

I, science

The Imperial College science magazine

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x-rated research!

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One ring to rule them all.

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Genome**
Did we interbreed?

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Welcome to the 11th issue of *I, science*. I am happy to report that we were selected as the 2nd best student magazine in the country by the Guardian Student Media Awards last November. This wasn't the first time we were nominated for the best student magazine, though. Back in 2005, when the publication first began, after just two issues we received our first nomination. Three years later, we were among the top five again, but this time we gained a ranking at second place. This is quite an achievement given that *I, Science* is a specialist magazine covering what many people see as a niche area of interest. As far as I am aware this is the first time any student science magazine has ever won such an award. This should assure you, the reader, of the quality of the magazine you are holding in front of you and should also leave

us all feeling optimistic about the future of science journalism.

In keeping with the tradition of the best student science journalism we bring you another excitement-packed issue covering various scientific and medical issues. Exploring the unexplored, we examine the unlikely bed fellows that are science and pornography. Refusing to be same as all the others by presenting you with yet another article on Charles Darwin and evolution we do something different to celebrate the 150th anniversary of his book *On the Origin of Species*: we bring you the story of his ancestor, the unsung hero that was Erasmus Darwin. We also look into why bees are dying across the planet: we investigate the menace of Colony Collapse Disorder. In *Stringing us Along* we explore the science and philosophy of string theory: is this the theory that will explain everything, and how can we know this if we cannot test it yet? For all the joggers and runners out there we look into the best substrate to run on for your bones and joints. And finally, we bring you the amazing medical story of a Haitian boy who was saved by modern medicine and the will of good people willing to reach out and help others in distress.

Alongside these features we also cover a variety of events, films and magazines in our reviews section. Enjoy your read!

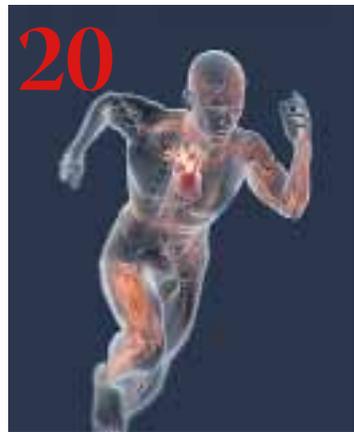
Mico Tatalovic

The next issue is coming out on the 1st of May 2009. Please send your article and photo submissions by the 1st April to:
i.science@imperial.ac.uk

In the next issue: Can we still save the planet? Read all about it in our special Focus section on the alternative energy sources...



***I, Science* team receiving our runner-up prize for the best student magazine at the Guardian Media Awards 2008**



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News from Imperial...

Second Life Summit



©JOHN LESTER

At the beginning of December scientists from around the world participated in a conference on climate change and carbon dioxide storage organised by Imperial and the Nature Publishing Group. Unlike usual conferences however, this one was held in the virtual online world Second Life rather than in real space.

Organised by Dr Tara LaForce, the virtual conference hoped to broadcast the benefits of scientists meeting online. By staying at their respective universities rather than travelling, the scientists saved about 1.5 tonnes of carbon dioxide, which is roughly equivalent to the amount produced by one London commuter in a year.

Chloé Sharrocks

Bacteria Have Built-in Compass

It has been proven that bacteria possessing crystal chains with magnetic properties called magnetosomes could use them to navigate their environment.

Magnetosomes were first discovered three decades ago, but previous studies have suggested that the crystals have the wrong properties to be used for navigation.

Imperial College researchers, collaborating with the University of Edinburgh, claim that their mathematical model confirms that the crystals do in fact have the correct magnetic properties.

More sophisticated animals like birds use the Earth's magnetic field to navigate their environment; researchers believe magnetosomes may be the first step in the evolutionary mechanism to allow this.

Seth Bell

Bacteria Burglars

New Imperial research published in *Current Biology* has revealed how a pathogen is able to initiate speck disease in tomato plants.

The bacteria work by disarming the plant's receptor system, much in the same way a human intruder can deactivate a burglar alarm. The plant's defences are then down so that the bacteria are able to quickly spread and feed off the tomato plant, resulting in black lesions on the leaves and fruit.

Understanding how the bacteria bypass the plant's immunity is an important step in disease control and producing less harmful pesticides.

Chloé Sharrocks



Sleep could help diabetes patients



©MAVR

A good night's sleep could help improve diabetes and higher than normal blood sugar levels, research has revealed.

Imperial College scientists and a group of international colleagues have identified a genetic mutation linked to diabetes and increased blood sugar, near a gene involved in regulating sleeping patterns. The researchers say that in the future, improving patients' sleeping habits may help

treat these conditions.

The study, published in *Nature Genetics*, analysed the genetic makeup of non-diabetic volunteers from across Europe and identified a mutation associated with high blood sugar levels. They then compared the genes of those volunteers with normal blood sugar levels to a genetic analysis of patients with type 2 diabetes and confirmed that the mutation was also linked to this condition.

The mutation is near the gene *MTNR1B*, which forms part of the regulatory pathway for the hormone melatonin. This hormone controls the body's circadian rhythm: the internal clock that controls sleeping and eating patterns in response to daylight.

Professor Philippe Froquel from Imperial College, one of the research team leaders, says these new findings suggest sleep problems may be contributing to the conditions: "Our new study

demonstrates that abnormalities in the circadian rhythm may partly be causing diabetes and high blood sugar levels." He believes that stabilising these rhythms in patients may help improve their condition: "We hope it will ultimately provide new options for treating people."

The study forms part of a wider series of research into the genes linked to diabetes, which includes the discovery of key genes associated with increased risk of developing type 2 diabetes. As well as leading to new therapies, Professor Froquel hopes the programme may help towards achieving earlier diagnosis: "We are also nearing the stage when we can develop tests that can identify the people at most risk of developing high blood sugar and diabetes later in their lives, so we can intervene to improve their health before they reach that point."

Catherine Luckin

...and elsewhere

Insight into Dementia

American scientists now have more information about the genetic nature of the neurodegenerative disease Alzheimer's thanks to new high-resolution research.

Studying over 900 people (half of whom have the disease) the researchers were able to look for the genes associated with the condition. By detecting single nucleotide polymorphisms (SNPs) the scientists were able to confirm previous research linking the disease to one gene, as well as a new association with a SNP on a different chromosome. Their research also highlighted four other regions of interest and other possible candidate genes.

Although still some way from fully understanding Alzheimer's, the new research offers future hope to the 25 million people currently suffering with it worldwide.

Chloé Sharrocks

Caffeine and Men



©JRAY

Caffeine has a greater effect on men, say the surprising findings of the first gender specific study on the stimulant beverage.

A research team headed by the University of Barcelona studied the effects of consuming a shot of espresso, or decaffeinated espresso, on 668 university students. The espresso had faster than expected effects, starting as little as 10 minutes post-consumption. Previous studies suggest it takes 45 minutes to take effect.

And contrary to expectation, the supposedly neutral decaffeinated espresso produced a small subjective effect on the alertness of the men and women in the study.

Catherine Jones

The Spirit Lives On

NASA Mars rovers Spirit and Opportunity have dumbfounded scientists by clocking up five years on the Martian surface. The mission, originally scheduled to last just ninety days, has now beamed back over a quarter of a million images of the 'Red Planet'

The plucky pair's story is even more remarkable due to the harsh conditions they have endured. Tenacious dust storms, plunging winter temperatures and viscous winds are just some of the obstacles overcome.

With the recent news of the credit-crunch induced delay to the next Mars mission, the unexpected mass of



data Spirit and Opportunity have collected will keep scientists wanting a glimpse of Mars' warm and habitable past busy for years to come.

Colin Stuart

Addicted Bees

A recent paper in the Journal of Experimental Biology has demonstrated that cocaine affects honey bees in a similar way to humans, altering judgement and causing an addictive pleasure.

After finding a food source, cocaine-induced honey bees perform their characteristic 'waggledance' much more vigorously than other bees. They also experience withdrawal symptoms similar to those of humans when forced to go "cold-turkey".

By studying the neural pathways of these responses to cocaine, researchers are aiming to develop new drugs to prevent or cure cocaine addiction in humans.

Emma Quilligan



WIKIPEDIA

Implants for Deaf Babies

New research from the Bionic Ear Institute in Melbourne, Australia, shows how cochlea implants for babies could help the deaf learn to speak.

Rob Shephard and colleagues recorded the electrical activity in the cortex of 18 month old cats deaf from birth. These responses are used as an indicator of whether sound is perceived normally.

"Completely scrambled" electrical activity was recorded from the cortex of deaf cats with recent implants. If the cats were implanted earlier, at 8 weeks old, they showed similar activity to hearing cats.

This adds fresh evidence to the controversial practice of cochlea implantation in early childhood.

Catherine Jones

Key Blocks Phones



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Using a phone whilst driving can make young people four times more likely to have an accident, so researchers from the University of Utah have developed a product to ease the concerns of parents.

By linking a wireless 'Key2SafeDriving' with their youngster's phone, parents can block all incoming and any outgoing calls and text messages whilst driving, other than to the emergency services. However, using a hands-free set is still allowed.

It is hoped that these low-cost keys will help to reduce insurance premiums for young drivers, as well as preventing accidents.

Emma Quilligan

Stem cell breakthrough paves the way for knockout rats

“Gene targeting” in experimental animals will aid research into human diseases.

Pioneering work by British and American scientists has laid the groundwork for the creation of rats in which a specific gene of interest has been rendered inactive. Such ‘knockout rats’ are expected to prove an invaluable tool for research into numerous human diseases that have a genetic component, including cancer, high blood pressure and diabetes.

A similar technique has been used for the last two decades to produce knockout mice, which have proven to be extremely useful for scientists working in genetics research. In 2007, the scientists who developed this technique, Mario Capecchi, Martin Evans and Oliver Smithies, were awarded the Nobel Prize for Medicine for their work. Since the development of the knockout mouse, the mouse has been the experimental model of choice for research in mammalian genetics. Over 10,000 mouse genes have been specifically knocked out using this method, amounting to about half of the genes in the mouse genome. It is now possible to introduce genetic variations that are specifically activated or deactivated in particular tissues, or at particular stages of development. Knockout mice have elucidated details about the roles of individual genes in every area of mammalian physiology.

Until now, technical difficulties have made it impossible to generate knockout rats using the same procedure, although they have been desired by researchers for some time. In terms of their physiology and responses to drugs, rats are more similar to humans than are mice, so knockout rats are expected to provide better models for human disease. Rats are also more social than mice, and are therefore likely to be more useful for studies of psychiatric conditions. Further, they are easier to handle than mice, although they require more space and are more expensive to keep.

To make a knockout mouse, scientists must take embryonic stem (ES) cells from the early embryo. ES cells have two distinctive characteristics: firstly, they are able to develop into any cell type in the body, a condition known as pluripotency. Secondly, they have the capacity for self-renewal. This means that they are able to divide whilst remaining in the unspecialised state indefinitely. Recently, a handful of key genes have been identified as playing vital roles in maintaining these special proper-



ties of ES cells.

Making knockout rats in this way was not previously possible because researchers have been unable to grow rat ES cells in culture. Now, a team from the University of Edinburgh, led by Austin Smith, and a group from the University of Southern California, led by Qi-Long Ying, have independently found a way to overcome the problem. The solution is to grow the ES cells in a medium containing inhibitors of the signalling molecules that cause the cells to differentiate, or develop into specialised cell types. Both groups reported their findings in the December 26 edition of the journal *Cell*.

Now that scientists can grow rat ES cells in culture, all of the techniques are in place to allow the production of a knockout rat. To do this, one genetically manipulates the isolated ES cells to ‘knock out’ the gene that is being investigated. The modified ES cells are then injected back into a normal rat embryo. After being implanted into a surrogate mother, this embryo will then

develop into a ‘chimera’, in which some of the cells in different parts of the body will be derived from the genetically modified ES cells. Crucially, some of the germline cells, which give rise to sperm or eggs, will carry the modification introduced by the researcher. If this rat breeds with another, similar chimera, some of the offspring will have the gene knockout in all of their cells. These rats can then be studied to find out about the function of the gene that has been inactivated.

“The research direction of many labs around the world will change because of the availability of rat ES cells,” Ying said. “The availability of these cells will greatly facilitate the creation of rat models for the study of different human diseases such as cancer, diabetes, high blood pressure, addiction and autoimmune diseases.”

Smith’s team note that the procedure they have developed to preserve the potency of rat ES cells might work for any mammalian species.

Sam Wong

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The Plight of the Honey Bee

Annabel Slater examines the mystery of the dying bees.

EINSTEIN IS reputed to have said “If the bee disappeared off the surface of the globe, then man would have only four years left.” Their use as mass pollinators make honeybees one of the most valuable domestic animals in the world, yet now a new, deadly phenomenon known as Colony Collapse Disorder is badly affecting modern beekeeping in the US, and

ism of tiny individuals which provide a crucial benefit for both local human-led agriculture and the natural environment. Commercial beekeeping for honey is only one aspect of their worth. As the pollinators of 80% of all insect-pollinated flowering plants, and of 90 commercial crops worldwide, it is estimated by researchers at the Cornell University that honeybee pollination is worth more than £30 billion

buzzing hives to find them nearly abandoned, the majority of the inhabitants mysteriously gone. There would be no obvious signs of infection, no dead bees littering the nearby ground, and no theft of the honey reserves. Instead, it was as though some unseen, pervasive signal had caused the interlinked working of the bee colony to collapse.

This phenomenon has been termed ‘Colony Collapse Disorder’ (CCD), and so far it is estimated to have caused the loss of 50-90% of colonies in beekeeping operations in the US. Indicated to have first begun in the US in 2004, it has continued to gather intensity; 800 000 colonies were lost to CCD in 2007, followed by one million in 2008. Meanwhile, reports of heavy colony losses in Canada, Europe, South America and Taiwan have heightened the fears that CCD has already spread between the continents. Modern commercial beekeeping often utilizes trade of live beestock, product, and equipment between

“If the bee disappeared off the surface of the globe, then man would only have four years left.”

perhaps beyond.

The familiar buzz of bees about flowers is a classic feature of spring and summer. Foraging bees fly from flower to flower, each bee visiting tens to hundreds of flowers a day in a quest for nectar and pollen to nourish the hive. Back at the hive, the bee colony, comprised of tens of thousands of siblings, work in a constant and ever-changing flux of studious activity, building new wax combs, rearing young, tending the queen, condensing nectar into honey, controlling the hive’s temperature with fluttering wingbeats, and guarding the entrance against invaders. Though most may think of bees with only fear of their stings, and for the indulgence of their honey, each hive is a massive superorgan-

a year worldwide. Bees affect the diversity of natural plants, the quality of grazing livestock, and the quality of crop harvests. They are one of the most valuable domestic animals in the world.

