelling typography, or planting monocultures” (vol 9, p 26).

Feedback had always thought that, since the introduction of mechanical typesetting, typography had been self-levelling. Does the threat to typography not come from design abominations like the Comic Sans font (24 June 2006)?

Ben Haller, who alerted us to this interesting hypothesis, wonders whether this example of a

typographical error involving the word “typography” is unique – or does it cancel itself out, to become a topographical error?

AN ARTICLE in London newspaper *The Daily Telegraph* about the first images from the European Space Agency’s orbiting Planck observatory ended with the paragraph: “The telescope is looking at the heat left behind by the big bang. It is a job comparable to measuring the body heat of a rabbit sitting on the moon.”

Peter Abrahams is frustrated by the lack of clarity of this statement and wants to see what he calls the lunalapin “defined more precisely with regard to the size of the rabbit, the colour of rabbit, and whether it is in sunlight or shade”. Only then is he prepared to decide “if 1 lunalapin is an accurate measure of the sensitivity of the observatory”.



FINALLY, former *New Scientist* editor Alun Anderson was searching the web for information about an obscure historical event called the 1832 Hannah Bay massacre. The sponsored link alongside the search results proclaimed: “Massacres on eBay for less. Over 11 million items to buy today.”

With so many cheap massacres on offer, how does one choose?

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.

Spotting a white van advertising “building in every dimension”, Peter Vincent wants to know what these builders know about the construction of the universe that we don’t

Swallow your pride

I've just seen a sword-swallowing act. Swords seemingly longer than the depth from throat to anus were swallowed. It has to be a trick, doesn't it? If it is, what's the trick? If it isn't, what's going on?

■ The taller you are the more sword you can swallow, but it cannot go past the pit of the stomach. And that is one thing that sword swallows have to get used to – the feeling as the point of the sword arrives there... just touching, and no more. This is why some swallows eat heavy food just before performing, to stretch the stomach a bit so they can swallow a longer sword.

The other thing they have to get used to is the gagging reflex when they start to swallow. This can be controlled eventually.

Swallows use silk to clean the sword just before it's inserted to remove any dust and again while the sword is being withdrawn (with a great flourish of silk) to clean off acid stomach juices that can attack the steel. It's all a matter of skill and nerve, with little room for trickery.

For the best account of this and more, including swallowing giant corkscrews that make the pharynx jump up and down as they twist; how to swallow neon tubes to make the chest glow from inside; and how to eat and swallow fire (when learning, have a lot of ice cream handy), can be found in *Memoirs of a Sword Swallower*, by Dan Mannix, first published in

1951 when I bought my copy. I'll never forget that opening sentence: "I probably never would have become America's leading fire-eater if Flamo the Great hadn't happened to explode that night in front of Krinko's Great Combined Carnival Side Shows." *Michael Boddy Binalong, New South Wales, Australia*

■ There is no trick to a genuine sword-swallowing act, or rather not the kind of trick your correspondent is probably thinking of. Strictly speaking, a true sword swallower doesn't actually swallow the sword, but that apparent contradiction is the key to how they actually manage to get the blade all the way down.

To join the Sword Swallower's Association International, a would-be member has to demonstrate the ability to "swallow" a non-retractable, solid steel blade that is at least 2 centimetres wide and

"Swallows use silk to clean the sword of acid stomach juices as it is being withdrawn"

38 centimetres long. With those qualifications, it's not really surprising that the current worldwide membership of the SSAI is restricted to a few dozen full-time professionals and a handful of amateurs. Nor is it a surprise that, despite the SSAI's strict membership criteria, many people believe a trick blade is

employed, particularly when one learns that the record length for a swallowed blade is an eye-watering 82.5 cm.

The performer, through a regime of practice, learns to suppress the natural gag instinct, by relaxing the upper oesophageal sphincter – which normally closes the throat to prevent us choking or drowning. To do this, they usually start by

"There is no trick to sword swallowing. The record length for a swallowed blade is 82.5 centimetres"

forcing their fingers down their throat and then work their way through a range of longer and bulkier everyday objects, before regularly exercising with a carefully folded wire coat hanger.

Curiously, in sword swallowing, as in so many other aspects of life, size apparently doesn't matter. Although the artiste who swallowed the aforementioned 82.5-cm sword was 220 cm tall, it is the configuration of a performer's insides that determines the length of blade they can swallow. Particularly critical is the angle of the gastro-oesophageal junction, or cardia, the point where the oesophagus joins the stomach.

The cardia is where the lower oesophageal sphincter is found. This sphincter prevents gastric juices flowing up out of the stomach into the throat. It is the ability to exercise control over this valve, and keep it relaxed when it should, by reflex, close,

that is critical for a performer.

It is scarcely surprising that industrial injuries among sword swallows produce a distinctive pathology. While no member of the SSAI has died as a result of a performance going awry, at least one sword swallower has brushed the side of his heart with a blade, and perforations and lacerations of both the oesophagus and pharynx are common, as are lower chest pains. These pains are often associated with a dramatic technique known as "the drop", where the sword is downed in one smooth action, controlled only by the muscles of the pharynx.

The most widespread occupational hazard suffered by sword swallows is a sore throat – "sword throat", as it is known. At least one swallower had to terminate their career through losing the ability to salivate, as saliva is the principal lubricant employed to ease the passage of the blade (although butter has been used as a substitute).

Of course, this is an experiment that would-be researchers should never, ever attempt at home.

*Hadrian Jeffs
Norwich, Norfolk, UK*

This week's question

GOOGLE WOBBLE

However tight I fasten my swimming goggles they always end up round my neck after I dive in. This never seems to happen to Olympic swimmers. Why not?

*Francis Melo
Birmingham, UK*

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