

WEEKLY NEWS IDEAS INNOVATION

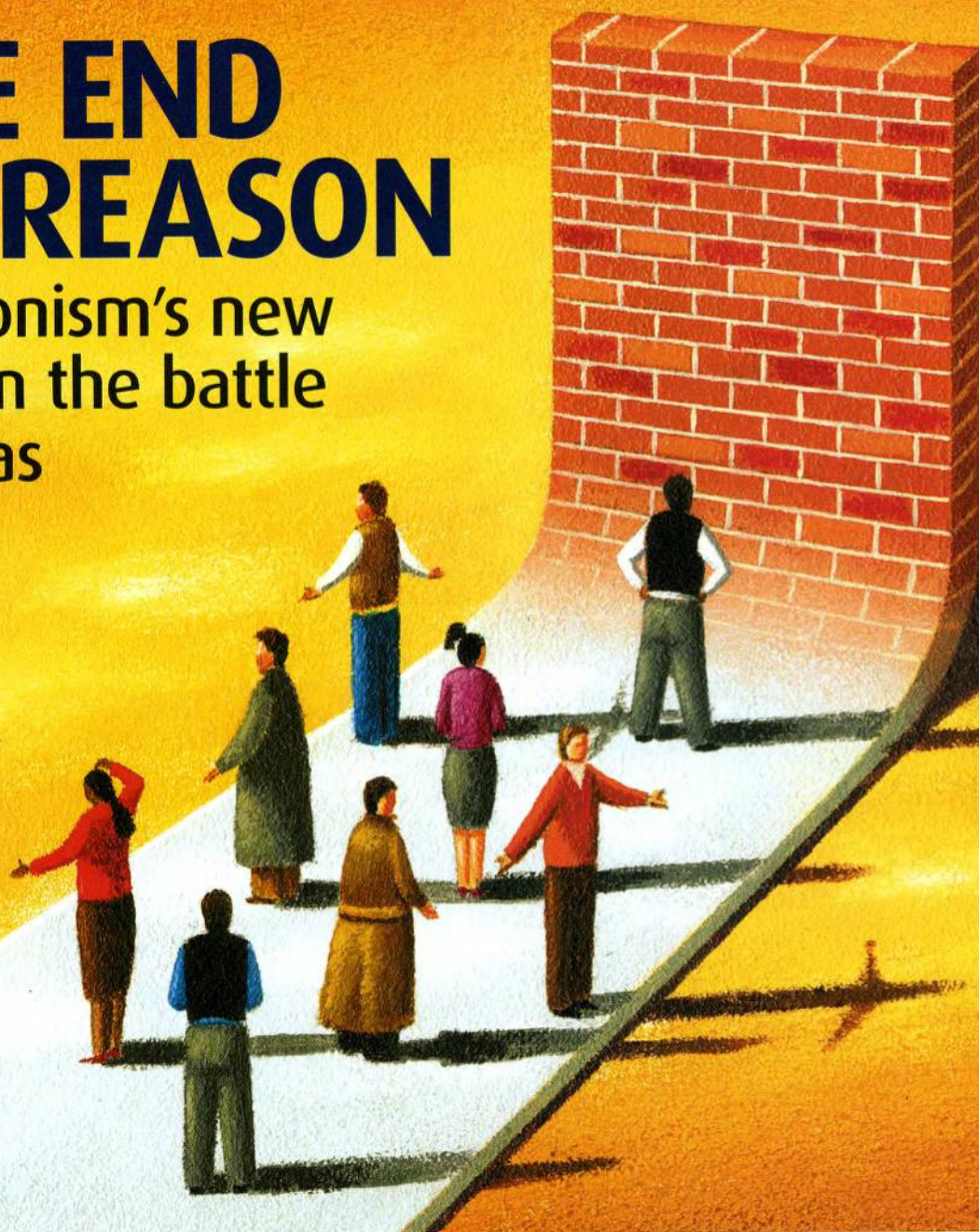
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NewScientist

9 July 2005

THE END OF REASON

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UK

Lacon House, 84 Theobald's Road,
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USA

275 Washington Street, Suite 290, Newton,
MA 02458
Tel +1 617 558 4939 Fax +1 617 558 4933

201 Mission Street, 26th Floor,
San Francisco, CA 94105
Tel +1 415 908 3348 Fax +1 415 704 3125

Australia

Tower 2, 475 Victoria Avenue, Chatswood,
NSW 2067
Tel +61 2 9422 2999 Fax +61 2 9422 2877

Publishing Director Dominic Feltham
Personal Assistant Lindsey Bezzina

Marketing

UK Tracey Syrett, Georgina Rushworth,
Paola Van Den Brande, Luise Mulholland
Tel +44 (0) 20 7611 1259
Fax +44 (0) 20 7611 1290

US Lauren Hoops, Alissa Menovich
Tel +1 617 558 4931/4908
marketing@newscientist.com

Display Advertising

Manager Jamie Labate

Team Rennell Scott-White, Jennifer
Holmes, Camilla Bailey, Aimee Williams
Tel +44 (0) 20 7611 1291

Online Advertising Tara Kellner

Recruitment Advertising

Sales Director Paul Cook
UK Emma Burtenshaw, Toby Phelps,
Anna Eccleston, Luke Whitehead,
Sara White, Victoria Wood
Europe Rafael Fernandes
Tel +44 (0) 20 8652 4444
Fax +44 (0) 20 8652 4422

US Director of Sales David Wilson
Tel +1 617 558 4904 Fax +1 617 558 4933

Australia David Pope
Tel +61 2 9422 8854 Fax +61 2 9422 2977

Asia Catherine Wong
Tel +65 6780 4305

Advertisement production

UK Simon Hall

Tel +44 (0) 20 8652 8233

Fax +44 (0) 20 8652 4422

US Tom Rooney

Tel +1 617 558 4933

Fax +1 617 558 4933

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

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enquiries@newscientist.com

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enquiries@newscientist.com

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enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

enquiries@newscientist.com

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"You get a curt letter informing you that your patent will not see the light of day. Tell anyone and you face two years in jail"

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Editor Jeremy Webb
 Personal Assistant Anita Staff
 Publisher-at-Large Natasha Ward
 natasha.ward@nbsi.co.uk
 Executive Editor Karl Schneider
 Researcher Lucy Middleton
 Associate Editors
 Liz Else, Stephanie Pain, Maggie McDonald

News Editor Matt Walker
 Editors Michael Le Page, James Randerson
 Anil Ananthaswamy
 Tel +44 (0) 20 7611 1210
 Fax +44 (0) 20 7611 1280

Reporters
 LONDON Andy Coghlan, Hazel Muir,
 Paul Marks
 news@newscientist.com

SAN FRANCISCO
 sanfran@newscientist.com

BOSTON Sylvia Pagan Westphal
 spwestphal@newscientist.com
 Eugenie Samuel Reich
 eugenie.reich@newscientist.com
 David L. Chandler
 david.chandler@newscientist.com
 Celeste Biever
 celeste.biever@newscientist.com

TORONTO Alison Motluk
 alisonmotluk@newscientist.com
 BRUSSELS Debora MacKenzie
 debora.mackenzie@newscientist.com
 MELBOURNE Australasian Editor
 Rachel Nowak
 Tel 03 9245 7365 Fax 03 9245 7511
 rnowak@newscientist.com.au

Features Editors Ben Crystall,
 Kate Douglas, Clare Wilson, David Cohen,
 Graham Lawton, Michael Brooks,
 Valerie Jamieson

Features Assistant Celia Thomas
 Tel +44 (0) 20 7611 1230
 Fax +44 (0) 20 7611 1280
 features@newscientist.com

Opinion
 Senior Editor Michael Bond
 Editors John Hoyland, Amanda Gelter
 Opinion Coordinator Eleanor Case
 Tel +44 (0) 20 7611 1240
 Fax +44 (0) 20 7611 1280
 opinion@newscientist.com
 Magazine Assistant Cheryl Forde

Production Editor Mick O'Hare
 Asst Production Editor Melanie Green

Chief Sub John Liebmann
 Subeditors Vivienne Greig, Ben Longstaff,
 Julia Brown, Katharine Davis, Barbara Kiser

Art Editor Allison Lawn
 Design Craig Mackie,
 Colin Brewster, David Knight
 Graphics Nigel Hawtin, Dave Johnston
 Pictures Adam Goff, Chris Allen,
 Ludwine Morel
 Tel +44 (0) 20 7611 1268
 Fax +44 (0) 20 7611 1250

Careers Editor Richard Fisher
 careers@newscientist.com
 Tel +44 (0) 20 7611 1248
 Fax +44 (0) 20 7611 1280

Consultants Alun Anderson, Stephen
 Battersby, Marcus Chown, Fred Pearce,
 Rob Edwards, Barry Fox, Mick Hamer,
 Justin Mullins, Ian Stewart, Gail Vines,
 Jeff Hecht, Richard Fildes, Bob Holmes,
 Helen Phillips, Gabrielle Walker

Press Office
 UK Claire Bowles
 Tel +44 (0) 20 7611 1210 Fax 7611 1280
 US Office
 Tel +1 617 558 4939

NEWSSCIENTIST.COM
 Online Manager John MacFarlane
 Online Editor Damian Carrington
 Deputy Online Editor Shaoni Bhattacharya
 Reporters Will Knight, Maggie McKee,
 Kelly Young webnews@newscientist.com
 Special Reports Editor John Pickrell
 Online Subeditor Sean O'Neill
 Web team Shaun Whitting, Neela Das,
 Nishil Mistry, Ashis Joshi, Richard Taylor,
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No contest

It will take more than thinly disguised creationism to defeat Darwin

NOW is an uncomfortable time to be a Darwinist in the US. Eighty years after the infamous "monkey trial", when John Scopes was tried for teaching evolution, pressure on Darwin's theory is growing once again. Creationist voices are becoming louder, and a new player is adding to the noise. Intelligent design (ID) uses the language of science to argue that we will never understand nature unless we take the supernatural into account.

Although ID has been around for more than a decade, it has only recently started to make a significant impact on university campuses and school boards, which decide what pupils are taught (see page 8). Its advocates argue that various biological structures are too complex to have been created by natural selection and so must have been designed.

To press home their case, they introduce two concepts. "Irreducible complexity" proposes that some molecular systems, such as the one that triggers blood clotting in humans, cannot be broken down into smaller functioning units, and so could not have been created by natural selection. "Specified complexity" uses probability theory to try to show that certain biological structures are so unlikely to have emerged through natural processes that they must have been designed.

These ideas seem plausible on the surface and so can have a powerful impact. Only with scientific understanding does it become clear that they are fundamentally flawed (see page 10). Crucially, they cannot be tested in any meaningful way, so they cannot qualify as science. If ID ever came to be accepted, it would stifle research. Molecular biologists would call a halt whenever they came across a biological structure that they could not explain and hence must be the work of the "designer". Science as an open-ended pursuit would come to an end, halted by an impenetrable barrier labelled "the designer did it".

Advocates of ID have persuaded many people that they have found evolution's Achilles heel. In the name of fairness and balance, they argue, students should be taught the controversy surrounding evolution and ID. This plays to a sense of even-handedness amongst non-scientists. But it is disingenuous. We don't teach children half-baked challenges to other scientific theories that have not run the gauntlet of scientific scrutiny, so why should ID be any different?

Worse, "teach the controversy" has fostered the notion that there is something fundamentally wrong with Darwin's big idea. Yet this is simply not borne out by the facts. Evolution by natural selection has survived 146 years of scientific scrutiny and has been called the "most important concept in modern biology" by the US National Academies of

Sciences.

Evolution has helped us to interpret the fossil record, understand how bacteria become resistant to antibiotics, and described the rapid changes in species taking place before our eyes (see page 28). It explains some spectacular examples

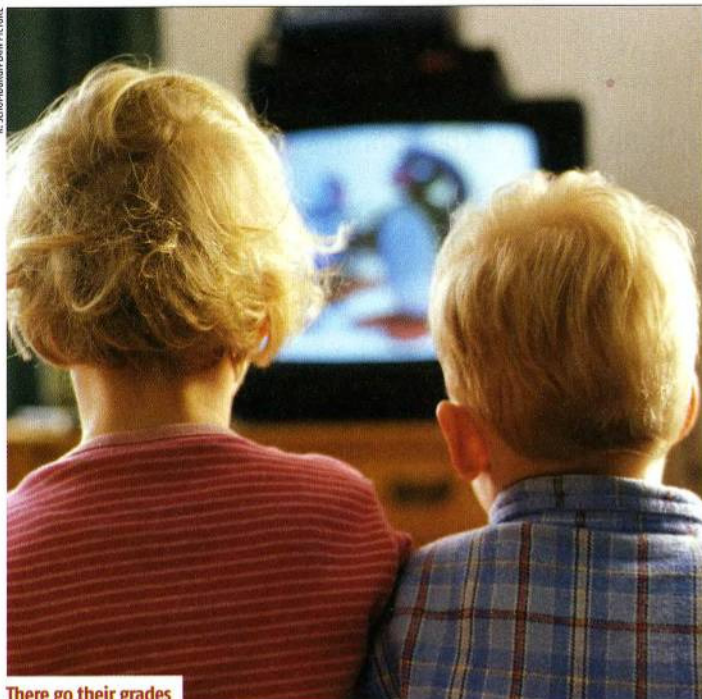
of mal-design, such as cave-dwelling species with functional eyes that are covered by skin flaps. Natural selection has even been harnessed by the biotechnology industry to create new drugs. By contrast, ID has produced not one prediction of value. Evidence against it is mounting from many branches of science, while supporting evidence comes only from a small group of committed ID advocates.

There is no scientific controversy between ID and evolution. The case for teaching them as valid alternatives is no stronger than the case for teaching students about some supposed controversy between astrology and astronomy.

Lurking beneath this debate is the issue of whether religion should make an appearance in science classes – as the creationist movement has long wanted it to. Here it is difficult not to suspect that the people behind ID are being disingenuous. In their books and papers. They would rather readers saw ID as purely scientific. Yet one of the governing goals of the Discovery Institute, ID's spiritual home, is to spread the word "that nature and human beings are created by God".

Let's be honest. This is creationism by another name. Tell a class of teenagers that the tail of a bacterium did not evolve but was designed, and who will they think the designer is? ID may qualify as a religious belief, but it is not science. Teach it in philosophy or sociology by all means. Its proper resting place, however, will be in history. ●

K. SCHOMBURG/PICTURE



There go their grades

TOO MUCH TV ISN'T SMART

They don't call it the idiot box for nothing. Three studies suggest that watching too much TV makes you stupid, at least as measured by school grades and test scores.

In the longest-running study, Bob Hancox's team at the University of Otago in New Zealand monitored the television-viewing habits of 1000 children at two-year intervals from the ages of 5 to 15, and compared them with their academic achievements at age 26. Children who watched the least TV between ages 5 and 11 were the most likely to graduate from university, while those who watched the most TV at ages 13 to 15 were most likely to drop out of school (*Archives of Pediatrics and Adolescent Medicine*, vol 159, p 614). "It is pretty convincing evidence that TV is not educational, at least not in a way that helps children academically," says Hancox.

Two US studies in the same journal draw similar conclusions (p 607 and p 619). One found that third-grade pupils (8-year-olds) in California with TVs in their bedrooms watched more TV and scored lower on standardised achievement tests than others. The other found that children had lower mathematics and reading scores at age 6 if they started watching TV before age 3.

Test scores were higher among children who watched more at ages 3 to 5 – the target audience for educational programmes such as *Sesame Street*. An editorial in the journal points out that the studies did not distinguish between educational and other programmes.

But persuading children to watch quality TV is easier said than done, says Barry Milne, who worked on the New Zealand study. "The type of TV kids actually watch is not good for them."

Titan's oilfield?

FIRST they said there were seas of liquid hydrocarbons. Then they said there were none. Now, maybe there's a lake full of the gooey gunk. A company prospecting for oil? No, just NASA dithering over whether liquid hydrocarbons exist on the surface of Saturn's largest moon, Titan.

Until recently, many scientists expected the methane in Titan's atmosphere to come from seas, or even an ocean, of liquid hydrocarbons on the moon. And when NASA's Cassini spacecraft arrived at Titan earlier this year and released the Huygens probe, many were hoping for a splashdown. Instead, Huygens landed on solid ground, and Cassini failed to spot the kind of reflections expected of a liquid surface as it flew by the moon.

Then Cassini spotted what NASA scientists believe is a giant methane-spewing volcano on Titan. Finally, there was an

explanation for where the atmospheric methane came from.

But hang on: Cassini's infrared cameras have now peered through the dense clouds surrounding Titan's south pole and found a kidney-shaped blob that looks like a lake. Its perimeter resembles the shorelines of lakes on Earth, smoothed by water erosion and deposition. The Cassini team said last week that this is the strongest candidate yet for a source of liquid hydrocarbon on Titan.

Cassini has 39 more fly-bys planned for Titan, so expect more twists in this oily tale.

Slack in Sellafield

COMPLACENT plant operators took an astounding eight months to spot a massive leak of highly radioactive liquid at the UK's Thermal Oxide Reprocessing Plant (THORP) at Sellafield in Cumbria, an internal board of inquiry reported on 29 June. THORP is operated by BNG, a subsidiary of British Nuclear Fuels, which runs nuclear facilities in 16 countries.

The plant extracts plutonium and uranium from spent nuclear fuel, but production was halted indefinitely in April after cameras

showed the floor of an unmanned stainless steel processing vessel had flooded. The 83 cubic metres of escaped liquor contained 20 tonnes of plutonium and uranium dissolved in nitric acid.

The report says that "operational complacency" led to the plant's operators failing to notice discrepancies in the expected liquor volumes in some vessels. To avoid such problems, the inquiry board recommended near real-time tracking of nuclear materials at the plant. BNG says it will "address and resolve every issue" raised in the report.

The big one

SINCE 2004, WWF scientists have been searching the murky and treacherous depths of the Mekong river for an endangered monster: the Mekong giant catfish. Imagine their horror, then, when they heard that Thai fishermen had landed one the size of a large horse, and eaten it.

The fish, *Pangasianodon gigas*, was a 2.7-metre adult male weighing in at 293 kilograms and is a contender for the largest freshwater fish ever caught.



This one didn't get away

"This is the strongest candidate yet for a source of liquid hydrocarbon on Titan"

Thai fishery officers arrived and "stripped" it, extracting sperm for a captive breeding programme. They also negotiated for its release, but the catfish died before it could be set free.

An expensive delicacy in Thailand, only four other giant catfish have been caught this year. The WWF says records show that their numbers have collapsed in recent times. As part of the breeding programme, four young catfish were released last month.

'Are you Jewish?'

WOMEN in Europe who happen to be of Ashkenazi Jewish descent may want to keep that fact from their doctor when being tested for breast cancer genes.

Myriad Genetics of Salt Lake City won a European patent on 1 July covering a specific mutation in the *BRCA2* gene, which increases the risk of breast cancer.

"Something is fundamentally wrong if an ethnic group can be singled out by patenting"

The mutation is found in 1 in 100 women of Ashkenazi Jewish descent. The ruling means that doctors offering tests for *BRCA2* mutations are now legally obliged to ask women if they are Ashkenazi Jews. If they say they are, doctors must pay a licence fee to Myriad. No fee is due if a patient says she does not know.

"We believe there is something fundamentally wrong if one ethnic group can be singled out by patenting," says Gert Matthijs of the Catholic University of Leuven (KUL) in Belgium, a member of the European Society of Human Genetics. "It means that someone is exploring the limits of what is acceptable legally and ethically."

But the society is delighted that two years of legal battles have so weakened Myriad's major European patents on *BRCA1* and *BRCA2* that no licence fees have to be paid for breast cancer tests in Europe except those involving Ashkenazi Jewish women.

Dolphin discovery

SAY hello to the Australian snubfin, the world's newest dolphin. *Orcaella heinsohni* has been recognised as a different species to the Asian Irrawaddy dolphin (*Orcaella brevirostris*), named after a river in Burma.

So say Isabel Beasley at James Cook University and Peter Arnold of the Museum of Tropical Queensland, both in Townsville. Anatomical studies by the pair strongly suggested that the Australian dolphin is a separate species. The clincher came from genetic studies by Kelly Robertson of the Southwest Fisheries Science

Center in La Jolla, California.

"There are clear differences between the two populations that had not previously been recognised," says Beasley.

The snubfin dolphins live in shallow coastal waters and are said to be shy of boats. It is not clear how many there are. "It is really incredible that so little is known," says Arnold. Recognising the dolphin as a species in its own right places new obligations on Australia and the international community to conserve it, he says.

The Latin name honours George Heinsohn, who studied the dolphins intensively in the 1960s and 1970s.

ELEPHANTS UP AND DOWN

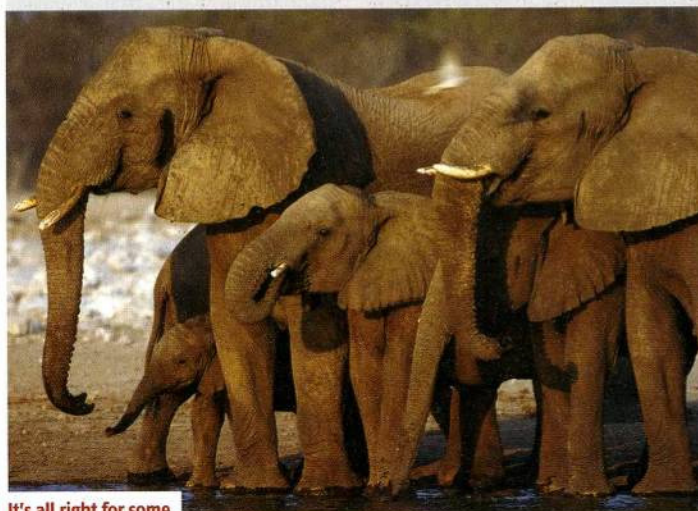
A stark dichotomy exists in the fate of Africa's elephants. While elephants in some parts of the continent are still beleaguered by ivory poachers, elsewhere they are multiplying rapidly.

A preliminary analysis of elephant death rates collected by Monitoring of Illegal Killing of Elephants suggests that elephant poaching is most severe and unsustainable in central African countries, such as the Democratic Republic of the Congo. MIKE was set up by the Convention on International Trade in Endangered Species to monitor poaching.

And last week conservationists, including the WWF, called for sanctions to be imposed on Mozambique for

failing to curb its illegal ivory trade. Like 29 other African nations, Mozambique agreed last October to take steps to crack down on domestic ivory markets or face sanctions. Researchers from TRAFFIC, the wildlife trade monitoring network, reported finding 500 ivory products openly on sale at the country's international airport in Maputo.

But in contrast to the MIKE data, a report released on Friday by the World Conservation Union (IUCN) revealed substantial increases in elephant populations in southern and east African countries over the last decade. Southern African countries including South Africa, Namibia and Botswana have seen annual rises of 5.5 per cent.



It's all right for some

60 SECONDS

Tsunami warning system

On 30 June the UN created an agency to set up and run a tsunami warning system for the Indian Ocean. The body will coordinate the various countries working to build the system, which is expected to be working by July 2006. It will have networks of seismographs, real-time sea-level gauges and deep-sea ocean pressure sensors.

Suicidal thoughts

The US Food and Drug Administration has issued a health warning about antidepressants, saying the drugs may increase suicidal thoughts and behaviour in adults. In October last year, the FDA ordered the relabelling of all antidepressants to warn that they double the risk of such problems in children. Now it has asked for the details of hundreds of clinical trials in adults to work out if the risk is the same for all ages.

There she blows

A kilometre-high plume of vapour that erupted up from the Pacific Ocean near a remote island off southern Japan on Sunday was caused by an underwater volcano, the Japanese coastguard said. Officials said that there was no danger of a tsunami but asked ships to avoid Fukutokuuoka-no-ba, where an undersea volcano erupted in 1986.

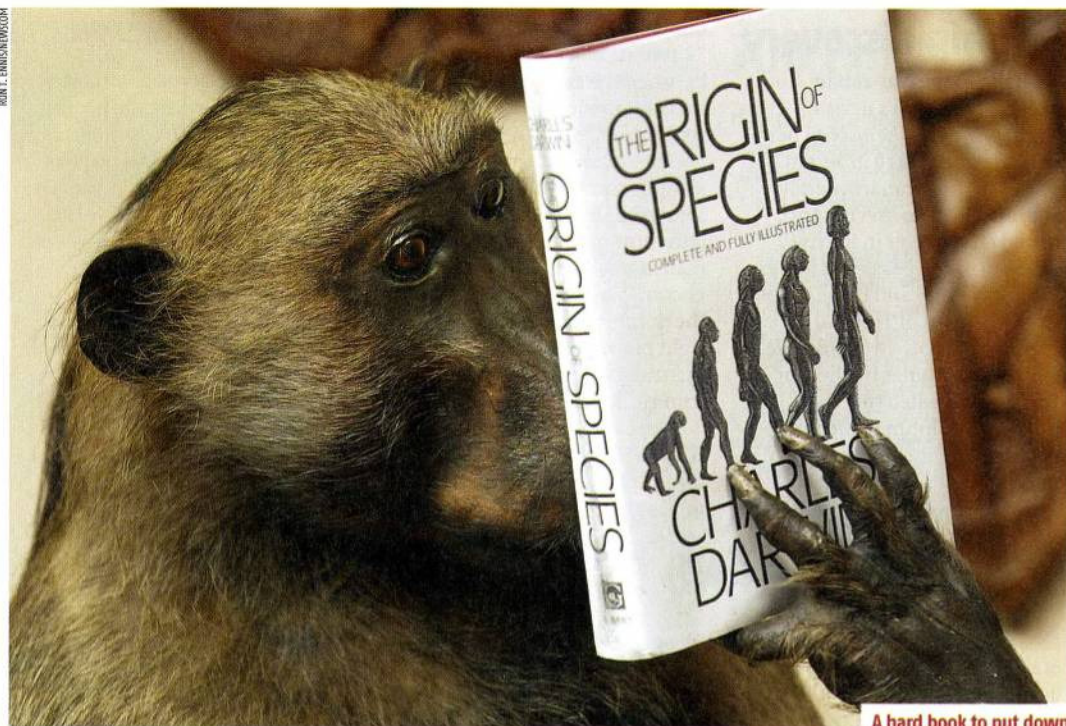
China's six for space

China has shortlisted six astronauts for a second manned mission into space later this year, according to Chinese media reports. The astronauts are training in pairs, and the best pair will be selected shortly before the flight.

