I, SCIENCE

THE SCIENCE MAGAZINE OF IMPERIAL COLLEGE

PLUS

CITY SCIENCE

IS 7 BILLION SUSTAINABLE?

THE SCIENTISTS THAT HISTORY FORGOT

INTERVIEWED: LORD JENKIN & SIR PATRICK MOORE

I, SCIENCE

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I, SCIENCE

Is seeing believing? It is probably safe to assume that none of the readers of *I, SCIENCE* have seen the dark side of the moon. Yet, disbelief in its existence would be considered demonstrative of, well, lunacy. I equally suspect that few readers have ever seen an electron, an Elephantiasis sufferer, an East African Bongo, or an El Oro Parakeet first hand. Nonetheless, we rightly do not doubt the existence of any of these things.

Science is often described as 'organised scepticism' and scientists are encouraged to accept nothing on authority. The idea is simple really: should one doubt the veracity of specific scientific claims, one can just go back, find the paper, look at the description of the experiments upon which these claims are based and repeat these experiments to see if the same results can be obtained.

However, as science becomes both increasingly specialised and expensive, such verification through repetition is becoming an ever-less realistic proposition. I, for one, will certainly not be building a hadron collider in my back garden anytime soon. Nor will I be flying round the dark side of the moon in the near future. Thus, it would at least superficially seem to appear that science is becoming ever-more reliant upon faith. And, this problem does not only exist with regards to lay members of the public wishing to learn more about science. The increased specialism of science equally means that a leading researcher in the field of particle physics will almost certainly have to accept the latest research findings from the field of, say, population genetics on authority.

So, what's the solution to this problem? How can scientists calibrate the quality of research across scientific disciplines? And how can we, the public, judge what is and isn't good science? Former President of the Royal Society, Lord Rees, has suggested that the solution lies with science journalists, who, with their 'jack of all trades' level of scientific understanding and extensive lists of contacts from varying scientific fields, are uniquely positioned to make judgements regarding the reliability of scientists' claims.

So, in this spirit, we at *I, SCIENCE* will endeavour to discern the good from the bad scientific research for you and throw a light upon the usually unseen inner workings of the ivory tower.

ANDREW & DAN

OUR BLOG REACHED 4,000 DAILY HITS LAST MONTH

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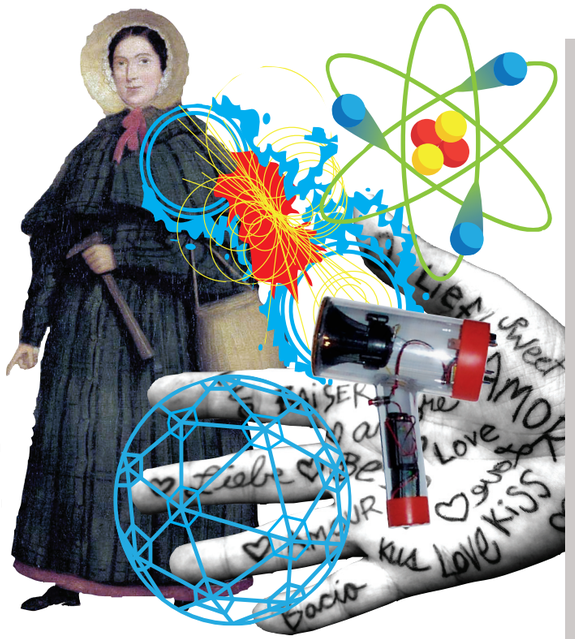
FRONT PAGE IMAGE BY JAN PIOTROWSKI

COVER FEATURE



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Planck is out there

Astronomers from Imperial College London and the European Space Agency have unveiled images of previously unknown objects from the outer reaches of our Universe. Europe's Planck spacecraft sits more than a million kilometres from Planet Earth, transmitting images of our own galaxy and what lies beyond the Milky Way.

Launched in May 2009, Planck's main purpose is to collect images of the Cosmic Microwave Background (CMB), the thermal radiation that filled the universe following the Big Bang. The data that is now being received will allow astronomers and astrophysicists greater insights into how galaxies evolve.

Information received from Planck has led to the discovery of 900 clumps of cold gas and dust from which stars are born. Galaxies that were previously invisible to scientists can now be seen forming new stars at rates of 10-1000 times higher than we see in our own galaxy. These images were previously contaminated by infrared light.

Another mystery solved by the Planck satellite is the origin of a strange diffuse light within our own galaxy. This microwave fog is now known to come from dust grains spinning at tens of billions of times a second after collisions with photons of ultraviolet light. Scientists are now able to remove this fog from the Planck images with greater accuracy, avoiding contamination of the vital CMB information and allowing much clearer images to be created.

Planck can also identify rare clusters of galaxies. Further knowledge of the number of these clusters could provide scientists with valuable information about the nature of our Universe and the rate at which it is expanding.

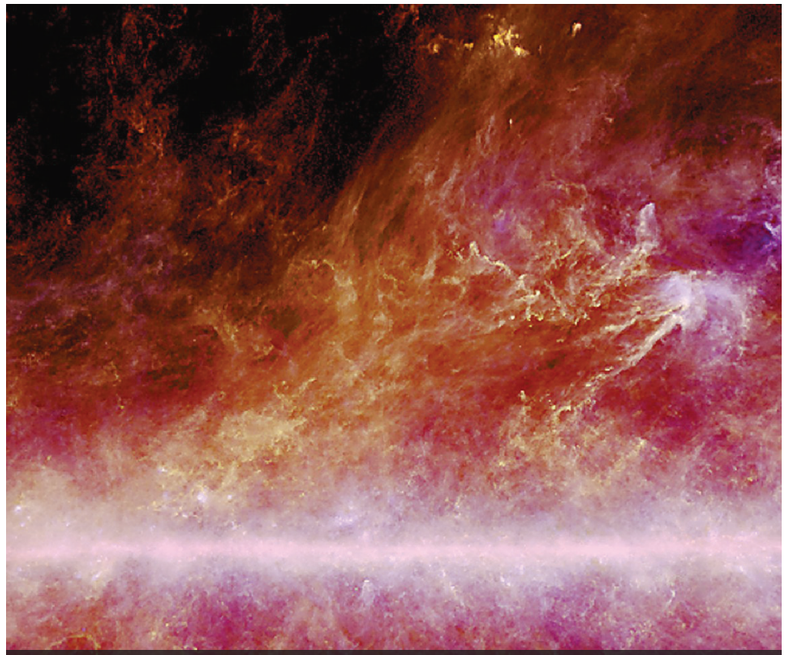
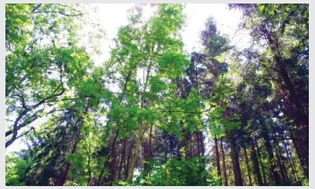


Image from Planck's all-sky survey showing dust structures within 500 light years of the sun

WOOD THAT IT WERE



A new project headed by Imperial college scientists has just been launched. The Stability of Altered Forest Ecosystems (SAFE) project plans to be one of the largest ecological studies in the world. It aims to construct a detailed picture of the effects of deforestation and fragmentation on the way forest ecosystems function via observations made over the next ten years. It is hoped that the results will improve management and conservation of forests in the future.

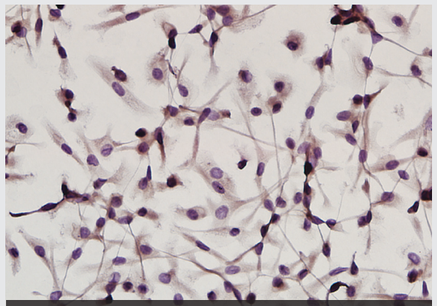
NO USE SWINE-ING ABOUT IT

A study published in the journal P.N.A.S. has revealed clues about how swine flu spread in schools during the 2009 pandemic. The results show that children are three times more likely to infect others of the same sex than of the opposite gender. The results also suggest that transmission is higher between members of the same class, but sitting next to someone with flu doesn't increase a pupil's chances of catching the disease.

SHINY NEW SEQUENCING

Technology that could sequence someone's genome in a matter of minutes has been patented by researchers at Imperial. Strands of DNA are fired through tiny nanopores cut in a silicon chip. The code is then read by a computer, which interprets the unique electrical signal produced by each base as the sequence emerges from the chip. The method is fast and relatively inexpensive and could soon give the general public the chance to know their own genetic code.

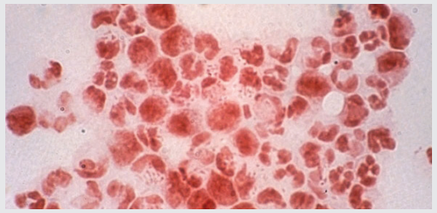
INFLAMMATION INFORMATION



Macrophages attached to IR5-binded antibodies

A 'master switch' in white blood cells that determines whether or not they promote inflammation has been identified by Imperial scientists. The protein known as IRF5 can switch on genes within white blood cells that activate inflammatory responses. IRF5 can also activate 'dampening' genes, which inhibit an inflammatory response. The human body triggers an inflammatory response to protect itself against harmful stimuli. However, diseases such as rheumatoid arthritis can cause excessive inflammation that can harm the body. This new understanding of how inflammatory responses are regulated is vital for the treatment and prevention of unwanted cell responses.