Yet in 2006, a new phenomenon was first officially reported in the US that

“Beekeepers opened once buzzing hives to find them nearly abandoned.”

could signal the demise of domestic beekeeping. For, without clear cause, and with growing intensity, bee colonies in the US were being lost. Beekeepers opened once

continents, opening paths for disease transmission. With no certain established cause and limited funding, are honeybees facing a deadly pandemic?

Current Research

Infecting bees with IAPV and additional pathogens or pesticides is difficult because it can cause too rapid mortality to study them, but researchers hope to continue investigating the effects of combinations of pesticides and known diseases.

US scientists intend to study affected bees to see which immune-response genes or detoxifying genes have been activated, which may indicate which pesticides or diseases are to blame.

Testing levels of local pesticides in hives from CCD areas may reveal common chemicals affecting bee behaviour.

Breeders hope that they can breed bees with greater immune and behavioural resistance using semen and stock imported from Europe, Russia and Australia.

Careful recording the epidemiology of losses will be important to discern patterns or presence of CCD.

One of the problems in scientifically assessing and controlling CCD has been the ambiguity of the condition, which has caused beekeepers to point to other known pathogens and problems as the cause of CCD. Although affected bees do not appear to display abnormal behaviour, studies show that healthy bees appear able to sense the presence of CCD, as a new colony placed into an abandoned CCD beehive will reject the hive and any remaining honey. Yet if the beehive is irradiated, a process which destroys all living micro-organisms, the colony will accept it. Such studies have indicated an unseen, fatal pathogen as the cause of CCD, one

which the bees can sense using their sensitive olfactory apparatus. Somehow, then, this pathogen must disrupt the behavior of the bees, and cause them to abandon the hive. A genetic analysis of the micro-organisms present in CCD bees has shown

“Are honey bees facing a deadly pandemic?”

one virus to be present in almost all the samples – the Israeli Acute Paralysis Virus (IAPV), a rapidly replicating virus known to cause widespread death of a colony. However, IAPV has still not been proven to be the cause of CCD, because bees from CCD hives do not show the typical behavior and ‘shivering’ symptoms of bees which are stricken with IAPV. The virus is also found in Australia, where CCD is not evident. Exactly how IAPV corre-

Whether CCD can be successfully identified in the past or even the present is debated by different researchers. In recent years, wide scale losses of bee colonies in France, Germany and Canada have been linked by researchers to the use of an in-

secticide containing the neurotoxin imidacloprid, which was commonly applied to seeds to kill crop parasites, but was also lethal to bees. Such recent occurrences in Europe currently mask the question of whether CCD is truly occurring there or not. Furthermore, past large-scale failure of bee colonies have been reported due to well known pathogens and parasites inadvertently circulated by the global bee farming community. For example, the tiny,

bloodsucking Varroa destructor mite has long been a major pest of bees and a cause of hive mortality, and attempts to control it with pesticides have led to the development of resistant populations.

With the implication that pesticides and known pathogens appear more and more likely to create the conditions for CCD, UK beekeepers fear the disorder will soon be present here. Though colonies throughout the UK and especially in North London

show failure, and DEFRA has estimated bees contribute £165 million a year to the economy through fruit and field crop pollination, the government has so far refused demands by the British Beekeeper’s Association for an additional £8 million to fund research into bee health.

Whether CCD can be called a new disorder or not, it has certainly led beekeepers to question the effects of intense selective breeding upon the health of modern domestic bees, and of the side-effects of effort to control and destroy known pathogens of the hives as they continue to grow in resistance.

Although the widespread and rapid nature of CCD implies a new, deadly pathogen, it appears that there is no definitive cause of CCD and that instead, the disappearances are a sign of the devastating vulnerability of the domestic honeybee. As the current threat to crops shows, the interrelationship of bee and crop farming exposes each industry to the hazards of the other, and with so much of the world’s food production reliant on what is fundamentally the bee’s natural foraging behaviour, human interest is very much vested in the plight of the honeybee.



BEE MOVIE SCREENSHOT

lates to CCD is still unknown, but present research suggests it is one of several unknown factors that together cause CCD. Future research intends to investigate the correlation of IAPV with various stressors on bees and to use genetic analysis to trace strains of IAPV back to its points of entry.



BEE MOVIE SCREENSHOT

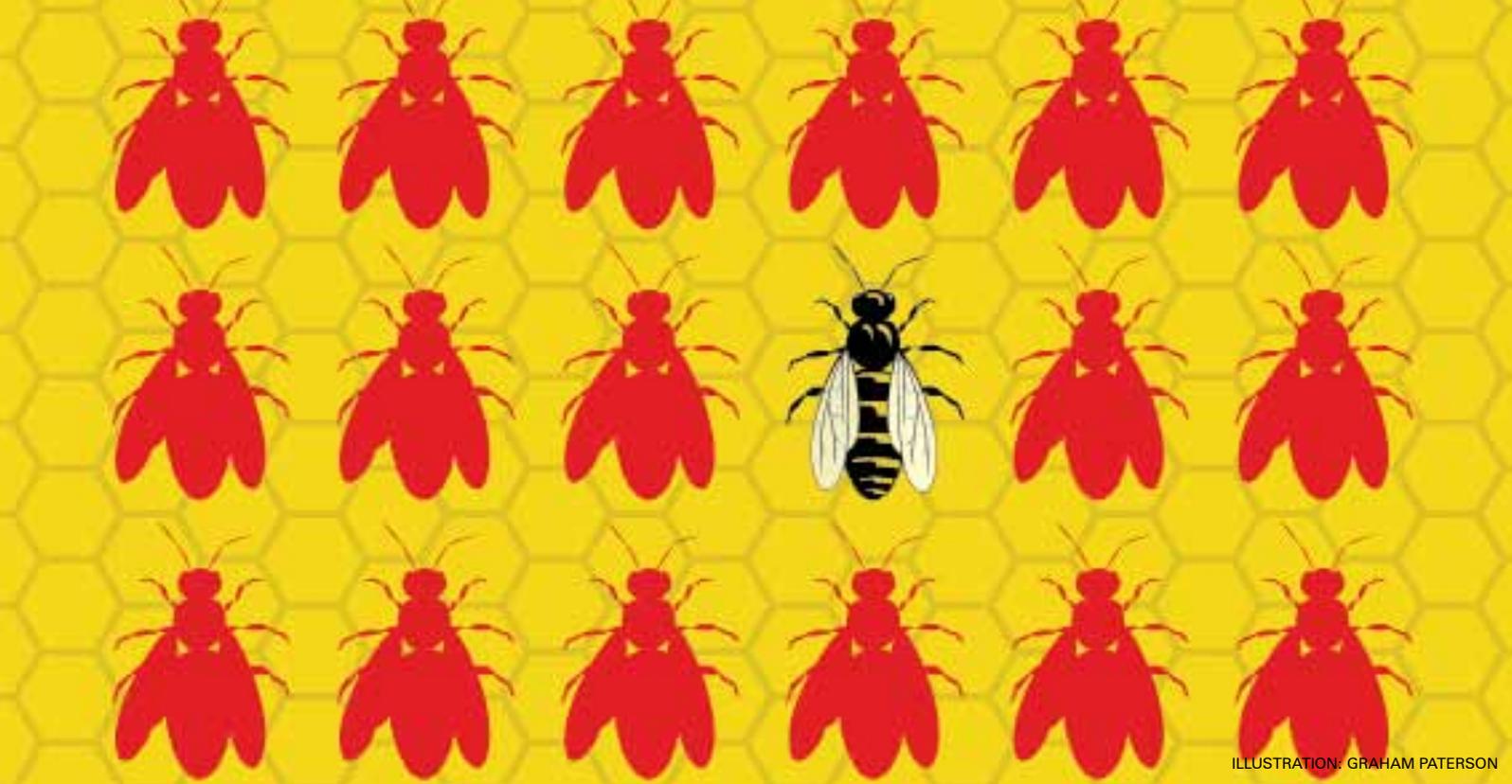


ILLUSTRATION: GRAHAM PATERSON

Bee losses

In the UK, The British Beekeepers Association (BBKA) estimates 1 in 3 colonies, or nearly 2 billion bees, died in 2008. Losses have been blamed on bad summers, disease, and pesticides.

Currently the government spends 200 000 pounds on research into bee health. This is less than 1% of the £825 million added value provided to the agriculture economy by pollination by bees over the same period (all BBKA estimates).

The US estimated that enough honey bees were left to provide all the pollination needed in 2007, but that 35% of hives were lost by beekeepers in 2007, compared to 31% in 2006.

IAPV has been identified in China, Australia, Hawaii, North America, Israel, and recently France.

Some bee colonies naturally fail in the winter months. Prior to CCD, normal winter losses for beekeepers in the US were 15-25%.

This increased to 31.8% during the winter of 2006–2007, and 35.9% over the winter 2007–2008.

An estimated 23% of beekeeping operations in the US have suffered from CCD, of which 50-90% of colonies have been lost.

0.75- 1.00 million honey bee colonies are estimated to have died in the United States over the winter of 2007–2008.

At least 24 US states and parts of Canada are affected by CCD. Heavy bee losses have occurred in Taiwan, India, Brazil, Europe, and the UK, but CCD has not been officially named.



Potential Causes

Low genetic diversity- Modern beekeeping uses a few dominant European breeds. Most commercial colonies come from a few select breeders, and *Varroa* have mostly wiped out wild bees in the US and Europe, which were the source of valuable genetic diversity. Studies indicate low genetic diversity can affect behavior, vulnerability to mites, and decrease immunity.

Differing strain virulence- Studies show that IAPV was present in the US from 2002, disproving the popular theory that it had been transmitted by imported Australian bees in 2005. However, 3 distinct 'clusters' of IAPV

have been found in the US, thus one strain may have become unusually virulent. Current research seeks to identify phenotypic and genetic differences in virulence.

Unknown 'disappearing disease' - CCD and Varroa are not present in Australian bees, although IAPV is. There have been incidental reports of 'disappearing disease' in the past.

Farming stress- The ability to easily move and manage honeybees makes them ideal pollinators for agriculture, but constantly moving may expose them to environmental stress. A study found commercial beekeeping operations were more likely to report CCD-like losses than smaller operations, although there

was no discernable geographic pattern.

Pesticides- Although no consistent pattern of pesticides have been identified, US scientists have found 'higher-than-expected' levels of miticides in both CCD and non-CCD hives. The chemical giant Bayer's best selling pesticide, imidacloprid, has been banned in France since 1999 when it had caused the death of a third of French honeybees from 1996-2001, and is currently under investigation in Canada. Tests show even 'safe' low concentrations affect bee behavior. Other pesticides of the same chemical family, neonicotinoids, have caused heavy losses in German honeybees.

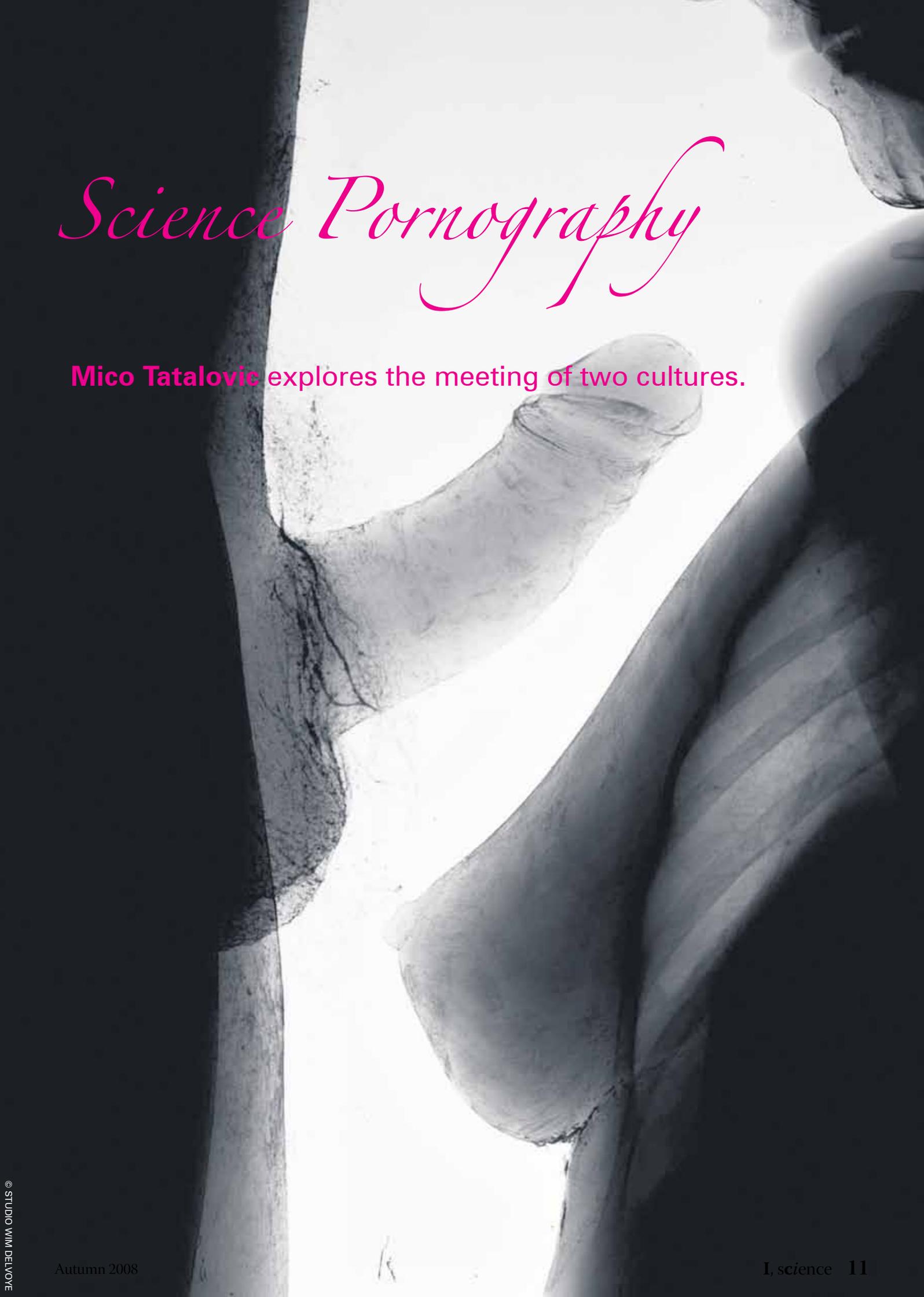
Varroa mites acting as viral vectors- Mites can transmit viral diseases rapidly within and between colonies, and the viruses can reside in and out of the hive without the vector. It is believed strains of Varroa mites originally came from eastern honeybees, but that the construction of better transport links in the early 20th century and the commercial movement of hives spread them to western countries, whose honeybees had no adaptive defences. The first infestation was reported in Russia in

1953, and the spread continued west until it reached the US in 1987. Varroa were ruled out as the cause of CCD due to their low presence in CCD hives, but comparatively small numbers of mites can still transmit various viruses rapidly through a colony.