Bushwhacking malaria

President George Bush has promised an extra \$1.2 billion over five years to fight malaria in Africa, provided Congress approves. Initial projects next year will provide Tanzania, Uganda and Angola with insecticide-treated bed nets and artemisinin-based anti-malaria drugs. The programme will be extended to four more countries in 2007 and another five in 2008.

This week Creationism



A hard book to put down

A battle for science's soul

Eighty years after the Scopes trial drew the battle lines over evolution and creationism, Darwin's theory is under renewed attack, this time from "intelligent design". It's an idea that is spreading into US culture and beyond

DEBORA MACKENZIE

ON 10 July 1925, a drama was played out in a small courtroom in a Tennessee town that touched off a far-reaching ideological battle. John Scopes, a schoolteacher, was found guilty of teaching evolution (see "The monkey trial"). Despite the verdict, Scopes, and the wider scientific project he sought to promote, seemed at the time to have been vindicated by the backlash in the urban press against his creationist opponents.

Yet 80 years on, creationist ideas have a powerful hold in the US, and science is still under attack. US Supreme Court decisions have made it impossible to teach divine creation as science in state-funded schools. But in response, creationists have invented "intelligent design",

which they say is a scientific alternative to Darwinism (see page 10). ID has already affected the way science is taught and perceived in schools, museums, zoos and national parks across the US.

In the US, Kansas has long been a focus of creationist activity. In 1999 creationists on the Kansas school board had all mention of evolution deleted from its state school standards. Their decision was reversed after conservative Christian board members were defeated in elections in 2002. But more elections brought a conservative majority in November 2004, and the standards are under threat again.

This time the creationists' proposals are "far more radical and much more dangerous", says Keith Miller of Kansas State University, a leading pro-evolution

campaigner. "They redefine science itself to include non-natural or supernatural explanations for natural phenomena." The Kansas standards now state that science finds "natural" explanations for things. But conservatives on the board want that changed to "adequate". They also want to define evolution as being based on an atheistic religious viewpoint. "Then they can argue that intelligent design must be included as 'balance'," Miller says.

In January in Dover, Pennsylvania, 9th-grade biology students were read a statement from the school board that said

"Proposed school standards redefine science to include supernatural explanations for natural phenomena"

state standards "require students to learn about Darwin's theory of evolution. The theory is not a fact. Gaps in the theory exist for which there is no evidence". Intelligent design, it went on, "is an explanation for the origin of life that differs from Darwin's view". Fifty donated copies of an ID textbook would be kept in each science classroom. Although ID was not formally taught, students were "encouraged to keep an open mind".

These moves are part of numerous recent efforts by fundamentalist Christians, emboldened by a permissive political climate, to discredit evolution. "As of January this year 18 pieces of legislation had been introduced in 13 states," says Eugenie Scott, head of the National Center for Science Education in Oakland, California, which helps oppose creationist campaigns. That is twice the typical number in recent years, and it stretched from Texas and South Carolina to Ohio and New York (see Map, page 10). The legislation seeks mainly to force the teaching of ID, or at least "evidence against evolution", in science classes.

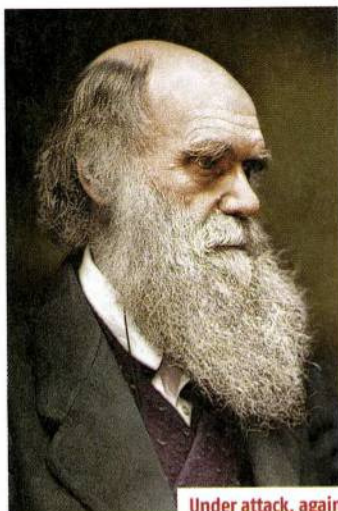
The fight is being waged on other fronts as well. Scott counts 39 creationist "incidents" other than legislative efforts in 20 states so far this year. In June, for example, the august Smithsonian Institution in Washington DC allowed the showing of an ID film on its premises and with its unwitting endorsement. After an outcry, the endorsement was withdrawn – officials insisted that it was all a mistake, although the screening did go ahead (*New Scientist*, 11 June, p 4).

Also in June, a publicly funded zoo in Tulsa, Oklahoma, voted to install a display showing the six-day creation described in *Genesis*. The science museum in Fort Worth, Texas, decided in March not to show an IMAX film entitled *Volcanoes of the Deep Sea* after negative reaction to its acceptance of evolution from a trial audience. The museum changed its mind after press

"Creationists depict evolutionists as a cultural elite, out of touch with American society"

coverage evoked an outcry, but IMAX theatres elsewhere in the US have not screened science films with evolutionary content to avoid controversy. Since 2003 the bookstores at the Grand Canyon, part of the US National Park Service, have sold a young-Earth creationist book about the canyon, repeating the creationist assertion that it was formed by Noah's flood.

Anti-Darwin campaigners have not won everywhere. A Georgia court ruled that stickers describing evolution as "theory not fact" must be removed from textbooks. A bill in Florida that might have allowed students to sue teachers "biased" towards evolution died. And Alaska rewrote its school science standards to emphasise evolution. But religious fundamentalists have succeeded in insinuating a general mistrust of evolution. "Creationists depict evolutionists as a cultural elite, out of touch with American society," says Kenneth Miller of



Under attack, again

Brown University in Rhode Island.

Creationism has had less cultural impact in Europe, but in the UK some state schools are incorporating it into science classes. The English education system allows private donors to invest in the refurbishment of state-funded schools in deprived areas, in return for controls over what is taught there. Emmanuel College at Gateshead in north-east England opened in 1990, financed by millionaire car dealer and

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Christian fundamentalist Peter Vardy. It teaches both evolution and creationism in science classes and, school officials say, lets children make up their own minds. Little notice was taken until 2002, when Vardy proposed opening more schools. A second opened last year in Middlesbrough, and a third will open near Doncaster in September.

Last September, Serbia briefly banned the teaching of evolution in schools. It changed its mind days later after scientists and even Serbian Orthodox bishops spoke out. There was also uproar over creationism in the Netherlands. The Dutch have several sects that teach creationism in their own schools. But in May, Cees Dekker, a physicist at the Delft University of Technology published a book on ID, and persuaded education minister Maria van der Hoeven that discussion of ID might promote dialogue between religious groups. She proposed

a conference in autumn, but dropped the plan after an outcry from Dutch scientists.

In Turkey there is a strong creationist movement, sparked initially by contact with US creationists. Since 1999, when Turkish professors who taught evolution were harassed and threatened, there is no longer public opposition to creationism, which is all that is presented in school texts. In another Muslim country, Pakistan, evolution is no longer taught in universities.

Fundamentalist Christianity is also sweeping Africa and Latin America. Last year Brazilian scientists protested when Rio de Janeiro's education department started teaching creationism in religious education classes.

The fear among creationism's critics is that a pattern is emerging that will culminate in a new wave of creationist teaching. They are worried that this will undermine science education and science's place in society. "The politicisation of science has increased at all levels," says Miller. "What is happening is a political effort to force a change in the content and nature of science itself." ●

"What is happening is a political effort to force a change in the nature of science itself"

THE MONKEY TRIAL

In 1925, John Thomas Scopes was a 24-year-old physical education teacher at the secondary school in Dayton, Tennessee. He was put on trial after confessing to teaching evolution while acting as a substitute biology teacher – something Tennessee had recently made illegal. The so-called "monkey" trial became a media circus and struck a powerful chord in American society.

The reasons are still with us. Natural selection provides an explanation for the origins of living things, including humans, that depends entirely on the workings of natural laws. It says nothing about the existence, or otherwise, of God.

But to many believers in such a God, if humans are just another product of nature with no special

status, then there is no need for morality. Worse, evolution with its dictum of survival of the fittest seems to encourage the unprincipled pursuit of selfishness. At the time of the Scopes trial these were not merely academic concerns. The first world war had convinced many of the brutalising effects of modernity.

Scopes lost. The newborn American Civil Liberties Union paid his \$100 fine and planned to appeal to the US Supreme Court, where they hoped laws like Tennessee's would be declared illegal. They were thwarted when the verdict was overturned on a technicality.

In Dayton, though, it appeared that Darwin had won. The anti-evolutionists and rural, religious society generally had been held



John Scopes: vindicated?

up to nationwide ridicule by the urban press covering the trial. As a result there were few overt efforts to pursue such legal attacks on evolution for decades.

But for some historians Scopes was no victory for Darwinism. The prosecutor, populist politician William Jennings Bryan, was seen as speaking for the "common people". Those people, repelled by an alien, arrogant, scientific world that seemed opposed to them and their values, developed a separate society increasingly bound to strict religious laws. Before the trial, evolution had not been an important issue for these people. Now it was. For many Americans, being in favour of evolution is still equated with being against God. Debora MacKenzie

A sceptic's guide to intelligent design

BOB HOLMES AND JAMES RANDERSON

ADVOCATES of intelligent design argue that it deserves to be taken seriously as a rigorous scientific alternative to evolution by natural selection. But just what is it, and is it science at all?

Intelligent design (ID) is more sophisticated than its predecessor, "creation science", which sought to gather scientific evidence in support of the Christian creation story. By starting from a pre-conceived conclusion and selectively using evidence to back it up, creation science was clearly unscientific.

ID is different. Its supporters argue that we can use science to find evidence of a designer's handiwork in nature, while claiming to be agnostic about exactly who the designer is. "Often people think the designer is the Big Guy in the Sky. But it doesn't have to be that at all," says William Dembski, a mathematician, philosopher and leading ID proponent affiliated with the Discovery Institute, a creationist think tank in Seattle. He describes ID as a scientific programme that leads to an understanding of a generic supernatural intelligence.

Like many creation scientists ID advocates are happy to accept a small role for natural selection, for example, in the evolution of antibiotic resistance. Unlike creation scientists, many of them are also willing to accept that all organisms came from a common ancestor. But that's where advocates of ID and

Darwinism part company.

The difference, says Michael Behe, a biochemist at Lehigh University in Bethlehem, Pennsylvania, and a leading proponent of ID, "is that Darwinism postulates random mutations and natural selection for essentially all aspects of life. ID says that at least some parts of life did not happen randomly but through purposeful design." Nevertheless, the arguments for the inadequacy of Darwinian evolution are nearly identical to those used unsuccessfully by traditional creationists.

Their case centres on the question of how complex structures originated. Living things are full of multi-component structures that only function if all their parts are present. The bacterial flagellum, a spinning whip-like tail, for example, is made up of 40 or more proteins; blood clotting involves the coordinated interaction of 10 different proteins.

These systems are examples of what Behe calls "irreducible complexity", meaning that they cannot function properly without all their components. Such systems, he says, could not evolve by the accumulation of chance mutations, since partial assemblies are useless.

Dembski argues that the odds against getting complex structures from chance mutations are insurmountable. For two proteins to interact to perform some new function, for example, their shapes would have to fit together. So in principle, he says, we can calculate the probability that one protein could change by chance to fit perfectly with another. Two such studies have been done. In both cases, Dembski claims the odds were so long as

CALIFORNIA 2004/5 – SAN DIEGO

The Intelligent Design and Evolution Awareness Center in San Diego has set up eight local centres over the course of the school year in Missouri, Oregon, Virginia (2), California, New York, Illinois, North Carolina

GRAND CANYON NATIONAL PARK 2003

A book *Grand Canyon: A different view* which says the Grand Canyon was formed during Noah's flood goes on sale in shops in the national park. It is still on sale there

TEXAS MARCH 2005 – FORT WORTH, DALLAS

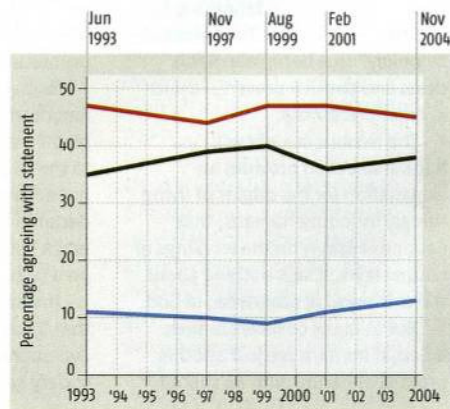
Planned showing at the science museum of IMAX film *Volcanoes of the Deep Sea* is pulled after creationists object to its discussion of evolution. It is subsequently reinstated

VIEWS ON EVOLUTION IN THE US

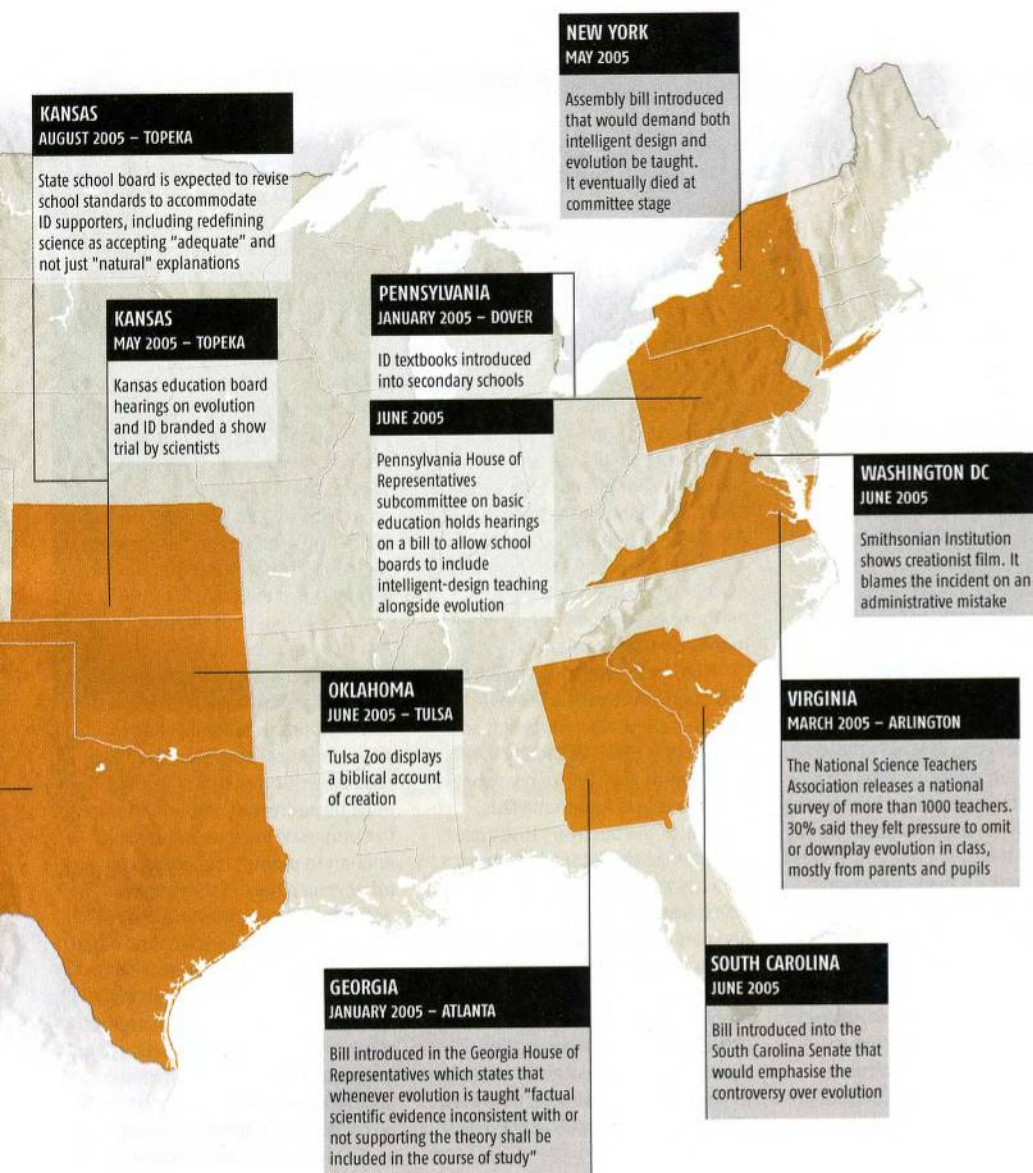
● **God created** human beings pretty much in their present form at one time within the last 10,000 years or so

● Human beings have developed over millions of years from less advanced forms of life, but **God guided** that process

● Human beings have developed over millions of years from less advanced forms of life, and **God had no part** in this process



"Predicting that we should find evidence of a designer is merely a catch-all for what natural selection has yet to explain"



"Most advocates of intelligent design are professed Christians, yet avoid spelling out the kind of designer they have in mind"

pathogenic bacteria use to inject toxins into their host's cells. Similarly, jawless fish accomplish blood clotting with just six proteins instead of the full 10.

So while it is true that no biologist has worked out the precise series of events that resulted in a flagellum, that in itself is not a refutation of natural selection, says Miller. It has long been argued that natural selection works by adapting pre-existing systems for new roles. The evidence so far points to exactly this process for the flagellum.

Crucially, ID does not make testable predictions. Its prediction that we should find evidence of a designer is actually nothing of the kind, say scientists: rather, it is a catch-all that takes up anything that natural selection cannot – so far, at least – explain. Dembski admits as much in his 2004 book *The Design Revolution*: "To require of ID that it predict specific novel instances of design in nature is to put design in the same boat as natural laws, locating their explanatory power in an extrapolation from past experience."

Though almost all ID advocates are professed Christians, they avoid spelling out exactly what kind of designer they have in mind. "The reason is they think the designer is God, and if they mention God then the jig is up," says Nick Matzke, a spokesman for the National Center for Science Education (NCSE), a pro-evolution organisation based in Oakland, California. This helps ID's supporters argue that it is not subject to the ban on teaching creationism in science classes, he says. But being vague about how the designer is supposed to operate also makes ID impossible to test.

And this is the nub of it. A scientific theory must be falsifiable in principle; it must

to rule out an explanation based on chance events.

But these calculations are logically flawed because they focus on a single, specified outcome, says Kenneth Miller, a cell biologist at Brown University in Providence, Rhode Island, a leading critic of ID. "It's what statisticians call a retrospective fallacy." It is like equating the odds of drawing two pairs in poker with the odds of drawing a particular two-pair hand – say a pair of red queens, a pair of black 10s and the ace of clubs. "By demanding a particular outcome, as opposed to a functional outcome, you stack

the odds," Miller says. What these calculations fail to recognise is that many different protein sequences can be functional. It is not uncommon for proteins in different species to vary by 80 to 90 per cent, yet still perform the same function.

The "improbability argument" also misrepresents natural selection. It is correct to say that a set of simultaneous mutations that form a complex protein structure is so unlikely as to be unfeasible, but that is not what Darwin advocated. His explanation is based on small accumulated changes that take

place without a final goal. Each step must be advantageous in its own right, although biologists may not yet understand the reason behind all of them.

There is also evidence that "irreducible complexity" is an illusion. Take, for example, the bacterial flagellum with its 40 proteins. One species, the stomach bacterium *Helicobacter pylori*, has a flagellum with just 33 proteins – "irreducibility" reduced. More tellingly, a subset of flagellar proteins turns out to serve an entirely different function, forming a mechanism called the type III secretory system, which

be possible to imagine evidence that would knock it down. This is not the case for ID. So even if proponents of ID were persuaded that, say, the bacterial flagellum was indeed the product of natural selection, that would not send them packing. ID says that we should be able to find evidence of design in nature, not that every structure has been designed. So ID proponents could simply concede that natural selection operated there, and then shift their ground to another molecular structure.

ID's appeal to supernatural forces by definition puts it outside the scope of science, says Eugenie Scott head of the NCSE. After all, saying "God did it" can never be disproved.

"ID's appeal to supernatural forces puts it outside the scope of science. Saying 'God did it' can never be disproved"

And that's the point. Underlying the ID agenda is a challenge to the basis of scientific method. The infamous *Wedge Strategy*, written in 1999 by fellows at the Discovery Institute, bemoans the "devastating" cultural consequences of scientific materialism. It also details a 20-year plan to defeat it "and its destructive moral, cultural and political legacies". The strategy aims "to replace materialistic explanations with the theistic understanding that nature and human beings are created by God".

In response to the controversy that followed the document's release on the internet, the Discovery Institute says the *Wedge Strategy* is merely a "fund-raising document", and should not be portrayed as some kind of sinister master plan. "We are challenging the philosophy of scientific materialism, not science itself," it states. But far from just redefining science, most scientists would argue that introducing the supernatural will destroy it. ●

www.newscientist.com/channel/life/evolution

Survival of the slickest

Scientists must use different tactics to argue against intelligent design, says director of the Center for Education and Research in Cosmology and Astrophysics at Case Western Reserve University, **Lawrence Krauss**

SCIENCE only functions with the presumption of honesty. It flounders when confronted by those who knowingly and willingly distort the truth. But this is exactly what faces scientists as we attempt to defend science in high-school classrooms against intelligent design (ID).

When I first took up the defence of science in my home state of Ohio, I presumed that those attacking evolution were well-meaning, but scientifically misguided. But my experience in March 2002 at a "debate" on evolution versus ID, sponsored by the state's school board in Columbus, changed all that. During the debate it became clear that I was competing with a well-organised marketing machine. These intelligent individuals were willing to tailor their message, even if it meant hiding their true motivations.

In the interests of fair play, they say, public schools should "teach the controversy" over Darwinian evolution. This phrase has become the mantra of the ID movement.

It is a brilliant manoeuvre, because it implies that there *is* a scientific controversy. In this sense the ID movement has already won the PR battle. Most Americans believe that Darwinian evolution is controversial – more so than relativity or quantum mechanics, say. By contrast, ID is neither well-defined nor debated in the scientific literature.

Who could disagree with fairness and open-mindedness? These qualities are vital to education and science. But this is not really the ID movement's aim. One of my debating opponents was Jonathan Wells, a fellow of the Discovery Institute, a creationist think tank in Seattle, who has a PhD in biology. He claimed his attacks on evolution follow from his years of studying biology. But in an essay entitled "Darwinism: Why I went for my second PhD", he says that as a follower of the Unification Church's founder, Reverend Sun Myung Moon, he was given a mission to undermine Darwinism. Only then did he decide a degree in biology

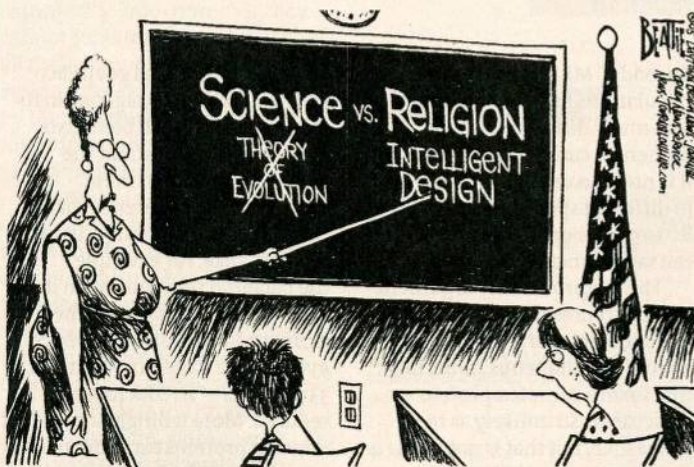
would boost his credentials.

At a recent debate, Stephen Meyer, also at the Discovery Institute and my other debating opponent in Ohio, indicated that one of the reasons why humans and chimpanzees cannot share a common ancestor is that humans have immortal souls and chimps do not. Comments such as these underscore the theological rather than scientific nature of the Discovery Institute's attacks on evolution. They also suggest that these attacks are based on *a priori* religious beliefs, and not on an unbiased analysis of the data.