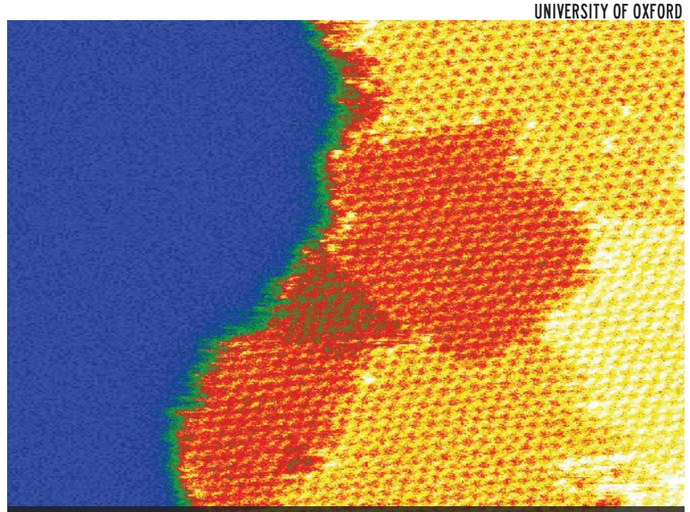
SMOKING OUT BACTERIAL LINK



An analysis led by Professor Majid Ezzati, Chair of Imperial's School of Public Health has revealed that children exposed to secondhand smoke are twice as likely to get invasive meningococcal disease as children not exposed to second-hand smoke. The analysis reviewed every previous study that has investigated the incidence of invasive bacterial diseases in children exposed to secondhand smoke compared with those not exposed. Further research could confirm a link between secondhand smoke exposure and an increased infection with streptococcal bacteria and *Haemophilus influenzae* type B.

Uncovering nanosheets

UNIVERSITY OF OXFORD



Atom-thick nanosheet imaged by an electron microscope

An international study carried out at Imperial College London has succeeded in creating nanosheets. While only one atom thick, these nanosheets could lead the way in revolutionizing energy storage technologies and electronic devices.

For decades, scientists have been trying to create nanosheets strong enough for practical use. The new technique involves the use of ultrasonic pulses and common solvents to create nanosheets from 'layered materials', structures similar to the graphite in your pencil. When split into nanosheets these layered materials are able to conduct and store energy. The layered material is mixed with a solvent that is then subjected to high frequency sound energy from an ultrasonic probe. The solvent and the ultrasonic vibrations causes these materials to split into nanosheets.

This method is simpler, quicker and cheaper than previous techniques and has the potential to be scaled up to an industrial level. The most important application of these nanosheets is their use as thermoelectric materials, where they could potentially generate electricity from waste heat. Gas, oil and coal-fired power plants can lose up to 70% of the energy they produce in waste heat; much of this could be recycled using thermoelectric devices created from nanosheets.

Professor David McComb of Imperial College's Department of Materials contributed to the research and believes that nanosheets could be combined with conventional materials to create new kinds of hybrid computing technologies. Nanosheets could also be used in next generation batteries known as 'Supercapacitors'. These are thousands of times faster at delivering energy than standard batteries, and could vastly improve technologies such as the electric car.

ARSENIC BACTERIA, FOREST HYSTERIA, CLIMATE CRITERIA AND A COMPUTUER THAT KNOWS EVEN MORE THAN WIKIPEDIA!

In December, NASA revealed that they had found something like alien life on Earth. A species of bacteria, discovered in Mono Lake, California had reportedly managed to incorporate arsenic into its DNA molecules in place of phosphorus. Rumours had ricocheted across the internet even before the embargo had been lifted and the paper itself had been released. When *Science* published the press release it seemed irrefutable: bacteria were using arsenic in molecular structures. However, cracks soon began to appear in the story and eventually, once *Science* had made the paper freely accessible, we were in for a rather large dose of disappointment. In fact, the bacteria could not be proved to have become fully independent of phosphorus and the situation they had been placed in was somewhat artificial. The internet storm the paper stirred up, however, provides some interesting food for thought on access to research and media hype, even if that food isn't based on a notoriously toxic element.

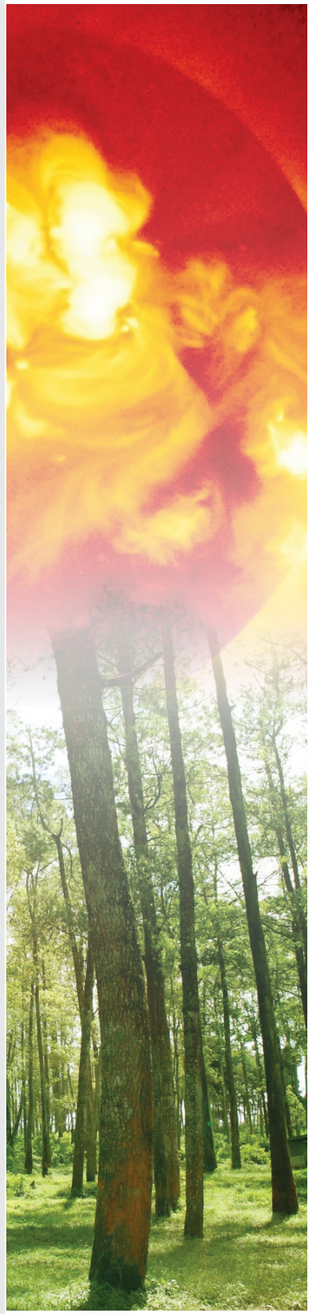
Speaking of hype, last week we were expecting to be cast into electronic oblivion by solar flare activity. Has anyone had any solar flare trouble? Anyone?

Here in the UK, planned protests became parties as the government announced that it was no longer planning to sell off 258,000 hectares of state owned English woodland. The proposed privatisation has been halted but campaigners are now calling for greater protection of forests, hoping to continue the support they drummed up to stop the sell-off.

Proposals that the EU should increase its carbon emissions reduction target from 20% to 30% have had a mixed reaction within the EU community. Chris Huhne, the UK's Climate Change Secretary, very much supports the increase, which he argues will keep the EU economy ahead of the game. However, reaching either target is dependent on countries keeping the promises they made on emissions reduction.

And finally, in an interesting twist to computers playing humans at chess. Watson, an IBM supercomputer developed in New York, competed against, and unsurprisingly triumphed over, two human contestants on the US gameshow *Jeopardy*. Watson might be able to understand and answer questions posed in spoken human language, but can the electronic champion understand the point of *Deal or No Deal*?

BY ALEX JENKIN



UNSEEN SCIENCE

The stereotypical image of a scientist is almost invariably male, white, middle-aged and has bad hair; basically it's Einstein. But, in addition to these physical characteristics, there is also (as most Imperial College students are probably all too aware) a view of scientists as reclusive and socially inadequate. To put it kindly, they are seen as focused and driven. To put it accurately, they are seen as geeks. Perhaps the image of the consumed, loner scientist, shut away in his lab for days on end, can simply be traced back to Mary Shelley's character of Victor Frankenstein. However, perhaps there's more to it than this. Perhaps there's actually some truth in this tired cliché .

Of course, even first year science undergraduates are aware that to succeed in science, one almost always has to specialise. In their quest to find out something original, scientists find themselves forced to concentrate on very specific, limited topics. This extremely narrow focus can be a scientist's greatest asset, but it can also be a fatal weakness.

Yet, it's not just scientists who do this; we all do it, on a daily basis. In fact, if we didn't do it, we would probably go completely crazy. Our brains constantly filter out the vast majority of stimuli they are presented with. It is this that allows us to focus on a specific task, without being driven to distraction by the thousands of other occurrences taking place within our immediate vicinity at any one moment in time.

We are all familiar with sporting mantras telling us to 'stay focused' and to 'keep our eye on the goal'. Quite simply, if we want to succeed, we are told that we have to ignore the distractions and forget all of the things which are going on around us.

So, like our cliché of a scientist, it is important that we occasionally step back and take a look at the wider picture. Particularly as students in a city like London, constantly rushing from one crowded place to the next, it is easy to miss so many of the amazing things happening all around us. Thus, for scientists and students alike, this issue is dedicated to the world of UNSEEN SCIENCE: from the scientists history forgot, to the way we choose our partners, to particles so elusive you probably never even knew they existed.

Oh, and by the way, while we're on the subject of stepping back and looking at the wider picture, you might want to do this with the front cover of the magazine...

CAMOUFLAGE

UNSEEN SCIENCE

Hiding behind nature

Katie Tomlinson examines camouflage in animals and humans

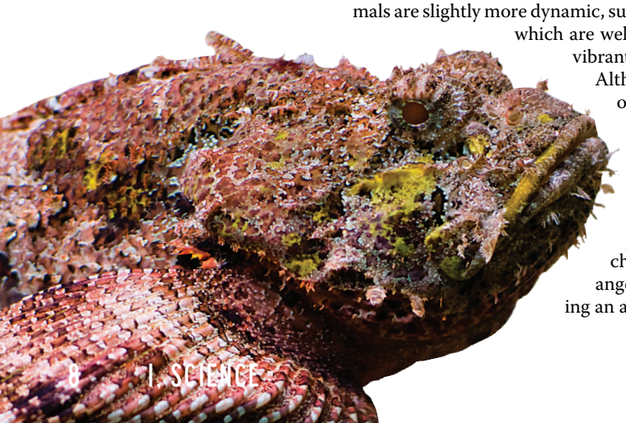
Hide and seek goes on just about everywhere. It's a simple case of looking hard enough. Camouflage allows organisms of all shapes and sizes to remain unnoticed by their predators or prey. Obvious examples include a tiger's stripes or a leopard's spots, but let's take a closer look at some more unusual cases of visual trickery.