Climate change- Some suggest changes in severity of seasonal weather and earlier blooming of flowers may have affected bee behavior, adding to

their overall stress. **Electromagnetic fields from cordless phone masts-** A study showing negative effects on bee navigation was reported by The Independent in April 2007, although the article mistakenly named 'mobile phones' as the cause. This has been heavily discredited in the wake of heated reactions.





Science Pornography

Mico Tatalovic explores the meeting of two cultures.

"There's a sense in which we are all taking part in sexual activity, whether we want to or not, and whether we are aware of it or not. We are constantly bombarded by films and TV commercials, magazine advertising, et cetera. Sex has become a sort of communal activity. It's an explicit element in all sorts of other activities -- advertising, publicity, sales promotion as well as in film and TV, every conceivable thing you can think of.

Elements of sexual imagery are constantly being jolted into the psychological space we inhabit. One has to be aware of these things and the unconscious role they play."

Excerpt from the Mississippi Review, Volume 20 (1991).



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THE FIRST porn movie was made in 1908, not long after the invention of cinema. In the late 1970s, only about 100 adult feature-length films were made annually; now, 10,000 are made each year. Pornography is a \$57 billion-a-year industry and is still growing. A survey by the Channel 4 programme 'Sex Education' showed that 27% of 14-17 year old boys in the UK access porn at least once a week. Another survey by the Internet research company Nielsen Online found that in 2006 40% of British men accessed Internet pornography. Are science communicators missing an enormous opportunity here to communicate science via porn? Most other genres and media could only hope for such a large and faithful audience. And yet science communication via porn movies seems to be non-existent. Sci-fi porn, yes. 'Nature' movies covering zoophilia, maybe. But science itself, no.

One of the most common denominators of porn movies is bad and boring story line. It only exists as a necessary pretext to and an interval between sex scenes. This is exactly where science could come in. Since the story does not matter anyway, why not make it a story about scientists? Maybe they had a bad day in the lab and need some attention after work. Or they had a great day in the lab and this leads to an affair with a colleague or a technician. Maybe, they are field researchers and they decide to relax after a long day of data collection in the sunny tropics... In any case, you could expose how science works in these scenes, making scientists look like humans with normal jobs and same passions as other

people. You could also have pornographic sex education videos. In some of these you see the genitalia anyway, so why not actually use the extremely popular hard-core sex, while science and health implications of the sexual intercourse are explained? Or is it possible that the public (mis)perception of scientists is so engrained in our minds that we couldn't possibly accept anything that associates scientists and sex? Is it that any x-rated film with science in it would be a complete flop?

New Scientist's 1975 survey of public opinion about scientists showed that we think of scientists as being 'remote, withdrawn, secretive and conventional' and believe that 'scientists have few interests and are rather unpopular.' Margaret Mead found similar perceptions of scientists in the US back in 1957

"27% of 14-17 year old boys in the UK access porn at least once a week."

and blamed it largely on the mass media, which she called on to break down 'the sense of discontinuity of scientists and other men... to bring about understanding of science as part of life, not divorced from it.' Wouldn't having more science in pornography help to deliver some of these goals?

With millions of users accessing porn websites each year, access to pornography is easier than ever. Many see this as a problem since pornography is highly

addictive; Wired suggested that it was society's new drug in their 2004 feature "Internet porn: worse than crack?" With sex being the most important thing in any sexual animal's life, for the sake of reproduction, it is no wonder that people also evolved to find sexual stimulation pleasing and addictive: imagine an individual who could spend all of his time having sex: those genes would spread like crazy! Recent research at Duke University Medical Center says that even monkeys will pay to watch 'porn.' When offered images of female hindquarters, male monkeys paid a lot in fruit juice currency to view the images again.

Others have studied pornography in the context of evolutionary psychology where human behaviour is thought to have evolved for millions of years to increase our odds of surviving and mating with high quality mates. Since pornography features so large in our economy and personal lives of many (men), biologists have looked for possible biological adaptations that could result from watching pornography, or that could have caused our prior bias towards becoming addicted to watching pornography. Nicholas Pound, a psychologist from McMaster University in Canada, has found that there are more porn websites and films featuring a woman and two or more men 'in action' than the other way around. When asked, men say they prefer to see additional men in porn rather than women. Researchers offered the following explanation for this preference: sperm competition among men is based on the possibility that a sexual partner has had sex with another man (or men)—the more men a partner has had sex with, the greater the sperm



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competition. It is therefore evolutionarily adaptive for men to become more sexually aroused after viewing a potential sexual partner having sex with multiple men. Pound said in his 2002 *Evolution and Human Behaviour* paper, "...although men should generally find mate sharing to be aversive, they may nevertheless find cues of increased sperm competition risk to be sexually arousing. Therefore, they should be more aroused by pornography that incorporates cues of sperm competition, than by comparable material in which such cues are absent." Higher arousal might prime that man to solicit sex sooner and be more active during mating in order to get his sperm into the competition as soon as possible to enable

"Porn needs to be viewed with caution, as cigarettes are: a guilty pleasure with detrimental effects..."

them a chance of reaching an egg.

A more recent study found further evidence for this hypothesis. In 2005, evolutionary biologist Leigh Simmons of the University of Western Australia reported in *Biology Letters* that men who watched porn featuring both men and women had an increased quality of ejaculated sperm (measured in terms of 'swimming' speed) compared to men who watched porn featuring only women. Such findings may actually be helpful when men are donating sperm for in vitro fertilizations, if we know that certain types of porn are more

likely to result in higher-quality sperm donations that in turn offer higher chances of subsequent conception. "We tested the evolutionary hypothesis that the men who viewed those sort of mixed sex images should have a higher semen quality if it was stimulating some innate evolved response to competition," Simmons said on ABC News. "We found men viewing images containing both men and women had higher sperm motility in masturbatory ejaculate compared to men who were viewing images of just women alone."

These studies are preliminary and repetitions with more subjects are needed before we can claim that there is definitely an evolved strategy to become more aroused and ejaculate better sperm when confronted with certain types of pornography. Interestingly, research into the effects of porn on people usually constrain their subjects (research participants) to men, probably because they are easier to study and it is easier to formulate hypotheses about why getting excited by watching porn would be evolutionarily beneficial to men. Bear in mind that the consensus, if any, is that watching porn is bad for the modern man, and in no way beneficial, unless you happen to be a producer making lots of money from it. For the consumer, addiction can lead to spending excessive amounts of money on porn and be detrimental to forming and maintaining real relationships. But many women watch and make pornography as well, as Alison Lee reports in the December 2008 issue of *ThisMagazine* in her feature, "The face of porn." So if you're thinking this might be a good research field for you, maybe you should start thinking about a PhD project on

"...there is a sense in which science and pornography are moving together on a curious collision course. Science is now more and more taking its subject matter not from nature as in the traditional physical sciences, but from the obsessions of its own practitioners... science is moving into an area where its obsessions begin to isolate completely its subject under the lens of its microscope, away from its links with the rest of nature. This is always the risk with science as a whole. The pornographic imagination detaches certain parts of the human anatomy from the human being and becomes obsessively focused on the breast or the genitalia, or what have you. That sort of obsession with what I call quantified functions is what lies at the core of science; there is a shedding of all responsibility by the scientist who is just looking at a particular subject with a tendency to ignore the contingent links."

Excerpt from the *Mississippi Review*, Volume 20 (1991).

whether some women should or do enjoy pornography.

Apart from the question of why and how our psychology interacts with pornography, some science research aims at understanding the physiology and anatomy of what is happening during a sexual intercourse. Surprisingly, the illustrations we usually see that aim to explain how the penis fits into the vagina are mostly based on Leonardo da Vinci's drawings, which were not anatomically correct. A 1999 paper in the *British Medical Journal* used "magnetic resonance imaging of male and female genitals during coitus and female sexual arousal" to study exactly what happens during penetrative sex. The main results say that "during intercourse in the missionary position the penis has the shape of a boomerang and a third of its length consists of the root of the penis" Further studies using imaging technologies should correct other inaccuracies in our understanding of sexual anatomy.

It is perhaps best to leave you with a word of caution: a recent feature article about porn addicts in the *Independent of Sunday "Dirty Secrets"* concludes that "Porn needs to be viewed with caution, as cigarettes are: a guilty pleasure with detrimental effects, addictive qualities and a propensity to cause ill effects on the user and the people around them."



It has been a thousand generations since humans and Neanderthals last stood face-to-face. Since then we have only been able to guess what our close Stone Age relatives were like from bones and artefacts. But now the sequencing of the Neanderthal genome is offering valuable insights not only to their story, but also our own. **Arko Olesk** investigates.

THERE IS one big question about Neanderthals that every palaeontologist would like to be able to answer: What happened to them? Did they just become extinct, unable to face the harsh climate and competition by modern humans? Or did humans assimilate their evolutionary cousins after the 10,000 year co-habitation period in Europe? There is not much that archaeology can reveal about these questions. So the experts are eagerly awaiting the possibility for quite another perspective: the complete sequence of the Neanderthal genome that is well underway in the Max Planck Institute of Evolutionary Anthropology in Leipzig, Germany. Initiated three years ago by Svante Pääbo, the leading figure and one of the founders of the field of paleogenetics, the study of ancient DNA, the project achieved the first draft of the genome this Christmas. Although incomplete, this first draft is already revealing some tantalizing hints about the history of the human species. 'We have sequenced 2.8 billion base-pairs of Neanderthal DNA,' said team member Johannes Krause. This is close to the size of the human genome. 'we have just 60 per cent of the genome,' he adds. The random choices of DNA regions made by this 'shotgun' sequencing technique mean that some parts of the genome have been sequenced sev-

eral times, while others have not been touched at all. 'We have to sequence the genome many more times, up to 20 more times. In next two years we want to get a high quality genome, where people can be sure that what they see is right, not just some problems with the old DNA,' continued Krause during a phone interview for *I, Science*. Being in the ground for around 40,000 years causes plenty of problems to the DNA: including degradation, chemical modifications and contamination. Getting reliable data involves solving many types of puzzles simultaneously. First there's the jigsaw: piecing together DNA that has degraded into short pieces. During a talk at the Nobel conference in Stockholm in October last year, Prof. Pääbo, director of the genetics department at the Max Planck Institute, described the first sample they got from a 38,000 year old bone found in Vindija Cave in Croatia. 'The fragments of DNA were on average 70 base pairs long.' Then the results are distorted by chemical damage to the bases. After the organism dies, DNA loses the protective mechanism of the cell and starts to react with the environment, mostly with water and atmospheric oxygen. For instance, one of the bases cytosine (C) is turned to uracil (U), which is then incorrectly read by the sequencer as thymine (T). 'Sometimes 70 per cent of the Cs have become Ts,' added

Pääbo. And finally, there is contamination. 'We have 200 extracts from 70 fossils and we have found only three bones that are almost free of contamination,' Pääbo said. According to him, only a few per cent of the sequenced DNA actually belongs to Neanderthals, the rest comes from fungi and bacteria. But these can be easily distinguished from Neanderthal DNA; the real problem is contamination with human DNA that can occur during excavations or when handling the samples in the laboratory. 'We are so close that just by looking it is impossible to tell whether the DNA is from a Neanderthal or from a modern human that handled the fossil,' Pääbo said. They try to bring the risk down by handling the samples in sterile conditions: in the lab and as much as possible during the excavations. The DNA of all the people coming to contact with the samples is also recorded so that any contamination can be recognised. To illustrate the difficulties in reading ancient DNA, Krause described his latest surprise: the Neanderthal man he was researching turned out to be a woman. Researchers prefer male DNA because it only has one X chromosome (women have two X chromosomes, men have an X and a Y chromosome) and this makes it easy to discover contamination with another DNA. Yet when Krause and his colleagues started to look at the Y chro-

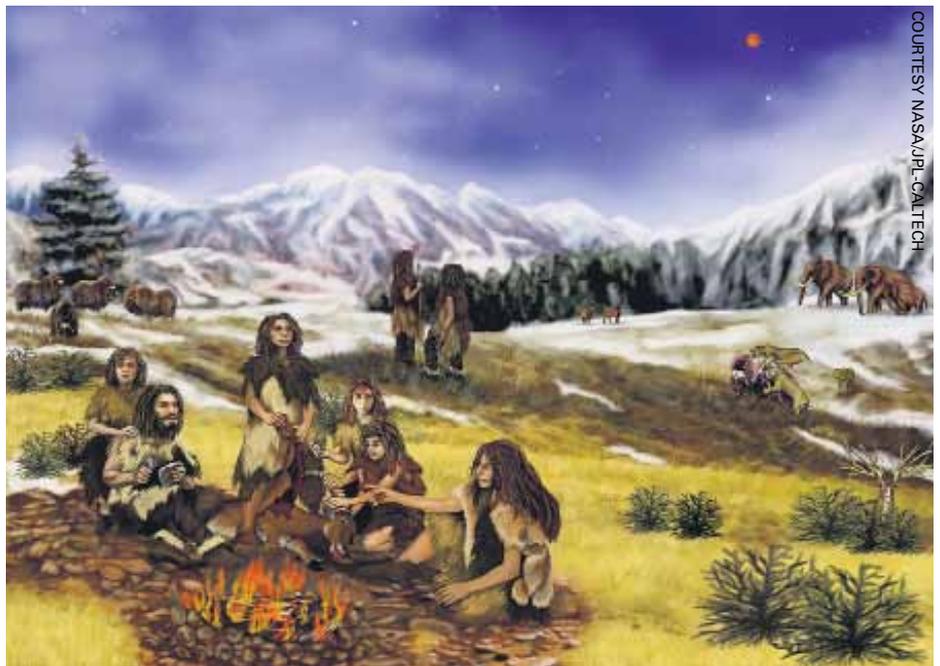
mosome on this sample, they found none of the genes which were supposed to be there. Everything that was originally thought to be Y chromosome was actually damaged pieces from other chromosomes or bacterial DNA. 'This was quite surprising but doesn't change much for us. Actually it is nice because now we have a really good way to estimate how much male contamination we have,' Krause said, 'Which is really cool.'