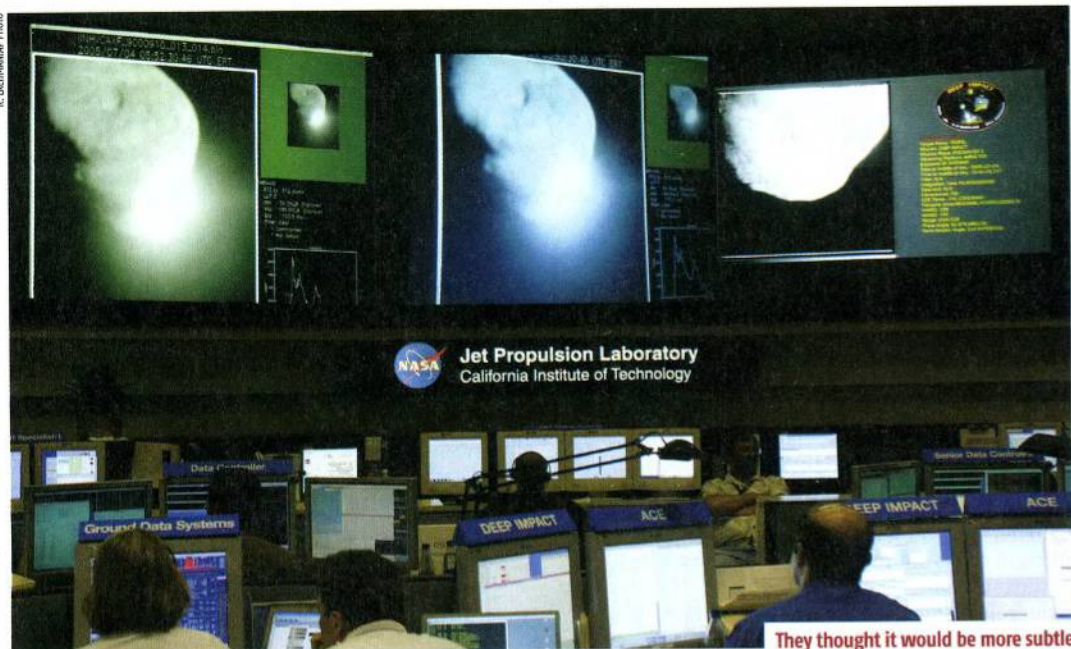
In fact, the "fairness" argument is itself disingenuous. Scientific ideas that have become sufficiently mainstream to be taught in high school have survived a gauntlet of stringent tests. The first takes place when proposals are published in peer-reviewed journals, often resulting in severe criticisms that must be addressed. After publication, the proposals must be compelling enough to prompt exploration by other researchers. If they survive perhaps 20 years of testing against evidence, they may make it into high-school texts. ID proponents wish to bypass these messy steps and go directly into classrooms. Key aspects of other theories such as relativity and quantum mechanics remain hotly debated in the literature, yet there is no call to "teach the controversy".

So having lost the PR battle, how can scientists hope to win the war over educating young people? Scientists must learn that fighting lobbyists is not the same as debating scientific ideas in journals. In science, incorrect ideas will ultimately be weeded out. But in a society in which marketing is king, the scientific community will have to learn to use the weapons of sound bites and emotional arguments. In short, we must deploy all the tools that are used to sell cars, diet drugs and intelligent design.

Lawrence Krauss's book, *Hiding in the Mirror: The mysterious allure of extra dimensions from Plato to string theory and beyond*, appears in October



"While we're at it... does the Earth REALLY travel around the sun?"



They thought it would be more subtle

Deep Impact strikes home

DAVID L. CHANDLER

IT WAS a celestial fireworks display that left even NASA speechless. After travelling for 172 days and 431 million kilometres, the agency's Deep Impact spacecraft smashed into comet Tempel 1 on 4 July at a speed of 36,800 kilometres per hour. And for a few spectacular moments, the debris shone six times brighter than the comet's nucleus.

"Jeez! And we thought it was going to be subtle," exulted Don Yeomans of NASA's Jet Propulsion Laboratory in Pasadena, California. "That was considerably brighter, and more material came out, than I had expected." Team member Peter Schultz of Brown University in Providence, Rhode Island, says the results exceeded his "wildest dreams".

Launched in January, the spacecraft was a combination of an impactor and a fly-by probe. The 370-kilogram impactor was released on 3 July into the comet's path, and NASA guided it towards Tempel 1 before it switched over to autonomous flight for

the final 2 hours before impact.

The collision was observed by cameras on board the impactor and the fly-by probe, and by observatories on Earth plus four orbiting telescopes, including Hubble. The plan is to study the debris and the crater formed from the impact in a bid to understand more about the interior of comets. These bodies of ice and dust a few kilometres across are believed to be well-preserved relics of the primordial material that formed the solar system 4.5 billion years ago.

Within hours of the impact, the dramatic plume of debris that erupted had disproved some theories about the structure of comets. Some scientists thought the comet's nucleus might be so porous that the impactor might sink with hardly a trace. But it didn't. "Clearly it rules out extremely porous material," says the mission's chief scientist, Mike A'Hearn of the University of Maryland in Baltimore.

According to Schultz, the images seem to show that the plume went through four

distinct stages. First, there was an almost horizontal movement of dust outwards, followed within 150 milliseconds by a very brief but bright flash. The flash was apparently caused by the explosion of the impactor after it had tunnelled into the comet's nucleus, producing gas so hot that it glowed. "A lot of it is incandescent gas, producing its own light," said Schultz.

Then a narrow vertical plume spewed out, followed by a much broader fan of material spreading

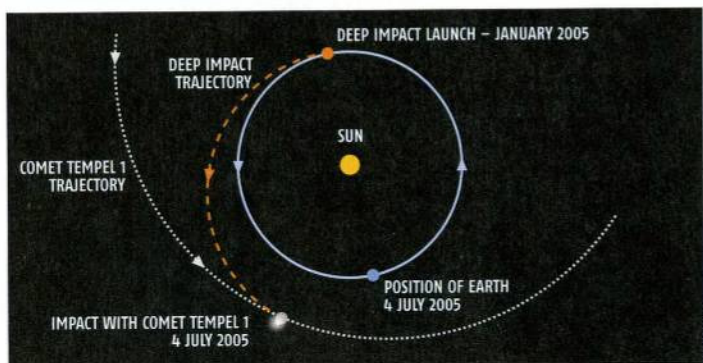
out from the impact point. This sequence suggests the impactor encountered different layers of material – perhaps a loose, fluffy surface, with denser ices beneath, Schultz says.

Before the impactor was vaporised by the collision, it snapped the best high-resolution pictures of the comet ever taken. It kept taking pictures until 3 seconds before it hit the comet; the best planners had hoped for was images up until 30 seconds before impact. These pictures, and those taken by the fly-by probe, show numerous perfectly circular features, which could be either impact craters or sinkholes, as well as long linear features and varied topography with some rough areas and one large very smooth feature. The images show "everything that a geologist would love", Yeomans says.

Over the coming weeks, the data from spectrographs on the Keck telescopes in Hawaii, as well as NASA's orbiting Chandra and Spitzer telescopes, should provide new insights into the comet's internal composition. The incredible volume of images and spectral measurements returned by this mission in less than a day represents "a wealth of data that will take me into retirement", A'Hearn says.

Meanwhile, instead of being irreparably damaged by the debris field of the comet's inner coma, the fly-by spacecraft survived intact – perhaps to study yet another comet at close range. ●

JOURNEY TO COMET TEMPEL 1



Bird flu may soon land in Europe and Australia

HUNDREDS of thousands of wild birds in north-west China have been infected by a bird flu virus closely related to the one that has devastated poultry farms in south-east Asia. The birds might carry the virus as far as India, Australia and Europe.

That is the warning from two teams of scientists in China. They report in *Nature* and *Science* this week that a massive die-off of birds at Qinghai Lake in north-west China, a major summering spot for millions of migratory waterfowl, is due to H5N1.

Officially, 6000 birds had died by 1 July. But taking into account the number of sick birds as well as the dead ones, "we estimate hundreds of thousands were affected", says George Gao of the Chinese Academy of Sciences, a member of one of the teams.

In mid-August, the survivors will start returning to their winter ranges, which stretch from eastern Europe to Australia and Alaska, and overlap with the ranges of other migrants. If some birds carrying the virus remain healthy enough to migrate, the disease could spread far and wide.

So far no testing has been done

to see if this is likely. "We have had no chance to sample healthy migratory birds by Qinghai Lake," says Yi Guan at Shantou University Medical College in Guangdong province, who led the other team. The Chinese ministry of agriculture is reportedly planning to investigate later this month, but neither Gao nor Guan has received permission to study healthy birds.

The DNA sequence of the Qinghai virus reveals that three of its eight genes are almost identical to those of a virus isolated from a chicken in Shantou in 2003. The other five genes resemble those of viruses found in southern China earlier this year, which belong to the "Z genotype" virus circulating across east Asia.

This means the Qinghai virus was not, as first claimed by officials, brought into China from other countries by migrating birds. The bird that started the outbreak might have picked up the virus in southern China or from poultry closer to Qinghai, say Guan and Gao.

What is not clear is whether the Qinghai virus is any more deadly to wild birds than the other H5N1 variants that have killed wild



Can flu take flight?

birds. The Qinghai outbreak might merely be the first time that H5N1 has had the opportunity to infect such a large number of wild birds.

Nor is it known if the Qinghai virus could kill humans. It does have a mutation associated with increased deadliness in mammals – Gao found that it kills all mice infected with it in four

days – but this mutation has been seen in other bird flu strains.

What is certain is that if the virus spreads to other countries, it will decimate poultry industries. The sequence also shows that H5N1 viruses in Asia are swapping genes – which could give rise to a virus capable of causing a human pandemic. **Debora MacKenzie** ●

Tasmanian devil's bite is the kiss of death

THE facial tumour disease that has wiped out nearly one-third of Tasmanian devils since the mid-1990s might be spreading through the transfer of cancerous cells between the animals during physical contact.

"It's still just a hypothesis, but we think the cells themselves might be acting as an infectious agent," says Stephen Pyecroft, a veterinary pathologist and head of the Devil

Facial Tumour Disease project in Tasmania.

Pyecroft's team tested 81 diseased animals from all over Tasmania and found that their tumours were all essentially the same. They develop in neuroendocrine tissue and affect the animal's mouth, head or neck regions. In one in five cases the aggressive cells spread to other parts of the body. The researchers don't yet know if the animals mount any kind of immune response, but if they do, it is not strong enough to beat the disease. "Once a devil develops a tumour it seems to be a one-way trip," Pyecroft says.

The cause of the disease is still not

entirely clear. A virus has not been ruled out, but no viral particles have been found in the tumours. However, the pattern of genetic material in the tumour suggests that it could be an "allograft" disease, transmitted by direct transfer of tumour cells during fighting and biting. The only other known example of such a disease is a venereal sarcoma that is spread between dogs during mating.

The researchers have also

"Unaffected wild populations are being isolated where possible, and some healthy devils are being captured for breeding"

sequenced the devil's genome and identified a genetic marker for the tumour. Such knowledge will be vital for the development of any vaccine, though it will not be enough on its own. "We need an awful lot more information before we get to that point," Pyecroft says. In the meantime, unaffected wild populations are being isolated where possible, and some healthy devils are being captured for monitoring and captive breeding.

Pyecroft's team presented the work at the Wildlife Disease Association's international conference in Cairns, Queensland, Australia, last week. **Emma Young, Sydney** ●

Sea life in peril as oceans turn acid

ROWAN HOOPER

THE oceans are gradually becoming more acidic as they soak up the excess carbon dioxide released into the atmosphere. The change could be catastrophic for marine ecosystems and for economies that rely on reef tourism and fishing – and there is no way to reverse it.

That is the conclusion of the first review looking at all the studies relating to the acidification of the oceans. It was commissioned from an international group of scientists by the Royal Society, the UK's national academy of science.

The rising level of CO_2 in the atmosphere is what causes global warming. As the gas dissolves in the oceans, however, it is causing a quite different problem by forming carbonic acid.

The seas, which are naturally alkaline with an average pH of 8.2, act as a "buffer" that can soak up vast quantities of CO_2 with little change in acidity. But levels of CO_2 in the atmosphere are now rising so fast – from 280 parts per million before the industrial age to 380 ppm today – that the oceans are becoming more acidic. Models suggest that if emissions continue at present rates, then by 2100 the pH of the sea will fall by as much as 0.5 units.

Surprisingly little research has been carried out into the effects of increasing acidity on ocean chemistry and biology, and the report recommends that more is urgently carried out. But what we do know is ominous. "It would not directly kill penguins and orca and big animals like that, but it will affect the food chain, with potentially damaging effects on larger animals," says John Raven of the University of Dundee, UK,

who led the review.

For starters, oxygen becomes more difficult to extract from water as the pH falls. This could affect the growth and reproduction of animals with high oxygen demands, such as squid. The proportion of dissolved forms of toxic metals will also increase as pH falls.

The greatest effect is likely to be on organisms with calcium carbonate shells, from lobsters and crabs to shellfish, certain plankton species and coral polyps. Calcium carbonate is insoluble in seawater only because the water is saturated with carbonate ions. As acidity rises, the level of carbonate ions falls. That will make it more difficult for animals to make their shells, and in some parts of the ocean such structures might even start to dissolve.

Coral reefs face a triple whammy: global warming, coastal

pollution and now acidification. We can expect to see degradation of coral reefs in the tropics, Raven says, which would affect tourist industries, fisheries and also leave shorelines more vulnerable.

Some sceptics claim that corals will grow even faster as the oceans warm up, more than making up for the increased acidity. But all studies so far suggest coral calcification peaks at current temperatures, the review says.

What's more, acid oceans may be less able to mop up CO_2 , making the problem even worse. At the moment, photosynthetic plankton called coccolithophores, which grow calcium carbonate shells, form giant "blooms" in spring and summer. Many sink to the bottom of the ocean, safely locking away vast amounts of carbon in ocean sediments.

The sea has absorbed about half of the CO_2 produced by humans in the last 200 years and currently soaks up 1 tonne of the gas each year for every person on

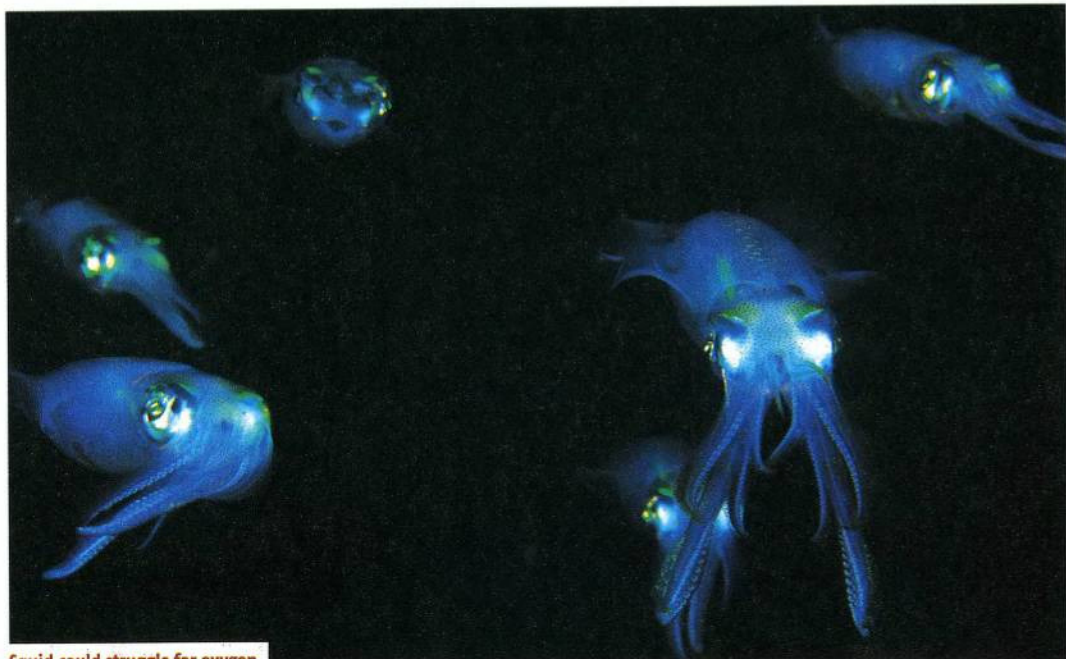
the planet. But if the growth of coccolithophores is hindered, less carbon might be removed from the atmosphere and oceans, speeding up both climate change and acidification.

Acidification is effectively irreversible. "It will take many thousands of years for natural processes to return the oceans to their pre-industrial state," says Raven.

The review group considered possible ways of neutralising the acid, such as dumping chalk into the sea, but all had major problems. "It's just not practical. You would have to denude an area of pure chalk covering 60 square kilometres and 100 metres deep," says Andrew Watson of the University of East Anglia, UK. It would be like dumping the White Cliffs of Dover into the sea each year, he says.

"The only way to minimise the long-term consequences is to decrease CO_2 emissions," Raven says. Watson agrees: "We need a sharp decline in CO_2 emissions, down to half that of today." That looks unlikely. The Kyoto protocol, rejected by the US, calls for cuts of only 5 per cent by 2012 relative to 1990 emissions. ●

"As acidity rises, animals will find it harder to make their shells, and in some parts of the ocean such structures might dissolve"



Squid could struggle for oxygen



In the footsteps of ancient Americans

America colonised 40,000 years ago

ROBERT ADLER

HUMAN footprints discovered beside an ancient Mexican lake have been dated to 40,000 years ago. If the finding survives the controversy it's bound to stir up, it means that humans must have moved into the New World at least 30,000 years earlier than previously thought.

"If true, this would completely change our view of how and when the Americas were first colonised," says Chris Stringer, head of human origins at the Natural History Museum in London. But like several US experts, he is reserving judgement until the dates can be independently confirmed.

The discovery was made by an international team led by Silvia Gonzalez, a geoarchaeologist at Liverpool John Moores University in the UK. She found the fossilised footprints in 2003 in a quarry near the city of Puebla, 100 kilometres south-east of Mexico City. "I walked one metre and started to see them," Gonzalez says. "It felt like a thunderbolt."

In just two days, Gonzalez and her colleagues found hundreds of human and animal footprints preserved in a layer of ash from a nearby volcano. The footprints were made along the shore of a lake and were submerged after the water level rose, preserving them under sediments.

"They are unmistakably human footprints," says team member Matthew Bennett at Bournemouth University in the UK. "They meet all the criteria that were set up after the Laetoli prints

were found [in Tanzania in 1976]." The sizes suggests around a third of them were made by children.

But when were they made? It has taken the team two years, using a panoply of high-tech dating techniques, to determine that the prints are around 40,000 years old. The key date came from shells in the lake sediments, which the team carbon-dated to 38,000 years ago. Sand grains baked into the ash and dated using optically stimulated luminescence corroborated the finding.

The researchers also used argon-argon, uranium series and electron spin resonance techniques to date the layers. "The footprints are clearly older than 38,000 years," says team member Tom Higham of the carbon-dating lab at the University of Oxford.

The conventional view is that humans arrived in the Americas via Beringia around 11,000 years ago, when a landbridge opened up. There have been claims about earlier waves of settlers, who must have made the crossing by water, based mainly on sites with signs of habitation dated up to 40,000 years ago, but these claims have drawn intense criticism.

Gonzalez and her team expect the same. "This will be incredibly controversial, there's no doubt of that," Higham says. They invite other researchers to scrutinise their findings, due to be published in the journal *Quaternary Science Review*. "We have done a year of solid work to make sure it's accurate and reproducible," Higham says.

How people got to Mexico 40 millennia ago is a matter for speculation. Bennett suspects that they migrated along the Pacific coasts of Asia and North America. But when it comes to the dates and footprints, he says: "Those are not speculation at all." ●

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"This will be incredibly controversial. We have done a year of solid work to make sure it's accurate and reproducible"

In brief



Gorilla deaths show eco-tourists should keep their distance

POACHING is the biggest killer of mountain gorillas, but respiratory diseases come a close second, accounting for about a quarter of deaths, according to a major survey.

Around 700 mountain gorillas live in two separate populations, one in Uganda and the other in a region that straddles Rwanda, the Democratic Republic of the Congo and Uganda. The animals are classed as critically endangered on the IUCN's red list, although they are the only great ape species whose numbers are increasing.

The Mountain Gorilla Veterinary Project, based in

Ruhengeri, Rwanda, investigated 100 gorilla deaths dating back to 1968. The team found that 40 were due to trauma, for which poaching is almost always the cause in adults. More surprising was the detrimental effect of respiratory diseases, including influenza A and parainfluenza viruses, which killed 24 of the animals.

In a bid to cut the risk of people passing these diseases on, eco-tourists who trek to see the gorillas in the wild already have to stay at least 7 metres away, and keep their visits to no more than an hour.

The populations are closely monitored, and relatively well protected. "But their overall numbers are small, and their situation is still pretty precarious," warns team member Chris Wittier at North Carolina State University in Raleigh.

Why computers are like weather

IF YOU think the complex microchips that drive modern computers are models of deterministic precision, think again. Their behaviour is inherently unpredictable and chaotic, a property one normally associates with the weather.

Intel's widely used Pentium 4 microprocessor has 42 million transistors and the newer Itanium 2 has no fewer than 410 million. "Their performance can be highly variable and difficult to predict,"

says Hugues Berry of the National Research Institute for Information and Automation in Orsay, France.

Berry, Daniel Perez and Olivier Temam say that chaos theory can explain the unpredictable behaviour. The team ran a standard program repeatedly on a simulator which engineers routinely use to design and test microprocessors, and found that the time taken to complete the task varied greatly from one run to the next.

But within the irregularity, the team detected a pattern, the mathematical signature of "deterministic chaos", a property that governs other chaotic systems such as weather. Such systems are extremely sensitive—a small change at one point can lead to wide fluctuations at a later time. For complex microprocessors, this means that the precise course of a computation, including how long it takes, is sensitive to the processor's state when the computation began (www.arxiv.org/nlin.AO/0506030).

Goodbye ulcers

THE first human trials of a non-steroidal anti-inflammatory that is claimed to be as potent as existing drugs but with fewer side effects are set to start within a year.

Traditional NSAIDs, such as indomethacin, reduce inflammation by blocking Cox 1 and Cox 2 enzymes. But Cox 1 protects the gut lining, so the drugs can cause ulcers. Adding copper ions to indomethacin prevents the drug interacting with Cox 1 in the gut, says Peter Lay of the University of Sydney, Australia. Animal tests show his team's latest formulation reduces stomach ulcers by 80 per cent with no intestinal ulceration at all, Lay told a meeting of the Royal Australian Chemical Institute in Sydney this week.

A company has already produced an early version of the copper-indomethacin drug for treating dogs, which are susceptible to ulcers. "It has been shown to be very safe and very effective," says Lay.

Dog days for leishmaniasis

A NEW vaccine against the parasitic disease leishmaniasis not only prevents the disease in dogs, it can cure them too.

The experimental vaccine was developed by researchers at the French Institute for Research and Development in Montpellier, who report their results in *Veterinary Immunology and Immunopathology*, vol 106, p 247. They are now planning safety trials of the vaccine in people.

Visceral leishmaniasis, which kills 200,000 people a year, is carried mainly by dogs, and spreads to people via sandflies. The drugs used to treat people with the disease are toxic, and the parasites are becoming resistant. Tackling the disease using drugs only increases resistance.

Shrinking lotus cut down in its prime

THE Himalayan snow lotus has been sent down an ever shrinking evolutionary path. And it's all down to people picking large flowers for herbal remedies and tourist souvenirs, according to a botanical survey.

Large flowers of *Saussurea laniceps* are prized as traditional treatments for headache and high blood pressure.

The flowers are picked when they have grown to their maximum size, but before they have the chance to set their seeds.

To see if harvesting the larger flowers was weeding out the genes for larger plant size, Wayne Law and Jan Salick of Missouri Botanical Garden in St Louis compared the heights of flowers in heavily picked areas with those at protected sites, such as the sacred Tibetan mountain of Khawa Karpo.

They found that on average the plants in heavily harvested areas were 40 per cent shorter when they reached maximum size. In contrast, there was no difference in another species of snow lotus whose flowers are seldom collected (*Proceedings of the National Academy of Science*, DOI: 10.1073/pnas.0502931102).

What's more, specimens placed in herbarium collections in the 19th and early 20th century are around 45 per cent larger than those found today (see "In the blink of an eye", page 28).



Parkinson's treatment works, but you can't have it

AN ABANDONED experimental treatment for Parkinson's really did encourage growth of the nerve cells that the disease destroys.

The treatment involved injecting a growth factor called glial cell-line derived neurotrophic factor (GDNF) directly into the brain. Five years ago, Steven Gill, a neurosurgeon at Frenchay Hospital, Bristol, UK, fitted five patients who had advanced Parkinson's with a tiny catheter that delivered GDNF to the putamen, the area of the brain where nerve cells producing the neurotransmitter dopamine are

lost. All five patients showed dramatic improvement in their symptoms, including motor skills, verbal memory, facial expressions and motivation.

However, Amgen, the company that makes GDNF, withdrew the drug because of safety fears and a second trial of 34 patients was halted. Now one of the patients in the original trial has died of a heart attack unrelated to the treatment. Studies of his brain show that dopaminergic fibres in the putamen and the substantia nigra in the right side of brain, where the catheter was implanted,

had "sprouted" compared with the left side (*Nature Medicine*, DOI: 10.1038/nm0705-703).

Gill is keen to restart the trials. The studies that led Amgen to withdraw GDNF involved giving very high doses to monkeys, he says, so he thinks the safety fears are overblown. "For people with Parkinson's disease the situation is frustrating when we've seen significant benefits of GDNF," says Gill. In the US, some patients who took part in halted clinical trials are taking legal action to try to force Amgen to supply them with GDNF.

Space gas beats a maser rhythm

A GIANT cloud in space is acting like a maser – the microwave equivalent of a laser – which is flashing in synch with a pulsar, whose intense beams of radiation sweep across space like light from a lighthouse.

Joel Weisberg of Carleton College in Northfield, Minnesota, and his team monitored the pulsar, which is about 15,000 light years away, and an intervening giant gas cloud. While the cloud was absorbing some of the pulsar's radiation, the team found that the hydroxyl molecules in the cloud were amplifying the pulsar's signals at a frequency of 1720 megahertz and emitting additional, identical radiation. "Humans invented masers in the 1950s, but nature invented them first," says Weisberg.