POISONED PEBBLES

Stonefish (*Synanceia verrucosa)* lurk in the waters of the Indo-Pacific oceans and disguise themselves as harmless stones. In fact, they're quite the opposite; stonefish are the most venomous fish in the world. They feed on small fish and take no more than 0.015 seconds to attack. Stonefish are preyed on by sharks and defend themselves with 13 lethal spines. When touched the spines release venomous neurotoxins, which cause paralysis and, in some cases, death. These feisty fish have acquired quite a reputation for themselves, to the point that Australian Aborigines even have a dance to warn against stepping on these hidden monsters.

GETTING DRESSED UP

The dresser crab manages to avoid predation with some serious style. This fashionista of a crustacean decorates its shell by attaching accessories from the sea bed to Velcro-like patches on its exoskeleton shell. Common outfit accessories include sponges, seaweed and even pearls, which allow the crab to blend perfectly into any sea-floor scene. Other animals are slightly more dynamic, such as chameleons, which are well known for their vibrant colour changes. Although their colour changing is important for camouflage, it originally evolved for social signalling purposes. When chameleons are angered or attempting an attack they appear darker, and take on multi-coloured patterns when courting prospective mates. Chameleons are able to change their colour due to specialised pigment cells called chromatophores under their transparent skin. Chromatophores are found in many organisms, including the illustrious golden tortoise beetle. These beetles dampen their golden gleam to an orange-brown colour and develop dark spots to don a ladybird disguise. Many birds find beetles an extremely nutritious treat, but ladybirds don't taste so good and, therefore, offer a safe disguise.



HUMANS DO IT TOO

Although animals are the camouflage experts, it isn't just in nature where we find this kind of visual subterfuge. Throughout history, humans have mimicked natural camouflage in military operations and artistic masterpieces. During the First World War, hiding from aeroplane surveillance became a top priority and prompted the French to create an artistic military division – aptly named The Camoufleurs. The Camoufleurs experimented with contrast and shape to invent the most effective military camouflage. Particularly effective was the 'Dazzle' pattern, which used bold geometric patterns to trick the mind of opponents and alter their perception of size and shape. Dazzle-emblazoned submarines confused the enemy, who couldn't work out the size, speed or direction the submarines were heading in.

INVISIBILITY CLOAK

Camouflage is still a major focus for research today. Scientists here at Imperial are currently developing an invisibility cloak. The cloaking device is a metamaterial, which is an artificial structure capable of bending light, so a cloaked object is hidden from view. Scientists are aiming to eventually make the invisibility 'cloak' functional and sensitive to movement. The invisibility technology has many powerful applications, such as being able to peer through rubble after an earthquake and allowing doctors to see through skin and bone at damaged organs. It would, therefore, seem that camouflage is a survival tool, not just for tigers and leopards, but for all of us humans.

THEORETICAL PARTICLES

UNSEEN SCIENCE

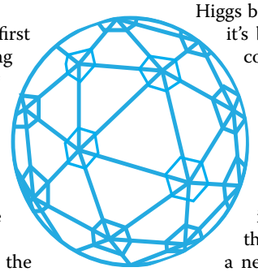
Lurking in the dark

Pippa Goldenberg explores the world of unseen particles

Science has a long-standing tradition of making more powerful microscopes, detectors and other instruments in its quest for greater understanding. From the first suggestion of the existence of atoms, to the high-energy probing taking place at the Large Hadron Collider (LHC) today, it is clear that science aims to unearth the absolute foundations of nature itself.

Yet, even with today's knowledge and technology, there are still some of these 'foundations' – including particles – we just can't see. We know they're there though, as theory predicts their encounters with things which we can see. In some cases, we haven't even seen the results of their encounters, but current theory predicts their existence.

NEUTRINOS



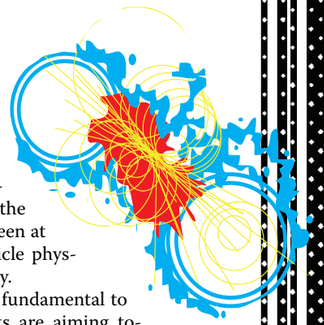
The existence of the neutrino was first suggested in 1930, when Wolfgang Pauli found that the beta-decay process (a neutron decaying into a proton and an electron, plus an electron neutrino) required an extra particle in order to balance momentum, but it wasn't until 1956 that the neutrino's existence was experimentally proven.

The first experiment to confirm the existence of neutrinos was carried out underground, using a massive tank of cadmium chloride in water. The only way to detect a neutrino is to detect the products of its interaction with something else, and use theory to determine whether or not it could have been produced by anything other than a neutrino. Neutrino detection experiments today still use similar methods: large tanks of solution which neutrinos are known to interact with in a unique, 'signature' way.

The vast majority of neutrinos pass through us, the Earth, and pretty much everything in their path, making them near impossible to see even indirectly – detectors have to be as big as possible in order to get a strong enough signal.

HIGGS BOSON

The Higgs boson is an elusive particle, to say the least. First postulated by Peter Higgs in 1964, it has become the most sought-after particle in modern physics. Culminating in the experiments now going ahead at the LHC, the search for the Higgs has been at the heart of modern particle physics for almost half a century.

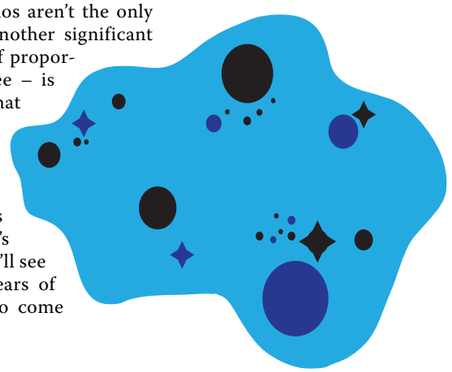


But why is the Higgs so fundamental to particle physics? Physicists are aiming towards a 'Grand Unified Theory' (or GUT) in which all the forces – electromagnetic, strong, weak and gravitational – are explained by one theory. They're one step towards this, having combined the electromagnetic and the weak forces into one explanation; but in order to make this work, the Higgs boson has to exist. And if it doesn't, well, it's back to square one, and an even more complex theory: supersymmetry.

In a similar way to neutrinos, the Higgs can only be detected through its 'signature' – the particles it leaves behind when it decays. The Higgs itself only appears for a fraction of a second (assuming it appears at all) and even if it were possible to detect in this time, the technology just isn't there yet. So, like a neutrino, we can never actually 'see' the Higgs, only its distinctive trail of particle residue.

AND THE REST...

The Higgs boson and neutrinos aren't the only particles we can't see yet. Another significant one – particularly in terms of proportion to everything we can see – is dark matter. No one is sure what dark matter is – it may not be a form of matter at all, or at least not one we know about yet – but we do know it's there, as we can measure its effects on our universe. There's a long way to go yet before we'll see everything, and we've got years of bigger and bigger colliders to come before we do.



ATOMIC THEORY

UNSEEN SCIENCE

Proofing the pudding

Thea Cunningham looks at the evolution of the simple atom

For something so small, it's not shy of a big theory. In fact, the atom and its activity have a long history in the world of theoretical science, punctuated by the ideas of many a perplexed physicist.

The birth of atomic theory takes us way, way back to ancient Greek times. Here, Democritus (460–370 BC), a philosopher pondering the make-up of the physical world, speculated that all matter consisted of minute little particles that moved around in an infinite space. He called these particles 'atoms', meaning 'indivisible'. However, a lack of evidence meant his idea went largely unnoticed and it took almost two millennia before the credibility of the concept was restored.

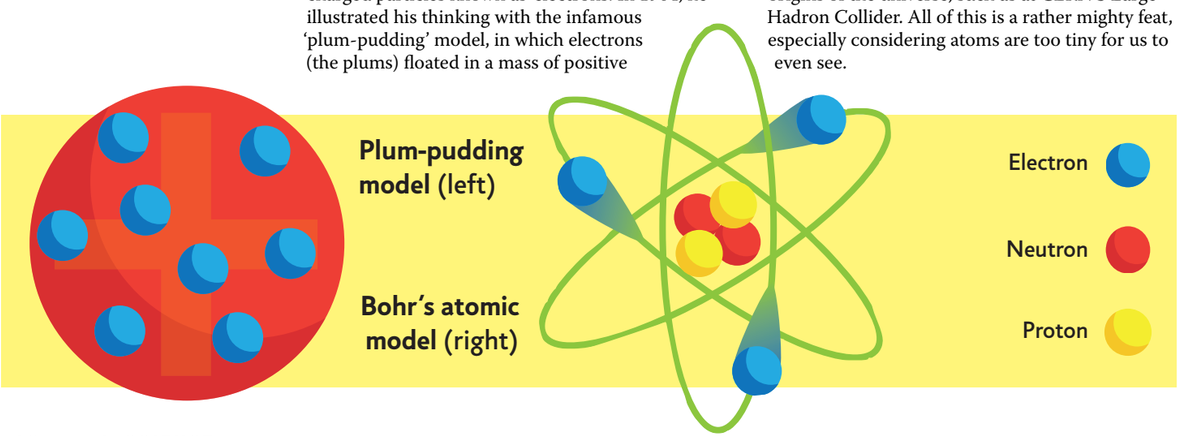
The man responsible for its revival was John Dalton (1766–1844), an English chemist with a penchant for gaseous mixtures. He took the idea of tiny, indestructible particles one step further by suggesting that each one had a certain size, mass and way of behaving that was determined by what kind of element they were. Dalton's theory, which he put forward in a lecture to the Royal Institution in 1803, added a dash of logic and rationality to Democritus' philosophy of matter.