All the problems with DNA quality mean that looking for the answer to what Neanderthals were like must wait until better coverage allows for a more reliable analysis. So far the researchers have only investigated a few interesting locations on the genome, establishing for instance that some of the Neanderthals had ginger hair and freckles, and that they shared with humans the same version of the speech-connected FOXP2 gene (see box). In next years we can expect a few more similar insights as well as discoveries that might leave us puzzled: we may see a gene that we can tell to be unique to Neanderthals but we have no idea and no way to find out what exactly it is that it used to do. This is why Neanderthal-specific genes are not the researchers' primary aim. 'We are mainly interested in what happened in humans and less in what happened in Neanderthals,' Krause said. The data helps to find the answer to a part of another big question: when did the branches of

"The Neanderthal man he was researching turned out to be a woman."

modern humans and Neanderthals start to grow apart on our family tree? And did they interweave again at some point? 'We can use the information to reconstruct history,' Pääbo said. Since DNA gathers mutations at a certain rate, comparing genomes allows geneticists to calculate the time when the last common ancestor of both species walked on Earth. The complete sequence of the Neanderthal mitochondrial DNA published last summer in the journal

Sharing The 'Language Gene': The most striking discovery so far has been a similarity between humans and Neanderthals where no one expected to find one. The gene FOXP2 has been hailed as the 'language gene' since in the 90s the genetic cause of severe impairment of linguistic skills in a family was tracked down to a faulty copy of this gene. 'FOXP2 should be a very good candidate for something that is human-specific because it has to do with language,' Krause said. 'We always assumed that this gene will be different in Neanderthals.' So when they found that Neanderthals had the same version of the FOXP2 gene, it was hard to swallow. 'For the only gene we know has to do with language, there is no reason to assume that Neanderthals were different from us,' Pääbo said. Truth is, of course, more complicated. There are many genes involved in language skills that we know nothing about. But how can we explain that the gene seems to be recently selected in humans and yet Neanderthals have the same version? 'This is really problematic,' Krause admitted. 'We went back to our earlier data and found, when we looked at more humans, that there is more than one selection event going on,' Krause said. 'We see that the signal of selection is not coming from this variation, it is coming from somewhere else. Only the Neanderthal made us aware of that, made us look and find that there is more going on than we had initially thought.'



COURTESY NASA/JPL-CALTECH

Cell puts the estimate of the divergence date between the two species, humans and Neanderthals to approximately 660,000 years. Whether 40,000 years ago, after our ancestors came to Europe, these two species converged again by interbreeding has been a matter of great speculation. Some genes, such as a variant of Microcephalin that regulates brain size or a larger region of genes on chromosome 17 linked to fertility, were believed to have been passed from Neanderthals to our genome since they are more common in the population of Europe and Middle East, the habitat we shared with Neanderthals. The Neanderthal genome finally allows testing of such theories. If Neanderthals made some genetic contribution to humans, some modern Europeans should be genetically closer to Neanderthals than, say, some people from Asia. This, Pääbo and colleagues found, was not the case for any of the suspected genes or the mitochondrial DNA. '[Genetic] distance to Neanderthals is the same everywhere we look in the world,' said Pääbo. 'Clearly Neanderthals fall outside the variation of modern humans.' They were they own

species.

If humans and Neanderthals share a certain gene, this must mean that it was already present in our common ancestor. If chimpanzees do not have this gene, it means that this genetic change happened after chimps diverged from common ancestor of humans and chimps some six million years ago. And if a certain gene is unique to humans, it must have been a recent addition to our genome and may hold clues to the success of our species. 'We would be able to say which genetic changes happened to our genome in the last little bit of human evolution after splitting from Neanderthals,' Pääbo explained. 'That will be a relatively short list and among them may be some interesting ones that actually are crucial in what makes fully modern humans different from other forms [such as Neanderthals].'

But can genes help us to settle the debate of why Neanderthals became extinct? Krause does not think so: 'We will never figure it out.' But some clues are there. 'What DNA can tell us is something about what was the structure of population in Neanderthals,' he said. 'We have done an analysis where we looked at six Neanderthals from around 40,000 years ago, just before modern humans came to Europe.' 'At that time it seems that Neanderthals had a very low population size. When modern humans came to Europe, probably there were not so many Neanderthals here; it was probably harsh for them to deal with the arrival of modern humans. Population size of modern humans was bigger and that already tells us something.' Perhaps we should also keep in mind what happened to the members of our own species that looked different when colonial Europeans arrived to Americas and Australia: the 'civilized' humans hunted aboriginals for sport and led to near extinction of majority of natives in Americas by violent wars and transmission of deadly diseases.

The Other Darwin Genius

Tim Jones explains why he finds Erasmus Darwin more interesting than Erasmus' famous grandson Charles.

YOU WILL hardly need reminding that this is the 200th anniversary of the birth of Charles Darwin, and the 150th anniversary of his best known work – *On the Origin of Species*. It's already a big deal: special events, new book editions, talks, t-shirts, diaries, calendars, and commemorative mugs – the lot! And rightly so – however we might nuance the term: there would be no Darwinism without Darwin. But, as the celebrations bubble up to a crescendo of reverence on February 12th, I wonder if the world will spare a thought for Darwin's own origins, and particularly his illustrious grandfather – Erasmus Darwin (1731-1802). He will certainly be struggling for attention, so consider this a pre-emptive strike on behalf of *The Other Darwin Genius*.

We automatically associate 'Darwin' with the name 'Charles'. A mention of Erasmus in conversation brings blank looks, even from devotees of the definitive Charles. Genius twice in the same family – impossible! And if the old fellow had some notoriety in his day, surely it must pale beside that of his grandson. Yet Erasmus is not to be compared to Charles in any competitive sense. Their skills, inclinations, personalities, temperaments, and achievements were very different. It was their shared inquisitiveness and intellectual energy that destined each to leave a lasting imprint on the world. We all know about Charles's lasting imprint, but few are aware that Erasmus was:

- Recognised as the greatest physician of his time
- A respected scientist and inventor

- A key player and catalyst in the industrial revolution
- One of England's most popular poets

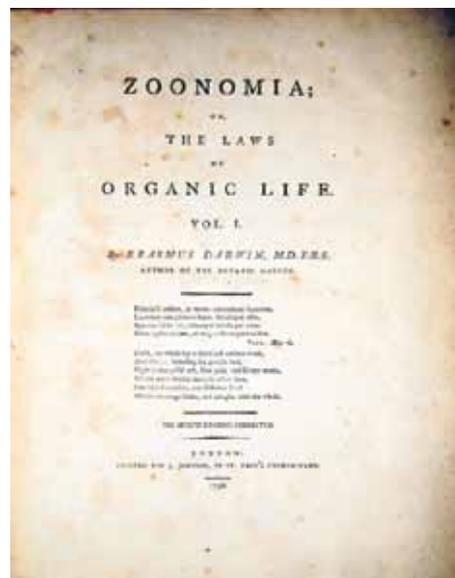
His life has been richly documented by physicist Desmond King-Hele, whose analysis reveals a breathtaking range of interests, involvements and achievements. Not associated with one single big theory or event, Erasmus confuses our conception of the traditional achiever. Charles by contrast is easy – well and truly Mr Evolution. So, what is it that makes Erasmus so appealing?

His lifelong profession was medicine. Widely recognised in England as the top doctor of his day, he famously declined to be King George III's personal physician. (Had he accepted of course, George's porphyria would have quickly cleared up, the King's eye would have stayed on the political ball, and America would still be ours :) Well, maybe not; Erasmus's sympathies actually tended towards the pro-revolutionary). He chose rather to spread his benefaction widely, making house calls to ordinary folk in all weathers and treating the poor for free.

Erasmus's medical knowledge was captured in the 1796 *Zoonomia*. At 5kg, the big and heavy first edition makes fascinating reading. Some of the 18th century cures sound worse than the diseases, but while Erasmus's use of the blood-letting lancet for physical conditions may have been typical, his approach to mental disease was ahead of its time. Lunatics in his care could expect compassion instead of the more familiar beatings.

Charles inherited his knack for ruffling religious feathers from his grandfather, who in *Zoonomia* classified religion as a mental disease – a 'Disease of Volition'. This is similar to some modern thinkers' approach, such as that found in Richard Dawkins' *God Delusion* (2006) or Daniel Dennett's *Breaking the Spell: Religion as a Natural Phenomenon* (2006). Here, he dismisses it with other superstitions in a discussion on "credulity":

"Ignorance and credulity have ever been companions, and have misled and enslaved mankind; philosophy



Erasmus's grandwork *Zoonomia*

has in all ages endeavoured to oppose their progress, and to loosen the shackles they had imposed; philosophers have on this account been called unbelievers: unbelievers of what? Of the fictions of fancy, of witchcraft, hobgoblins, apparitions, vampires, fairies; of the influence of stars on human actions, miracles wrought by the bones of saints, the flights of ominous birds..."

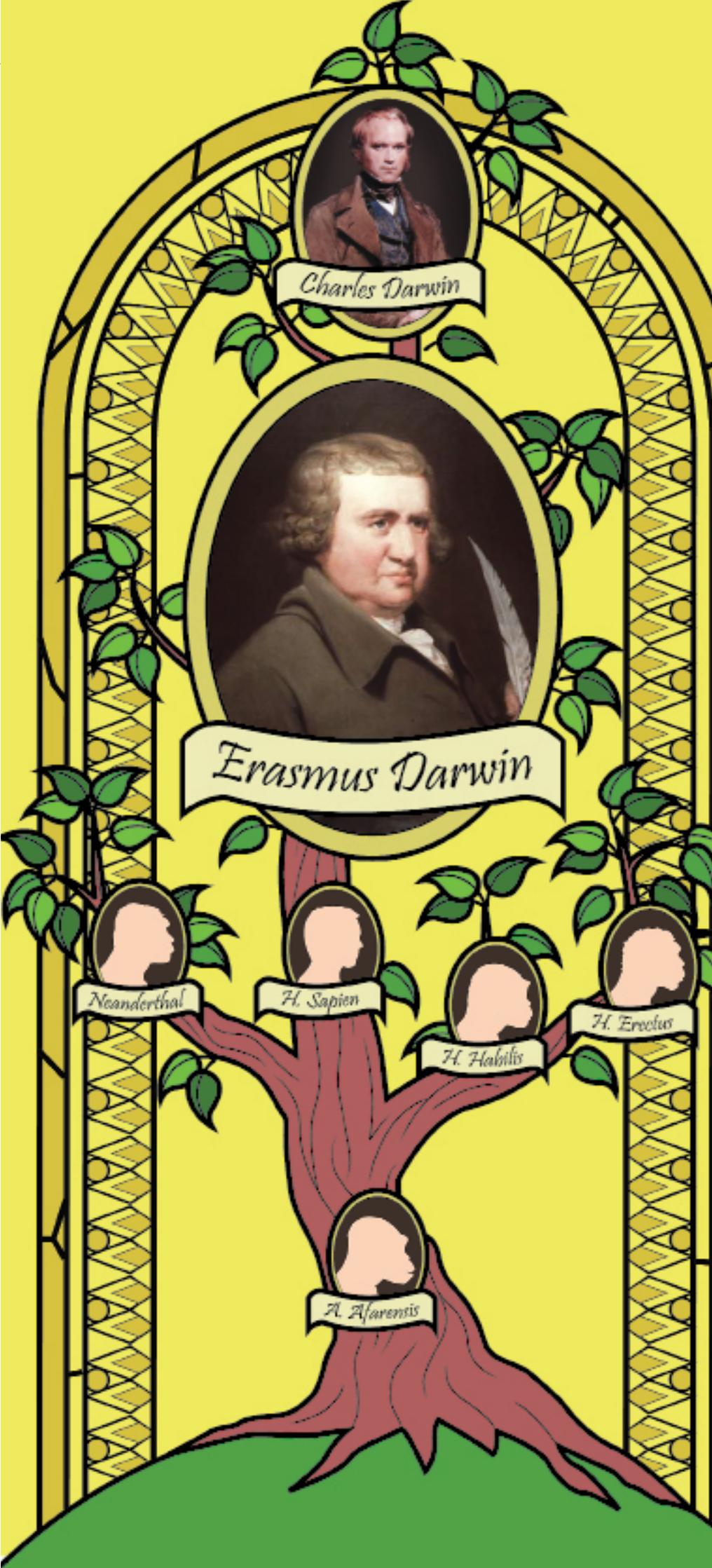
"...In regard to religious matters, there is an intellectual cowardice instilled in the minds of the people from their infancy; which prevents their inquiry: credulity is made an indispensable virtue; to inquire or exert their reason in religious matters is denounced as sinful; and in the catholic church is punished with more severe penances than moral crimes..."

And the cure was straightforward: "The method of cure is to increase our knowledge of the laws of nature, and our habit of comparing whatever ideas are presented to us with those known laws, and thus to counteract the fallacies or our senses, to emancipate ourselves from the false impressions which we have imbibed in our infancy, and to set the faculty of reason above that of imagination."

Rational thinking and appeal to scientific method shine through – not surprising given the interesting people Erasmus was mixing with: James Watt and Matthew Boulton of steam engine fame, Josiah Wedgwood of pottery fame, the Scottish chemist James Kier, and the politically animated chemist and co-discoverer of oxygen Joseph Priestley. With Erasmus's support, Wedgwood got England's first canal built, while his friendship and technical exchanges with Watt and Boulton cata-



Erasmus's house in Lichfield, behind the famous cathedral.



lysed the steam age. Together known as the Lunar Men (so called because they travelled to monthly meetings assisted by moonlight), this group drove the industrial revolution and gave us the roots of our technological world.

A pioneering scientist and engineer in his own right, Erasmus is unsung in many fields. He discovered 'Charles's Gas Law' before Charles – who claimed it 24 years later – glimpsed partial pressures ahead of Dalton, and explained the formation of clouds. His musings appear almost casually in a letter to Boulton, where we first learn that his plans for weather forecasting will be enhanced by the accuracy of John Harrison's new clock – that is Harrison of longitude fame, then:

"I am extremely impatient for this Play-Thing! [Harrison's clock] as I intend to fortell every Shower by it, and make great medical discovery as far as relates to the specific Gravity of Air: and from the Quantity of Vapor. Thus the Specific Gravity of the Air, should be as the Absolute Gravity (shew'd by the Barometer) and as the Heat (shew'd by Boulton's Thermometer). Now if it is not always found as these two (that is as one and inversely as the other) then the deviations at different Times must be as the Quantity of dissolved Vapour in the Air."

Evolution is also discussed in *Zoonomia* and other books by Erasmus. His coat of arms comprised three scallop shells with the telling motto *E conchis omnia* – 'everything from shells' – reflecting his belief that all life started from sea creatures. Unfortunately, the device was not subtle enough to evade the local clergy, leaving Erasmus force-put to paint it out and thereby keep the peace (it remained on his bookplate). Erasmus's gift for marrying art with science matured in his narrative poem *The Botanic Garden*, which brought him literary fame alongside the respect of influential friends like the poets Wordsworth and Coleridge, both of whom record him as an important influence on their work.

Erasmus was clever but not boring. A true man of the Enlightenment, he took all his pleasures seriously. Shunning alcohol, he preferred to act on his conviction that sugar and cream were the healthiest of foods, consuming both in quantity. He had a semi-circular profile carved in his dining table to accommodate the girth of his indulgence. Always amorously inclined, his successful bid for the hand of the young socialite Elizabeth Pole, whilst in the disrepair of his fifties, is intriguing – not to say impressive, as are his liberal reproductive powers, evidenced by 14 children including two illegitimacies.

And so it goes on: from speaking machines to steam turbines, from educational reform to carriage design, from the moon's origin to the formation of coal; in all these areas and many more, Erasmus made valuable and original contributions to knowledge. For me though, it is the combination of The Other Darwin Genius's bon-viveur attitude, innovative energy, rationality, compassion, and his measured disrespect for authority, convention and the status quo, that makes him (and I know this is blasphemy) the more interesting Darwin. Spare him a thought on February 12th.