Astronomers have known about maser in interstellar gas since the 1960s. But this is the first maser spotted in space that has been keeping time with a pulsar (*Science*, vol 309, p 106). "We see the maser flashing on and off exactly when the pulsar pulse does, hence there can be no question about it being a maser," says Weisberg.



China's captive pandas in trouble

CHINA'S captive giant pandas are in bad health and urgently need better veterinary care, according to a study of pandas in the country's zoos.

More than 50 per cent of the world's captive giant pandas are at three locations in China. "Their health is very, very badly neglected and many of us consider this a significant threat to the population," says Kati Loeffler of the Smithsonian's National Zoological Park in Washington DC, who presented the results of the Wildlife Disease Association's

international conference in Cairns, Australia, last week.

The World Conservation Union organised a survey of China's captive giant pandas between 1998 and 2000. It reported numerous problems and called for further investigation.

Loeffler's team studied 13 animals at the Chengdu Research Base of Giant Panda Breeding in Sichuan. Almost every animal had gastrointestinal disease and dental problems.

Loeffler says poor veterinary training is to blame. "The director of the Chengdu Research Base is very keen on improving the pandas' health, but he meets resistance from even his own staff."

No way to treat a patient

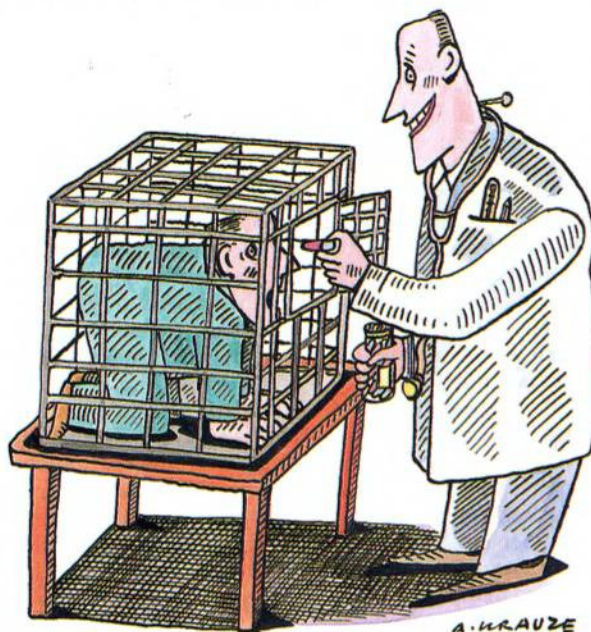
Tens of thousands of people have been subjected to unnecessary drug trials. **Robert Matthews** says the outrage cannot go on

FEW scandals in science are more chilling than those in which patients have been subjected to risky medical experiments without their knowing it. It's a scenario that seems almost unthinkable in these days of ethics boards, oversight committees and whistle-blowers. Yet new research has lifted the lid on just such a scandal, and one that has been running for decades in many countries. It is now clear that tens of thousands of patients have been subjected to pointless, unethical and potentially lethal medical experiments in hospitals around the world.

The experiments are of the type known as randomised controlled trials (RCTs), which are widely and rightly acknowledged as the acid test of the effectiveness of new therapies. Over the years, RCTs have identified countless life-saving therapies, from new surgical techniques to cancer drugs. Patients who take part are randomly divided into two groups. One is prescribed the new treatment, the other a "control" such as a placebo. By comparing the success rates of the two groups, doctors can gauge the effectiveness of a new treatment. Their conclusions have been confirmed by years of experience on wards. No one seriously doubts that therapies identified in this way work.

No one, that is, apart from the many researchers who insist on carrying out RCTs on proven therapies. In dividing their patients into treatment and control groups, they are denying half of them access to the already proven therapy. At best, these patients have their health unjustifiably jeopardised. At worst, they could be receiving a death sentence.

It seems incredible that such trials could escape the notice of the ethics committees who vet RCTs, the journals that publish the results and the numerous physicians already using the therapies. Yet this is what a team led by Dean Fergusson of the Ottawa Health Research Institute has shown in a study published in the June issue of the journal *Clinical Trials* (vol 2, p 218).



They focused on the RCTs for aprotinin, a protein which first showed promise in the 1980s as a way of combating blood loss during surgery. By June 1992 it had been tested on more than 2000 patients in a dozen RCTs, and the evidence was unequivocal: aprotinin radically reduces the need for blood transfusions in heart surgery. It won approval from the US Food and Drug Administration in 1993, and was soon in use in hospitals worldwide.

Yet dozens of research teams recruited yet more patients for yet more RCTs. Fergusson and his colleagues tracked down no fewer than 50 subsequent trials, together involving more than 5000 patients. All confirmed that aprotinin reduces the need for blood transfusions in heart surgery. In gathering this superfluous data, thousands of patients ended up as controls, and were thus denied access to the proven therapy, with potentially life-threatening results.

Aprotinin is by no means an isolated case. As long ago as the mid-1970s, RCTs of clot-buster drugs like streptokinase

had shown they could save the lives of heart-attack patients. Even so, researchers persisted with a dozen further RCTs over the following decade testing the clot-busting ability of streptokinase compounds, needlessly denying effective treatment to tens of thousands of patients.

It is not always patients in the control group whose health is jeopardised. During the mid-1970s, trials proved conclusively that certain drugs used to combat the effects of heart attacks did more harm than good. Even so, a decade later patients were still being recruited into trials, the results of which only confirmed what was already known.

What leads researchers to carry out such pointless studies? One possibility is the publish-or-perish syndrome, which drives academics to churn out essentially worthless research to boost their portfolio of published work. Another possibility is that pharmaceutical companies offer to fund RCTs as a way of getting their latest drugs onto wards.

The truth may be far simpler, but no less scandalous. Fergusson and his colleagues found that the academic papers that reported the additional trials of aprotinin were astonishingly thin on references to previous studies. Typically, they mentioned references to just four previous RCTs – and usually the same ones. This is a classic sign of references simply being cribbed from previous papers, rather than located through rigorous literature searches.

True, literature searches were not easy without online databases. But that was never an excuse for failing to carry them out. What Fergusson and his colleagues appear to have found is that the health of thousands of patients is being threatened by researchers who do not know that their trials are pointless because they cannot be bothered to do the necessary checks.

These researchers, the ethics committees who approved their trials and the journals that published the results can no longer ignore this scandal. For it cannot be long before some of the patients discover what was done to them – and start asking awkward questions. ●

"These patients have their health jeopardised. At worst, they could be receiving a death sentence"

Robert Matthews is visiting reader in science at Aston University, Birmingham

Nuclear disarray

From David Lowenthal,
University College London

The strategies being adopted in the US for disposing of nuclear waste offer less comfort for the UK's nuclear industry than you imply (18 June, p 3). The Carlsbad waste isolation pilot plant in New Mexico, supposedly safe for 10,000 years, is unsecured against our remote successors, who may be greedy, vengeful, curious or just unable to decipher warning markers decayed into unintelligible babble.

So high is the risk of wilful or inadvertent intrusion into the stored radionuclides that the



Environmental Protection Agency has concluded that it can see no way in which it can discharge its responsibility to prevent this. "We can do little more than guess about how best to protect our descendants, or even ourselves," wrote EPA analyst Martin Pasqualetti in 1997. "Attempts to develop permanent landscape warnings for long-lived hazardous waste only underscore the futility of the exercise."

Plans for Yucca Mountain, Nevada, which was finally approved by Congress for waste burial in 2002, are in utter disarray. On top of anxiety over site safety, transport risks and geological uncertainties came email leaks this year that showed water infiltration rates had been falsified to make the mountain look good. As *The New York Times* reported (6 April 2005), a US Geological Survey employee

admitted keeping "two sets of files, the ones that will keep QA [Quality Assurance] happy and the ones that were actually used".

With its planned opening delayed from 1998 to 2010 and now way beyond, Yucca Mountain may be too gravely compromised to survive at all. A federal claims court in April 2005 judged it unlikely that the site would ever be licensed. Then there is the cost. On top of the \$6 billion so far spent in site searching, there are damage suits from utilities that contracted to have their wastes taken, which will likely cost billions more. Yet the US Department of Energy, along with the industry itself, has termed Yucca Mountain essential to the future of the nation's nuclear energy.

Radioactive waste remains dangerous not just for a few years but for hundreds of thousands of years. The long half-life of many residues means that leaks into groundwater or air may be lethal for over a million years.

A US federal court in 2004, in a case brought by the state of Nevada and a number of environmental groups, upheld the view of the US National Academy of Sciences that the period of guaranteed security of the Yucca Mountain strata and containers should be lengthened from 10,000 to 300,000 years.

Meanwhile, as long ago as 1995 the US Department of Energy required that assessments of the viability of container security should be based on radiation doses over a million years. A government geologist later commented that this requirement "effectively negates high level waste storage or disposal at any site, above or below ground".

Nuclear energy everywhere must come to terms with these hard truths. Burying waste out of sight, whether at Sellafield or at Yucca Mountain, only puts it out of mind. Sooner or later it will come back into view as our era's most accursed legacy to our hapless heirs.

London, UK

Dying differently

From Rod Munday

Your thought-provoking feature on animals and humans (4 June, p 42) reminded me that there is one area in which we treat animals and humans very differently. It is the case of terminal illness.

If I am responsible for the well being of an animal and it develops terminal cancer, I am required by law to see that it is killed painlessly before it can suffer pain from the cancer. If a human being I am close to develops terminal cancer I am forbidden by law to end their suffering and must watch them endure whatever pain cannot be relieved by analgesics, until the cancer kills them.

Does this mean we are more concerned over animal suffering, or do we regard human life in a totally different way from the lives of other animals?

Cardiff, UK

Two moons in June?

From Brian Robinson

David Chandler's article on the threat of an asteroid colliding with the Earth is an example of determined pessimism (25 June,



p 34). An alternative to a "killer asteroid" causing devastation could be that an asteroid passing close by is captured by the Earth, giving us an extra moon.

In devising a strategy to protect ourselves, let's not ignore the possibilities another moon would bring for the quality of life as exemplified by poetry and music.

Science must occasionally think optimistically, and of art and beauty.

Brentwood, Essex, UK

Blame the brain

From Peter Asher

I think Michael S. Gazzaniga gets off a bit too easily suggesting simply that neuroscience should have nothing to do with the "my brain made me do it" defence (11 June, p 48).

There have been cases in which someone developed serious and violent antisocial tendencies which ended completely when a brain tumour was discovered and removed. Surely we are compelled to agree, in these cases, that "their brain made them do it".

But then the problems really start. If we accept that a brain fault can make someone do something their "real" self would not, how can we then make a clear distinction between faults that can be fixed with a knife and those that cannot? And how should courts judge cases in which defendants claim they suffer from a brain fault caused by maternal drug use, malnutrition or some other excuse?

The answers are difficult, but the question cannot be brushed aside.

Malibu, California, US

Autistic strengths

From Michelle Dawson,

No Autistics Allowed, Canada, and the University of Montreal

I am autistic, and I have severe self-injury and self-care issues (18 June, p 36). I'm also a researcher affiliated with a well-respected autism research group in Montreal. We have, in the course of trying to locate the supposed cognitive "deficit" in autism, repeatedly unearthed strengths. These strengths are not confined to aspies [people with Asperger's syndrome]. Autistic strengths go right across the spectrum, as does our pervasive

See our website for letters on:

- Autistic strengths ● Changing the past
- Pain control ● Race specific drugs
- Goooooooooogle search

susceptibility to savant abilities.

To claim that being "more" autistic is bad, while being "less" autistic is good, is the same as saying that autism is inherently and intrinsically bad or wrong. It is an apartheid idea. In a society where being black is judged inherently and intrinsically bad or wrong, being "less" black is better, and being not black at all is ideal.

No doubt a bioethicist in such a society could trot out statistics proving it is better to be less black (so you can pass as white), or not black at all.

Autistics must be given the assistance we need in order to learn and succeed as autistics.
Montreal, Quebec, Canada

From Ben Haller

Once a firmer genetic basis for autism has been established, what will happen if an autistic couple undergo IVF and deliberately select an autistic child over one who does not carry whatever gene or genes are responsible for autism? Would this simply be a matter of personal preference, or would it constitute child abuse?
Menlo Park, California, US

Changing the past

From Henry Harris

Mark Buchanan asks what physical principle must we sacrifice to make Einstein consistent with our view of reality (18 June, p 32). He provides some interesting options but, unfortunately, doesn't mention the correct one. Quantum mechanics can be made completely plausible and consistent if we give up something that is very simple but so ingrained in our way of thinking that it is hard to recognise that we are even making the assumption.

What we must give up is the idea that actions in the present only change things in the future. Indeed, if we look at the mathematics, it seems entirely plausible that actions can travel

both ways. Once we allow this possibility, the concept of entangled states becomes easy to understand. Indeed, the very word "entangled states" means connected in the past.

Pasadena, California, US

From Tony Fowler

Rather than supposing that the message that appears to pass between entangled particles travels faster than light (18 June, p 35), it seems to me to be more logical to suppose that this message travels back in time to the point at which the particles originally divided, then forward again to the present frame of reference for the other particle.
Reading, Berkshire, UK

God's intelligence

From Vasudev Godbole

You report that the Smithsonian has cancelled the screening of a film that "ponders 'purpose within cosmic evolution'" – the idea that has become known as "intelligent design" (11 June, p 4). One interesting question that no one seems to ask is why people feel a need to adopt this viewpoint.

An engineer who builds a plane that travels from London to New York without a pilot is more intelligent than an engineer whose plane needs a pilot. Yet passengers may feel better in the second type of plane. Similarly a God who creates evolution, which needs no further intervention, is more intelligent than a God whose creation needs constant supervision and directives. Perhaps some people feel better and more cared for by the second type of God, and then out of gratitude declare this to be the more intelligent.

This psychological problem is at the root of a lot of the hostility shown by advocates of intelligent design (ID) towards those who argue for evolution. This gratitude can become so compulsive, vehement, "holier-than-thou" and even neurotic that the ID-ists start

vilifying those who reject ID. When the evolutionists refuse to buckle under, the ID-ists become even more angry and hate-filled, and wish to take over the state and



enforce this "gratitudinal" behaviour and related "holiness" by means of laws or other threats. "How dare you deny or be ungrateful to a caring God?" – that is their bitter-angry question. They are 110 per cent sure that a God who intervenes every half an hour is more caring than a God who intervenes only at infinity. In the depth of their psychology this is what motivates the ID-ists and drives them to ridicule or demonise the evolutionists.

Much nuisance has emanated from those who wish to enforce gratitude towards their God.
Seevetal, Germany

- See page 8 for more on this topic

Wind and weather

From Mike Taylor

Another slant on the energy problem: lots of people are lauding wind power as the way forward, but if we shift a major part of our energy requirement to wind, what effects will we have on weather systems? If you take energy out of the wind, you must alter that wind and this must eventually have an effect on the wind patterns that drive our weather. Why is no one studying this before we make a bad mess even worse?

Borough Green, Kent, UK

Incompatible units

From Bob Cowley

Having read Ben Bowie's article on the Airbus A380 (11 June, p 34), I am very worried that this giant airliner may suffer from a similar problem to NASA's Mars Climate Orbiter. The space probe infamously came to grief because of confusion between the metric units used by one part of the project team and the imperial units used by another.

With components of the A380 being manufactured at sites all over the world, it is obviously essential for the project managers to ensure that all parties are using compatible units of measurement. Yet it seems from your article that the engineers working on the Rolls-Royce engines are still using the old British industrial unit of weight, the "railway locomotive", whereas the engineers at Goodrich, manufacturers of the main landing gear, are using the Canadian organic unit, the "adult blue whale".
Oxford, UK

For the record

● Feedback has been reminded by well-informed readers that the Isle of Man is not part of the United Kingdom (18 June) but an internally self-governing dependency of the British Crown.

● There was a bit of over-revving in the 11 June issue when we stated (p 25) that an electric motor invented by IMP of Neath, UK, produces 400 times more torque, size for size, than any existing motor. It should have read 400 per cent, or 4 times the torque.

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Letters to the Editor, New Scientist,
84 Theobald's Road, London WC1X 8NS
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Technology

TECHNOLOGY CAN'T STOP THEM

Technology is no better than good old-fashioned detective work at preventing suicide-bomb attacks, says a new study.

Newly developed terahertz scanners and sensitive sensors can detect explosives carried by would-be bombers. However, even if the technology were affordable and reliable, and could be widely deployed in urban areas, it still would not save many lives, says Edward Kaplan at Yale University.

Kaplan and Moshe Kress at the Naval Postgraduate School in Monterey, California, mathematically modelled how many sensors would be needed to warn that a suicide bomber was walking through either an open plaza or a grid of city streets.

Even if every sensor worked perfectly, more than 150 would be needed to cover a 500-metre-square plaza and detect a suicide bomber at

least 10 seconds before they detonated their bomb. Within a street grid, there would have to be sensors at 80 per cent of all road intersections (*Proceedings of the National Academy of Sciences*, DOI: 10.1073/pnas.0500567102). Even then, in both scenarios such sensor networks would only identify four out of five bombers, and would not reliably reduce the number of expected casualties, the researchers found.

"Trying to rely upon last-minute detection of random suicide bombers is the wrong way to go," says Kaplan. Sensors could be effective at protecting specific areas, such as sporting events or government buildings, he says, but many suicide bombers attack random targets, as is evident in Iraq and Israel. Investing in intelligence-gathering to stop the bombers before they attack seems a wiser strategy, says Kaplan.



KIRSTEN ASHBURN/CONCEPT PRESS IMAGES/ANI PICTURES

Crossword cheat, seven letters...

SOME might consider it cheating – a computer program that can complete crossword puzzles better than many people – and in any language. And like many a quiz cheat, it gets its answers by surfing the web.

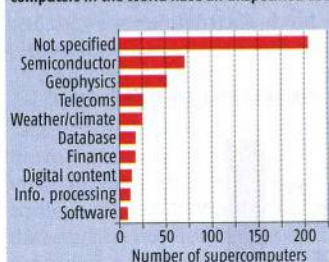
Called WebCrow, the program rephrases clues to make them Google-friendly, runs a search and then mines the results pages for possible solutions. It is slightly better at solving crosswords than an average undergraduate, filling in 80 per cent of all complete words and 90 per cent of all letters correctly within 15 minutes, say its creators at the University of Siena in Italy.

But it struggles with puns and general clues such as "a small bird". WebCrow will be unveiled at the American Association for Artificial Intelligence conference on 9 July.

13
computers that route all internet traffic are to remain under US supervision, the government said on 30 June

Supercomputing enigma

Almost half of the 500 most powerful supercomputers in the world have an unspecified use



SOURCE: 25th TOP 500 LIST OF SUPERCOMPUTERS, 24 JUNE 2005

Why HDTV will be good in parts

HOW can you broadcast pristine high-definition TV programmes to users of giant flat-panel TVs when there are no channels allocated to HDTV broadcasts?

BBC engineers have an answer: harness unused frequencies to transmit an HDTV programme piecemeal, at low data rates, during the day and night before

its scheduled broadcast.

A viewer's hard-disc-based personal video recorder (PVR) then stores the HDTV data on its hard disc and, using software designed by the BBC, stitches the pieces together ready for playback. At the programme's transmission time, a trigger signal hidden in the broadcaster's over-the-air TV signal activates the HDTV recording from the PVR. The BBC is hoping PVR makers will adopt its idea.

GIZMO

Pregnant mothers could soon produce their own baby-blogs, filled with their unborn child's heartbeat sounds and ultrasound images. Hyoung Won of the Umeå Institute of Design in Sweden says that mothers-to-be who link a hand-held ultrasound transducer to a smartphone will be able to record pictures and sounds and upload them into a blog for family and friends. Won is looking for commercial partners to develop his concept.

A prototype hydrogen-powered unmanned aerial vehicle (UAV) has flown for the first time. The UAV, called High Altitude Long Endurance (HALE), flew for 1 hour, powered by a fuel cell, according to an announcement by California-based AeroVironment on 28 June. Hydrogen can release three times as much energy as the same mass of fossil fuel, raising the possibility that a UAV could fly continuously for up to a week.



"The forces fighting to keep this illegal behaviour are incredibly strong"

Henrik Ponten, a spokesperson for Antipiratbyran, a Swedish anti-piracy agency funded by film studios and game makers. On 1 July, Sweden outlawed the downloading of copyrighted movies, games and music, ending its status as the only European country without a law banning file-sharing.

Patents gagged in the name of national security

Each year, governments suppress a handful of inventions. All in the national interest, of course

PAUL MARKS

AFTER years of hard work, you have finally perfected your greatest invention. You file for a patent, and then sit back to wait for the money to roll in.

Except that it doesn't. Instead, you get a curt letter from a security official at the patent office, informing you that your patent will not see the light of day any time soon. The technology you have designed is a threat to national security and has been designated a state secret. Tell anyone, or try to patent the idea in another country, and you face two years in jail. Welcome to the murky world of black patents.

Secrecy orders can be slapped on private inventions in 13 of the 26 member countries of NATO, as well as in Australia and New Zealand. And the trend, from US figures at least, appears to be upwards: while 18 private American citizens had their inventions gagged in 1999, by last year the figure had risen to 61 (see Chart). Including patents filed by companies such as defence contractors, 4885 secrecy orders are now in place in the US compared with 4741 in 2001.

The terror attacks on the World Trade Center and the Pentagon have helped to fuel patent prohibitions in the US, says Don Hajec, a director at the

US Patent and Trademark Office in Alexandria, Virginia, who is responsible for handling so called "secure patent applications". "9/11 generated ideas on the anti-terror front as inventors do tend to react to events," he says. "But it also raised the level of awareness and concern about invention secrecy."

In the UK, figures are vague: of the 30,000 patent applications sent to the UK Patent Office in Cardiff every year, 600 to 1500 are pulled aside for closer scrutiny by military experts. "We don't reveal how many of those we prohibit from dissemination," says Patent Office information officer Jeremy Philpott. However, on the orders of the Ministry of Defence, the UKPO declassifies about 100 patents each year – typically a decade or two after they were filed.

Just what does patent-gagging legislation cover? The US Invention Secrecy Act of 1951 says that whenever the "publication or disclosure of the invention by the granting of a patent would be detrimental to the national security, the Commissioner of Patents shall order that the invention be kept secret". The UK Patents Act of 2004 runs along similar lines. In both cases, penalties for infringement include two years' imprisonment and/or heavy fines.

In the UK, patent officers identify potential black patents by checking every filing for innovations the military would want to keep under wraps. "A small examining team of Patent Office staff handles all the secure applications and they work in a secure section," says Philpott. They are not, he stresses, employees of the government security services.

Philpott says that of all the applications coming their way, there will be a small number that stand out in the early stages as having a potential impact on national security. "Certain technologies like camouflage and radar reflectors, perhaps useful in stealth technology, might pique our interest," he explains. "But that doesn't mean that every application that ever relates to those things will be pulled."

In the US, most applications that go for secrecy checks are filed by government defence agencies and contractors. "They hit our door marked as being under

secrecy orders and go straight to private review," says Hajec.

But for the rest, including those filed by private inventors, the USPTO uses software to initially sift electronic scans of paper patent filings. The software compares the text with a list of military-critical hit terms, and any documents it identifies are sent to a team of expert human screeners. "The hit list includes terms that should pick out bioweapons or nuclear technologies, for instance," says Hajec.

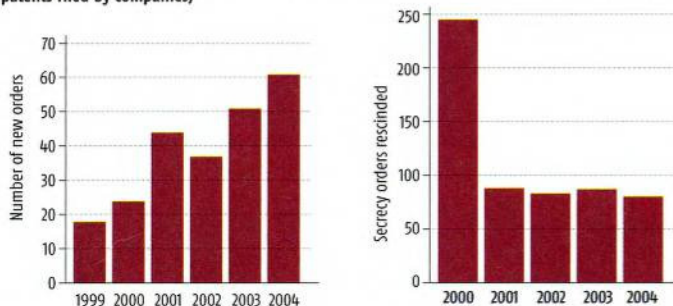
The screeners, patent examiners with military knowledge, then decide whether the filing should be sent to the Pentagon's Defense Technology Security Administration in Washington DC, where army, navy and air force specialists make the final decision on whether a secrecy order should be placed on the invention.

As an example, Hajec highlights a recent case where a private inventor narrowly escaped a secrecy order. The inventor had designed a device that electronically raised pivotable spikes buried in a road to burst vehicle tyres. "While it was invented to stop people leaving a parking lot without paying, it would also be useful in stopping a car bomber approaching an embassy," says Hajec. "It was decided not to impose an order because it had wider applications than anti-terror ones. We don't want to stifle innovation."

But what if somebody designed a new way to disperse pesticide from a crop-spraying plane? Would its potential to spread a bioweapon such as anthrax attract a secrecy order? Philpott won't say. "How that judgement is exercised isn't really a suitable topic of conversation. The point is

CLASSIFIED PATENTS

Secrecy orders imposed on private inventors in the US, and total number rescinded (including patents filed by companies)



SOURCE: US PATENTS AND TRADEMARK OFFICE

CONFIDENTIAL

United States Patent Application Publication

Pub No: US/2005 [REDACTED]
Pub date: July 9, 2005

(8) **LASER GUIDED
FIRING MECHANISM**

SECRET

we have
guidance and we
apply it accordingly."