Towards the end of the same century, English physicist Sir J. J. Thomson (1856–1940) debunked the notion of atoms being indivisible when he discovered an electric current could be used to break atoms down into parts – tiny, negatively charged particles known as 'electrons'. In 1904, he illustrated his thinking with the infamous 'plum-pudding' model, in which electrons (the plums) floated in a mass of positive charge (the pudding).

A few years later, English chemist and physicist Ernest Rutherford (1871-1937) put Thomson's ideas to the test using some gold foil. If the plum pudding model were right, alpha particles (speedy particles with a positive charge) fired at foil should all pass through it. But when Rutherford bombarded his piece of foil with these particles, a few bounced back. From this, he concluded that the positive charge inside an atom must be squeezed together into one small place, creating a force strong enough to cause it to repel. Rutherford called this spot the 'nucleus'.

This year marks 100 years since Rutherford's paper on atomic structure was published. Although some parts were later discovered to be inaccurate, his work remains instrumental to atomic theory; not only did it disprove Thomson's pudding model, but it provided the groundwork for fellow physicist, Danish-born Niels Bohr (1885–1962), who suggested that the nucleus is orbited by electrons that hop between different energy levels. Bohr's model is still taught in schools today and his work has sparked numerous mathematical approaches to atomic theory, such as quantum mechanics.

Although no theory has been proven with absolute certainty, each idea has filled one more piece in the atomic puzzle. No longer a whimsical philosophical concept, our atomic knowledge is fundamental to both physics and chemistry. It is allowing scientists to better understand the origins of the universe, such as at CERN'S Large Hadron Collider. All of this is a rather mighty feat, especially considering atoms are too tiny for us to even see.



UNSEEN SCIENCE

Love at first scent

Camila Ruz sniffs out the truth about the MHC

No, it's not your personality that really matters, and neither is it your looks. The way that you smell is what really makes it or breaks it for you when it comes to attracting the opposite sex. There's also no cheating – you can cover yourself with as much cologne as you like, but there is something in your body that is going to give you away: it's called the MHC.

SEXY GENES

The Major Histocompatibility Complex (MHC) is a cluster of genes that tell your body what is and isn't you. Our immune system relies on the MHC to recognise foreign material in our cells and to provide a warning that our body is under attack. MHC alleles vary hugely between individuals, so unless you are closely related, your MHC and that of the person sitting next to you will be very different. This is a good thing if you're thinking of asking them out, because humans don't fancy people who have an MHC too similar to their own. In a monogamous mating system like ours, the pressure to find a partner with 'good genes' is huge. Get it wrong and not only could you be stuck with them for a very long time, but your kids might not be as good at surviving as someone else's. Avoiding MHC similar mates will mean children with a greater variety of MHC genes and a better immune system overall. It also means that you avoid inbreeding and all the health problems that can go with it.

LOVE IS IN THE AIR

So how do we actually detect MHC differences? Well, studies have shown that we can smell them. Researchers performed t-shirt tests where men were asked to wear the same top for a few days, with no showers or deodorant allowed. A group of women had to smell the t-shirts and rate them in order of attractiveness. The results showed that the more dissimilar a man's MHC was to their own, the more attractive that woman found them.

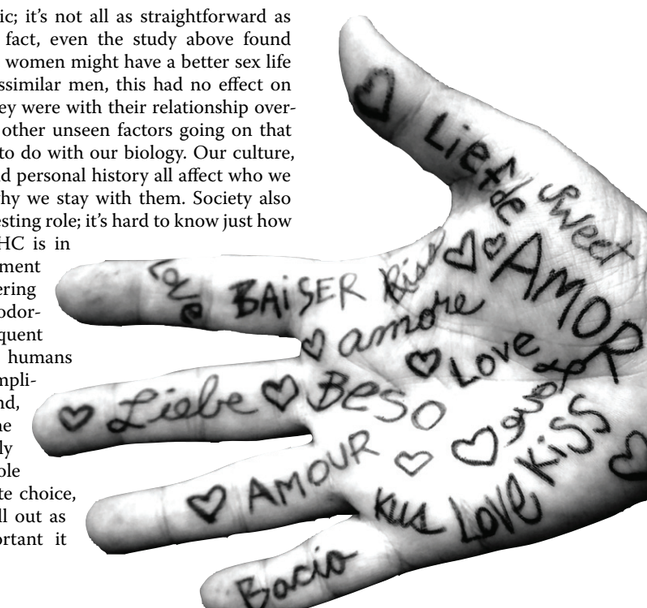
Yet, preferring a certain smell does not automatically lead to preferring a particular person. So does the MHC really affect who we choose? The clearest results, thus far, have come from studying an isolated religious group in the US, known as the Hutterites. The Hutterites have a high risk of inbreeding because of their tiny population sizes. Studying the MHCs of married Hutterite couples has shown that they share fewer MHC alleles than would be expected had random pairing occurred.

OPPOSITES ATTRACT

The MHC can also affect your sex life: women who share a high proportion of MHC alleles with their partner tend, on average, to be less sexually responsive to them, finding it more difficult to feel aroused by them in general. In addition, the researchers from this study found that high MHC similarity may make women more likely to cheat: as the number of shared MHC alleles increased, so did the number of other men the women had slept with during the relationship. The idea is that if your boyfriend isn't going to give you the good genes you need, then you should probably look for them elsewhere.

A COMPLEX SITUATION

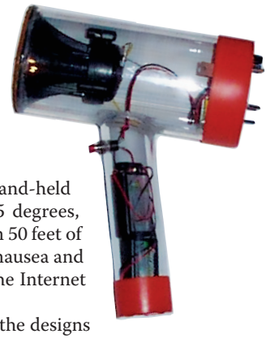
But don't panic; it's not all as straightforward as it sounds. In fact, even the study above found that, although women might have a better sex life with MHC dissimilar men, this had no effect on how happy they were with their relationship overall. There are other unseen factors going on that have nothing to do with our biology. Our culture, personality and personal history all affect who we choose and why we stay with them. Society also plays an interesting role; it's hard to know just how useful the MHC is in an environment of bewildering scents, deodorants and frequent washing. We humans live in a complicated world and, although the MHC clearly plays some role in human mate choice, the jury is still out as to how important it really is.



TOP 5 UNSEEN WEAPONS

BY JAMES POPE

5 ULTRASOUND GUN
THE SONIC DEVASTATOR



Imagine the sound of fingernails scraping down a blackboard, then amplify it to 130 decibels (which is equivalent to a jet plane taking off) and you begin to understand how the *Sonic Devastator* got its name.

Designed for riot control, the hand-held gun's design restricts its beam to 45 degrees, protecting the user, but anyone within 50 feet of the business end can expect horrific nausea and headaches. It's available for sale on the Internet – yours for just $400.

This weapon is no secret either, as the designs are also open source informaiton.

4 THE INTERNET
CYBERARMS

Cyberspace has been dubbed the 'fifth mode of war', after land, sea, air and space.

In January this year, five members of the hacktivist group 'Anonymous' were arrested on suspicion of crippling the websites of corporations that had withdrawn services from Wikileaks.

In the 2008 buildup to the South Ossetia war, Georgian governmental websites were plastered with photographs comparing the country's president to Hitler and news agency websites collapsed – both coincided with the Russian army's advance across the Caucasus.

In 2007, the websites of the Estonian parliament, banks and several media organisations came under attack from hackers protesting against the removal of a Soviet-era memorial.

It is feared that cyber assaults on power stations, emergency services or transport systems could be disastrous. Governments across the world now employ cyber armies; Iran claims to have the second largest after the USA.

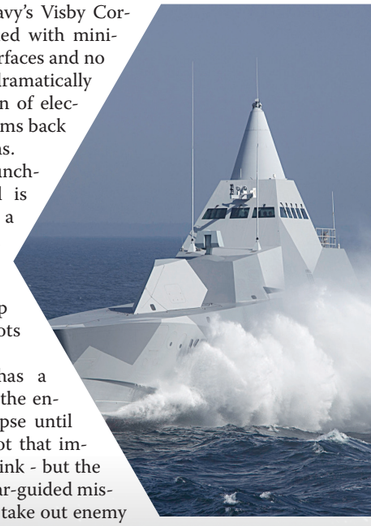
3 ACTIVE DENIAL SYSTEM
THE 'HEAT RAY'

Also known as the 'heat ray', the Active Denial System (ADS) is another non-lethal weapon that's designed for use in crowd control.

The transmitter fires a high-powered beam of high-frequency (95 gigahertz) electromagnetic radiation that excites fat and water molecules in the body, rather like a microwave oven. The skin heats rapidly causing intense pain, but thankfully the beam has low penetrating power so victims don't cook and there are no permanent effects.

ADS was briefly deployed by the US Army in Afghanistan, but wasn't actually used in warfare.

2 STEALTH BOAT
THE VISBY CORVETTE



The Swedish Navy's Visby Corvette is designed with minimal vertical surfaces and no right angles, dramatically reducing the reflection of electromagnetic radar beams back towards enemy stations.

Nicknamed 'The Lunchbox', the Visby's hull is constructed from a sandwich of carbon fibre, PVC and vinyl, making it extremely light and fast with a top speed of over 35 knots (40 mph).

The ship's radar has a range of 100 km, but the enemy won't get a glimpse until it's within 30 km. Not that impressive, you might think - but the Visby also packs a radar-guided missile system which can take out enemy craft 70 km away.