ILLUSTRATION: GRAHAM PATERSON

Stringing us along

Jessica Bland looks for the theory of everything.

THERE IS a lot of fuss about String Theory. The idea that the basic building blocks of the Universe are string-like loops might be bizarre, but it has a huge number of physicists and mathematicians as excited as electrons. However, so far, it is only a conjecture; String Theory does not yet have any concrete results that can be proved or disproved by experiment. So, why are we sinking so much time and money into it?

It begins with a quite straightforward puzzle. By the early 20th century both Quantum Theory and General Relativity established themselves as highly successful physical theories: quantum theory at describing events on a very small scale and general relativity at describing very heavy things, such as planets. But it was thought that the two theories could not be combined to form one overarching picture of nature.

We could, and perhaps should, just accept this. But there is something uneasy about having two different basic pictures of the Universe that can be swapped, depending on the scale of the phenomena we are examining. Ideally, there would be 'one ring to rule them all': one Theory of Everything. There would be a way to pull together General Relativity and Quantum Theory into a single picture of the Universe. Such a theory is currently the physics community's holy grail; and String Theory is a potential candidate.

String Theory started life in 1968, as a description of the Strong Nuclear Force, which governs the interactions of quarks - the constituents of protons and neutrons. When the atom was split, protons and neutrons were found within its nucleus. For some time these were seen as the most basic constituents of the Universe. But by colliding protons and electrons, physicists developed the idea that protons are actually made from several components (quarks). So quarks were now the most basic particles. String Theory claims that there are still yet more fundamental entities, and that these explain how the Strong Nuclear Force 'works on' quarks. These fundamental entities are tiny one-dimensional loops of string, 10-35 m long. Within ten years of the birth of this theory, scientists recognised that the string-like picture could be used to unite Quantum Theory and General Relativity.

Controversy

Today, String Theory is one of the pre-eminent contenders for the title of Theory of Everything. But there is much public debate, particularly in the US, over the worth of continuing String Theory research. Such is the subject's popularity that in March 2006 a public discussion between two opposing physicists sold out the 900-seat Washington Auditorium. The popular debate was spearheaded by two physicists. Brian Greene, (String theorist and best-selling author of *The Elegant Universe*), has received unprecedented media attention; from cameo appearances in films to interviews on the CBS's late-night show *Letterman*.

Lee Smolin, Greene's great rival on this subject, can often be heard on radio and he recently wrote the critically acclaimed *The Trouble With Physics*. But how is it that a debate over a single physics theory has managed to capture the public imagination? Statistical Mechanics certainly never managed it.

First, String Theory has had so much public attention because the picture it draws is quite comprehensible; we can all imagine a loop of string. The theory itself is mathematically complex, but we can all manage the landscape that the maths outlines. This facet of String Theory allows the public, rightly or wrongly, to think they have a conceptual grasp of the theory, and are licensed to comment on its worth.

The second reason for this debate is the widely held belief that the worth of a scientific theory lies in its resilience to experimental testing. String Theory has not been tested. Indeed, we are sixteen orders of magnitude away from testing it; if the strings were the height of a woman, then our equipment could not make measurements smaller than the distance between our sun and the nearest star!

Moreover, there are no testable results that are likely in the near future (the Large Hadron Collider can only provide evidence of phenomena that are consistent with, but not unique to, String Theory).

Putting the debate into a philosophical framework

Thomas Kuhn's *The Structure of Scientific Revolutions* is a historical analysis of the scientific progress that has spawned a whole genre of theories in the philosophy of science. One of the central doctrines is the distinction between "normal science" and "scientific revolution". The former are periods in which scientists are all committed to the same rules and standards for scientific practice. Governed by these rules, they set about refining and testing theories. The latter are periods of upheaval when theories undergo fundamental change; the rules of scientific practice are not so set in stone at these times.

Normal science fits well with the generic image of the scientist as an experimenter testing a particular theory. But the scientific revolutions that join together periods of normal science are not led by experimental results or even,

necessarily, rational thought.

If Kuhn's description of scientific progress is a model for how science will continue to develop (as it was intended), then it gives us a

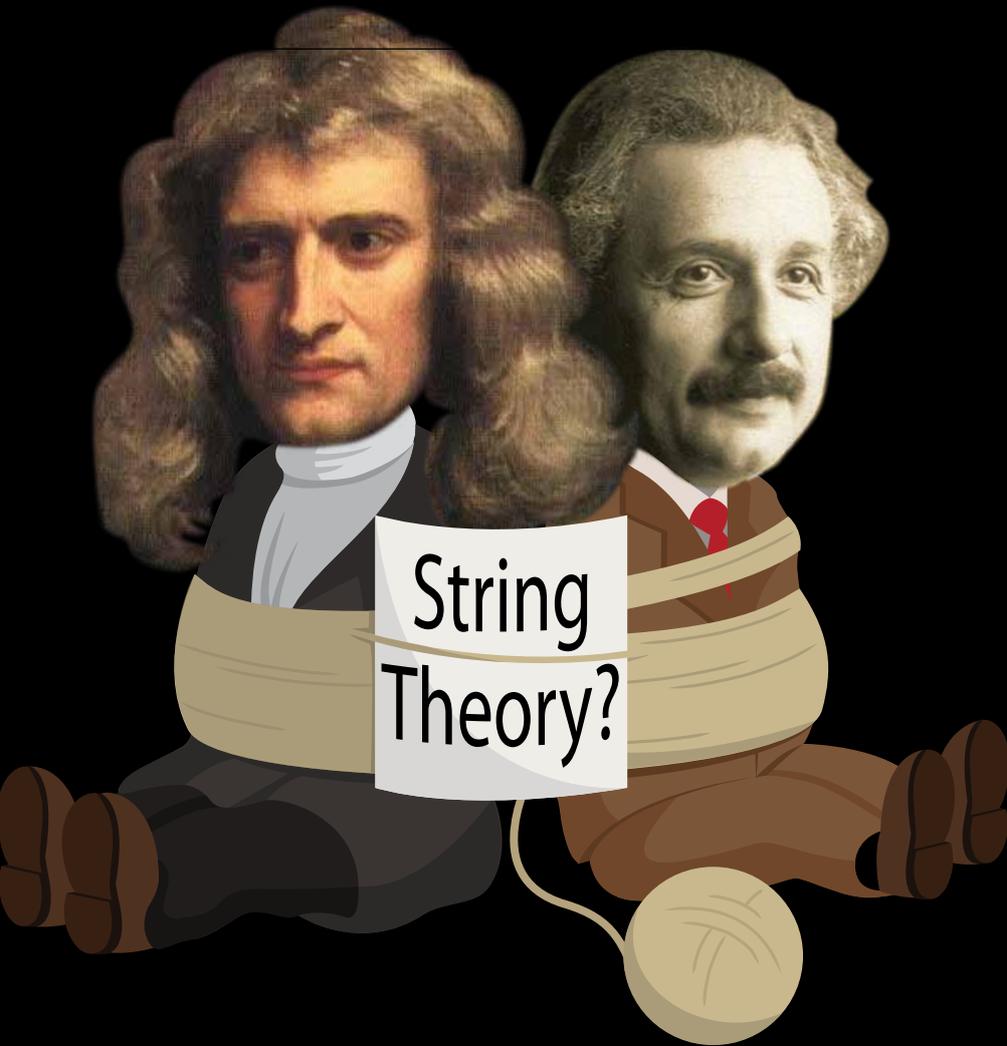
framework in which to judge research into String Theory.

One of Kuhn's favourite examples is Antoine Lavoisier's discovery of oxygen - the basis for the Chemical Revolution that occurred in the late 18th century. The dominant theory prior to Lavoisier's work was that there is some element, phlogiston, that is released during combustion. But Lavoisier thought that burning matter absorbs part of the atmosphere (oxygen) during combustion rather than releasing phlogiston.

This instinct, as opposed to some experiment, drove Lavoisier to develop his new theory. Likewise, there is a similar instinct amongst string theorists. They are on the right lines; they have a Theory of Everything.

So maybe in parallel with other periods of revolutionary science, our search for a Theory of Everything should be led by instinct, and not by its testability. This

"String theory is one of the preeminent contenders for the title of Theory of Everything."



means that lack of experimental predictions made by String Theory need not be a problem. After all, String Theory is not intrinsically un-testable, it is just that physicists are quite far away from the stage at which they can test it.

Why don't we just let them get on with it?

A Kuhnian analysis would advise patience with String Theory, but it's unlikely that this would do much to convince the theory's public critics. The point they make over and over again is that String theory has spent too long at this purely conceptual stage; if it really is the correct Theory of Everything, then it would have provided us with some testable results by now. To quote an audience member at the Washington debate: "But anything that's been around this long, and has had this much intellectual talent that hasn't shown anything - it must not be it."

The objection is not that Kuhn's picture is wrong but that, additionally, there should be included in it somewhere a kind of time restriction between the point of theory conception and the point at which it is testable. During the Chemical Revolution, there were only six years between Lavoisier's initial anti-phlogiston instinct and his experimental proof: in 1777 he put forward a new

theory of oxygen, and phlogiston theory was disproved in a paper published in 1783. String theory, on the other hand, has been around for almost 40 years without any proof (or, for that matter, any disproof).

There is nothing specific in Kuhn's theory that guides us on this kind of timescale. But, there is a more contemporary theory that might help.

Modifying the framework

Michael Friedman recently advocated a theory of scientific progress that modifies Kuhn's. It offers guidance about what drives periods of scientific revolutions and so sets out a more exact framework for judging String Theory's current status. It suggests three underlying factors that will lead us through a scientific revolution:

1) A new theory should contain previous theories as approximates or limiting cases.

2) The constitutive principles of a new theory, i.e. the picture of the world it draws, should evolve from the constitutive principles of previous theories.

3) The instinct that motivates theory change should instigate a new philosophical framework that relates to both previous frameworks and new scientific

discoveries.

Now String Theory certainly fulfils the first of these requirements since Quantum Theory and General Relativity follow from it on the scale appropriate to each - the very small and the very heavy. But so would any other Theory of Everything, otherwise it would not be such a theory. So the fulfillment of the first factor offers no argument for String Theory over any other Theory of Everything.

It is, however, not clear whether the idea that the world is made from string-like loops can be said to have evolved from our previous theories, fulfilling the second stipulation. This kind of judgment should therefore be left to people more familiar with the exact mathematics of the theory. Perhaps, at that level there is some evolution, which is not obvious if we simply look at the theory qualitatively.

But it is the third criterion that is generally seen as the problem for String Theory: it has not, as yet, provided us with new discoveries. Since the theory's conception, there have been numerous discoveries in Physics, particularly in Particle Physics, but all String Theory has contributed is a useful description of quark-gluon plasmas. Maybe it's not patience we should be showing towards String Theory, but the degree of skepticism appropriate to a theory that does not yet have any real explanatory power.

Friedman's guidelines for periods of scientific revolution do not recommend further research into String Theory. But given that the other potential Theories of Everything are equally theoretical, the same goes for them. So instead of condemning String Theory now, any judgement should be held off until nearer to the point whereby it can be judged by its interaction with scientific discoveries. In the mean time, String Theory mathematics is still being developed, maths that has proved useful in unexpected corners of physics. So, in the immediate future, there is no worry of the string theorist just sitting back and twiddling their thumbs.

The String Theory debate is really a discussion of a future revolution in science, and especially physics: the revolution associated with a competent Theory of Everything. Only if and when candidates begin to be tested will this 'Everything Revolution' have started. Indeed, Greene, as perhaps the strongest public advocate of String Theory, states: "We will not believe this theory until it's experimentally tested." Even he will not commit to the theory just yet. Similarly, it would be rash to believe that String Theory will not provide us with a Theory of Everything. And so, to some extent the public debate is futile. In the end, we will need some cold, hard evidence to help us decide



ILLUSTRATION: GRAHAM PATERSON

Should we Run on Roads?

Geoffrey Marsh runs us through some sports science and biomechanics to answer the question.

AS OBESITY levels increasingly threaten our nation's health, exercise has never been of greater importance to the UK's sofa-bound sedentaries. Running is a great form of exercise, but as many Londoners will tell you, our choices of running terrain are slim.

The concrete pavements we invariably face as modern urbanites offer a much harder surface than our ancestral athletes would perhaps have experienced over the

runners. From the cartilage point of view, a more compliant surface such as grass would be a safer option.

However, another important tissue to consider is the bone. It seems that the high peak strain rate, which we would expect from running on a hard surface, gives rise to more of an osteogenic (bone-generating) response in animal skeletons than lower strain rates. Thus running on a hard surface could increase our peak bone mass, thought to be the best preventative meas-



“...a more compliant surface such as grass would be a safer option.”

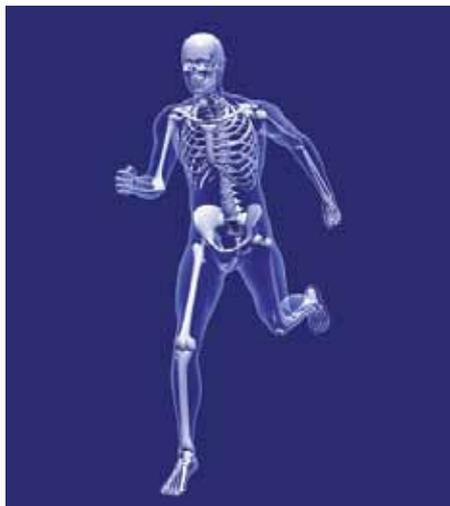
past 90,000 years of human evolution. The key difference between a hard and a soft surface when translated onto our skeletons' mechanical experience, concerns the impact of hitting the floor with each foot strike. In particular, the rate of strain experienced by the skeleton as each foot hits the floor is higher on a stiffer surface. Consequently, this presents a dichotomy. On the one hand a high peak rate of strain is more likely to cause damage to joint cartilage; on the other hand it provides the most effective stimulus for bones to grow stronger. So the question begs: should we run on hard surfaces?

A high peak rate of strain translates to high compressive and shear forces on joint cartilage, and since the knee is the primary shock absorber, it dissipates the impact thus protecting the rest of the body. Athletes will no doubt inform you that the knee is the most common site of injury in

ure against osteoporosis and associated fragility fractures in later years. This is important as osteoporosis causes a huge burden on the NHS, and great morbidity and mortality to those unfortunately affected.

Central to this phenomenon is the notion of adaptive bone remodelling, generally attributed to Julius Wolff, a nineteenth century German anatomist. Wolff's law states that the skeleton adapts its structure in response to a changing mechanical environment. From an evolutionary point of view this adaptive mechanism makes perfect sense, allowing a finely tuned balance between strong bones (avoiding breaks) and the energy inefficiencies of growing and maintaining an over-engineered skeleton.

“..running on a hard surface could increase our peak bone mass.”