Classified patents go through a very similar process to ordinary patents. Patent examiners still search all previous patents looking for prior art to determine whether a patent is indeed novel. The difference is that an official patent is not granted on sensitive inventions until the secrecy order has been lifted, which could be many years later. By then, technological innovation may have advanced so far that the patent is worthless financially.

"I know this has happened to some inventors," says David Wardell, chairman of the UK Institute of Patentees and Inventors, based in Kingston upon Thames, Surrey. "Unfortunately most of the stories are probably apocryphal because it becomes an official secret once the order is imposed and they cannot then talk about it to anyone."

And when such a patent is declassified, it is done quietly. The patent is published as normal, the only clue being a large discrepancy, usually of some decades, between the filing date and the publication date. On ordinary patents, the two dates are usually less than

two years apart.

While secrecy orders in the US are not supposed to be permanent, in practice they often are. "When the US is not in a state of war, the secrecy order is imposed for one year. But we almost always renew those every year. In a state of war, the order is permanent," says Hajec, although that does not apply today, despite the conflicts in Iraq and Afghanistan. "Congress advises us when we are at war. We are not at war."

Wardell understands why the military imposes its secrecy rules. "Before the second world war, the defence ministry didn't take Frank Whittle's jet engine idea seriously, so his patents were published. It meant the Nazis got hold of it and developed a jet engine before they otherwise would have."

"The defence ministry didn't take Frank Whittle's jet engine idea seriously. The patents were published and the Nazis got hold of them"

For their eyes only. Patents can be kept under wraps for decades

Steven Aftergood is editor of *Secrecy News*, a newsletter that challenges government secrecy and is published by the Federation of American Scientists. He recognises the need for a patent secrecy option but is sceptical about the scope and application of the current system. "The truth is, I don't know if the system is being wisely and prudently employed. I don't know if secret inventions are being disclosed as soon as their sensitivity lapses. And I don't know if the scope of what is withheld has broadened significantly or at all since 9/11. I would like to know."

Yet another mystery is compensation. Both the UK and US patent secrecy legislation says inventors should be compensated if they can prove their idea would

have made money had it not been kept secret. But it is unclear how they prove this when they cannot disclose information about the invention. "It is the applicant's responsibility to prove financial harm and my understanding is that it is very difficult to prove," says Hajec.

In the UK, the Ministry of Defence says decisions on compensation are assessed by its in-house patent attorneys and economic forecasters, probably in tandem with the Patent Office's view on the novelty and inventiveness involved. Independent auditing is not ruled out when disputes crop up as long as it has security clearance.

But assessing the commercial worth of a gagged patent is not really possible because the restrictions are open-ended. If you knew your patent would be declassified in 10 years, you might be able to calculate your lost sales. "There are currently 4800 secrecy orders in force in the US," says Hajec. "And some of them have been in force since the 1930s." That's an awful lot of sales years to have missed out on. ●

String, mud and bamboo make a quake-proof house

WHEN an earthquake strikes, it is not just modern concrete or brick buildings that are damaged or destroyed. Traditional adobe houses, which shelter around a third of the world's population, are just as vulnerable – witness the two earthquakes that hit El Salvador in early 2001, destroying more than 110,000 adobe homes.

Now a team led by Bijan Samali, director of the Centre for Built Infrastructure Research at the University of Technology in Sydney, Australia, has developed a cheap, simple way of reinforcing existing adobe houses to help them withstand quakes.

Adobe bricks consist of sun-baked mud that may have straw, or occasionally sand, added. To strengthen adobe houses, Samali and his team start by hand-drilling holes through the bricks. They then thread through a loop of string – preferably made of a



Catastrophe in El Salvador

durable material such as polypropylene – and fill the holes with mud. After the mud has dried, they use the string to tie vertical bamboo struts to the outside of the house every half metre or so, which they then tie to each other with horizontal strands of wire.

“The bamboo is ductile enough to withstand an earthquake, and strong enough to confine the adobe structure so that when it breaks – which is inevitable with a big quake – the pieces are held together,” says team

member Dominic Dowling.

Dowling has taken half-scale models of “partial” houses, comprising one wall and two corners, and tested them on a shake table. Models of traditionally built houses were severely damaged when shaken at 75 per cent of the intensity of the worse of the El Salvador quakes, which measured 7.7 on the Richter scale. With the same amount of shaking, reinforced models were unscathed. Simulations of 100 per cent and 125 per cent of the intensity of the El Salvador

“When the house breaks during an earthquake the pieces are held together”

earthquake caused only minor cracking to the reinforced models.

Most earthquake engineering research takes a high-tech approach to protecting buildings, and is aimed at developed countries. The few attempts to find ways to reinforce traditional housing in poor countries have failed to catch on, usually because they depend on materials or techniques that are beyond the reach of the average home builder, such as fitting struts within the walls or using wooden beams.

“Most of these houses are do-it-yourself, and we’ve never quite grasped the enormity of the practical side. The new technique has a huge potential application in south and central America, central Asia and India,” says structural engineer Michael Griffith of the University of Adelaide, South Australia.

Samali and his team are now constructing complete half-scale adobe models to test on the shake table. They plan to report their findings at the Australian Structural Engineering Conference in Newcastle, New South Wales, in September. Rachel Nowak, Melbourne ●

No escape for the oil slick cheats

FINDING the tanker responsible for an oil spill can be surprisingly difficult. Malaysian officials are wrestling with the problem after a huge spill in a busy shipping route on 25 June left a 5-kilometre slick off the country's coast. A new software system

developed in Australia could soon make the task easier.

To identify the culprit, environmental protection officers usually test the chemical composition of a slick and compare it with samples taken from the tanks of suspect ships. But deciding whether two samples match is not easy, says Brynn Hibbert of the University of New South Wales, who led the software design team.

False positive matches, where two different oil samples are thought to be the same, can happen because petroleum products often have a similar basic chemical composition, even if they come from different places and were refined differently. False negative matches, when two samples that should match do not,

occur because the chemical profile of an oil slick can change significantly in a matter of days. “As soon as oil or another pollutant hits the environment, it starts to change. The more volatile stuff comes off, bugs start to eat it, seabirds might shit in it. Establishing whether an oil sample really did come from a suspect source is often very difficult to do.”

To make identification more reliable, Hibbert's team has devised software that decides how likely it is that a pollutant sample and a suspected source really do match.

“Spilt oil can quickly change in the environment. Bugs eat it, while birds shit in it”

They developed the system using decades of records of the results of investigations conducted by the Environmental Protection Agency of New South Wales. The software looks for similar case studies, their test results, and other pertinent information about the oil samples, before generating a probability that the suspect source was responsible.

The New South Wales EPA does not investigate oil spills at sea, but the software could easily be adapted to examine past oil spill records, says Hibbert, who presents his research at a Royal Australian Chemical Institute conference in Sydney this week. He thinks the software's predictions are reliable enough to be used as evidence in court. Emma Young, Sydney ●

In the blink of an eye

PHOTOGRAPH BY WILLIAMS

If you thought evolution was slow and gradual, think again. You may even be helping it along, says **Bob Holmes**

● EVERY weekend angler knows to throw back the tiddlers. Likewise, commercial fishermen use large-meshed nets to spare smaller fish. Both are working on the principle that by reducing their haul this way, they can keep fish populations vigorous and healthy. But they could be making a terrible mistake. It is becoming increasingly clear that such well-meaning strategies may actually have the opposite effect to what the fishermen intend.

What they and most of the rest of us have overlooked is evolution – not the familiar glacier-slow process found in textbooks, which takes millennia to work its wonders, but a burbling freshet of evolutionary change that can occur in a matter of years or decades. By leaving the smaller fish, fishermen may be shifting the evolutionary goalposts, reshaping fish species as they go. In fact, biologists are

starting to suspect that this phenomenon, which they have dubbed contemporary evolution, is happening all around us. Besides emptying fishing nets, rapid evolutionary change cripples the efforts of doctors and farmers, thwarts trophy hunters in search of the big prize, and frustrates conservation biologists trying to rescue endangered species.

What's more, in the decades to come, the pace of evolution may quicken still further, as human activities transform the Earth, forcing species to adapt or die. That makes our need to understand the forces at work even more compelling. If we know what's going on, we may be able to find ways to control evolution, and even shape it for our benefit and that of the world around us.

Evolutionary biologists have long known that the process can happen rapidly –

Charles Darwin himself pointed out the observable changes wrought by pigeon fanciers and dog breeders. A century later biologists showed that peppered moths in England's industrial heartland had evolved darker colours to camouflage themselves against soot-blackened trees. And by the end of the 20th century everyone knew that bacteria, insects and weeds were able to evolve resistance to antibiotics and pesticides within a few years. But few thought such speedy evolution was more than just a special case.

"When I was a graduate student in the 1970s, the prevailing idea was that evolution was this gradual, slow process," says David Reznick of the University of California, Riverside. "We already knew there were instances of evolution that people had witnessed, but it was considered to be exceptional, not the usual pattern."

The experts had good reason to be sceptical that evolution could happen quickly. After all, evolution is driven by a mismatch between an organism's needs and its abilities to meet them. The prevailing wisdom was that most



Adaptation is a dynamic process for Galapagos finches and side-blotched lizards



By taking only the biggest cod, fishermen favour fish that grow slowly and stay small

organisms were already well adapted to their circumstances. Although there would be genetic variation between individuals within a population, no combination of genes would be particularly better adapted than any other, so there would be little pressure for natural selection to favour the survival and reproduction of some individuals over others. In other words, selection would generally be low and evolution slow – except where humans used antibiotics or pesticides to wipe out all but the one-in-a-million resistant individuals, or allowed only the gaudiest pigeons to breed.

All change

But in the 1980s biologists began to realise that adaptation might be a more dynamic process than they had thought. For example, on one of the Galapagos Islands, Peter and Rosemary Grant of Princeton University discovered that among one species of finch, individuals with small beaks do best in wet years, when small-seeded plants thrive, while their larger-beaked nestmates have the edge in drier years, when

larger-seeded plants predominate. As a result, beak size see-saws back and forth rapidly.

More recently, a team led by Barry Sinervo of the University of California, Santa Cruz, has found the same kind of rapid change in the side-blotched lizard in the south-western US. Male lizards pursue one of three different genetically determined mating strategies, each corresponding with a different throat colour. Orange-throated males are big and aggressive, and easily bully the more timid blue-throated males into ceding their females. Yellow-throated males, which sneak in disguised as females, can steal mating opportunities from the orange males while they are busy blustering, but fail to fool the blue males as these pay close attention to their precious mates. The result is a game of evolutionary rock-paper-scissors, with each strategy becoming dominant every four to five years.

No one knows how common this sort of contemporary evolution is, because it is hard to spot in the wild. The change happens so fast that biologists are likely to miss it unless they keep very detailed records of exactly the right

characters – a complete reversal of the old view that evolution is too slow to see in real time. “There’s no reason this couldn’t be going on all the time in organisms all over the place,” says Reznick.

Nor is rapid evolution confined to the cycling of different versions of the same trait. Sometimes evolution drives steadily in one direction. This may be crucial to our understanding of the biology of invasive species. Biologists have often noted that introduced species, such as zebra mussels or garlic mustard in the US, can lurk inconspicuously in their new home for decades or even centuries before suddenly exploding into problem pests. One possible, though not yet well tested, explanation is that the invaders are at first poorly adapted to their new setting, and cannot take off until they evolve a better match. And once that happens, the result can be dramatic. “Many of these invasions may reflect a genetic shift in the invading population,” says Donald Waller from the University of Wisconsin-Madison. “A lot of [organisms] are just a couple of percentage points above or below break-even, so it only takes a little change to make a big difference.”

Human activity is changing some ecosystems faster, and more dramatically, than ever before, and strong directional selection may be especially common in these cases. “It’s possible these human-induced changes are not just greater, but more consistent and more permanent. They may be resulting in evolutionary changes that are rapid, but may also be persistent as well,” says Andrew McAdam from Michigan State University in East Lansing. For example, ivory hunting has favoured the evolution of tuskless elephants in parts of Africa and Asia.

One of the best places to see evolution in action is high in the Rocky Mountains of Alberta, Canada, home of the largest bighorn sheep in North America. Hunters can pay six-figure sums for the right to shoot a big ram, the massive, curling horns of which make it the continent’s most highly prized hunting trophy. On one peak, aptly named Ram Mountain, hunting has been so intense that rams can expect to live only a year or two after their horns reach the almost-360-degree curl that makes them a legal target for hunters. Not surprisingly, this has led to intense selection in favour of males whose horns never grow to reach trophy status.

Sure enough, a study led by Dave Coltman, now at the University of Alberta in Edmonton, found that average horn size has declined by about 25 per cent over the past 30 years (*Nature*, vol 426, p 655). And the genetic erosion doesn’t end there, because larger-horned rams tend to have better genes in general. “You start taking out the prime-quality rams and the next generation will be missing those genes, because their fathers will be lower quality,” ▶



Hunting has reduced horn size by a quarter among Canada's bighorn sheep

says Coltman. In other words, every time they pull the trigger, hunters are working against their own long-term interests. "It's a form of artificial selection where instead of getting more of what you want you're actually going to end up with less," he says.

The same thing happens at sea, where fishermen are typically only allowed to keep fish larger than a particular size. Three years ago, David Conover from Stony Brook University in New York showed just how counterproductive this might be. Conover and his colleague Stephan Munch simulated intense size-selective fishing on lab populations of a small commercial fish called the Atlantic silverside. After just four generations, fish from the "fished" populations – in which the largest 90 per cent of fish were removed before breeding – averaged barely half the size of fish in the

Red squirrels are among several species adapting to global warming

"anti-fished" populations, in which the smallest 90 per cent were removed. As a result of the size difference, the total weight of fish removed (analogous to the fishery harvest) in the fifth generation of the fished population was barely half that of the anti-fished one (*Science*, vol 297, p 94).

Since then other researchers have shown that cod off the coast of Newfoundland, Canada, have also evolved toward maturing at smaller sizes – presumably as a result of the capture of the largest fish. As well as contributing to the crash of the area's fishery, this shift may also hinder the cod's ability to recover, since small fish produce many fewer eggs than large fish. This could help explain why cod populations have failed to bounce back on the Grand Banks, off south-east Newfoundland, despite closure of the fishery there for the past 13 years.



FRANÇOIS GUY/ISTOCK

Change for the better

When it comes to rapid evolution, microbes are the clear champions – just ask any physician struggling to treat an antibiotic-resistant infection. But that same evolutionary precociousness also makes microbes an unparalleled tool for cleaning up toxic messes.

Take weedkillers such as atrazine and 2,4-D, or nitrotoluenes such as TNT. Born in chemists' labs, these chemicals had never existed on Earth before. Yet just a few decades after their introduction, bacteria whose ancestors have been around for 3.5 billion years had evolved the enzymes needed to break them down for food. Their secret? They can pick up second-hand genes from their neighbours at what is essentially a vast, freewheeling flea market, and then tinker with them to alter their function.

Microbiologist Michael Sadowsky from the University of Minnesota, Twin Cities, has found evidence for this in the soil bacterium *Pseudomonas*. The four genes it uses to break down atrazine are scattered at random in its genome, suggesting that they were picked up one at a time. What's more, each is bracketed by transposons, bits of mobile DNA often implicated in genetic reshuffling.

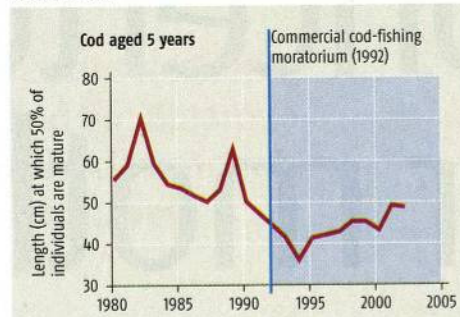
Off-the-shelf genes, even in new combinations, will not always work against novel chemicals. But bacteria have other ways of opening the evolutionary throttle when they need to. One tactic is to up the mutation rate when times are tough. Some bacterial plasmids carry a gene encoding an error-prone DNA-copying enzyme called DNA polymerase V that is activated during times of stress. More mutations mean more tickets in the genetic lottery, which increases the chance that some lucky bacterium ends up with a useful new variant on an old enzyme.

If contemporary evolution really is a dominant force in heavily fished populations, then fisheries managers may unwittingly be doing just the opposite of what they should to maintain healthy stocks. Instead of catching the biggest fish and letting the rest go, we need to treasure the big fish as bearers of the best genes. One solution, says Conover, would be to let fishers take only medium-sized fish. If we did that, he says, a fish's best strategy would then be to grow through that window as fast as possible. Such a scheme would select for fast growth rates – a big improvement over the present system, which selects for scrawny fish that never reach the minimum catch size.

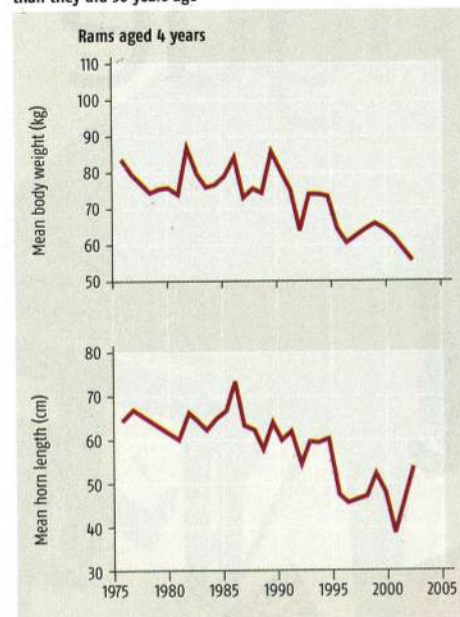
Turning evolution back from the "dark side" in fisheries can be done, but it won't be easy. "If you had a maximum size limit, under present trawl technology there wouldn't be a way to let the large ones go except by picking

EVOLVING FAST

The adult body size of cod off the Atlantic coast of Labrador, Canada, shrank progressively over the time commercial fishing was permitted



Mature bighorn rams weigh less and have much smaller horns than they did 30 years ago



thing, though. It is already being used to fit microbes for useful work (see "Change for the better"). And with man-made climate change looming, plants and animals will need the ability to adapt quickly. Biologists have noticed that several species have already responded to the warmer temperatures, and hence earlier springs, of the past few years by migrating or breeding earlier. For example, Stan Boutin and his colleagues at the University of Alberta found that red squirrels in Canada's Yukon territory now give birth about 18 days earlier than they did just a decade ago. Using tissue samples to determine each squirrel's parentage, the researchers could see how much of the variation in birth date ran in families. From this they calculated that at least 13 per cent of the change – representing a shift of almost a full day per generation – was due to evolution and not behavioural flexibility.

Fast forward

Whether evolution can move fast enough to cope with the unprecedented rates of climate change expected over the next century remains to be seen. Clearly though, a species cannot evolve a new adaptation unless it has the right genes – and larger populations are more likely to possess this genetic capital than small ones. This means the losers in the climate-change shuffle are likely to be the species that are already rare. Conservationists might even need to consider abandoning some marginal populations and concentrating on those with the genetic resources to evolve successfully, says Boutin. "That means we maybe don't save every caribou herd in Alberta, but we focus on the ones with the highest probability of success."

And if rapid contemporary evolution really is as widespread as some researchers are beginning to suspect, it has one more unsettling implication: we may have to modify our notion of "preserving" rare species, because every effort to rescue a species through captive breeding, founding new wild populations, or modifying existing habitats may cause it to evolve away from its starting point.

"This brings up an interesting philosophical question," says McAdam. "What is it that we're hoping to conserve? Is it particular species, or is it something about those species? Would we be happy if we were able to maintain all the species we have today, but human-induced evolutionary changes were so great that they essentially became functionally domesticated? Would we be satisfied with that? I would say no, that's not satisfying – at least to me." ●

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Concerto for mother tongue



Music: the international language? Not if you really listen, says **Philip Ball**

THE Proms, London's annual classical music festival, invariably concludes with Elgar's *Pomp and Circumstance* march, which concert-goers accompany with a lusty rendition of the anthem *Land of Hope and Glory*. It is a champagne-fuelled, teary-eyed orgy of patriotism. There seems to be something distinctly English about that tune. But why?

Because music does indeed have a national character, says Aniruddh Patel of the Neurosciences Institute in San Diego, California. Put simply, music echoes speech.

Patel and his colleagues came to this conclusion after comparing the rhythms and pitch variations of English and French music and speech, focusing on the classical music of the late 19th and early 20th centuries. This was a time when many composers were actively seeking to express their own nationality, so national musical characteristics might be expected to be particularly prevalent. Also, by choosing a relatively recent period, the researchers did not have to worry about less well-known patterns of spoken language from the more distant past.

To create a suitable selection of music to compare, the researchers had to avoid some musical traps. Songs were excluded because lyrics inevitably force the music to comply at least loosely with their rhythms, and perhaps also with their changes in pitch. And for classical compositions based on a folk melody, such as Vaughan Williams's *Fantasia on Greensleeves*, it is likely that the original tune

BRETT FRYER

"The French selection included the dreamy fin-de-siècle tunes of Debussy, Ravel and Fauré"



once accompanied a song. (In case you are wondering, the words of *Land of Hope and Glory* were added long after Elgar wrote *Pomp and Circumstance*. In fact the words required the addition of an extra note to the melody.) Compositions such as chorales and serenades whose titles implied a link to the vocal tradition were excluded too.

The team also filtered out other potentially complicating factors, including tunes whose rhythms were fixed by dances such as waltzes and gavottes, and compositions intended to mimic the style of a specific foreign tradition, such as Ravel's *Bolero*. Eventually they settled on a selection of 318 musical themes by 16 composers. In the English team were Elgar, Holst, Bax and Vaughan Williams, while the French selection included the dreamy

fin-de-siècle tunes of Debussy, Ravel and Fauré.

With their choice complete, Patel and his colleague Joseph Daniele started their analysis by looking at rhythm. The rhythms of everyday speech are notoriously hard to codify, but there is a measure called the normalised pairwise variability index (nPVI), devised by linguists Esther Grabe of the University of Oxford and her colleagues Low Ee Ling and Francis Nolan. This index measures the variation in length between successive vowels in a spoken phrase. Grabe and others have shown that the average nPVI of British English is significantly higher than that of French. That is, adjacent vowels in English tend to have rather different durations – long and then short, say – whereas in French the durations are more similar.

Inner harmonies

The Czech composer Leoš Janáček was convinced that the inflections of everyday speech hold the key to understanding the emotional content of music. These inflections, or prosody, fascinated him, and he took to scribbling down on manuscript paper the tonal rise and fall of phrases that he heard, as if they were little melodies. "Whenever someone spoke to me," he said, "I may have not grasped the words, but I grasped the rise and fall of the notes. At once I knew what the person was like: I knew how he or she felt, whether he or she was lying, whether he or she was upset. Sounds, the intonation of human speech, indeed of every living being, have had for me the deepest truth."

"Thai is a tonal language, and that may be reflected in the country's music"

So can the same pattern be seen in musical rhythm? When Patel and Daniele examined the patterning of note duration in their music samples, they saw no clear national bias in nPVI among individual composers: the ranges for Debussy and Fauré, for example, both lie within that spanned by Bax. But when they averaged the values for all composers from each country, they found a significant

Musilanguage

WHY should links exist between music and language? Some researchers think that the two might have a common evolutionary origin. Steven Brown, a neuroscientist at the Karolinska Institute in Huddinge, Sweden, proposes that our ancestors developed a system of communication that he calls musilanguage, in which meaning was conveyed not so much by the shapes of sounds as by their pitch. A kind of phrasing akin to the intonation of modern speech could have implied emotive nuances. In support, Brown points out that some animals make use of pitch to communicate, for example in birdsong, and in the alarm calls of the African vervet monkey.

Brown argues that some remnant of this tone-based musilanguage exists in tonal languages such as the various forms of Chinese, and in the sing-song of Japanese and Scandinavian languages. Brown is in good company. Darwin, in his 1871 book *The Descent of Man*, speculated that language might have developed from an essentially musical means of communication.

If that is true, it seems likely that music and language would be processed by the same or overlapping areas of the brain. For many years, there was scepticism that any such neurological connection existed, largely because some people with brain damage can process music but not words (a condition known as aphasia) or vice versa (amusia). But Patel says that the rare cases of aphasia without amusia tended to be people with unusually high musical ability, such as the Russian composer Vissarion Shebalin. And modern imaging studies of neural activity show that overlapping areas of the brain "light up" when someone is listening to speech and to music – even though language refers to quite specific objects, ideas and actions in a way that music cannot.

"I don't think we'll ever know which came first – music or language," says Patel.

difference. As with speech, the nPVI of the English music was higher than that of the French selection.

A composer's nPVI doesn't always reflect our expectations. The index places Elgar as the most "English" of all the composers studied. But Holst, whose *Jupiter* theme from *The Planets* suite has been proposed as an alternative to Britain's dirge-like national anthem, has an nPVI score typical of French composers. By this criterion, his music is more French than Ravel's or Debussy's.

Pitch proved more difficult to analyse. Music tends to be "quantised" in pitch – composed from a discrete scale of notes. But while spoken English sounds as though it has more pitch variation than French, quantifying the changes in pitch is tricky.

Patel and his colleagues John Iversen and Jason Rosenberg turned to the work of linguist Piet Mertens of the Catholic University of Leuven (KUL), Belgium. Mertens has noted that the pitch perceived by listeners for a given syllable is largely defined by the average pitch of the syllable's vowel. So a spoken sentence can be reduced to a series of steps between these pitches.