1 NUCLEAR WARFARE
ELECTROMAGNETIC PULSE

If a nuclear weapon detonated 400 km above London, there'd be no sound and nothing to see, but every piece of electrical technology this side of Russia would fry. The culprit: an electromagnetic pulse.

Airborne nuclear explosions produce gamma rays that knock electrons from nearby atoms. These electrons then hurtle Earthward at over 90% of the speed of light, spreading out as they hit the Earth's magnetic field and generating the massive electromagnetic pulse (EMP).

EMP is well documented in nuclear tests; an experimental airburst over the South Pacific in 1962 took out electrics in Hawaii (well over two thousand miles away).

UNSEEN SCIENTISTS

SCIENCE BEHIND THE PHOTO

It can be hard to see through the polished surface of media science. Here, we look beyond the headlines and professors to uncover the people behind the stories. What motivates them to stick with something which can be complex, frustrating and tedious?

To achieve this, we interviewed several people at the 'coal face', from first year MSc students to those in the final year of PhDs. We wanted to get the perspectives of people who are almost invisible within the scientific machine; to uncover the unseen side of the science and catch a glimpse of some of the personalities who make it happen.

PHOTOGRAPHY & WORDS BY
DAVID ROBERTSON
ROBERTO TENACE
GEORGE WIGMORE

SARAH LANGLEY

We're frequently told that science should be isolated, viewed through objective eyes, free of emotion and personality. At its heart, though, science is a human creation, and social influences are an inescapable part of how we understand the world.

Sarah, originally from Maine, USA, is in the final year of her PhD. When we asked if she could show us an object that carried meaning for her, she rather coyly presented us with a scrap of paper. While seemingly unrelated to anything (as far as we could tell), it actually speaks volumes about the nature of science and the people who make it their lives.

Researching statistical techniques for the identification of genetic contributors to hypertension lends itself well to the stereotype of dry, emotionless science. However, the hand-drawn picture on a square of plain paper, which has made a home in Sarah's wallet for 10 years, is the antithesis of this oversimplified perception of science.

Sarah's tattered memento subverts the notion of science as a totally rational discipline. It represents friendship and sentimentality, making a clear statement that not everything in life is about science.

JOHN CASTLE

Work and play are often seen as non-overlapping spheres of life, but at its heart, science is a huge game of discovery. John, an MSc research student at Hammersmith Hospital, is the very embodiment of this idea. Before meeting with John for an interview, we asked him to bring along an object that carried meaning for him and his science. We left it open; anything from a sentimental desk ornament to an inspirational childhood book.

Imagine our surprise when we saw him pull a crumpled football shirt from his bag. While it's something that we wouldn't normally associate with research into lung cancer, John's shirt manifested the overlap between many different aspects of his life.

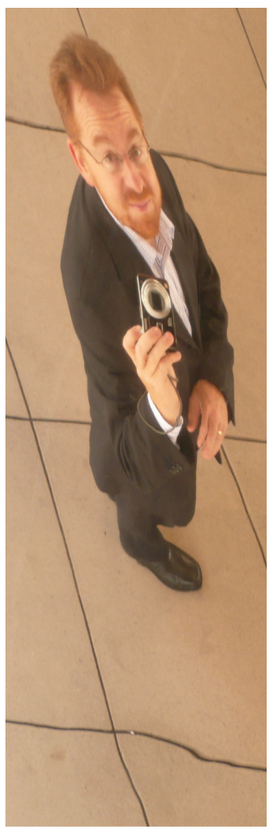
John works on a frontier of cancer research, studying a protein called MARK4. This protein influences cell shape and therefore the ability of cancerous cells to mobilise and spread throughout the body, a process known as metastasis. He employs techniques such as western blotting and confocal microscopy to link gene expression, protein formation and microtubule assembly.

Even though John is just starting in research, he's expected to produce results which will stand alone in a field of experts. He faces long hours in the lab, grappling with new techniques and findings. On the sporting field, he's known for his perseverance; this is embodied by his attachment to his football shirt, but such an energetic approach feeds equally strongly into John's scientific life.

CATCHING UP WITH ONE OF IMPERIAL'S MOST HIGH-PROFILE ACADEMICS

ACADEMICS AMONGST US

DR STEPHEN CURRY



WHO IS STEPHEN CURRY?

I was born in Ballymena in Northern Ireland in the cold, cold winter of '63. To cut a long story short I am now a Professor of Structural Biology in the Department of Life Sciences, having worked at the College for over 15 years. My association with Imperial goes back even further since I got my Physics degree here and a PhD in Biophysics in the '80s. However, I am proud to be able to say that I had the initiative to leave the College for six or seven years to pursue my postdoctoral career. During this time I became greatly enamoured with structural biology, in particular with protein crystallography. My primary research interests are in proteins involved in the replication of RNA viruses such as norovirus and foot-and-mouth disease virus.

WHAT MADE YOU START YOUR BLOG, RECIPROCAL SPACE?

I was looking for a way to fulfill some of the public engagement activities that all scientists are required to sign up to without having to work too hard at it. Blogging seemed to be an easy way to reach out to the general public. I was wrong about the easiness – good writing is hard to do – but it has been an enjoyable ride. Though my subject matter varies loosely around scientific themes, I hope that it gives some insight into what it's like to work as a scientist in the UK. I think many people have an over-inflated idea of what scientists get up to. I wanted to demystify that – and make us more accessible.

IS BLOGGING AN ATTEMPT AT AN ESCAPE FROM THE INESCAPABLE STUDENTS AT IMPERIAL?

No, I do that by wearing a heavy disguise outside lectures and tutorials. Seriously though: no, not at all. I haven't advertised my blog to students or aimed the content specifically at them; but I suspect some may have stumbled across it and hope that they might have found it diverting. Comments are always welcome. Hint, hint.

DID YOU EXPECT THE READERSHIP AND MEDIA ATTENTION YOUR BLOG HAS RECEIVED OVER THE YEARS?

No – and nor should that be a goal or I might find myself trying to write about lurid subjects for the sake of the attention. I've been reasonably honest and straight-forward in tackling subjects that interest me and that I think I can pitch to my readership. While I was at Nature Network, the readership was probably mostly fellow scientists but at my new home (Occam's Typewriter) I hope I can branch out more.

The media attention (which isn't massive – let's be honest), has come from different sources. In part it's from deciding not to lie down and take it when Simon Jenkins chooses to pontificate (usually without encumbering himself with facts) about science and scientists in *The Guardian.* Otherwise, it has been through involvement in important and visible campaigns such as for libel reform and the Science is Vital campaign in support of public funding of research, which I was happy to play a small part in.

WHAT PERKS HAS RELATIVE FAME ON THE BLOGOSPHERE BROUGHT?

You mean apart from the sex with all the groupies? I've had invitations to a couple of receptions and met some very interesting people which wouldn't have happened without being known as a blogger. But for me the main benefit has been that blogging has pulled me out of the lab and made me think more broadly about the role of a scientist in society. It's not just about finding stuff out — though that is a core activity – we do have a responsibility, especially if we are publicly funded, to give a good account of ourselves. And perhaps to inspire the next generation.

YOU WANT TO SWITCH OFF FROM SCIENCE. WHAT ELSE OCCUPIES YOUR SPARE TIME?

I run a taxi service for three people who claim a genetic relationship with me. Apart from that, I love great cinema. And every now and then I enjoy making and editing my own short films, though these are mostly about science so perhaps that doesn't count.

FANTASY DINNER PARTY: YOU CAN INVITE ANY TWO-SCIENTISTS, DEAD OR ALIVE. WHO WOULD YOU CHOOSE?

I'd invite Einstein and Newton. The conversation would be fascinating in scientific and historical terms. But mainly I'd want to see the look on Newton's face when Einstein explains general relativity.

SCIENCE STATISTICS

The value of p-values

Jan Piotrowski examines the problems with how scientists measure significance

Despite lurking underneath the surface of virtually every scientific paper, the statistics of significance testing are often misunderstood. However, understanding exactly what the statistics explain has a fundamental effect on how the data are viewed.

Put simply, p-values are a way of determining if the means of two samples are actually different, or just a coincidence of sampling error. So a result of $p < 0.05$ means that there is less than a 5% chance that any difference in the means is down to chance. Right? Wrong.

What it does tell you is that your experimental effect (the difference between samples) would be observed 5 % of the time if both samples were taken from the same population.

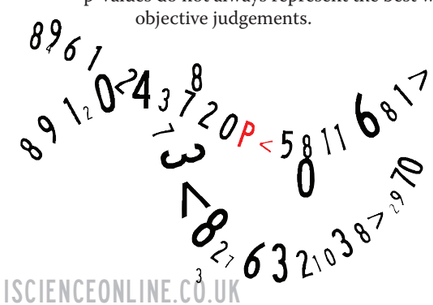
It is essentially a prediction of future results, and therefore gives no indication of the probability of obtaining the actual results. By extrapolating the data to describe hypothetical tests, p-values help scientists make judgements about long term error rates. It also forces a binary choice when assessing hypotheses that leaves no room for subjectivity to sway decisions. The established system exists because it allows for the smallest number of errors occurring over a long period of time.

Despite being the norm, the use of p-values has some strong critics. The irony is that science is based on observed data, yet the method used to validate its claims is not: p-values are a description of data that has never been collected. Since they are based on hypothetical samples, inferences cannot be drawn as to the relative strength of hypotheses.

A theory is very rarely thrown out on the basis of one experiment, yet the method of significance testing requires scientists to do just that. If a scientist continues to pursue a theory in the face of a contradictory significance test, they do so without any statistical guidance.