There is evidence to suggest that bone cells do respond preferentially to a subset of their mechanical environment, dominated by high strains changing at fast rates, which we would expect from running on harder surfaces.

Human exercise studies support the data from animal studies that local strain induces local, site-specific changes in bone architecture.

For example, researchers at the Royal Veterinary College in London in the late nineties evaluated the osteogenic potential of the adaptive modelling response in relation to the rate of strain change, by non-invasively loading anaesthetised rats' ulnas (elbow bone) during daily sessions. The rats that were in the 'high strain rate group' showed a statistically significant increase

in bone. Whereas, those in the moderately-strained group showed no change in bone structure and those in the low-strain group showed a reduction in net bone deposition compared with controls. The low strain rate used was equivalent to the lower end of those experienced during normal locomotion as measured from living rats, whereas a higher strain rate was achieved by dropping them onto a hard surface (from 30 cm). So with rats at least, within the physiological range, high strain rates are associated with a more osteogenic response than low strain rates.

The key question, as yet unanswered, is what is the lowest possible strain rate for humans capable of having osteogenic effects, and what is the highest possible tolerable strain rate to avoid injury, and is there a safe window between these values where we can run around safely?

It may be possible to reduce the peak strains endured by changing the way we

run. 'The Pose' method for example, where by changing the position in which the foot strikes the floor, reduces the peak vertical ground reaction forces at the knee can have a positive effect. Furthermore, good running shoes create a compliant interface between the floor surface and the foot, and thus inhibiting some of the pressure off the knee as the principle site of shockwave transmission.

This question is about the impact of the environment on the human body. Our skeletons are transducers of our mechanical communication with the environment, and there seems to be room for more collaboration between the creators of the environment, like civil engineers, shoemakers and the researchers of our skeletons' mechanobiology.

Dumanel's Luck

Graham Paterson brings us the story of a young Haitian boy who beat the odds with the help of doctors from half a world away.

For many, plastic surgery conjures up images of celebrities wanting that perfect smile, but 11 month old Dumanel Luxama already has a picture perfect smile, so why is his family consulting with a plastic surgeon? Dumanel suffers from a rare neurological defect called a frontoethmoidal encephalocele, a protrusion of the brain through a hole in the front of his skull that he's had since birth. To have this defect treated, Dumanel underwent surgery at Children's Hospital Boston, but his story did not start here, it started in his home country of Haiti.

"Today, this condition occurs in about 1 out of every 4000 live births and is equally distributed between males and females."

Since his birth, Dumanel had a lump just below his forehead. Many in the town of Ti Riviere thought that the lump might have been caused by his mother's cravings during pregnancy or even an evil spirit. His parents, however, felt differently and sought a medical solution for their child. Almane Luxama, Dumanel's father, had to sell a piece of the family's land and their only two cows to pay for their more than 14 hour journey from their home to Zanmi Lasante's hospital in Cange.

When they arrived at the hospital they were met with the hospital's minimal resources and doctors who were unfamiliar with Dumanel's rare condition. But the week Dumanel and his father arrived, a special clinic for cleft lip patients had been set up by Operation Smile and Partners in Health, two nonprofits well known for providing free health care to the disadvantaged people of the world, setting the stage for a meeting between this sick child and the doctor who would help save his life.

Dr. John Meara, plastic surgeon-in-chief at Children's Hospital Boston, was one of the doctors participating in this clinic and as he made his rounds, he noticed little Dumanel. Unlike the other doctors there that week, Dr. Meara had a history of treating a very rare medical condition: encephaloceles. He recognized Dumanel's condition immediately and went to work

to try and help this child. Because the hospital neither had the expertise nor the equipment required for the complicated surgery required to help Dumanel, it was quickly determined that the child would have to travel to the U.S. to receive proper medical treatment.

"It was obviously not something that could be managed [here]. So we thought



Dumanel before the operation.

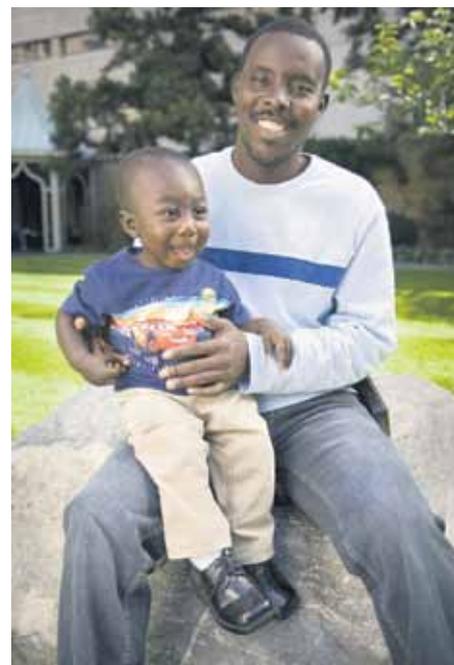
it was best to get him up to [Boston] to have a CT scan and have an evaluation with the neurosurgical team and our team," says Dr. Meara on the Children's Hospital Website.

"Encephaloceles are the result of aberrations in the normal development."

Partners in Health has a history of bringing patients who cannot be treated at local hospitals to larger, better equipped hospitals in other parts of the world. With their help, and money on one hand, and time and facilities from donations on the other, Dumanel traveled even farther from home to Boston, Massachusetts where he could receive the life-saving care he so desperately required. When asked how he felt

about all of this, Almane told the Boston Globe that he was "a proud father and he is my son, it is my duty to take care of him."

The first description of an encephalocele in a medical report appeared in the 16th century. Today, this condition occurs in about 1 out of every 4000 live births and is equally distributed between males and females. For unknown reasons, encephaloceles appear to be more prevalent in South East Asian populations. Encephaloceles are the result of aberrations in the normal development in the womb where a part of the brain and its covering create a defect in the skull. Encephaloceles almost exclusively appear in the pediatric population and can cause nasal obstruction, difficulty feeding, interference with binocular vision, and cos-



Dumanel with his father after the operation.

metic deformities. While encephaloceles are not necessarily life threatening, these lesions can also be the site of infection and create potentially cause complications. The most common treatment for an encephalocele is surgical removal, and early treatment is advocated to prevent later complications.

The details of the surgery are unique to each patient, but in all cases it starts with the removal of the encephalocele. Normally these protrusions (encephaloceles) do not contain any functioning brain,

so when they are removed they do not affect the brain functions of patients. After it has been removed, surgeons reshape the front of the skull which had been deformed by the encephalocele. Parts of the skull are removed from the patient's head, trimmed, and fitted back together like a jigsaw puzzle to give the face a more 'normal' look. See the figure for more details on Dumanel's surgery.

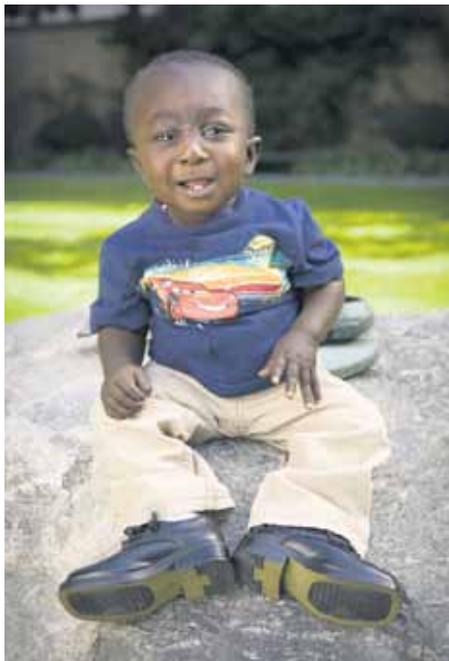
The Surgery

Scans in preparation for Dumanel's surgery revealed another medical complication called an arachnoid cyst. An apple-sized bubble of fluid surrounded by a spider web-like tissue that normally protects the brain, an arachnoid cyst can enlarge over time and cause pressure on the brain. On finding the cyst, Dr. Meara said, "It was fortuitous in this particular case

"Parts of the skull are removed from the patient's head, trimmed, and fitted back back together like a jigsaw puzzle."

because, although it is possible he could have lived for quite some time with the encephalocele, the arachnoid cyst is something that could have given him more difficulty later on."

The doctors decided to treat both the encephalocele and the arachnid cyst in the same operation and on the 21st of August



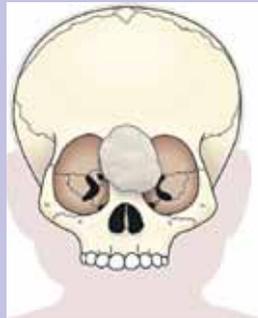
Dumanel after the operation.

COURTESY OF CHILDREN'S HOSPITAL BOSTON

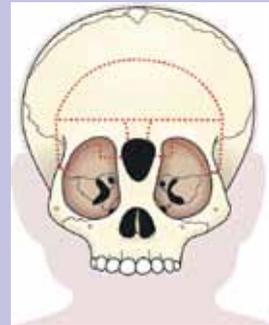
2008, Dumanel went into one of the world's highest tech operating rooms where his life would be changed forever.

First Dr. Ed Smith, a neurosurgeon,

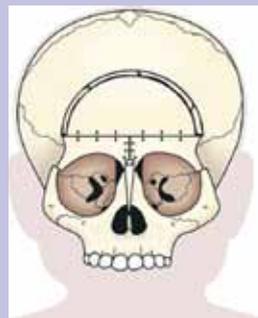
Figure



(a) A frontoethmoidal encephalocele is a protrusion of the brain through an opening in a skull due to a birth defect. This protrusion causes an elongation of the forehead and orbits around the eyes.



(b) The encephalocele is removed, exposing the opening in the skull. Lines are traced along which the skull will be cut. Once cut, these pieces are removed from the rest of the skull so the surgeons can trim and shape them.



(c) The reconstructed piece of skull is placed back on the skull and extra bone from the trimming process is used to fill any gaps. Finally, another bone fragment is used to support the nose to prevent what is called the 'long nose deformity'. Over time, as the patient heals, the bone fragments fuse together again.

ILLUSTRATIONS BY GRAHAM PATERSON, COURTESY OF CHILDREN'S HOSPITAL BOSTON

drained the arachnoid cyst. By carefully creating a channel in the brain, the fluid was drained into the body, the way a body would normally drain excess fluid, rather than externally. Dr. Smith also worked to remove the encephalocele. After this was taken care of, Dr. Meara and his team went to work on reconstructing Dumanel's skull.

The entire surgery lasted almost ten hours, though not that long ago, this kind of surgery would have taken twenty four hours or several operations. The doctors encountered no major difficulties during the surgery and only a day or so later, Dumanel was out of the intensive care unit. Looking at scans taken soon after the surgery was complete, Dr. Meara said, "It's looks so far that it has been successful and from the last CT scan we obtained looked wonderful".

Life After Surgery

While the risk for complication was high, on September 1st, Dumanel celebrated his first birthday. The cyst had put pressure on the part of the brain that controlled his left arm and leg, but now his activity level has increased and he has begun to show increased mobility in those appendages with the removal of the arachnoid cyst.

Dumanel stayed in the hospital for about two weeks after his surgery and remained in Boston for several months after. Almane hopes Dumanel will now be able to grow up and help him on their farm in Haiti.

Almane said, "Now he can start on his road in life."

EXPERIMENTING WITH DREAMS

LOUISE WHITELEY SPENDS A NIGHT AT THE INSTITUTE OF CONTEMPORARY ARTS

Dream Director at the Institute of Contemporary Arts

On a wintry evening in November, clutching sleeping bag and pillow, I dashed through Hyde Park towards the Institute of Contemporary Arts, running late for an appointment with The Dream Director. Artist Luke Jerram, described in a recent book about his work as “an inventor, a researcher, an amateur scientist, an artist: a chameleon of sorts” has developed an installation in which 20 members of the public stay overnight in cosy sleep pods. Each wears a specially designed mask, which responds to the rapid eye movements (REM) that occur during dreaming by playing evocative sound samples. The idea is that these sounds might be ‘incorporated’ into peoples’ dreams – a phenomenon first investigated by scientists in 1958 and familiar to anyone who has dreamt about a siren only to wake and find their alarm clock ringing away.

In Shakespeare’s famous soliloquy, a tortured Hamlet contemplates death, but is put off by the thought of “what dreams may come / when we shuffle off this mortal coil”. It’s tempting to speculate that analogies between sleep and death, between dreams and a spiritual realm, are found in all cultures, and the idea of dreaming as a place where creativity runs riot, or our deepest desires find florid form, appears in such disparate places as Romantic painting, Freudian analysis, and Kekulé’s apocryphal claim to have discovered the chemical structure of benzene in a dream. Following

in this tradition, Jerram is interested in exploring the space between sleeping and waking as a canvas, a place for “making art in the viewer’s mind”. A psychologist would probably respond that all art is in a sense made in the viewer’s mind – our unique neural pathways shape our perception as well as our judgements. In a previous installation, Jerram flashed different coloured versions of a shape in quick succession, building up a 3D after-image that floated in front of the viewer’s vision. This essentially hijacks our perceptual machinery; painting on the eye rather than on the page, but in The Dream Director, Jerram also wants the viewer to

“...analogies between sleep and death, between dreams and spiritual realm...”



DREAMDIRECTOR.NET

interact imaginatively with the artwork.

Anthony Gormley, whose *Case for an Angel* I currently fills the British Museum’s entrance hall, has talked about a ‘paradigm shift’ in contemporary art that resonates with this aim. Gormley hopes to pass the role of the artist to the viewer, who is invited to construct their own experience of the work, putting themselves into the spaces his cast metal bodies push aside. Jerram gestures at a similar idea, but it is hard to see how dreaming about a siren when the sound of an alarm is played is really a creative experience. Although our brains react to the sound in a unique way, there’s no Cartesian ‘I’ that consciously causes this to happen. Some artists have deliberately tried to reveal the impulses of the unconscious, but this sits uneasily with the intention to empower people in their response to art.

Lucid dreaming, when someone becomes aware they are asleep and can direct their dreams, would perhaps be Jerram’s ideal canvas – where the sleeper could intentionally interpret the sounds they are played in dream space. Unfortunately, the team were unable to turn any of us into lucid dreamers, and in fact many people failed to remember any dreams at all! I suspect that the ‘lullaby’ soundscape that played as we dropped off to sleep was an attempt to circumvent this problem, to try and mimic lucid dreaming. As the music began, we were told to close our eyes and explore the mental imagery it evoked. I saw mountaintop monasteries and steam-train journeys through wild landscapes, but these images were far more conventional than those generated unbidden by my sleeping mind.

The book published alongside the installation, *Art in Mind*,

“...building up a 3D floated in front of the

RARY ARTS.

records the 'experimental' progress of the project, and is organised a bit like a lab book. It includes ideas, sketches, records of test runs and failures, and brief essays from other scientists and collaborators. One interesting section reports Jerram's early worries that the project wouldn't succeed as good art, or good science – a thorny issue for the burgeoning 'art-science' field. Tests had found that playing sounds simultaneously to a large group of people was too crude, as it couldn't match the variable timing of REM. At that point, the artistic aims had to take a back seat whilst techie sleep pods were developed to tailor the sounds to individual REM patterns. Now the two (somewhat uneasily) co-exist – despite being presented primarily as an installation, scientists at UWE will use our dream reports in their research.