Applying this to French and English, Patel's team found that although the average change in pitch between two syllables is the same in each language, there is more variation in English. And when the researchers analysed their selection of music, they found precisely the same distinction: the variation from the average interval tended to be greater for English composers.

Again, the ranges spanned by composers of each nationality overlapped considerably. Saint-Saëns, who is rhythmically very French, is melodically English, while the reverse is true of his fellow French composer Vincent d'Indy. Oddly, Holst falls squarely in the French camp on both counts, even though his music feels subjectively English. Patel cautions against drawing too strong a conclusion from this, though. "The Holst sample is small," he says, "and if more of his music was sampled, it might turn out that his melodic and rhythmic values would be higher."

But why should music share these acoustic similarities with speech? Patel thinks that the latter probably shapes the former. Composers,

he suggests, absorb the speech patterns – the contours of pitch and rhythm – that they have heard since childhood, and unconsciously build these into their music. And people listen with the same conditioning, making British and French people particularly attuned and responsive to the sounds of Elgar and Debussy respectively.

Patel's latest work shows that the contingencies of history, as well as the exigencies of nationality, can play a part. Even though German is a language with a relatively high nPVI, the rhythms of German and Austrian music from the baroque and classical eras of the 17th and 18th centuries have a relatively low nPVI. Patel suggests that is because it was strongly influenced by the music of Italy – a country with a low-nPVI language. But starting in the 17th century, the nPVI value of German and Austrian musical rhythms increased steadily as the countries found their own musical voice. "It looks like the connection is not limited to English and French music of the period I studied," says Patel. "But more empirical work is needed."

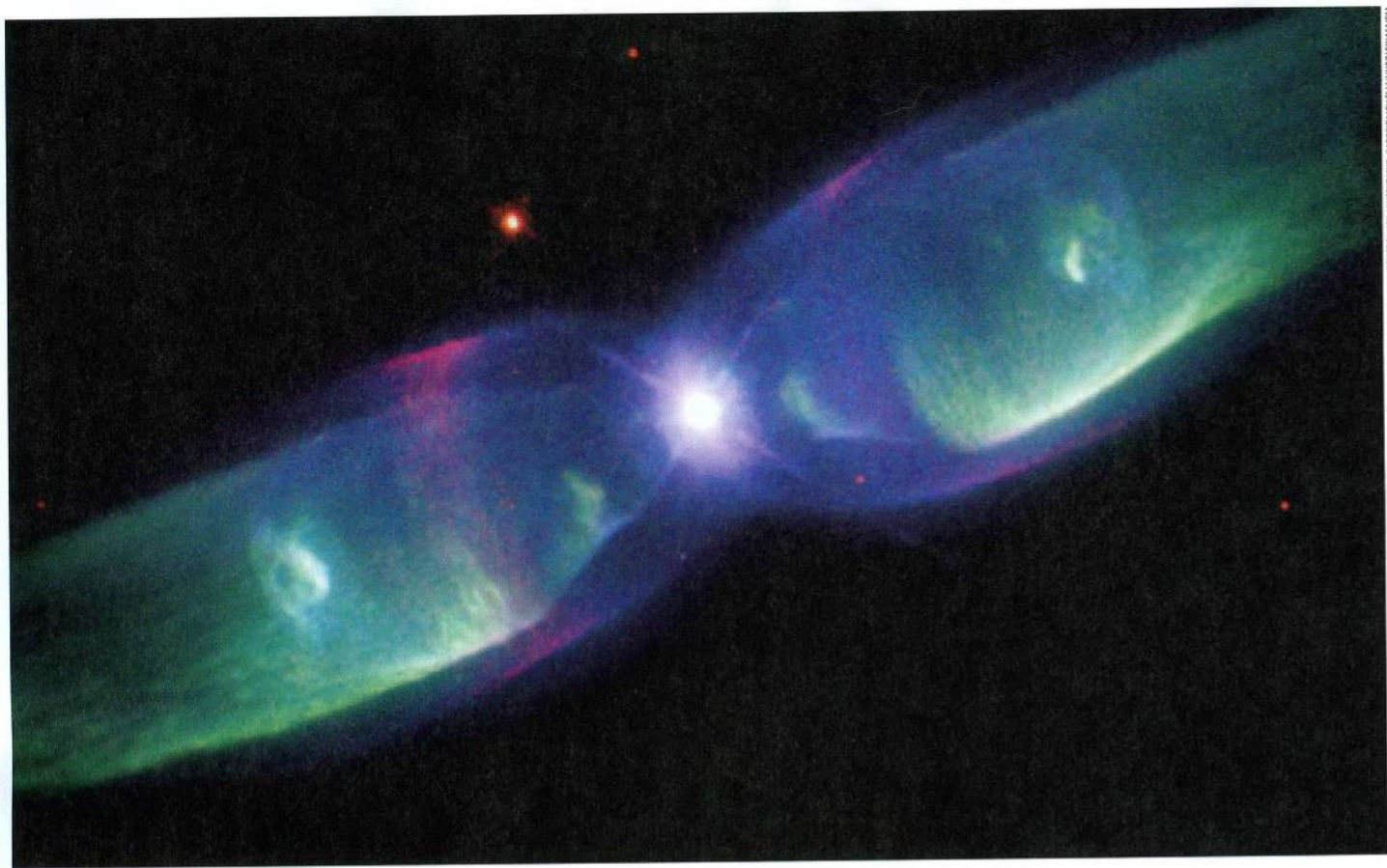
His methods are now being used to study the rhythms in speech and music of other cultures, such as Welsh and Japanese. "One of our group's interests is in Thai music," says Patel, "since Thai has a high linguistic nPVI, and Thai culture has a well-developed classical instrumental musical tradition." What's more, Thai is a tonal language (see "Musilanguage", left), and Patel is keen to discover if that is reflected in the country's music. He also hopes to study the music from cultures in which the music is not written down, such as those in many African countries, to find out whether the link with language patterns still emerges.

Patel thinks that this analysis might find practical applications. For example, his method of measuring rhythm and tone might allow a computer to assess the intonations of non-native speakers, so they can get feedback on their accents in language labs.

And could the new research help to guide composers of patriotic tunes? A deeper understanding of emotional responses to music probably awaits brain-imaging studies, but Patel's work is already suggestive: perhaps those mawkish renditions of *Land of Hope and Glory* at the Proms are simply playing on the patterns of speech that English people heard in the cradle. ●

Philip Ball is a consultant at *Nature*

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BRUCE CALDWELL, VINCENT VOICE, GABRIEL MELLENHARDT/ESA

The last blast

How do dying stars produce the most spectacular sights in the galaxy? **Hazel Muir** finds an explosive answer

FOR a while there, Adam Frank and his fellow astronomers were worried. Their work had been moving along so nicely, but then suddenly everything changed. "We realised we didn't have a clue what was going on," says Frank, who is based at the University of Rochester in New York state.

Happily, they are back on their feet now. The ethereal, hovering clouds of glowing gas known as planetary nebulae are beginning to shed their mystique. And their unveiling could answer an intriguing question: what kind of spectacle will mark the last gasps of our sun, 5 billion years from now?

A planetary nebula is the spectacular swansong of a sun-like star. "What you are seeing is a star coming unhinged," says Frank. We know of some 1500 of these in our galaxy. A classic example is the Ring nebula, which lies about 2000 light years away in the constellation Lyra. Once the star at its centre had exhausted its helium core, it began to burn hydrogen and helium outside the core, swelling as it entered the final giant phase of

its life. Radiation from the star blew a wind of gas and dust into space at a speed of about 10 kilometres per second.

When the star ran out of fuel altogether, the stellar core started to shrink into a white dwarf star with a temperature of more than 100,000 °C. The atmosphere started to stream outwards faster, at 1000 kilometres per second, ramming the earlier, slower wind into a thin shell. The molecules in the shell, excited by radiation from the central star, started to glow: from Earth the phenomenon can be seen as a giant shimmering ring a light year across.

But the simple structure of the Ring nebula is unusual. Most planetary nebulae are either elliptical or "bipolar", with two lobes that stick out like butterfly wings or rocket jets. Others are reminiscent of jellyfish tendrils or skinny-legged insects, all with their own curious symmetry. "There's every possible shape you can imagine," Frank says. And these shapes are harder to explain.

In the early 1990s, astronomers thought they had the answer. An old giant star might

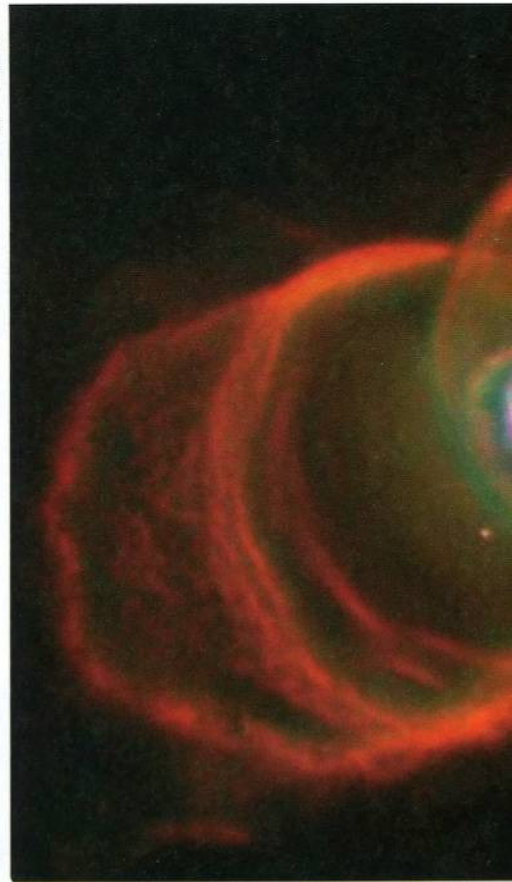
Images from the Hubble Space Telescope have revolutionised the way we look at nebulae

belch out most gas and dust around its equator where the surface rotates fastest, they reasoned. Perhaps dark patches similar to sunspots around the star's equator could also make the wind denser around the equator. Later, as the star turned into a white dwarf and ejected its atmosphere in a faster wind, the dusty doughnut at the equator would inhibit the outflow of gas, which would instead escape at the poles, creating the double lobes. "We thought this model did a pretty good job of explaining the entire range," Frank says.

But then the Hubble Space Telescope came along. From 1994, Hubble beamed back image after image of planetary nebulae far too complex for any existing theory to explain. The Cat's Eye, for example, which had appeared as a blobby bubble from ground-based telescopes, turns out to have extended gas shells with pointy caps, spiky jets at both ends, and curious little knots. Hubble images of other planetary nebulae showed with devastating clarity an array of strange and intricate symmetries, with multiple jets, radial wisps and even honeycomb-like structures. While the world marvelled at the pictures, the astronomers, who had thought the book on planetary nebulae was closed,



ANDREW FRUCHT/STERN/AGENCE FRANCE PRES



discovered they had more thinking to do.

There was more puzzling evidence to come. Observations of many intricately shaped planetary nebulae have revealed starlight reflecting off spherical dusty shells around them. That suggests that the wind streaming out from an old, giant star is spherically symmetrical, so it would not create a dusty doughnut around the equator. The nail in the old model's coffin came in 2001 when Javier Alcolea and his colleagues at Spain's National Astronomical Observatory measured the momentum carried by the outflows from fledgling planetary nebulae: the winds carried up to 1000 times more momentum than the star's radiation could supply. Where could the energy possibly come from?

One potential source, favoured by Frank and others, is magnetic fields. "The star's magnetic field could act as a drive belt that taps the star's rotational energy and flings material away," Frank says. With his colleague Eric Blackman, Frank has modelled the way in which material from the star could be pulled into a disc around a companion star. Magnetic field lines threading through the disc channel hot ionised gas into outflows at right angles to the disc. If the disc wobbles slightly, or "precesses" like a spinning top, the two jets would naturally swing around like a garden sprinkler, which could explain the odd shapes of some planetary nebulae.

One problem with this model is that while

Could a magnetic explosion have created the weird and wonderful shapes of the Eskimo, Hourglass and Rotten Egg nebulae?

the central stars of at least 16 bipolar nebulae harbour a close companion, many others show no signs of one. That could be because the companion is too faint to see through the glare of the white dwarf, or because it has already fallen into the central star and vanished without trace. But it could also be that there is no companion, and never was.

Frank is unperturbed, however. He thinks a "magnetic explosion" on the star's surface could create some of the strange shapes without the need for a companion star. This idea is supported by some of Alcolea's results. His team has shown that gas flowing from young planetary nebulae follows an intriguing pattern in which the outflowing gas furthest from the core moves much faster than the inner layers. In fact, the speed of the outflow is directly proportional to the distance from the central star, and that velocity profile is the hallmark of a sudden explosion. If a bomb exploded in space, for instance, fast shrapnel would go farther than slow shrapnel, and the distance of any fragment from the explosion

site would always be proportional to its speed.

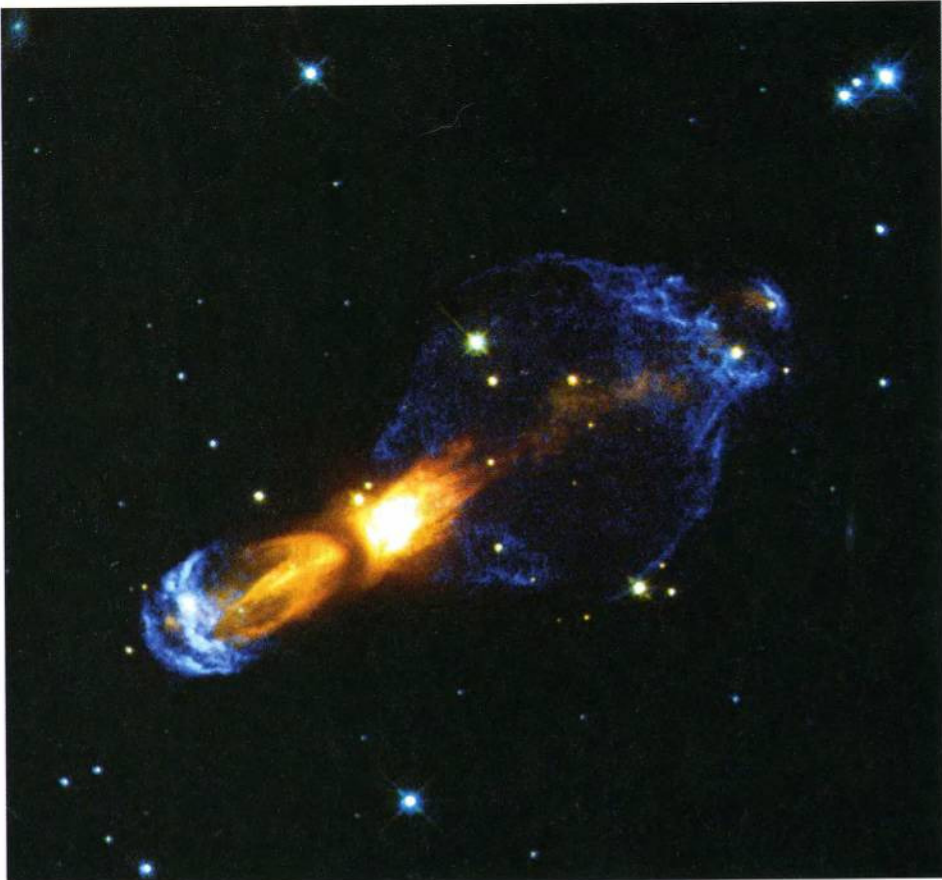
This explosion could occur if the newborn white dwarf has a strong magnetic field and rotates very fast, while the envelope of gas around it expands and rotates very slowly, Frank says. A powerful dynamo would be created as the magnetic field lines fold tightly at the white dwarf's surface. Eventually, there would be so much stored energy in the twisted field that the field would reconfigure in a giant explosion, accelerating the atmosphere outward over just a few decades.

Magnetic key

"It's like winding up a big coiled spring – eventually, you have a big magnetic explosion," Frank says. Simulations of this outburst by Frank, Blackman and Sean Matt of McMaster University in Hamilton, Ontario, in Canada show that factors including the mass of the stellar core, its rotation rate and its magnetic field strength will affect the shape of the planetary nebula. By changing these



R. SAHAI, J. TRAUGER/HUBBLE INCA



V. GUARABAI/HUBBLE INCA

inputs, it is possible to recreate many of the typical multi-lobed shapes Hubble observed.

Last year, a team led by Stefan Jordan of the Astronomy Research Institute in Heidelberg, Germany, provided further confirmation that magnetism is a key force in creating bipolar planetary nebulae. The team reasoned that if magnetism is important, bipolar nebulae should only form around highly magnetised stars. To test this idea, they used the knowledge that a strong magnetic field splits the energy levels of atoms in a characteristic way that polarises the light that atoms emit. Using the Very Large Telescope (VLT) at the European Southern Observatory in Chile, they measured the polarisation of starlight from four white dwarfs inside bipolar nebulae. Their results suggested that all four have strong magnetic fields, roughly 1000 times that of the sun (*Astronomy & Astrophysics*, vol 432, p 273). Next month, Jordan plans to use the VLT to find out if the same principle holds for spherical planetary nebulae. If the magnetic field theory is correct, then the central stars of these nebulae should have weak magnetic fields, or none at all.

Not everyone is convinced that magnetic fields are necessary to explain the nebulae. Noam Stoker at the Technion-Israel Institute of Technology in Haifa, for example, still thinks that a companion star, or even a giant planet like Jupiter, could give rise to bipolar nebulae. The fact that some don't have a visible

"It might be possible to predict what the last gasp of the sun will look like 5 billion years from now"

companion is not reason enough to dismiss the idea, he says. The issue may be resolved by astronomers who are monitoring the central stars of planetary nebulae to see if the gravitational pull of an unseen companion is giving them a slight wobble.

So there is still no definitive explanation. But astronomers now have some more observations to help them make sense of the strange zoo of planetary nebulae. NASA's Chandra X-ray Observatory and Europe's XMM-Newton satellite have revealed intense X-rays coming from several planetary nebulae. They signal the existence of outflows of gas at temperatures of several million degrees. These might result from shock waves as gas outflows collide or from flares powered by intense magnetic fields, but no one knows for certain.

Frank thinks enlightenment might come from using top-line telescopes to capture images of nebulae over many years to make "movies". These could be matched against a theoretical model to show how planetary nebulae evolve. He points out that new


computer techniques are slashing the time needed to develop the theories. "To make those movies would be very important," he says. "We could see how all the stuff is moving and get away from this snapshot mentality."

He is confident that astronomers are on the right track with a mix of magnetic fields, rotation and possibly companion stars. "In the mid-1990s, we were flailing around trying to figure out which direction to go," he says. "I believe we have a good direction now, and in the next few years we're going to make a lot of progress." This could have benefits beyond understanding planetary nebulae, as similar processes involving magnetism and rotation may well be a driving force in other astronomical objects, from newborn stars to energetic gamma-ray bursts.

The results could also give us a glimpse of our sun's likely future. The sun is roughly halfway through its life, and in about 5 billion years' time will swell into a red giant. The swelling sun is expected to swallow the innermost planets Mercury and Venus, and possibly the Earth too, before entering its planetary nebula phase. If magnetism is a major player in shaping planetary nebulae, and if we can predict the sun's future magnetic field, it might be possible to take a stab at what the sun's nebula will look like. Perhaps our home will play host to the most beautiful nebula of all. It's a shame we won't be around to see it. ●

Take it to the limit

Communication is about to hit top speed, says Dana Mackenzie – so turn on your turbo boost

 NOISE is the blight of the information age. It can be far more than an annoyance: if you send instructions to an interplanetary spacecraft, and the message gets scrambled going through the ionosphere, your probe might fire its engines at the wrong time. But now noise has met its match, in the form of two miraculous methods for pulling clear messages out of what was previously considered to be undecipherable static. It's like hearing a whisper in a thunderstorm or reading road signs in a blizzard.

These static-bashing technologies, called turbo codes and LDPC codes, are already on their way into your home, programmed into

provost of the University of Illinois at Chicago.

Turbo and LDPC codes have nothing to do with spies or security. Quite the opposite: they are designed to preserve data rather than to hide it. They exist to fix an inevitable problem with communication. No communication channel is free of errors: analogue phone lines hiss with noise, radio reception is plagued with static and even the internet loses packets of information from time to time.

But for some applications, perfect fidelity is critical. In other cases it may be less important, but we have got used to it. When you download a photo or a music file over the internet, you expect it not to be corrupted.

“These codes will be serving the human race for as long as it's on the Earth”

digital TV receivers and computers with third-generation wireless. They are also on their way to Mercury and will soon be used on spaceships bound for Mars.

The new codes are very close to a perfect technology. No matter how much faster computers become, the codes they use to send data will never get significantly better. You might compare them to the wheel: although it is possible to dress up the wheel in different ways or make it from different materials, you will never improve on its basic shape. “These kinds of codes will be serving the human race for as long as it's on the Earth,” says Michael Tanner, a pioneer of LDPC codes who is now the

Fortunately, perfect communication is possible even over a noisy line. The key is forward error correction – preparing for errors before they happen by adding redundancy to a message. A military commander does this when calling for “Bravo company” instead of “B company” over a staticky radio channel. It isn't an affectation invented for war movies; there's a practical reason. Background noise might make “B” sound a lot like “C”, but no one can confuse “Bravo” with “Charlie”.

Forward error correction works in a similar way. If you send a string of bits through a modem, noise in the phone lines could change the message, say from “1, 1, 0, 1” to “1, 0, 0, 1”.

It's like confusing “B” with “C”. The solution is to add redundant information, like the extra syllables in “Bravo” and “Charlie”. In digital communication, this could be achieved by sending each bit many times over, so that a moderate amount of noise will leave the message clear. But there are more efficient means than that.

For instance, you might group the string into blocks of four bits and add four “check digits” that are related to the four information bits by four different mathematical formulae. The whole set of eight bits forms a code “word”. If the receiver can find the set among a list of valid code words, it will assume that the message came through cleanly. If it receives an invalid word, it can substitute the nearest valid word. The first to realise the power of this



method was Claude Shannon, an engineer at Bell Labs in New Jersey, who established modern information theory in a 1948 paper.

But there is a price to pay for perfection. Shannon also showed that there are two factors controlling the speed at which you can transmit data. One is the bandwidth of your channel. The other is the signal-to-noise ratio. The more noise, the more check digits you must add to each code word to make it understood. Instead of saying "Bravo" and "Charlie", you might have to say "Bravissimo" and "Charlemagne". And the more check digits you are transmitting, the less actual information you can send per second.

Shannon derived a formula for how much information you can send with essentially perfect fidelity at a given signal-to-noise ratio.

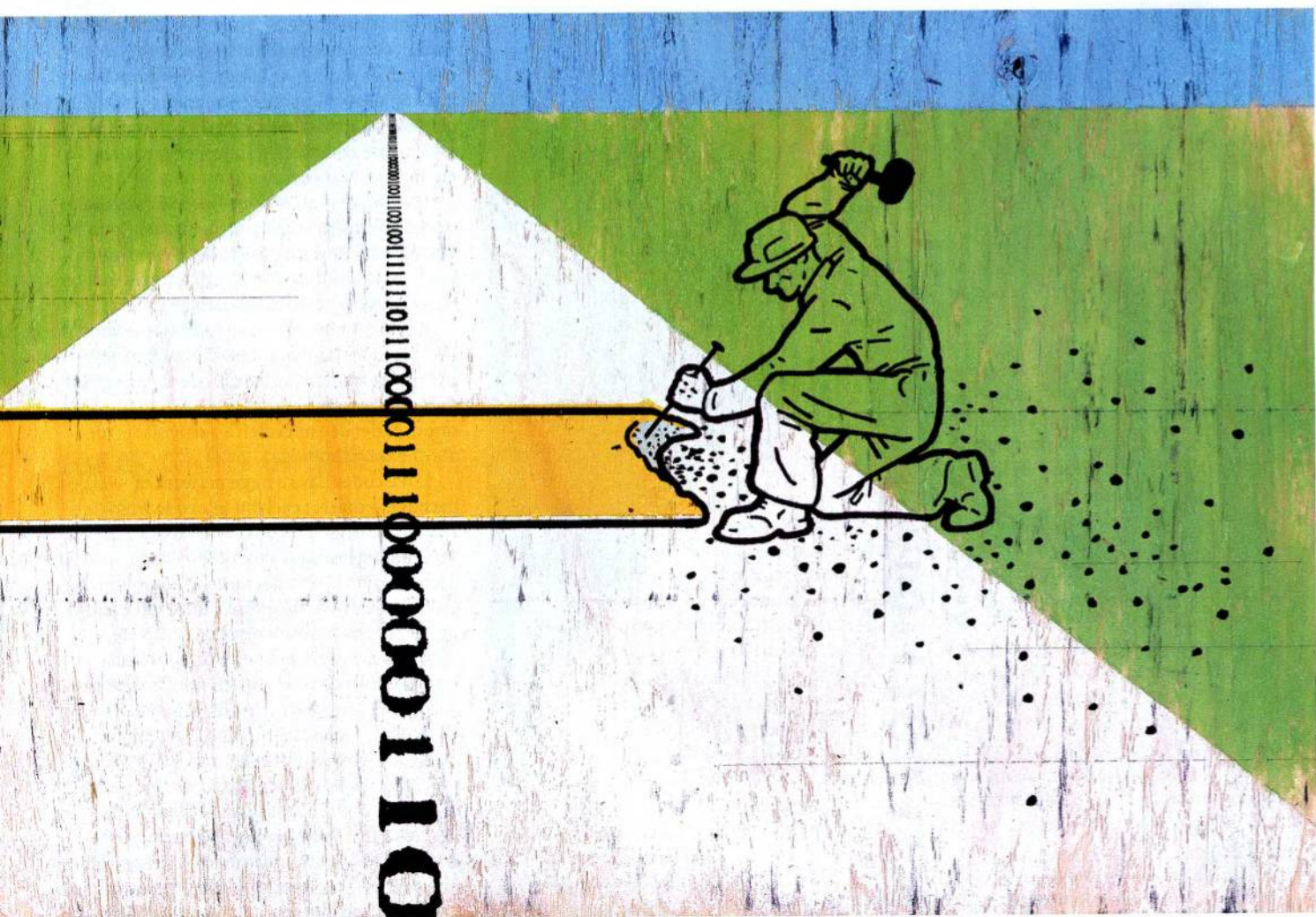
That formula is now called the Shannon limit, and it is inviolable. If you try to send your data with too few check digits, it will be corrupted. Whatever coding scheme you use, the decoder on the receiving end is bound to confuse some code words with others.