P-values offer the best way of conducting objective statistical analysis in an ideal world. However, we do not live in an ideal world, and scientists do not always act as rational automatons.

Paradoxically, by not addressing the inevitable subjectivity in science, p-values do not always represent the best way of making objective judgements.



historybook

Alan Mathison Turing

Information

Birthday:
23 June 1912

Home town:
Hastings

Interested in:
Men

Alan Turing is bored with learning classics – give me mechanics any day 1928

Alan has joined Cambridge University 1931

Alan likes computable numbers, mathematics and algorithms

Alan has joined Princeton 1936

Alan Turing has branched out into cryptology, is back in England and working on breaking the Enigma Machine – shhhh, it's a secret 1939

Alan checked into Bletchley Park

Alan Turing - job done, code broken. Onto the next one 1940

Alan has updated his title to OBE 1945

Alan has joined the National Physical Laboratory 1946

Alan Turing has developed a machine that can execute a stored programme 1947

Alan Turing ... my computer is not a great conversationalist – artificial intelligence has a long way to go 1950

Alan Turing has been charged with homosexual behaviour, had his security clearance revoked and refused entry to the US 1952

Alan Turing has finished playing out God's holy pantomime 1954

Gordon Brown would like to apologise to Alan for his unfair treatment on behalf of the British government and all those who live freely thanks to his work **2009**

CITY SCIENCE

Metropolitan metrics

Lizzie Crouch finds out how mathematics makes our cities come alive

How would you describe a city? A unique maze of people-lined streets? A series of districts linked through things which make up your life; that coffee shop you like, that bar that serves the best margarita, and home? However you describe it, you probably don't think there's anything similar, or even scientific, linking all the cities around the world.

But Geoffrey West, a physicist captivated by finding mathematical answers to fundamental questions, was enticed by the seemingly random and complex collection of cities around the world. He sought for the mathematical rules that govern urban areas.

Before cities, West had taken on biology. He searched for the equations that would explain every aspect of life. He claims that, given the size of an animal, he is able to tell you every single one of its characteristics, such as the pressure on the wall of the third branch of its artery. Although controversial, his arguments are compelling.

When he turned his attention to cities, he asked some unusual questions, "Maybe London is just a great big whale? To what extent is a city an organism?" This isn't a trivial subject, by 2030 it is estimated about around 4 billion people will live in urban areas. It is important that we can understand the secret rules that govern our lives in these areas, but the seemingly endless variations in cities all over the world couldn't surely be connected by a universal set of rules. How could historic London compare to the geographically-isolated New York?

West and his colleagues accumulated a mind-boggling wealth of numbers and statistics pulled from the dullest databases imaginable. From this seemingly never-ending data set, they started to create information and the reveal the secret science of how we live in a city.

After two years worth of analysis, the team presented a handful of elegant equations describing a whole host of urban variables. A city became an organism in their eyes, and to their delight each of these organisms were the same, just on different scales. If given the population figures, the equations they produced allow them to predict a diverse range of factors for a city with 85% accuracy. These factors are as detailed as the average income of the city's dwellers, and even the dimensions of its sewer system.

His first observation was that, as with a biological organism, the infrastructure of a city was scaled sublinearly. But what was more interesting was the range of indicators that had a social element to them. According to the data outlining economic factors, whenever a city doubles its population, the economic activity increases 15% per capita. In simple terms, a person living in a bigger city does more of everything. This was even observed for the negative variables; double the population and 15% more crime is experienced per person.

West had in fact initially predicted the exact opposite. The fact that all these diverse factors scale in a very similar manner, even in different cultures on different continents, suggests that a human social dynamic drives them all. West emphasised that cities are valuable human dwellings as more social interaction is facilitated through proximity; ease of access to people determines views and disciplines, as well as chance meetings.

Cities are an important human invention; they allow us to be more productive than our physiology truly allows. But, however unique our lives and our cities may seem, West has shown that we live by an unseen code. We all live by a simple set of equations which dictate how our bodies work and the way we live with each other.

PHOTOGRAPHY BY JAN PIOTROWSKI

SCIENCE FRICTION

SUDDEN OR SLOW?

BY JAMES POPE

Were the dinosaurs immediately killed by an asteroid colision? Or, were there other more important factors which led to their eventual extinction? Dr Paul Barrett and Dr Paul Upchurch argue the latter

What killed the dinosaurs? It's a debate that's raged for 30 years and, if last year's fiery exchanges in one of science's most prestigious journals are anything to go by, there's no sign of a resolution in sight.

In March 2010, a paper in *Science* by Dr Peter Schulte and forty other scientists claimed that the extinction at what's known as the Cretaceous-Palaeogene (K-Pg) boundary was sudden and that an asteroid impact was entirely to blame. Thirty six researchers were moved to respond.

Dr Paul Barrett, palaeontology researcher at the Natural History Museum, was one of them. "There were only three palaeontologists in that massive author list," he says, "they misrepresented the fossil record by only focusing on forams (tiny sea creatures) and a few species of plants. There are very different signals for different sorts of organisms in different parts of the world."

Barrett believes an asteroid was involved, but takes issue with the lack of evidence from vertebrate fossils in Schulte's paper. His own research suggests that many species were already in decline before the K-Pg event.

So was something else making life difficult? Many scientists point to the Deccan flood basalts – massive volcanic eruptions in India that lasted for a million years and coincided with the K-Pg boundary – but even these aren't without their doubters.

Some claim that the eruptions were continuous and the sulphur dioxide they emitted would never have built up enough to catastrophically cool the climate, while others suggest that distinct bursts of activity would have provided as much sulphur as an asteroid strike. "I went to India," says Dr Barrett, "you can see bands of basalt with sediment deposits between them in the cliffs. There were clearly pulses of activity."

"It's likely that there were a number of factors that caused living conditions to deteriorate in the years leading up to the K-Pg event," says Dr Paul Upchurch, lecturer in palaeobiology at University College London, "The Deccan volcanism, climate change and falling sea levels all had an impact and the asteroid provided one more blow to an already weakened ecosystem."

"It was probably the straw the broke the camel's back," says Dr Barrett.

This all seems fairly convincing, so why does the debate persist?

"The problem is that evidence from the K-Pg crosses lots of different disciplines," says Dr Upchurch, "you have input from palaeontologists, geophysicists, petrologists and climate modellers and they all have their own theories about what happened."

"Personally, I wish we could move on from arguing about the causes and focus on the effects," says Paul Barrett, "The K-Pg attracts the limelight because of creatures with big, sharp teeth; but it's not only how things go extinct, it's also how they recover."

Paul Upchurch agrees; "We are potentially living through a mass extinction now," he says, "Obviously the causes are very different, but there may be lessons we can learn from the fossil record in terms of which groups are more vulnerable under certain circumstances."

So is it time to let sleeping dinosaurs lie? Will we ever truly know what happened?

"Not unless someone invents a time machine and we can go back and actually watch it all unfolding," says Dr Barrett.

Until then, it'll remain unseen science.

STUDENT SCIENCE

Hangover from Hell

Ruth's paying the price of a heavy night. We'll be uncovering the source of her suffering and offering up some unusual remedies.

OH DEAR GOD, WHY DO I FEEL LIKE THIS?

It is probably an all too familiar story for anyone who has ever over indulged on a night out in the pub. Burning thirst, muscle ache, nausea and a head that feels like the bass drum at a Metallica gig – but what exactly is a hangover?

Dehydration is a major factor in determining the severity of hangovers due to alcohol inhibiting the release of vasopressin, an anti-diuretic hormone. As a result, the kidneys are prevented from reabsorbing water from urine, meaning a lot of trips to the loo. Alcohol is such a powerful diuretic that consuming the equivalent of four drinks worth of alcohol in 250 ml of water can cause the excretion of up to a litre of water in urine. So if you spend a night on the booze, you are going to inevitably wake up feeling like a shrivelled prune.

Another familiar feeling is the over-whelming desire to vomit from the slightest movement, smell – well anything really. This sensitivity is caused by the inflammation of the gastric lining of the stomach. Also, alcohol increases the production of corrosive acids that are contained longer in the stomach than other fluids, which end up assaulting your poor stomach lining. This effect is exaggerated by drinks with high alcohol content – so hitting shots may be a sure fire way of spending the morning face down in the toilet (and that's if you manage to get there in time).

Acetaldehyde, a chemical product from the breakdown of alcohol is toxic in high concentrations, and causes symptoms synonymous with hangovers; sweating, skin flushing, nausea, and vomiting. Although the liver eventually metabolises acetaldehyde into harmless by-products, the high concentrations that result from excessive alcohol consumption have an overwhelming effect. Acetaldehyde escapes into the blood stream, where its toxicity results in the typical hangover symptoms.

Alcohol withdrawal is also thought to play a part in hangovers. When high levels of alcohol are present, the nerve receptors that it affects increase or decrease sensitivity to maintain an equilibrium. When alcohol is removed from the body, the nervous system remains unbalanced, which causes over or under-excitation of the nervous pathways.

While most experts extol the virtues of responsible drinking, this isn't realistically going to happen for most people. Thus, in the name of science, and with a selfless act of generosity, Ruth will be testing out the best cures out there. So, you know where to turn next time you've drunk one too many...

DRINKING WITHOUT THE AFTER-EFFECTS?

Here at Imperial, Professor David Nutt is working on something students can really appreciate; an alcohol substitute. His team has devloped the drug from benzodiazepines, similar to the anti-anxiety chemical in Valium.

The new tipple would still give the drinker a pleasant tipsy feeling but avoids the aggression, addiction and hangovers associated with traditional alcohol.