Sufferers of post-traumatic stress disorder are often plagued by nightmares, and The Dream Director might also lead to a new therapy – previous tests found the proportion of negative dreams was reduced from the typical two thirds to only one third. But rather than paying undergraduates to sleep in labs, the team have managed to get people like me to pay to take part in their experiments. Cultural events that collect scientific data, rather than exploring peoples' opinions about science, are usually restricted to simple observations such as the number of rare birds in your garden. The peculiar nature

"...there's nothing more boring than someone else's dreams."

**after-image that
viewer's vision."**

of dream research, which is fundamentally interested in subjective experience, allows The Dream Director to move beyond this mechanical approach, but I wonder how useful the resulting data will be.

On his website, Jerram writes that the installation "raises questions about the rules of interaction and boundaries of science and art". By placing an experiment in a gallery, he certainly challenges assumptions about how the public can take part in science. But the more important idea for me was that we can take a 'scientific' approach to our own experience – like Jerram, cultivating a magpie's eye for the startling ways that our senses filter and interpret the world. There are echoes here of the 'phenomenological' psychology that historically struggled against behaviourism – for most of the 20th century, scientists preferred the observable phenomenon of Pavlov's salivating dogs to the ineffable introspections of philosophers.

In recent decades, with the advent of scanners that have begun to reveal the ongoing activity of the human brain, scientific interest in phenomena such as dreaming, consciousness, and emotion has exploded. Such studies have the potential to bring "wonder and awe to everyday experience", as Gormley (and Jerram) hope to do through art. And although



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The Dream Director shares with psychologists the tension between collective experience, and the fact that consciousness is ultimately private, the excited discussion over breakfast in the ICA café challenged the cliché that "there's nothing more boring than someone else's dreams".

The Dream Director is currently on tour, see www.dreamdirector.net. 'Art in Mind', which explores Luke Jerram's practice, is edited by Aikaterini Gegisian and Gill Haworth in collaboration with the artist, and is published by Watershed and UWE.

Statuephilia, including Anthony Gormley's work 'Case for an Angel I', is on until the 29th of January at the British Museum, see www.britishmuseum.org.

DREAMDIRECTOR.NET



Popular Science Magazines

Katherine Jones reviews *Cosmos*, *Seed* and *Discover* magazines.

Popular Science

www.cosmosmagazine.com
www.discovermagazine.com
www.seedmagazine.com

Cosmos? No there hasn't been a typing mistake. This is a review of *Cosmos*, the Australian science magazine. Not *Cosmo(politan)*, the much loved magazine for "Fun and fearless females". Don't be disappointed, the three glossy science magazines here have much entertainment value and plenty to say about the world and science. So much so, I am disappointed to only have time for a brief review of the highlights of these magazines. In short they're entertaining, topical and quirky, each with their own distinctive brand of popular science.

Like the media in general, the December issues are a little celebrity obsessed. Famous faces from the world of science grace the covers of the magazines. The "50 Best Brains in Science" could not possibly be complete without Steven Hawking. It comes as no surprise to see the iconic physicist gazing stoically on the *Discover* cover. The celebrity usage continues with the "private" face of the Human Genome Project, Craig Venter, on the cover of *Seed* magazine. His piercing blue eyes give edge to the headline "A New Kind of Science".

As the year draws to a close, the three magazines have taken a topical agenda, writing about the year that was 2008. *Discover*, for example, features "The Top 50 scientists" of the year. This is not a literal count down of scientists in rank order, like the music charts or football league (Though imagine if it was...). Instead it is a collection of profile pieces, describing the challenges and motivations of these inspirational scientists. The top 50 is grouped into categories such as "5 Scientists Under 20" and the "10 Influentials". The lifetime achievers include E. O. Wilson, Vinton Cerf, Stephen Hawking, Edward Witten and Noam Chomsky. I was pleased to get a sense of who these people are, and the different paths their lives had taken. I felt a slight disappointment at the bias towards US based scientists, but it is an American magazine.

Seed magazine took a rather different angle on the end of year report. This issue featured an in-depth analysis of the state of science. Peppered with statistics and graphs, this evaluation was highly informative and covered every corner of science, from finance to the latest emergent science cities around the globe. The content is predominantly interview based, with an almost random selection of contributors. Hedge fund managers featured alongside *Cafe Scientifique* and seventh graders Draw-A-Scientist sketches. Judging by what I have read, *Seed* might be aimed at

those in science industries looking to see the bigger picture. It's an interesting read, with plenty to say about today's changing science landscape.

The big story in *Cosmos* magazine this month: Charles Darwin Bicentennial. 2009 is a celebration marking 200 years since Charles Darwin's birth, plus the 150th anniversary of the publication of his seminal work "On the Origin of Species". Hence, *Cosmos* made the December issue an evolution special, dedicating several articles to the hot topic.

Cosmos's "Origin of a theory" is about the historical circumstances surrounding the publication of "On the Origin of Species". Darwin, too, had selective pressures influencing the evolution of his work. Next, the future of the human race comes under discussion, as Geneticist Steve Jones proposes humans will undergo a sort of "grand averaging" of genetic diversity. Instead of *Homo sapiens* evolving into new species, he suggests we may over time become increasingly similar, genetically speaking.

Finally, my favourite article of the trio. A biographical walking tour of landmarks of Charles Darwin's life in London! I was somewhat surprised this was included in *Cosmos*, as the magazine is published in Australia. Nonetheless, Darwin has made his mark all over the city.

In South Kensington, you may have seen the statue of Darwin in The Natural History Museum cafe. There's Brown's Hotel where the intriguing elite pro-Darwin "X-club" would hold meetings. The site of his bachelor pad at 36 Marlborough Street is still physically intact, although it's purpose has changed over the centuries. It is now home to Leon, a healthy takeaway cafe, conveniently placed for shopping on Carnaby Street.

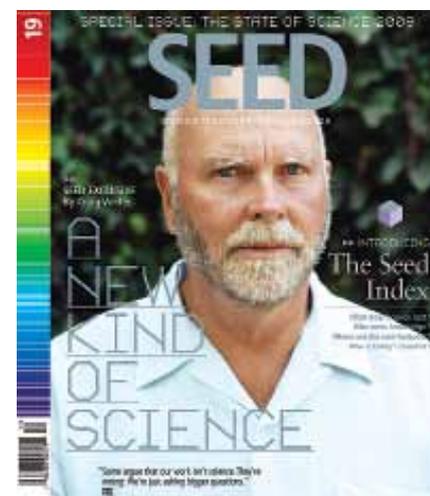
Cosmos again excelled it's namesake with some great short stories in the fiction section. "The Noise Machine" is a crime thriller about mysterious lethal tattoos with human eyes. "The Broken Hourglass" by Andy Heizeler is a time travel story, with a plot loosely based around the neuroscience of memory. This was a great read, and pleasantly reminded me



"*Discover* provides access to startling developments in science, technology and medicine with a renewed emphasis on how those breakthroughs affect the world."



"*Cosmos* is a print magazine, an online news and features service and a weekly newsletter. All treat science as natural part of culture, covering it from many angles: art, design, travel, interviews, humour, history and opinion."



Seed aims to provide their readers "with the most relevant, insightful and entertaining original science content" it "communicates science's fast-changing place in our culture to an international audience."

of one of my favourite books, “The Time Traveller’s Wife” by Audrey Niffenegger.

“Vital signs” in *Discover* magazine is a monthly column written from the doctor’s perspective, detailing the logical workings of a medic’s mind. In this case an initial uncertain diagnosis of spousal abuse is ruled out in this otherwise happy couple, in favour of an uncommon neurological sleep disorder.

From the cover to cover, all three magazines had great articles, news and reviews. I thought *Discover* was accessible and very relevant, maybe created with a broader audience in mind. Seed critically evaluated a whole host of subjects in depth, from the ethics of primate experimentation to intellectual property. *Cosmos* was very entertaining, taking every enjoyable angle on the science, from art to ice, fiction to evolution.

The Most Controversial Theory

Flora Mactavish reviews Darwin’s Big Idea.

Darwin Big Idea

Natural History Museum, until 19 April 2009



The exhibition coincides with the 200th anniversary of Darwin’s birth. It includes displays of Darwin’s personal letters and belongings as well as extensive coverage of his evolutionary theory and its social impact.

Darwin first started to formulate his theory when he noticed the differences between the species of mockingbirds found on different islands in the Galapagos. His finches also showed the same pattern. Darwin’s notes and letters relating to these finds are on display as well as stuffed specimens of the mockingbirds and finches.

There are several other examples of the ways in which different species exhibit the evidence for evolution. The bone structure of the legs and hooves of ancient equestrian species show a adaptive changes seen in the modern horse, whilst the bat skeleton looks a bit like a tiny human with very long, thin fingers. These provide excellent examples of the similarity between the skeletal structure of different mammals. The skulls of early hominids demonstrate the evidence for human evolution.

Darwin himself did not have access to these fossils, but his studies of modern apes convinced him that humans and apes have a common ancestor. The ideas are well known, but nothing compares with seeing the overwhelming evidence for evolution in the form of skeletons and animals.

Darwin’s list of the pros and cons of getting married provides some light relief; he wonders whether a family will get in the way of his scientific pursuits, and mentions that a wife would “provide a constant companion ... better than a dog”. His letters to his future wife, Emma Wedgewood, appear to show that he was happy with his decision.

There is also some memorabilia from his children, who were encouraged by their father to take an interest in natural history. In particular there are mementos of his daughter Annie, who died as a child. Darwin lost his religious faith following her death, when

he became an agnostic. It is interesting that it was the death of his child and not natural selection theory that caused him to lose his faith.

Darwin’s circumstances and working environment differed from those of most modern scientists. His father, Robert, supported him financially in his early career. Although initially opposed to Darwin’s participation in the voyage of the *Beagle*, he paid Darwin’s expenses after an uncle, Josiah Wedgewood, persuaded him that it was a good idea. The correspondence relating to this is displayed in the exhibition.

Darwin lived in London for a few years following the return of the *Beagle*, but soon moved to the country, suffering from bouts of ill health for the rest of his life. The reconstruction of Darwin’s comfortable study at his country home provides further insight into his way of life. Although he was a respected member of the scientific community throughout his life, and kept up with scientific developments by reading books and journals, he worked in relative isolation for long periods of time. He published *On the Origin of the Species* after nearly twenty years of work, eight of which he spent working mainly on barnacles.

Part of the reason why Darwin took so long to publish his theory was that he worried that the public would not accept it, and that it would be interpreted as a direct attack on the Church. However, he was not the first person to suggest a form of evolution as an explanation for the diversity of life on earth, just the first to come up with a feasible mechanism (natural selection) that was supported by evidence and that made predictions that could be tested. His book was actually received well and he was eventually given a state funeral, although there has been a degree of opposition to evolutionary theory.

Although there is not necessarily a lot of new information in the exhibition, I think the skeletons and fossils provide a good way to illustrate evolutionary theory, and will add something to your understanding of it. I also found it interesting to learn about Darwin’s personal life, and the story of his discovery.



Questioning Gender

Louise Whiteley reviews the debut film from Argentinian director Lucia Puenzo.

XXY

Lucia Puenzo (2007)

XXY begins with a claustrophobic run through a dry, autumnal wood – feet pound in rhythm with ragged breath and snapping twigs, and we catch glimpses of two slender forms chasing each other through the trees. This feels a lot like the opening sequence of a horror movie, but quickly gives way to realistic drama, establishing the film's ambiguous tone. Argentinean director Lucía Puenzo mixes a linear narrative about Alex, an intersex (or hermaphrodite) teenager whose parents are wrestling with how to 'choose' a gender for their child, with dark, symbolic glimpses into her struggle for identity.

Gender and sexuality are often used as examples of how a science-centric worldview can create distinctions that fail to reflect peoples' experience, especially with concepts that are partly culture-dependent. Even from the scientific perspective, there are ongoing arguments about how chromosomal abnormalities (when people have combinations other than the typical XX or XY) should be combined with developmental and psychological factors in defining intersexuality. Alex doesn't actually appear to have the syndrome caused by an XXY genotype, and the film doesn't teach us very much about the medical science. By instead focusing on an individual's experience of this schism in the neat, tick-box categories of gender, it resists the voyeuristic nature of 'freak show' medical documentaries in favour of messier psychological insights.

The bravery of the film is reflected in the bravery of the family at its heart – when Alex was born her parents moved to a remote Uruguayan island to avoid the scrutiny of society, and whilst Alex has been raised as a girl, they have opposed genital surgery until she is old enough to decide for herself. The film begins when Alex is fifteen, and has secretly stopped taking hormone tablets that suppress male puberty. Impatient for her transition to 'womanhood', Alex's mother has invited a friend to stay, who, unknown to Alex, is a plastic surgeon. The lack of communication between family members who care deeply for each other is perfectly observed, and the encounter between Alex and the surgeon's son Álvaro further illuminates faultlines in the idea of binary choice, as Alex's uncertainty about gender is echoed by Álvaro's confused feelings about the masculinity brutally embodied by his father.

Symbolism abounds, as the surgeon slices meat in a kitchen bathed in cold, turquoise light, and Alex's father tends to turtles mutilat-



ed by fishing nets. Hermaphroditic sea-creatures appear throughout the film, and the story of Alex's conception on a rocky outcrop at the edge of the ocean sets up a disconcertingly mythic backdrop for the naturalistic acting. Refusing to play by the rules of either heavy-handed Hollywood symbolism, or realistic psychodrama, Puenzo creates a visual language that directly speaks about the themes of the film, but at times I found this intrusion of metaphor almost too insistent.

XXY could perhaps be described as a modern fairytale - taking the idea of a story that helps us to come terms with the difficulty of negotiating boundaries between natural and unnatural, child and adult, but resisting a complete or moralistic ending. In Hans Christian Anderson's *The Little Mermaid*, which asks whether a creature from another realm can become human, a sea-witch offers the mermaid an irrevocable and fatal choice. In XXY, the rough magic of medical intervention is questioned, experimented with, and shown to reveal challengeable assumptions about the borderlands of identity. The narrative, like Inés Efron's impressive performance as Alex, teeters between awkwardness and grace, flirting with resolution right up to the credits.

Puenzo's debut steps into a rich history of cinematic challenges to traditional gender roles, but also shares territory with a diverse group of films that challenge the omniscience of the scientific establishment, including Erin Brockovich, *Far from Heaven* and *Lorenzo's Oil*. XXY uses the common motif of a lone protestor against a faceless institution, but also ponders how the potential conflict between personal experience and the stories 'written in our genes' is weaved into all our lives – revealing the universality of what is often presented as unique and strange.