Shannon's discovery is as fundamental to the information age as the speed of light is to physics, setting a limit on the speed and performance of all the communication devices we use today. Unfortunately, just as the theory of relativity does not tell you how to build a spacecraft that can approach the speed of light, Shannon's formulae do not describe how to approach his limit.

So what error-correcting codes do you need? "If you've been in this field for very long, you have certainly heard the code designer's

lament: 'All codes are good except the ones we know about,'" says Keith Chugg, an electrical engineer at the University of Southern California in Los Angeles.

For many years, engineers couldn't even get close to the Shannon limit. Indeed, photographs from early space missions had some truly horrible blemishes. By the time the two Voyager spacecraft were launched in the late 1970s, things had improved a great deal. But data transmission has continued to be a bottleneck on NASA missions, with the rate limited by the power of the transmitter. Even with the best available codes of the day, when the Jupiter-bound spacecraft Galileo was launched in 1992, it required 60 per cent more power to achieve error-free transmission than it would have needed with a perfect code. ►



To put this into perspective, when NASA spent \$80 million to upgrade the Deep Space Network, which is used to receive signals from such spacecraft, the signal-to-noise ratio improved by 25 per cent. A code that let you communicate at the Shannon limit would get you twice that improvement for free.

Before 1993, engineers didn't think that was possible. Then came what Robert McEliece of Caltech calls "the earthquake". Claude Berrou of the French National School of Telecommunications in Brest and his collaborator Alain Glavieux announced that they had found a way to get within 10 per cent of the Shannon limit, using what they called a turbo code.

At first nobody believed them. "It took us many months to be convinced," says Fabrizio

Pollara of the Jet Propulsion Laboratory in California, who works on NASA's communications systems.

An aftershock came later in the decade, when three separate groups of researchers realised that a similar code had been invented way back in 1963. That year, a graduate student at the Massachusetts Institute of Technology, named Robert Gallager, invented what he called low-density parity check (LDPC) codes. They were impractical for the computers of the time, so they passed by almost unnoticed.

These new codes represent an entirely different way of thinking about coding. Instead of focusing on the code words themselves and how to make them as distinctive as possible, Berrou and Glavieux worked on the encoding and decoding process. They replaced "hard"

decisions with "soft" ones, such as "there is a 75 per cent chance that this bit is a 1" rather than "this bit is a 1". They also turned the decoding process into a conversation between several decoders, rather than a unilateral decision by one decoder.

And in a break with tradition, they did not prove mathematically that their method worked. "The paradigm in coding theory was very mathematical," says Tanner. "You had to provide proofs." To this day, there is no formal proof that turbo codes come so close to the Shannon limit. They just do.

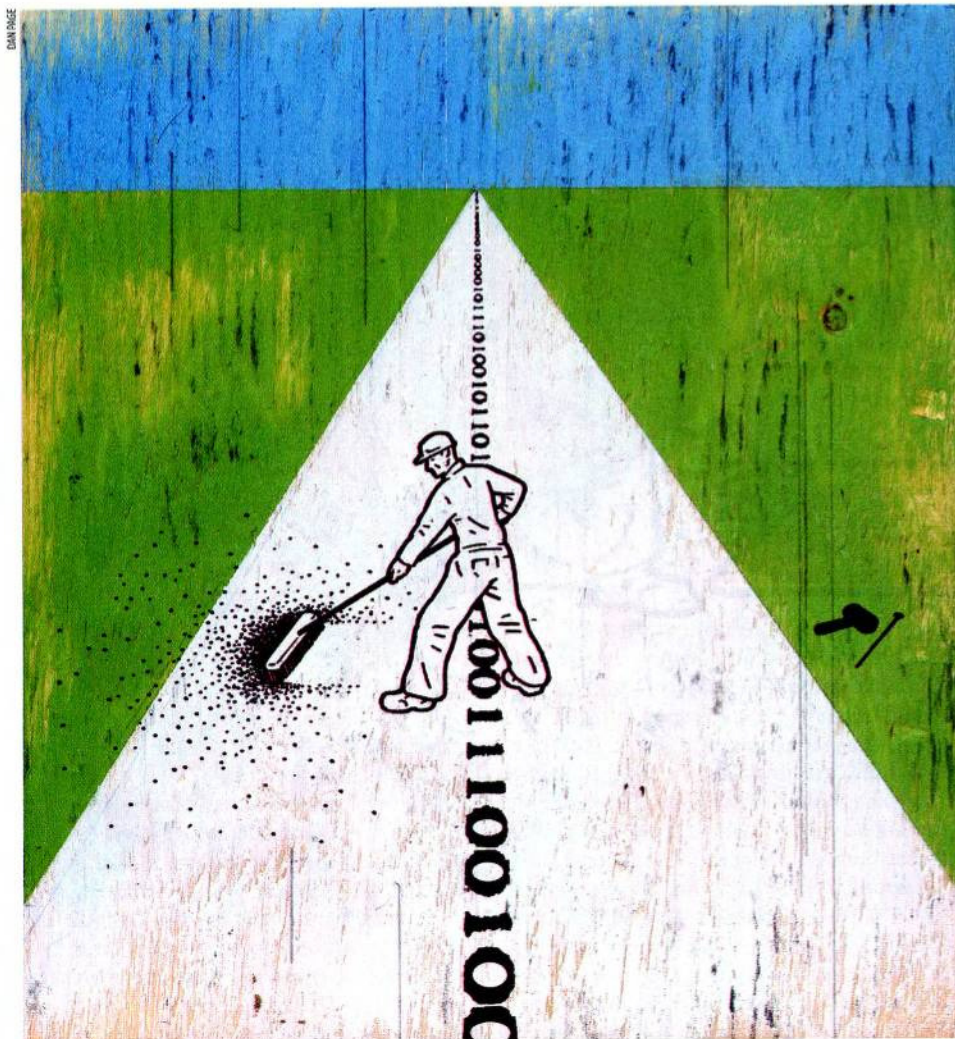
The secret to both turbo codes and LDPC codes is a technique called belief propagation. You could liken it to solving a crossword puzzle. Often there will be words or letters that you aren't quite sure of. A clue may lead you to think that a letter is probably a B, so you pencil that into the square. As you solve more of the puzzle, your beliefs about the solutions to other clues propagate back to your pencilled-in answer. They may confirm it, giving you the confidence to ink it in, or they may conflict with your earlier belief, prompting you to change the B to a C, say.

One innovation of the new codes was their use of a decoder "pencil" rather than a "pen". The decoder doesn't have to decide outright whether a particular bit is a 1 or a 0. Instead, it can assign a probability that the bit is a 1.

An even more important difference is that there is more than one decoder. Turbo codes use two or more separate decoders, each given a shuffled version of the code word so that if one decoder doesn't catch a particular error another one should.

LDPC codes have a huge network of decoders – one for each bit in a code word (see Diagram). These processors talk to each other, exchanging messages about the likelihood that each bit is a 1. LDPC codes were impractical in Gallager's day because you couldn't fit enough processors on a chip: a typical LDPC code might have 8192 data bits and 4096 check bits in each code word, which means 12,288 decoders connected in a vast network.

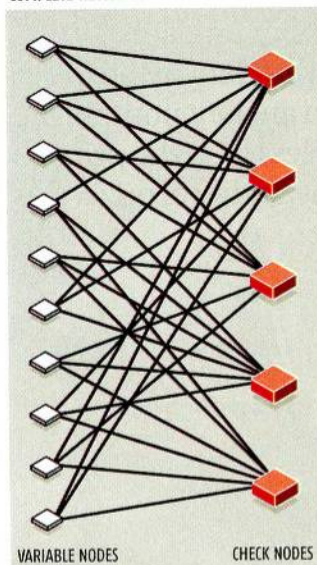
Perhaps most surprisingly, LDPC codes work best when the connections between processors are somewhat random. For years, coding theorists had struggled along with highly structured, non-random sets of code words, the better to make them distinct from one another. The Reed-Solomon code used in CD and DVD players is of this type. But they



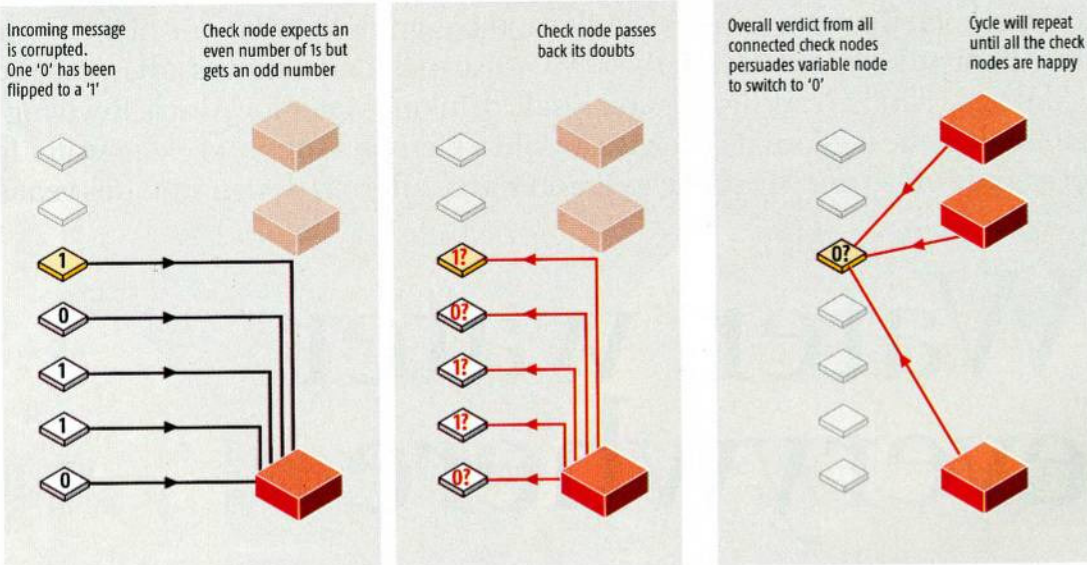
ARGUING THE TOSS

LDPC error-correcting codes use a network of processors to ensure information is transmitted faithfully. Variable nodes each hold one bit of the message, while check nodes use simple formulae to look for errors

COMPLETE NETWORK



DETAIL OF NETWORK



were barking up the wrong tree: randomness will get you closer to the Shannon limit than mathematical ingenuity.

The list of applications for the new codes is growing. "Often our customers are stunned at the improvements," says Chugg, who co-founded a company called TrellisWare in San Diego. "In one example, we demonstrated a turbo-like code over a live satellite link for a large US contractor. During a conference call with the contractor, they kept turning down the transmit power, expecting to break the link, and were truly shocked when they were unable to do so."

phone or wireless computer, because they will make up for a weaker signal as you wander away from the transmitter.

Of course, it is no good if your satellite speaks one code and my satellite dish speaks another. Turbo codes' head start has given them an edge in becoming industry standards and they will soon be used in cellphone and next-generation wireless networks. But LDPC codes have some advantages: they are less complicated and less encumbered by patents, as France Telecom patented turbo codes even before Berrou and Glavieux announced them to the world. In 2003, an LDPC code beat six

loops. In a randomly wired network, it's impossible to avoid them, so Berrou and Glavieux brazenly charged in where, for decades, engineers had feared to tread. Loops didn't matter. Somehow the efficiency of the network more than compensates for its rare inaccuracies. "The algorithm, albeit invalid, actually works extremely well," MacKay says.

So loopy message-passing may come into vogue in fields other than coding. For example, speech-recognition software might use belief propagation to navigate the ambiguities of human speech. And image processing can be souped up by connecting the pixels of a digital image like the nodes in an LDPC decoder: in 2000, computer scientist Bill Freeman of Mitsubishi Electronic Research Labs demonstrated the use of loopy message-passing to sharpen a blurred picture of a tiger. A similar method could be used to convert old television programmes from low-resolution analogue to high-definition digital formats.

And yet, for all their potential, McEliece thinks that LDPC and turbo codes will eventually be seen as just the final stroke to Shannon's original masterpiece. A thousand years from now, he imagines, the *Galactic Encyclopedia* will read: "Shannon formulated the notion of channel capacity in AD 1948. Within several decades, mathematicians and engineers had devised practical ways to communicate reliably at data rates within 1 per cent of the Shannon limit..." ●

"Berrou and Glavieux brazenly charged in where for decades engineers had feared to tread"

The two kinds of code are now battling it out to dominate communications technology. LDPC codes use less computing power to decode than turbo codes do, so they can be used at higher data rates. But turbo codes had a head start, having been invented four years before LDPC codes were rediscovered. NASA now uses them for such ventures as the Messenger mission to Mercury, which launched last year. LDPC codes will take a few more years to catch up, but Pollara thinks both types will be used eventually.

The standard codes used in commercial applications are not as good as NASA's, so the improvement will be even greater. The new codes will extend the range of your mobile

turbo codes to become the new standard for the satellite transmission of digital television.

The techniques used in both codes may have a future outside the communications business. The idea of belief propagation in networks is actually quite old: David MacKay, a coding theorist at the University of Cambridge, traces it back to a 19th-century astronomer and statistician named Thorvald Thiele. Since then, MacKay says, "It has been discovered about 10 times over, once for each of 10 fields." But belief propagation was always believed to be theoretically unsound if the networks had loops in them, because a loop can generate self-reinforcing delusions.

However, the turbo and LDPC codes allow

Dana Mackenzie is a science writer based in Santa Cruz, California

He has been hit by an assassin's bullet and has grappled with one of the world's largest bats. **Ian Thorpe's** student days in the 1980s also included a stint as adviser to the president of the Comoros islands. Now his mission is safe drinking water for Africa. Reviving an ancient pumping technology, he reckons he can give a child a lifetime's supply of clean water for less than the price of a bottle of Perrier. He spoke to **Fred Pearce** after his design won this year's St Andrews prize.

Water, water everywhere

Tell me about being an environmental adviser to the president of the Comoros islands; and how did you get shot at?

It was surreal, especially for a student. The president, Ahmed Abdallah Abderemane, gave me his chauffeur-driven car to go to the remote villages, and I was the first white person the villagers had ever seen. My task was to find a long-lost bat. The chauffeur would get out of the car and salute me as I went off into the rainforest armed with the only words in Comorean that I knew: "I'm looking for fruit bats."

I was in the presidential palace when the president was assassinated in 1989. A group of mercenaries had a deal to take a percentage from fuel revenues, but the president had stopped paying them. It was late at night and I overheard an argument and a scuffle involving the presidential guard, followed by gunfire. As I made a run for it through the palace grounds, I was shot at and took a bullet in the hip.

What brought you to Africa for the first time?

I first went to Africa as an 18-year-old gap-year student. I taught in a rural school in eastern Zimbabwe, where they made me head of science and maths. My department was a cardboard box containing a few materials and a couple of books, the classroom was an area under a fig tree, and I ate maize porridge for almost every meal.

The water supply for the village was an open well a couple of miles away. One day, a snake fell into the well, died and decomposed. As a result there was a dysentery outbreak, and two of the children I was teaching died. It had a real impact on me.

Back in the UK doing a degree in environmental sciences at the University of East Anglia, I researched different technologies for providing clean water. In 1991, after my studies, I returned to Zimbabwe to carry on teaching and to try and put some of these ideas into practice.

Profile

Ian Thorpe is the co-founder and executive director of the charity Pump Aid, which provides ultra-low-cost water pumps to communities in Africa. His "elephant" pump won the 2005 St Andrews Prize for the Environment. The prize was created by the University of St Andrews, UK, with support from the energy company ConocoPhillips, to recognise innovative and practical solutions to environmental problems (www.thestandrewsprize.com).

Working with two other teachers, Tendai Mawunga and Amos Chitungo, I set up Pump Aid and we started experimenting with different water pump designs.

How did you come to settle on an ancient design?

It's called the elephant pump and it is based on a water-lifting device used in China 2000 years ago, in which water is drawn up through a pipe by plastic washers knotted to a loop of rope. It uses a bicycle system to lift the water from the well, though you can also fit a hand-crank or a small wind turbine, or even a solar panel.

What are the advantages of an elephant pump, and how did it get the name?

One of the women working the pump invented the name. She said that the spillway of the pump looked like an elephant's trunk. And when people stand on either side to operate it, from above it looks like an elephant's ears.

The pump is a community enterprise: local people contribute bricks, help with the digging and do all the maintenance. When the rope starts to fray, it can be replaced with any rope. Most villages have some, or they can use tree-bark twine, which they make themselves. The washers are critical. The Chinese used discs made of leather. We hit on washers made from waste plastic. We train people to take an existing washer and press it into wet clay to make a mould. Then they just melt any waste plastic in a tin can, pour the liquid into the mould, and they've got another washer.

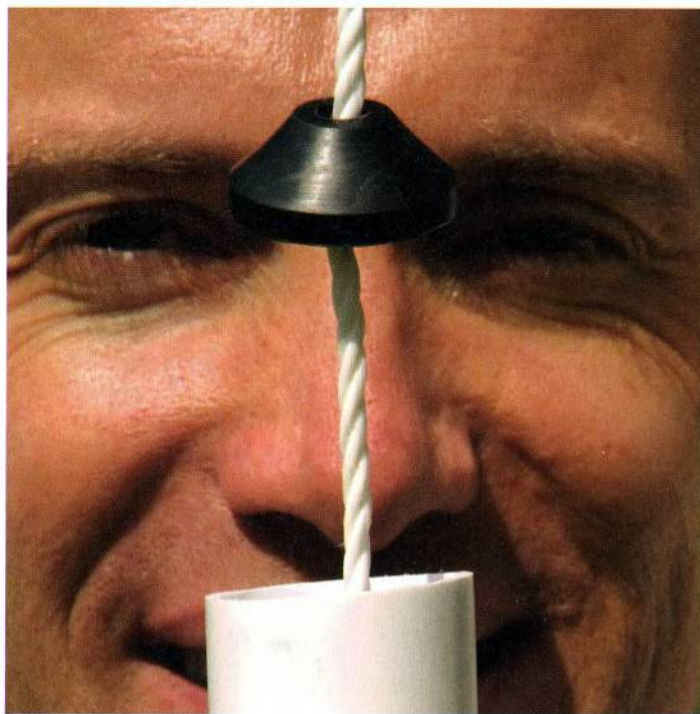
When did the charity begin to take off?

Pump Aid got serious after 1996, when we installed a hundred pumps. We started at the school where I had first been a teacher, St Matthias school, near the border with Mozambique. So far we have installed 1200 pumps in over 200 villages in eastern Zimbabwe. There are some places where the water tables are too deep, but we reckon 70 per cent of rural Zimbabwe and wide areas of the rest of Africa could benefit.

Why not use a conventional pump like other aid organisations?

Conventional piston pumps installed across Africa cost between \$3000 and \$8000 each, including drilling and installation. They cost a lot to maintain and use materials you have to buy from a shop. As a result, two-thirds of them are out of order. Our pump produces just as much ►





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A child dies every 15 seconds from unsafe water. It's like 15 jumbo jets full of children crashing every day

water, but it is simpler, more robust, costs only \$300 and is virtually free to repair with village materials. Nearly all of our pumps remain in use.

In what ways have you seen the pumps benefit people?

Diarrhoea results in a huge number of children missing school. But absences drop right off when the pumps are installed. And the pump really changes girls' lives. In Zimbabwe most girls have to collect water in the morning before going to school. If they have to go a long way, they are often late for school. They may get beaten by the teachers for being late. And if the teachers want water during the day they send a girl to get it, so they miss more of their lessons. Having water on site means those girls have an equal chance of education.

What would you say is the potential for this technology?

A billion people around the world don't have clean water. A child dies every 15 seconds from illnesses caused by unsafe water, most of them in Africa. It's like 15 jumbo jets full of children crashing every day. And yet a child can have clean drinking water for the rest of their life from an elephant pump for about one dollar.

Twenty-one African countries have invited us to do pump trials. We also want corporate sponsors, such as mineral water companies. A penny on the price of a bottle of water would provide clean water from an elephant pump for one child for a year. A UK water cooler company, AquaAid, is donating £20 for every water cooler it installs. And the company's sales have gone up thanks to the association with Pump Aid.

How did your strange relationship with the Comoros islands come about?

During my gap year, I wanted to go to the Seychelles, but I only got as far as the Comoros islands because I ran out of money. I stayed with fishermen while I was there, which was an amazing experience. But when I left, I felt guilty that I knew nothing about the country or its culture. So at university, as well as researching water pumps, I found out about the Comoros.

There is a species of bat endemic to that region, which was discovered by the British explorer David Livingstone. It is now called the Livingstone's fruit bat (*Pteropus livingstonii*) and is one of the largest flying mammals in the world, with one specimen having a wingspan of more than 2 metres. But the species is endangered by deforestation, and at the time it had not been recorded for 11 years. So I got some money to lead an expedition to look for it.

The president of the Comoros islands was keen on my work, which is why he made me an adviser. The zoologist Gerald Durrell, who was at Jersey Zoo on the Channel Islands, sponsored me to capture some fruit bats for breeding.

How did you eventually find one of these giant bats?

We trekked for six weeks in the rainforest before one evening we found this huge animal gliding like a pterodactyl in the crater of an extinct volcano. It was black, the size of a cat, with huge wings and Mickey Mouse ears. On the first expedition I fell from a tree in the rainforest grappling with one of these bats. So we put up nets in the canopy, and that worked. Now a captive breeding programme is under way.

Any other scrapes?

I was shot again while a friend and I were camping in Mozambique. We were held at gunpoint by Renamo guerrillas. We made a run for it, and I got a bullet in the ankle before hiding in the bush and crawling back across the border. I have also been spat in the eye by a Mozambican spitting cobra. It would have blinded me had my eyes not been washed out with milk straight away.

You are a fluent Shona speaker and well integrated into Shona society.

What do you make of the spiritual and cultural life that you see?

Even now in the villages, people can tell you stories going back 30 generations. But there is increasing westernisation. People buy small black-and-white TVs and sit around glued to them. They don't tell the stories so much any more, and a lot of traditional knowledge about the environment and plants will be gone within a generation if it's not recorded now.

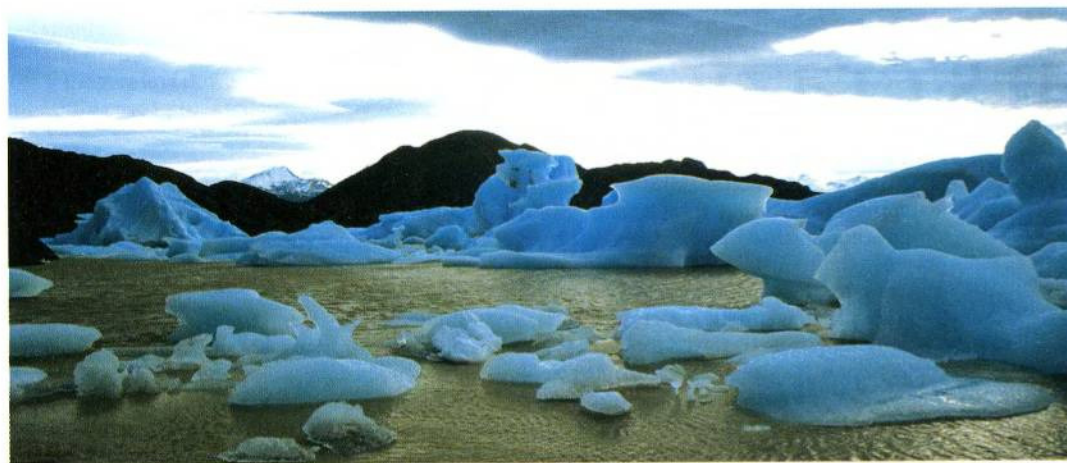
I worked for some time with a former paramount chief of the Shona, Abisha Mutasa, to record their culture. He wanted to build a library of Shona knowledge. Just before he died he gave me the task, which is one reason why I keep going back to the villages.

Often people do things that to an outsider may seem totally irrational. But the more people I meet around the world, the more I realise that everyone operates rationally within their understanding of the world. Especially in the west, we have to break down our arrogance and try to understand this.

Does the political situation in Zimbabwe make it more difficult for you to work there today?