The team are also working on an antidote pill, allowing you to pass rapidly and pain-free from drunk to sober. The pill works by muting the effect of the synthetic alcohol on receptors in the brain.

Nutt wants to try it in Scotland first, which has the highest rate of alcohol related liver disease.

I JUST WANT A FRY-UP. WHERE'S THE NEAREST CAFE?

A good old full English breakfast definitely gives the digestive system something to work on. All the grease contains lots of calories, which should help you perk up your energy levels but may leave you feeling even more bloated than before. A recent study by Newcastle University has put the classic bacon sarnie top of the hangover cure list. In fact, the mere smell of bacon sizzling is thought to kick start the body's metabolism and help speed up the process of recovery.

WILL A BACON SARNIE DO?

Every culture has its own favourite hangover cure that involves protein, including tripe soup, pickled sheep eyeballs and even bull's penis. Proteins are a source of amino acids that are needed for synthesising neurotransmitters. Alcohol prevents the absorption of amino acids in the gut, so tucking into your favourite protein-based snack is the best way of topping your levels up.

A German favourite is 'rollmops'. This 'cure' consists of pickled herring fillets, rolled around slices of onion, pickled gherkin and olives, marinated in vinegar and salt. As well as providing protein, this cure is believed to restore electrolytes, which maintain the voltage across cell membranes.

One of the most important amino acids for combating a hangover is N-acetylcysteine; instrumental in the breakdown of the toxin acetaldehyde, a metabolite of alcohol. It is particularly abundant in egg yolk, so the following recipe might be exactly what the doctor ordered. The ketchup is a source of bioflavinoids, which contain antioxidants to help boost your immune system.

1 part olive oil,
1 raw egg yolk
Salt and pepper
1-2 tablespoons of tomato ketchup
Dash of Tabasco and Worcestershire sauce
Lemon juice (or vinegar)

NO BACON! SURELY THERE MUST BE SOMETHING ELSE?

The coffee delivers a caffeine kick, which not only boosts energy levels but also adds to the anti-inflammatory effect of the aspirin. This helps to reduce headaches, caused by acetate, a harmful by-product of alcohol. A recent study at Philadelphia University has confirmed the science behind this well-used hangover cure by testing it on inebriated rats. Each rat was given a small amount of alcohol to induce a headache and then given their own rat-sized dose of anti-inflammatories. The treatment was shown to block the acetate produced by the alcohol and soothe the rat's headache.

I'M GETTING QUITE DESPERATE...

Charcoal acts as an absorbent, mopping up excess alcohol and gastric acid that causes nausea and vomiting in the morning. It is one of the most common forms of treating chemical and drug poisining because of its unrivalled ability to remove toxins and unwanted chemicals.

This was popular with the chimney sweeps of the nineteenth century, who found that a 'mop of soot' was one of the most convenient hangover remedies. A 21st century version of this might be a charcoal tablet mixed with warm milk. Appetising, eh?

HANGOVERS FROM HISTORY

History has thrown up some gut-wrenching remedies that sound worse than the hangover itself.

1. Deep fried canaries
A Roman favourite

2. Bulls Penis
Sicilians enjoy a traditional feast of dried penis, to help flush out the toxins

3. Pickled Sheeps eyeballs
A hit in Outer Mongolia; pickled eyeballs in a tangy tomato soup

4. Rabbit dropping tea
A common cowboy cure in the Old American West

5. Raw eel and almonds
Popular in Europe back in the Middle Ages

BY KATIE TOMLINSON & JAN PIOTROWSKI

AFRICAN SCIENCE CAFES

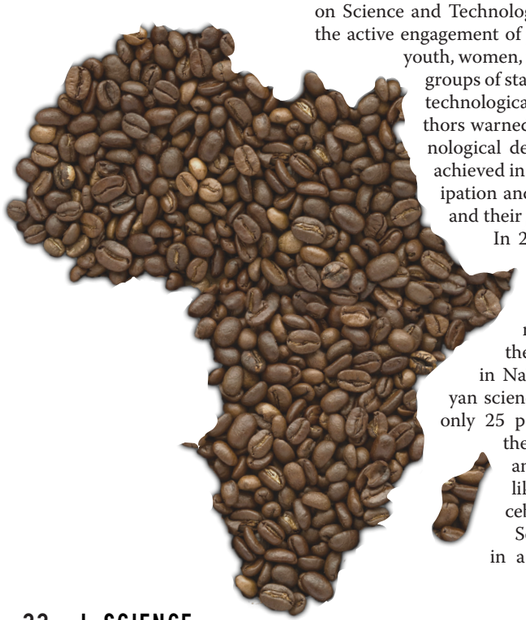
Brewing knowledge

In Kenya, science has been brought to a new audience. Juliette Mutheu and Ruth Wanjala tell us how

Science cafés are forums where scientists discuss or debate on topical and thought provoking scientific issues with the public in a relaxed, informal and accessible way. Held at coffee houses or restaurants or any other informal setting, the cafes are known for their informality and friendly atmosphere and are a good way of getting people interested in science and on ongoing public conversations on science.

The Kenya science cafés were inspired by the realisation that plenty of interesting and useful scientific research was taking place in Kenya, but this was hardly communicated or shared with the public. Furthermore, existing communication or dissemination practices within the scientific community are limited. An innovative approach was needed to help Kenyans learn and embrace the scientific research done in the country.

Scientific research in Kenya focuses primarily on developmental areas, such as health, agriculture and environment, all of which are crucial to improving people's standards of living in the country. Over the last few years, there has been a growing emphasis on communicating science to the public to help boost the practical use of scientific knowledge and its application in policymaking. A 2006 action plan developed at the African Ministerial conference on Science and Technology (AMCOST), called for the active engagement of policymakers, politicians, youth, women, private industry and other groups of stakeholders in scientific and technological development. The authors warned that "scientific and technological development would not be achieved in Africa without the participation and support of the populace and their political institutions.



In 2008, with the aim of engaging the Kenyan public with science, an adaptation of the science café model, first established in the UK in 1997, was started in Nairobi. The first ever Kenyan science café had a guest list of only 25 people. Numbers grew as the events attracted both old and new media coverage, like blogs, Twitter and Facebook.

Science communication in a developing country like Kenya is as interesting as it is challenging. The cafés rapidly became popular among the urban Nairobi middle-class, who happily sipped their drinks as they discussed scientific research and tweeted, blogged and checked the facts on their smart phones. The excitement at each session demonstrated the public's enthusiasm to interact with scientists and debate scientific issues.

In an effort to expand beyond of this audience, we transported the science café model to semi-rural and lower socio-economic communities within Kenya. However, these efforts rely heavily on strategic planning, organisation and finance. Engaging these audiences with science was both an insightful and eye-opening experience. Most of the communities are starved for information and thus, the engagement exercise unwittingly turned into public education, with the community expecting more than just information. In contrast to urban science cafés, cafés in semi-urban areas, with lower socio-economic communities, are much richer and the questions asked are of more practical relevance to their everyday lives.

In the three years since the cafés began, the events have taught us much about the willingness of scientists to speak to the public and the public's appetite for dialogue and debate.

The Kenyan Science Cafés are currently focusing on training and building the capacity of future science café organisers. Following a capacity building workshop in September 2010, plans by one of the trainees are underway to use the science café model to engage scientists, science journalists and the public. The aim of these journalism-focused cafés is to help science journalists to not only report on science stories from a scientist's point of view, but also from that of the public.

Major lessons learnt from the science café model are that African scientists are open and willing to engage with the public and that there is certainly an appetite for relevant and appropriately packaged scientific research among the Kenyan public. African science communicators should take advantage of these lessons to promote public engagement of science throughout Africa.

For more information, visit www.cafescientifique.org.

INTERVIEW

PEER REVIEW

Chairman of the Foundation for Science and Technology, Lord Jenkin of Roding, discusses the importance of public engagement of science in policy with Alex Jenkin

PHOTO: THE EIC

You opened the Science and Citizenship conference in December last year on the tenth anniversary of the House of Lords report on Science in Society – what do you feel has changed in science communication since the report?

The main change that I am aware of is a very much greater awareness now of the need for scientists to communicate with the public. Not just top down explaining what they do, but the word "engaging", as used in the report, means that it is a two way discussion. To begin with, I think the science community found that actually quite difficult. They had become used to the former process of the public understanding of science, which we described as rather top down, one way and condescending. So the idea that scientists should actually engage with the public, listening as well as talking, is something which has taken at least ten years to begin to become better understood.

Public engagement is now very much more a part of grant proposals when applying for research funding. Some scientists may have concerns that public engagement might detract from their research. Do you think that it is right for public engagement to be so tied to funding?

I am absolutely certain that that's right. Of course it's got to be done well and it's got to be in proportion to the value of the research work.

One of the criticisms that we had in our report was that science communication and engagement did not count for anything in grant applications, in the question of the quality of work, none of that was accounted for. And we criticised that very fiercely because we said science doesn't exist in a bubble of its own; scientists have a licence to practise from the public. And if the public are going to be happy to continue to give that licence to the scientists to practice, they have got to have some understanding of what is being done and to have been consulted, to be aware, and to have an opportunity to question. And that it is now becoming an automatic part of the grant application is a very splendid thing.

You suggest that public engagement has improved over last ten years – could you give an example of where public informed policy has been successful?