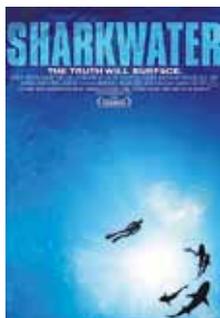


Friendly Jaws

Katie Wookey dives into Sharkwater

Sharkwater

Rob Stewart (2008)

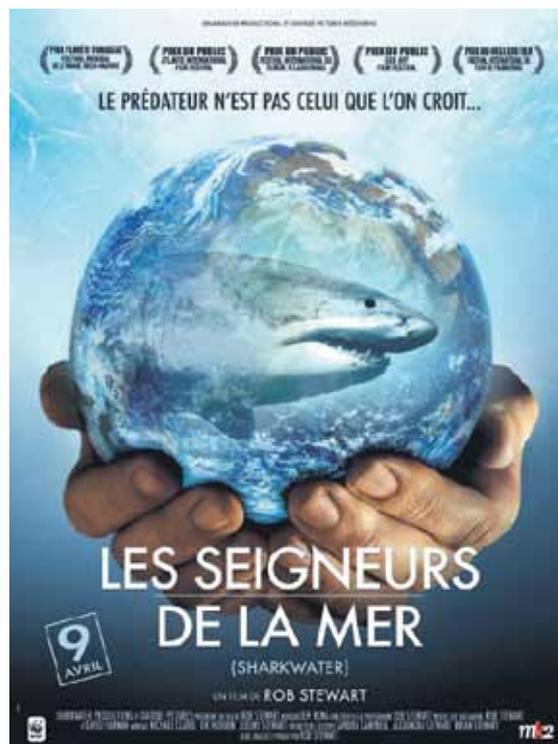


Sharks have long been demonised by the media as man-eating monsters, and films like *Jaws* fuel our fears. Actually, it's the sharks who should be afraid. Illegal fishing to feed the multi-billion dollar shark-fin industry is pushing some species dangerously close to extinction, and unlike their cuter counterparts such as pandas and elephants, no-one knows or cares about the loss of the world's shark population. Cue Rob Stewart – photographer, biologist and self confessed shark aficionado, who was so disturbed by the plundering of our

oceans that he decided to make a film to highlight their plight.

One of the opening scenes of the film shows writer/director/producer/presenter Stewart, enjoying an underwater embrace with a shark – they're not dangerous, apparently. But do sharks need to be sweet and cuddly before we'll help them? No, but, Stewart does go on to demonstrate that sharks are not the aggressive fiends of our imaginations - did you know that in one year crocodiles kill as many people as sharks have over the last hundred? Reassuring perhaps, but it is the overarching environmental implications at stake that drive home the need for action.

The crux of Stewart's argument, presented through interview clips with several scientists, is that the ocean regulates the Earth's atmosphere through plankton, microscopic organisms that lock-up carbon dioxide and produce 70% of our oxygen. With sharks positioned at the top of the food-chain, killing them off would dramatically alter the balance of marine ecosystems, and ultimately impact on our climate – as Stewart laments, "Life on land depends on life in the ocean. I finally realised it's not just about saving sharks, it's about saving ourselves". On a more immediate level, the methods used to catch the sharks as portrayed by Stewart are vicious and inhumane: the poachers use long lines, which are unselective and capture all kinds of marine life, to maximise their catch. Hauled aboard the boat, the shark's fins are sawn off and transported to China, where shark-fin soup is a delicacy and status symbol. Meanwhile their bodies are tossed



into the ocean to die – the footage of butchered sharks is truly gruesome and makes for harrowing viewing.

The brutal tactics employed by the fishers have pushed environmental activists to take severe actions, and the story really picks up pace when Stewart unites with renegade conservationist Paul Watson. The pair journey to Costa Rica in a bid to bring illegal shark fishers to justice, where a full-on battle with pirate poachers ensues, shot viscerally on hand-held cameras from Stewart's boat - the use of editing and music, alongside the manic boat-to-boat combat on screen involving a giant "can-opener" and hoses, really cranks up the tension.

However, after disabling the pirates' boat and presenting them to the authorities, it is the conservationists that are arrested and charged with attempted murder. Stewart suggests that the shark-fin mafia have friends in high places to protect the poachers, although his actions can also be viewed as extreme and dangerous. In this way (perhaps unwittingly) the film invokes a moral debate over the ethics of vigilantism versus a more considered approach to tackle the issue through legitimate channels for a longer term solution.

Stewart's struggles against the pirates make for a fascinating insight into the shark-fin trade and the fight against it. All the more frustrating, then, when the documentary is hijacked by Stewart's own ego and a chunk of the film's running time is taken up by his recuperation in a South American hospital from a dose of flesh-eating bacteria. At these points the film loses focus as it makes some ham-fisted attempts to gain sympathy for the documentary-maker as the put-upon hero of the piece, rather than concentrate on the weighty issues at hand.

Sharkwater treats us to some stunning wildlife scenes in the Galapagos Islands, and the underwater photography is superb, a testament to Stewart's skills as a camera man. Although he drags the focus of the story out of the water and into his personal life - his fondness for posing in speedos would be better placed behind the camera, and his monotonous voiceovers wear thin after a while - nonetheless, Stewart has crafted a film that is impassioned, brutal, emotive, and has a true ecological and ethical relevance.



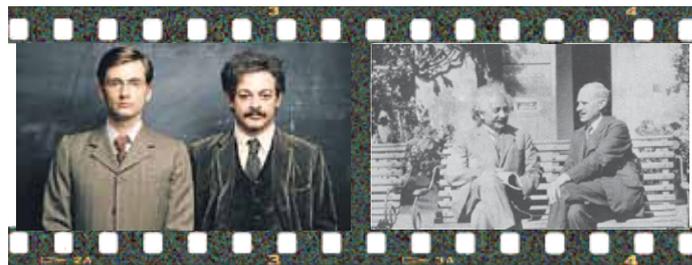


Einstein and Eddington

Reviewed by: **Jacob Aron**

Einstein and Eddington

on BBC 2



Einstein and Eddington is the story of two men - one so famous that his image has become the very icon of a scientist, the other mostly forgotten by the world outside of science. Everyone has heard of $E = mc^2$, even if they do not know its meaning, but I can only name one of Eddington's achievements; namely the 1919 expedition to the South African island of Principe to observe a solar eclipse. It was here that Einstein's Theory of General Relativity was put to the test, and it is here that the BBC drama Einstein and Eddington begins.

As Eddington awaits the eclipse, hoping for the rain to end, we flashback to five years earlier. The First World War is beginning, and the conflict between England and Germany has spilled over into science. Germany is rounding up its experts in preparation for war, and there is one man they desperately want: Einstein. Eddington is tasked with finding out why.

The film is a treat for fans of science fiction as much as fans of science. Andy Serkis (Gollum from Lord of the Rings) and David Tennant (Doctor Who) take the titular roles and make them their own. Writer Paul Moffat takes every opportunity to contrast the two men, and Serkis's crazy-haired womanising Einstein is a far cry from the homosexually repressed Quaker Eddington, who makes a welcome change from Tennant's typically manic Tardis dweller.

At times, this was perhaps taken a little too far - although I admit to not being widely read on Eddington, I've literally never seen any mention of him being gay. It might be that this aspect of his personality was accentuated a little to further stand apart from Einstein. This could be because their differences were essential to the message of the film: science transcends all. Eddington, railing against a proposal to banish all German members from the Royal Observatory following the gas attack at Ypres cries "The pursuit of truth in science transcends national boundaries, takes us beyond hatred, and anger and fear! It is the best of us!" Einstein is equally horrified by what his countrymen in Berlin have done, and his outbursts lead to him being denied access to the University.

These two men, so different in their approach both to science

(Einstein was a theorist, whilst Eddington prided himself on being "the best measuring man in England) and to life, brought about a scientific revolution and overthrew Newton despite only corresponding by letter. Indeed, our protagonists don't even meet in the film until one, final, handshake.

It's undoubtedly great drama, but what about the science? As is perhaps unavoidable, much of the explanations of relativity seem outside from the unfolding story. Einstein explains his ideas to his son, and Eddington turns to a convenient German family that he rescues from beatings at the hands of the English. The concepts are there, including a nice demonstration of the curvature of space using a tablecloth, a loaf of bread, and an apple, but it can't help but feel slightly off.

Still, the ideas are presented interestingly enough for the casual viewer to pursue if they wish. Disputes about the accuracy of Eddington's confirmation in Africa are also swiftly brushed under the table - but that's only to be expected, as they don't fit into the tidy narrative the film wishes to impart.

The film was broadcast by the BBC in November of last year, and is now available on DVD. The DVD itself is a rather miserable affair with no special features whatsoever, but then this is a television production so it is hard to expect too much. It does however come with an audio description soundtrack for the blind.

If you're interested in physics, I'd highly recommend the film for bringing to life two of the architects of Newton's demise. It's not often that the story of scientists gets told in such an engaging and well produced manner, so be sure not to pass up this rare treat. Even if you don't know your Special from your General Relativity, Einstein and Eddington makes a great period piece for fans of the genre. Finally, for those of you already mourning the replacement of David Tennant as the Tenth Doctor, here's another chance to see the man in action.

Japan Car

Japan Car: Designs for the Crowded Globe

Science Museum, until 19 April 2009

Upon entering the Science Museum's Japan Car exhibition, you might be forgiven for thinking you've wandered in to the wrong room. Visitors are greeted by a display of bonsai trees, the miniature Japanese trees. Don't worry, you're in the right place - these were created by artist Seiji Morimae to complement the cars on display. Indeed, each bonsai display contains a small model car, evoking the natural stones typical of the bonsai art form. All very good, but isn't this the Science Museum?

Moving in to the next room, we find "The view from there", a short film that artistically explores the urban landscape of modern Japan. Roads weave across the three large screens in a pleasantly re-



laxing manner, but I couldn't help feel like I was watching an extended car advert - an impression that would only grow as I walked through the rest of the exhibition.



Leaving the film to its eternal looping, I entered the exhibition proper. The stark white appearance of both the cars and accompanying displays gave the effect of being inside an iPod. Everything oozed style, but in a way that seemed extremely calculated. Looking down at my feet, I spotted the exhibit barriers, and winced. Bamboo-like poles supported by tripods made from chopsticks, clearly intended to evoke Japanese culture, just seemed a little bit crass.

Each of the 14 cars in the exhibit are displayed alongside information about the relationship between their design and Japanese culture. It all comes off very slogan-like, with titles such as "One of the Very Best Off-Road Performers" and "Cars Finely Honed for Fuel Efficiency". I almost expected to be offered zero-percent finance.

Determined to find some actual science content, I pressed on. One car had all of its inner workings laid out for easy viewing – interesting, but it didn't tell me anything about how the pieces actually fit together to make the car run. Later displays explained the principles of hydrogen fuel cells, but with the information directly above Honda's latest model, I couldn't help but feel uncomfortable about the commercial undertones.

One of the last pieces in the exhibition is the Toyota i-REAL, a concept car in the loosest sense of the word. Looking somewhat like a cross between a wheelchair and a motorcycle, its sleek aesthetics instantly reminded me of the film *Wall-E*. In Pixar's 2008

animated hit, intrepid robot *Wall-E* discovers that human beings have been reduced to mega-obese consumers who glide around in hovering wheelchairs very similar in form to the i-REAL. Probably not the image intended by Toyota, but once I'd made the connection I couldn't get it out of my head.

Understandably the exhibition was put on with the aid of leading Japanese car manufacturers, and a little bit of product placement can be forgiven, but having reached the end in under half an hour it seemed that Japan Car is all product and no exhibition. When you consider the £8 cost of admission, it's hard to recommend to all but the most devoted petrol-heads or Japan-o-philes. If the exhibition had been put on at the V & A museum, the focus on design and culture might have felt more comfortable, but in the Science Museum I want a little more substance. **Jacob Aron**

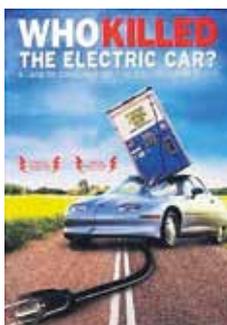


No Crime but Punishment?

Katie Wookey investigates an environmental murder mystery.

Who Killed the Electric Car?

Chris Paine (2006)



Now you see it, now you don't: Chris Paine investigates the 'mystery' of the vanishing electric car in his feature length documentary.

Air pollution is of huge concern in California and lung diseases are rife. Gas guzzling cars are one of the main culprits, so in the mid 90s when General Motors (GM) launched their electric vehicle, the fast, clean and quiet EV-1, surely it couldn't fail to succeed? It seems not: less than ten years later, all electric cars had disappeared.

A factual whodunit, the film explores the roles of various 'suspects' that had a hand in the demise of the electric car. By blending interviews and TV footage Paine builds masses of evidence in favour of the EV-1 – it's endorsed by celebrity fans Mel Gibson and Tom Hanks, and drivers and GM-insiders alike rave about this efficient and attractive looking vehicle. You can imagine then their surprise when all EV-1s were recalled, only for the per-

fectly conditioned cars to be scrapped.

According to Paine, California was the first state to pass legislation requiring auto-makers to produce a certain proportion of cars with zero emission engines. Sadly, Paine says, this progressive thinking from a traditionally environmentally backward country was not to last; car manufacturers, oil companies and the central government are all accused of conspiring in a plot against the electric car and new legislation since, put simply, the financial incentives to keep a nation of oil-junkies hooked are too great.

Maintaining an element of balance, GM are invited to explain why the EV-1 was eradicated from showrooms, and contrary to numerous other accounts, they cite insufficient demand. However, through his selection of interviews, Paine argues that GM employed underhand tactics to drive away customers because the profit from servicing and replacing parts was practically nil: and for this crime of efficiency the EV-1 was sentenced to death.

The film features a tongue-in-cheek funeral for the EV-1 before it passes judgement on each of the suspects. Consumers, oil companies, car manufacturers and the government are all guilty, according to Paine. Although arguably some are more so than others, the reasoning behind GM's bizarre efforts to destroy their fleet still remains to be unearthed.

Paine is clearly passionate about the EV-1, and despite Martin Sheen's dreary narration, he has created a persuasive film with a brisk pace and jam-packed with interesting nuggets. The film effectively ridicules car manufacturers as it stacks up compelling evidence against them, and as their explanations (or excuses) drift further and further from the viewer's realm of believability, Paine adds a slither of humour to an otherwise bleak issue.

Although produced in 2006, this battle of corrupt, greedy institutions versus the environment and its defenders takes on a new relevance during this time of unstable fuel prices, and with President Barack Obama's pledged commitment to tackling global warming, perhaps the electric car will rise again.

Chris Paine is now making a sequel with, when first announced working title was *Who saved the electric car?* but it now changed to *Revenge of the Electric car* with release date planned for 2009. You can follow his filming escapades on <http://revengeoftheelectriccar.com/>.