Many NGOs have pulled out because of interference, but we at Pump Aid feel secure. We try to avoid politicisation. We make clear that we assist people on the basis of need and nothing else. There is this battle between the international community and Zimbabwe, and the people who are suffering are the people at the grass roots. There is a Shona proverb: "Where elephants fight, the grass dies." ●

The word



Psychrophile

THE idea that a person could be cryogenically frozen and then revived tens or hundreds of years later is still in the realm of science fiction. For some microbes, however, it is reality. Known as psychrophiles – literally, lovers of ice – they can survive at extremely cold temperatures for hundreds of thousands of years. Though frozen parts of the world such as Antarctica and Siberia appear comatose and desolate, they are actually vast reservoirs of creatures in a state of suspended animation, and in some cases they are not suspended at all, but fully functioning living organisms.

In fact, it appears these things can actually thrive in such conditions. Researchers have found evidence – in the form of methane, for instance – that bacteria and other microbes

metabolise while buried deep in ice and permafrost. Down to about -20°C , thin films of unfrozen salty water remain, and these allow cells to take in nutrients and expel waste products by diffusion. Below -20°C , there is no unfrozen water and metabolism is impossible. You can find more details in *Life in Ancient Ice*, edited by John D. Castello and Scott O. Rogers (Princeton University Press, 2005).

Just how extreme does it get for psychrophiles? There seems to be no limit. Biologists have found living fungi, bacteria, viruses, prokaryotes, green algae and yeasts buried up to 4 kilometres deep in solid ice. What is really amazing is how long they can live. Microbes more than 400,000 years old have been discovered in Antarctic ice, and several million years old in permafrost.

What happens when the ice melts?

The more gradual the thaw, the more likely it is that microbes will survive. As global warming causes glaciers to melt, the number of microbes flooding back into the environment is mind-boggling, estimated at 10^{17} to 10^{21} organisms a year.

The big question is, what happens to these things when they re-enter the world? Do they die because they cannot adjust to their new surroundings, or do they reproduce and spread, pouring ancient genes back into the gene pool? No one knows. But here's a scary thought: if viruses that we thought had disappeared, such as those causing smallpox or the Spanish flu, have been frozen in the ice and re-emerge one day, they could in theory trigger an epidemic – to say nothing of other pathogens that we've had no contact with for millennia, and to which we would have no immunity. According to researchers, we shouldn't rule it out. ●

Enigma

Team promotions

No. 1348 Richard England

All the teams in our area have until now been divided up into a number of identical local leagues, but from next season they will come together to play in an area league in which each team will play each of the other teams once. All matches will be completed in less than a year even though each team will play on average less than one match a week.

The number of teams that will be promoted from the area league at the end of the season has not yet been decided. The number of different combinations of teams that could be promoted if four teams are promoted is a multiple of the number of different combinations of teams that could be promoted if three teams are promoted, and the latter number is itself a multiple of the number of different combinations of teams that could be promoted if two teams are promoted. How many teams will be in the area league?

£15 will be awarded to the sender of the first correct answer opened on Thursday 11 August. The Editor's decision is final. Please send entries to Enigma 1348, New Scientist, Lacon House, 84 Theobald's Road, London WC1X 8NS, or to enigma@newscientist.com (please include your postal address).

The winner of Enigma 1342 is Peter Smith of Leicester, UK.

Answer to 1342 GOSH

There are 33 pins in this work of art.

Bookends

All change

Climate Change in Prehistory

by William J. Burroughs, Cambridge University Press, £19.99, ISBN 0521824095

Reviewed by Fred Pearce



CLIMATE CHANGE IN PREHISTORY
The End of the Ice Age

This is an intriguing book of unexpected relevance to the 21st century. The main narrative is a climate history from the last ice

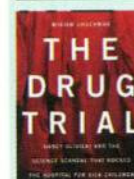
age to the 10,000 years of relative tranquillity that has followed. Burroughs also shows how humans took advantage of this period of calm to build a vaulting dominance of the planet. He invites hard questions on how societies will cope with the return to climatic turbulence. But it's hard to know what to make of his final thought – that the traits that helped us survive the ice ages could come in handy again.

Truth will out

The Drug Trial

by Miriam Shuchman, Random House Canada, \$34.95, ISBN 0679310843

Reviewed by Alison Motluk



Nancy Olivieri seemed like the classic whistleblower. A leader in thalassaemia research, she fought to publicise her reservations about a drug she was testing, and came up against the might of big pharma and the medical establishment. This book claims she was not quite the innocent victim she made herself out to be. Miriam Shuchman suggests the story was more complex, and that Olivieri may have been vengeful. Yet this does not alter the fact that she was a dedicated researcher who lost years of her career fighting for funding, academic freedom and justice.

Napoleon's crazy navy

The rumours began in 1798. France and Britain had been at war for five years and now the French army was massing on the Normandy coast. Surrounded by sea, the British had felt safe until now. But Napoleon Bonaparte, alias the Corsican Ogre, had found a way to transport his army of invasion across the English Channel. How? According to newspaper reports, the French had invented a gigantic raft powered by windmills and waterwheels and bristling with guns. It could carry 30,000 men. No, it could hold 60,000 men and 600 cannon besides. Artists were soon turning out "accurate representations" and "correct plans" of the terrible invention so the British could see what Napoleon had in store for them.

FRANCE's floating war machine was a fearsome thing. The details of its structure varied according to which "reliable" source had provided them – usually a French prisoner of war or "a man lately arrived from France". But they all agreed on the basics. The raft was huge. And it was on its way. If the enemy could land such a sizeable force in one go, then Britain was truly under threat.

At the beginning of 1798, the people of Britain were convinced the French were coming. Napoleon Bonaparte, the most successful general in France, had been given the task of invading the country. He had won great battles against the Italians and the Austrians; now it was the turn of the British. People were jittery and rumours were rife.

The jitters soon turned to sniggers. "This raft, a sort of floating Bastille, appeared a lot. It was supposedly based on eyewitness accounts but it was more like a UFO sighting. It was preposterous, a product of national hysteria," says Geoff Quilley, curator of maritime art at the National Maritime Museum in London. By the end of March the monster machine was no longer giving the nation nightmares. Instead, it featured in a musical drama at the Theatre Royal, Covent Garden, where it was blown to bits at the end of each performance.

Across the English Channel, Napoleon had been quicker to dismiss the idea of invasion. Although his army was far superior to Britain's, his navy was outclassed in every way. As long as the Royal Navy controlled the seaways, there was little chance of reaching England. He invaded Egypt instead.

Three years later, Britain was in the grip of a new invasion scare. The government warned the Lord Mayor of London that "His Majesty's Ministers FULLY EXPECTED the French would attempt an IMMEDIATE DESCENT upon the island." This time the British had more reason to be afraid. Napoleon, who had seized power in a military coup in 1799, was determined to conquer the kingdom that had been such a thorn in his side. He had defeated his other European enemies; now he could concentrate on Britain. He was optimistic. The British were tired of war, and their army was weak. Some were tired of their king too and might welcome the French and the prospect of exchanging the monarchy for a republic. The Channel was still a major obstacle, but this time Napoleon believed he could overcome it. It was, he pronounced, merely "a ditch which one can

jump whenever one is bold enough to try it". All he had to do was find a way for 100,000 men to jump it at once.

The following spring the invasion was cancelled. France and Britain had made peace, but it didn't last, and by 1803 the invasion was on again. Rumours of remarkable rafts began to circulate once more. This time, they were not quite so ludicrous, carrying perhaps 500 men and powered by oarsmen. "These seemed to have slightly more basis in fact," says Quilley. Besides, there was little reason to doubt them: stranger things had emerged during the long years of war. It was common knowledge that in Paris, Robert Fulton, an American inspired by the French revolution, had built an underwater boat – a fish-shaped, three-man submarine powered by a hand-cranked propeller. Equally ingenious were his plans for a new type of underwater weapon, the torpedo. In England, William Congreve was busy developing rockets that would ignite or explode on impact.

"The raft was a sort of floating Bastille. It was preposterous"

There were still more madcap ideas. Frenchman Jean-Charles Thilorier suggested flying troops over in gigantic hot-air balloons, each carrying 3000 men. That plan never got off the ground, but another French scheme caused much consternation across the water: a plan to dig a tunnel under the Channel. First mooted during the peace of 1802 as a symbol of friendship, it now seemed more malevolent: if it was built, Napoleon's troops could march to England without getting their boots wet.

But Napoleon had something more traditional in mind. "The British public feared he was building huge rafts but what he was actually building were chunky little boats," says historian Colin White, one of the curators of the Nelson & Napoleon exhibition at the National Maritime Museum. By August 1803 he had a flotilla a thousand strong.

Fortunately for the British, Napoleon was a soldier, not a sailor. A brilliant strategist on land, he was out of his depth when it came to the sea. His first mistake was to choose the wrong man to design the boats. Pierre Forfait was an engineer and "marine architect" who



MUSEE D'ART MODERNE ET D'ART CONTEMPORAIN DE LA VILLE DE LORZ

Nelson & Napoleon, an exhibition exploring the lives of Horatio Nelson and Napoleon Bonaparte, is at the National Maritime Museum in Greenwich, London, from 7 July until 13 November. For information visit www.nmm.ac.uk/tickets

had spent his career digging canals and designing barges. His boats would have been fine sailing up and down the river Seine, but would have foundered in a choppy sea. Napoleon's second mistake was to ignore those who pointed this out.

Even if the boats had been up to the job, Napoleon had a problem. There are no deep-water anchorages on the north coast of France large enough for a fleet this size. "He was forced to assemble his troops at places like Boulogne, which dry out at low tide," says White. For the invasion to succeed, all the troops would have to reach England at the same time. "Napoleon didn't seem to realise the problem of tides. He didn't understand that you can't load 100,000 men and get them to sea on one tide. They practised for months and they still couldn't do it."

And if they had, and the boats had been seaworthy, the flotilla faced a further obstacle. "The British were right there," says White. "They had a vast number of small ships – brigs, schooners and small frigates – close to

the French coast ready to harry and attack." Further west, the Royal Navy's Channel Fleet was on station, ready to race up the seaway if needed. Napoleon's own warships, and those of his Spanish allies, were in no position to help. They were blockaded in ports around the French and Spanish coasts, trapped by patrolling British ships.

The British public knew little of this. "They probably thought like Napoleon did and assumed that he could just get on the boats, cross the Channel and conquer England," says White. Nor did the government try to dispel their fears. If people thought the French were coming they might be more willing to accept the huge cost of the war and even fight for king or country. After so long at war, the people's patriotic fervour had waned. The threat of invasion was just the thing to revive it.

There was no invasion in 1803. Nor in 1804. In 1805, Napoleon, now emperor, came up with a grand new strategy. He ordered his ships to escape their blockades, by stealth or by force, and sail for the West Indies. There they would

unite into a single, huge fleet and speed back to the mouth of the Channel, where they would sweep aside the British ships guarding it and allow the invasion force to cross.

The plan failed. "The British checked his every move," says White. Some ships escaped the blockades, some sailed back and forth across the Atlantic, but within a few months Napoleon's fleet was again scattered. His main force, a combined fleet of French and Spanish ships, had taken refuge at Cadiz on the south coast of Spain. Britain sent the nation's hero, vice-admiral Horatio Nelson, to deal with it. Against logic, Napoleon ordered his fleet to the Mediterranean and on 21 October it found itself facing the battle-hardened British fleet off Cape Trafalgar. Nelson's resounding victory finally convinced Napoleon to call off the invasion – this time for good. **Stephanie Pain** ●

Further reading: *Nelson – The new letters* edited by Colin White (Boydell & Brewer, 2005); *The Terror Before Trafalgar: Nelson, Napoleon and the secret war* by Tom Pocock (John Murray, 2002)



AN ACCURATE REPRESENTATION of the FLOATING MACHINE
Invented by the FRENCH for INVADING ENGLAND. and Acts
on the principals of both Wind & Water Mills. carries 60-000 Men & 600 Cannon.
Sketch & put by Lighton (Paris) from a Drawing by Monsieur Freuille just arrived.

Review

The Grail Bird: Hot on the trail of the ivory-billed woodpecker
by Tim Gallagher (Houghton Mifflin Company, 2005)



HANG ON IN THERE

Just because one “extinct” species has survived against the odds doesn’t mean we can rest easy about the thousands that are dying out all around us, says **Gail Vines**

THE story has all the features of a boys’ adventure yarn. The ivory-billed woodpecker, the largest and most magnificent of its tribe, goes missing at the end of the second world war and is presumed extinct. But rumours persist that a few birds remain in the swampy forests of America’s Deep South, like soldiers hiding

on remote Pacific islands, unaware that the war is over.

Tim Gallagher, a natural history editor at the Cornell Lab of Ornithology in Ithaca, New York, heads south to see if the rumours are true. He interviews everyone who claims to have seen an ivory-billed woodpecker and investigates the sightings.

Living legend, a nestling ivory-billed woodpecker

His informants usually seem reliable, though whiffs of fraud and delusion linger. As with the Loch Ness monster and the yeti, an encounter with the ivory bill seems to guarantee equipment failure.

Gallagher visits small southern towns, eats lots of junk food, and occasionally ventures into the swamps. At last, he sees one. Reinforcements are called in. Crack squads of ornithologists – more than two dozen of the world’s best birders – descend upon the Arkansas swamps. Recording units are wired to trees, along with decoys, feeders and remote cameras. Observers stake out potential roost holes and simulate ivory-bill calls, hoping to elicit an answer. Back at Cornell, sound technicians analyse hours of recordings. Just when they think they have detected the telltale “kent-kent-kent” call, they track the sound to their own simulations. The spies are watching themselves.

Fifteen months later, despite tantalising glimpses, there is little evidence that even a second ivory bill survives in today’s logged-out “bottomland”. Scientists break the news to the media anyway, announcing the “rediscovery” of the species “back from the dead”. In *The Grail Bird*, which chronicles this adventure, Gallagher waxes lyrical: “It’s as though a funeral shroud has been pulled back, giving us a brief glimpse of a living bird, rising like Lazarus from the grave.”

Far from an ecological triumph, Gallagher’s lone ivory bill bears all the hallmarks of evolution’s living dead, its numbers dwindled below the point of return, its habitat in ruins. \$10 million in federal aid is promised “for research, habitat protection and law enforcement efforts to protect the bird”, reports *The New York Times*. But how can anyone protect this bird? Perhaps scientists are intent on capturing

it and banking its DNA for future cloning, but cloning has yet to prove viable for reviving any species. Even if it worked, what environment would the birds inhabit? Wouldn’t they be doomed to meet the same fate all over again? Instead of shelling out millions to “save” a woodpecker, wouldn’t it be better if the US government re-evaluated its climate change and oil consumption policies that are actively driving extinctions on a global scale?

Around the world, species are dying out at a rate perhaps 10,000 times faster than nature’s regular pace. Five mass extinctions have occurred in the past. During the worst of these, at the end of the Permian 250 million years ago, up to 96 per cent of the world’s species perished. But the sixth mass extinction, now under way, is unique in the history of the planet – the first to result from the activities of a single species.

Every time a species is lost, a unique solution to the equation of life vanishes, and with it an irreplaceable inheritance, a legacy from the past. Each extinction marks the end of a continuous chain of being that reaches back to the beginnings of life on Earth. Yet as we mourn such irreparable loss, we fancy ourselves immune to the very same tragedy – the extinction of our own species brought on by our own thoughtless actions. It is telling that “dead as a dodo” is used as a light-hearted, whimsical remark.

The history of life on Earth shows that every multicellular species is eventually snuffed out. Maybe we have already overstayed our welcome. We over-exploit our fellow species, we eradicate their habitats, and now we are messing with the global climate.

Perhaps it is time we recognised that feel-good adventure quests like *The Grail Bird* are a distraction from the real message of extinctions, and acknowledge that there are limits to what humans can take from the world. ●



YET more from the wonderful world of sciency-sounding plugs for unusual products and services. The School of Awakening in Chulmleigh, Devon, UK, informs us promisingly on its website that: "In quantum physics, the energy that fills the cosmos is called zero-point energy." It then launches into hitherto untrodden realms of knowledge with its description of the amazing properties of tachyons, subatomic particles that until now have been regarded as strictly hypothetical.

"Like zero-point energy, tachyon moves faster than the speed of light and is omnipresent...At the point of the speed of light, tachyon interacts with the subtle organizing energy fields (SOEFs). Becoming energized, the SOEFs convert tachyon energy into whatever frequencies are needed to bring balance to the being...SOEFs are the 'cosmic glue' that holds all forms together. They are the matrix upon which physical and subtle bodies are formed. Tachyon, pure life-force energy, is converted by the SOEFs into the exact frequencies needed to maintain and restore perfect balance to a life form."

As Bill Chadkirk, who spotted this, notes, "CERN and the Medical Research Council will want to attend this course rather than waste more time in the laboratory." They might even want to join the tachyon-partners.com multilevel marketing scheme, to fund those few of their activities that are not made redundant by the School of Awakening's breakthrough findings.

In the window of a restaurant in Blackheath, south London, a poster tells customers that, "Prior notice is required for all reservations"

LAST week a colleague received an invitation from the UK Particle Physics and Astronomy Research Council to a live press conference, timed for the collision of a projectile from the spacecraft Deep Impact with its target comet. It promised, "On-the-Spot reactionary comment from UK astronomers and space scientists".

Presumably this would be to the effect that we jolly well shouldn't meddle with such matters, and there are some kinds of knowledge that were never meant to be revealed to the world, and Deep Impact should be sent back to the country it came from.

FORBES Magazine used to market itself as a "capitalist tool". But is it still sharp?

Bob Cockshott points us to an article stating that 1 in 8 pounds sterling spent in British shops goes to the supermarket chain Tesco. Then, presumably out of concern for readers not familiar with the value of the UK pound, it helpfully informs us that this is equivalent to 1.89 in every 15.15 US dollars or 1.43 in every 11.48 euros.

EARTH'S magnetic field helps create the great taste of fresh fruit, we are informed at www.sylves.com/shooterbuddy. "During the long growing season, fruit is held in a relatively constant position in relation to the Earth's magnetic field, aligning the liquid particles much like tiny compass needles. This natural balance gives fresh picked fruit its smooth, natural flavor."

Now the bad news: "The delicate magnetic alignment of the liquid particles is destroyed during the crushing, straining, pasteurizing, fermenting, and distilling used to manufacture liquid beverages..." But there is a cure for this terrible destruction. For as little as \$29.95 you can buy the Shooter Buddy Junior. This "quickly realigns the particles in your beverage by surrounding them with extremely powerful Neodymium (ne-o-dim-e-um) magnets...In as little as 10 seconds, Shooter Buddy restores the natural balance destroyed in the production process, recaptures the fresh taste of nature, and duplicates the smooth mellow flavor generated by years of traditional slow aging". A bargain. Makes an excellent gift. Not recommended for physicists with high blood pressure.

THE job description for a synthetic chemist's position that Ben Lindsey discovered on jobsearch.monster.co.uk pointed out:

"Part of the job may involve being required to provide technical support during evening or overnight. You will get time off in loco for this."

We've heard of slackers who spend their time sitting in the toilets to avoid work, but find it hard to believe anyone would choose to do this to make up for their overtime.

VISITORS to www.lyricsandsongs.com will join Trevor Coe in appreciating the stunning technological achievement implied at the bottom of the page, which informed him that the page was "generated in 0.030807971954346 seconds". That is precise to a few millionths of a "tick" of the clock that controls his computer. So how is it able to tell?



ONE of the cover stories in a recent issue of *Graduate Contact*, the magazine of the University of Queensland, Australia, is: "New \$24 million home for sustainable mining."

Sustainable mining? What does that mean, wonders Jerry Vancley. Could it be digging up minerals at a rate not exceeding the rate at which they are formed within the Earth?

FINALLY, from the department of no-brainers. Andi Hindle spotted this on a label on some Microsoft software packaging: "This label indicates that the package contains genuine Microsoft Product. If the label is missing... please e-mail Microsoft."

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.

The last word

FLOATING FEELING

I have a clear childhood memory of sitting in the back of a car as it was driven over an arched bridge, and feeling an odd sensation, known colloquially as "butterflies", in my stomach, similar to the one you feel on a fairground wheel. I remember that the adults in the front of the car felt nothing. Now, as an adult, I no longer experience this. Is this feeling, which my contemporary friends also recall, age-related or are cars manufactured differently? Or is something else at work?

Our readers are divided on this. Below we present three likely explanations – Ed

● The feeling is a reduction of apparent gravity, due to the downward acceleration as the car passed over the hump of a bridge. The back seat of the car is usually positioned over the back wheels – in some old cars even further back – which maximises the effect. The front seats, on the other hand, are about half way between front and back wheels, which reduces the effect.

While the questioner's age may have something to do with not feeling butterflies any more, so too might the fact that adults usually sit in the front. And then there's the age of the car, modern suspensions smooth out the bumps much more than the old ones did.

*Tim Gossling
Cambridge, UK*

● This phenomenon was known in my family as "leaving your tummy behind" and it occurs far less these days because modern roads have been levelled off, so there are very few good take-off points left.

I can, however, highly recommend a stretch of road on the A38 near

Lichfield where the dual carriageway passes over a canal bridge. The road engineers have tried their best to remove the fun, but my children used to scream with delight when this was taken at a legal speed that was fast enough to cause momentary freefall of car and occupants. Adults notice it less because in the front of the car you can see it coming. The kids in the back can't. And you certainly don't tell them...

*Richard Jack
Lichfield, Staffordshire, UK*

● The feeling of disorientation is caused by the brain's confusion over the motion that the inner ear senses but the eye does not see.

Adults can see out of the car windows while children normally end up staring at the back of the front seats. When the car passes over a humpback bridge, the fluid in the inner ear that detects movement senses the rise and fall of the car, yet the child's eyes are fixed on a stationary seat in front of them. It is this mismatch of sensory input that causes the sensation of butterflies in the stomach.

This is exactly what causes sea sickness too. Everything on the boat seems stationary to the eye, but the inner ear is sensing a rise and fall as you pass through the waves.

*Neil McGonigle
Dublin, Ireland*

REPULSIVE VEGETABLES

Why do the surfaces of cabbage leaves repel water so superbly?

● Most leaves are coated in water-repellent waxes, which form a smooth cuticle. The super-repellent surface of cabbage leaves, however, has an extra powdering of flaky wax. When a droplet of water lands on this rough surface, it touches only the tips of the

flakes. On a smooth cuticle, surface tension pulls the water over the surface, spreading it out, but this does not happen on the flaky wax because of the lack of contact with the surface.

Instead, the water beads up and runs off the leaf. Other rough surfaces, such as leaves with fine hairs, have the same effect. An additional side effect of rough wax surfaces is that they scatter light more effectively – this is the source of the bluish-white sheen to your cabbage leaves.

For a simple proof that it is the texture and not the chemistry of the wax that counts, smooth down a portion of the cabbage leaf with your thumb and then see how water behaves on this surface. Although cabbages are crop plants, the water-repellent effect is well studied in wild plants such as some alpine and tropical cloud forest species. These habitats regularly experience heavy rain and splash-back from the ground and surrounding vegetation.

"The super-repellent surface of cabbage leaves has an extra powdering of flaky wax"

Indeed, the leaves of some species are more repellent the closer they are to the ground. The repellent coating keeps stomatal pores free from water that would otherwise block the intake of carbon dioxide needed for photosynthesis.

Dust particles stick readily to water droplets but not to the wax, so rain cleans the dirt off the leaf. Bacteria might also be removed from leaves in this way. A similar system is used in "self-cleaning" paints, windows and self-flushing urinals, which are entertaining to use as the liquid skitters around before draining out, leaving the receptacle apparently bone dry.
*Simon Pierce
University of Insubria,
Varese, Italy*

Last Words past and present, plus a full list of unanswered questions, are available on New Scientist's website at www.newscientist.com

● Like other plants, including aquilegia, honeysuckle, nasturtium and fat hen, cabbage has a surface that is super-hydrophobic. This surface is coated in tiny pillars of wax, which can be seen in the electron microscope image at http://uk.pg.photos.yahoo.com/ph/n_shirtcliffe/album?.dir=/32f8&.src=ph&.tok=phsA53CBb.cCx5F8.

Drops of water balance on the tops of the rough peaks and make little contact with the leaf surface. They can therefore move more easily than on a smooth surface and only a slight tilt of the surface will cause the water to roll off completely. After rain or in the early morning, most plants are covered with a layer of water. But super-hydrophobic leaves have just a few small drops; the rest have rolled off.

When water drops roll over a super-hydrophobic surface they carry away dust. You can test this in the garden by blowing cocoa powder onto leaves and spraying them with a little water. Cabbage leaves will be easier to clean than lettuce. Dust on the leaf surface blocks sunlight, making photosynthesis less efficient, so removing dust is an advantage. It is also possible that a super-hydrophobic surface protects plants from animals such as slugs by making them less easy to climb.

However, the rough surface costs the plant extra energy to produce and may reflect some sunlight, which perhaps explains why not all plants have this kind of surface.

*Neil Shirtcliffe
Nottingham Trent University, UK*

THIS WEEK'S QUESTION

Water wheels

When driving a speedboat, why don't you have to change gear when you change speed, as you do in a car?

*Graham Lundegaard
Gloucester, UK*

Questions and answers should be kept as concise as possible. We reserve the right to edit items for clarity and style. Please include a daytime telephone number and a fax if you have one. Questions should be restricted to scientific enquiries about everyday phenomena. The writers of all

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all unanswered questions please send an SAE to LWQlist at the above address.

Two books containing many of the best questions and answers from 10 years of The Last Word are now available from all good book stores and are published in a number of languages.