When we had the great stem cell debate there was a proposal that the scientists should be allowed to move on from the comparatively straightforward research and be allowed to use hybrid embryos.
We had a joint select committee of both houses and we had some immensely expert witnesses who came and talked to us and we produced a report, as a result of which the government accepted that it was right to go ahead and licence the use of hybrid embryos, subject to the very strict conditions that had been laid down. And why? Because a lot of the charities and medical research bodies had gone to the public and said "Look, if we're going to be able to do our work, if we're going to be able to find new cures, if we're going to be able to find new drugs, we have got to be able to do this research." The public trusted what they said, and the result was, when the Bill came before Parliament, the question of the licensing of hybrid embryos was approved substantially in both Houses of Parliament.

There are many examples of the media stirring up fear amongst the public about science, particularly in the case of GM crops. Do you think that it will take a long time to undo the damage done to public confidence of GM crops?

I think there has been far too little readiness on the part of the scientific community to actually enter that particular lion's den.

There are endless reports now which say that, if we're going to feed 9 billion people in the world by 2050, we've got to use all the new technologies that are available. And clearly genetic modification has to be one of them.

This is something which one has got to be working away at. Some scientists are so frightened of upsetting public opinion and then becoming a hate figure that they don't raise their heads above the parapet. And that is what has got to change.

"Science doesn't exist in a bubble of its own; scientists have a licence to practise from the public."

7 Billion

Andrew Purcell looks at the numbers concerning population growth

BEWARE THE RELATIVISTS

Is population growth really still a problem? You may have heard recent reports about the rate of population growth slowing. However, don't be fooled. It is important to look at the difference between absolute and relative population growth rates in order to fully understand this issue. It is true that the population is now growing at a rate of 1.1% per annum, whereas, at its peak in 1963, the relative annual population growth rate reached a staggering 2.2%. Yet, the global population in 1963 was only 3.3 billion, compared to 6.9 billion today. Consequently, a growth rate of 2.2% in 1963 equates to a population increase of around 73 million individuals per year, while the current growth rate of 1.1.% actually means that the global population is growing at a rate of roughly 76 million individuals per year. Thus, by concentrating on the absolute growth rate, the one that matters as far as our environment is concerned, we can see that the rate of population growth is not actually decreasing at all: in fact, it has slightly increased.

This year, the global population is set to hit 7 billion. This represents a quadrupling of the population in just over a century. With this increase putting a massive strain on resources, from food to fresh water and from energy to ecosystem services, can we really afford to continue turning a blind eye to the problem of overpopulation?

In the 1960s, books such as Paul Ehrlich's *The Population Bomb* had successfully brought the issue into the realm of acceptable political discourse, culminating in the founding of the United Nations Fund for Population Activities in 1969. However, in the ensuing decades, the population issue has become a taboo subject, with those who talk openly about this problem often being lumped in with the eugenicists of the 1930s – or even branded 21st century imperialists, seeking to limit the economic growth of developing nations. Yet, it is for the benefit of these very nations that we must begin to address population increase, since the challenges of overpopulation and poverty alleviation are inherently linked.

This link stems from the disproportionate way in which the world's resources are consumed. In developed nations, such as the UK, the US and most of Western Europe, we each require around eight to twelve hectares of land per annum to support our lifestyles. By contrast, people living in developing nations, such as India and China, only require, on average, around one and a half hectares of land per annum to support their current levels of living. Yet, it is in these countries in which the population is growing most rapidly. Were all poverty to be alleviated overnight, and all of the world's population suddenly started enjoying an average Western European or North American lifestyle, with the associated amount of annual per capita land use, we would have a very large problem indeed – we would need three Earths! Thus, by continuing to reproduce in an unrestricted manner, are we actually unwittingly consigning the majority of the Earth's population to a life of destitute poverty? And, to put it rather crudely, do we have to make a choice between quality and quantity of life on this planet?

Perhaps I have been a little hasty in presenting this dilemma to you; perhaps this binary distinction really is too crude. Maybe the scientific advances of the future will provide a way for us to increase both the quantity and quality of life on Earth, just as the industrial revolution helped us avert the crisis Malthus once prophesied. Perhaps advances in GM, hydroponics, or other as-yet-unforeseen technologies will allow the Earth to support an even larger population than today's. Yet, even if this were achieved, which is by no means a certainty, is it really desirable to treat our planet in this utilitarian manner, as though it were a factory whose output one must strive to increase at all costs? And, if we are going to start talking about our planet as a factory, perhaps we should start talking less about increasing productivity and more about improving working conditions.

However, it isn't just increased efficiency of food and energy production which is regularly touted as a potential panacea. Extra-terrestrial migration is regularly put forward, even by scientists, as a potential solution to the problem of overpopulation. While one may be tempted to applaud these people's visionary optimism, I'm afraid they are guilty of plain denial, as even a cursory glance at the numbers involved will quickly elucidate. If one considers that the world population is currently growing at around 76 million people per year and that the highest number of people we could realistically hope for a spaceship to hold is around, say, 300 (this is generous, given that the shuttle carries only around 7 crew members), we would need to launch almost one spacecraft every two minutes just to keep the global population at the current level! And, even if we could find a way of producing and launching spacecraft at this phenomenal rate, our problems still wouldn't be over – not by a long shot. It would take the space shuttle around 150,000 years to reach Alpha Centauri, the nearest star outside of our solar system. Whilst it is likely that we will be able to develop spaceships which can travel much faster than the shuttle, there are limitations, primarily due to fuel availability and limits to the acceleration force the human body can withstand. Also, in our quest to find other Earth-like planets, suitable for habitation, we are likely to have to travel much further than Alpha Centauri. Consequently, 150,000 years still remains a generously low approximation of the likely journey time. Not only would such an extended journey time result in massive inbreeding problems, but it would also mean the spacefarers would have to deal with extremely limited resources. In the inherently finite world of the spaceship, unlimited reproduction would clearly be an antisocial act. Thus, prior to embarking the spaceship, the travellers would have to surrender their right to unrestricted procreation. Of course, if they are willing to do this, then surely they might as well just stay put and accept similar restrictions here on Earth.

Now, on the theme of limiting reproductive rights, this is where things start to get really complicated. Perhaps you agree that overpopulation is an issue which needs to be tackled, but surely all governments don't need to start enforcing draconian laws such as those employed in China? Will not a little education and increased prevalence of birth control methods lead to a stabilisation of population growth? Sadly, the solution is not that simple.

There is evidence to suggest that the number of children one wishes to have has a genetic component. Consequently, wherever people are asked to limit population growth through responsible levels of procreation, those individuals who are genetically predisposed to have less children will do so and the genes for wanting fewer children will become rarer within the population. By contrast, those individuals who are genetically predisposed to want more children will submit to this desire. Thus, the genes for wanting more children will become increasingly prevalent within the population with each passing generation, potentially triggering a dangerous positive feedback effect. At the same time, the genes for wanting fewer children will inevitably become ever-more scarce, as they are passed onto fewer individuals in subsequent generations. Ergo, if we are to go down the line of reducing birth rates, there is an argument for enforcing legal limits upon individuals' reproductive rights, rather than simply relying on individuals to make apparently-responsible decisions.

> "THE CHALLENGES OF OVERPOPULATION AND POVERTY ALLEVIATION ARE INHERENTLY LINKED"

Consideration of the alternatives available will hopefully render the above statement slightly less controversial. However, in order to consider these alternatives, I will first have to introduce a concept known as the 'Malthusian demostat'. The 'Malthusian demostat' can be best explained using the metaphor of a living room, whose occupants strive to keep the temperature at a stable, comfortable 21 degrees Celsius. Should the temperature of the room drop below this optimum, the temperature can easily be brought back up to the desired level by simply turning up the heating. Equally, should the temperature of the room overshoot the desired level, this can just as easily be rectified by opening a window and leaving it open until the temperature has sunken sufficiently. This is analogous to the phenomenon of overpopulation in the giant living room we call planet Earth, except now, instead of the temperature rising, it is the population which is overshooting the optimum level. Thus, should the population rise above the level our planet can support, increased mortality rates will inevitably bring it back down to a stable level. Surely this is less desirable than taking measured steps to decrease fertility rates, in order to ensure such levels of overpopulation are not reached in the first place?

Obviously, there are very few people who would advocate limiting population growth without due consideration. The argument I am propounding in this article is simply that taking steps to reduce the global birth rate, whilst certainly not a measure to be taken lightly, may be the lesser of two evils. The alternative, to continue increasing population at the current unsustainable rate, until war and famine reduce the population growth rate for us, is far less morally acceptable in my view. If you deem this prophecy unrealistically pessimistic, then just look around you: water wars have already been fought in the Middle East, Africa and Asia. Conflicts over oil, minerals and other limited resources are also increasingly regular occurrences on the global political stage. So, whilst larger population sizes have historically been advantageous for individual nations, usually in terms of providing a ready supply of cheap labourers or foot-soldiers, can we really afford to continue politely ignoring the problems our increasing global population is causing?

Sir David Attenborough, one of several high profile patrons of the charity 'The Optimum Population Trust', has had this to say on the matter:

"For far too long, governments and environmental NGOs have observed a taboo, invented in the 1980s by a bizarre coalition of the religious right and the liberal left. By encouraging us to ignore the vital need to stabilise our numbers by humane means, before nature does it for us by inhumane, natural means [famine, disease, war], this absurd taboo betrays our children."

'GO FORTH AND MULTIPLY'

Organised religions long ago realised that the easiest way to increase their respective followings was to incorporate an ideology of unlimited reproductive growth into their teachings. Hence, the prominence of the above mantra in the very first book of the Bible. One could also argue that a desire to increase their number of followers underpins the Catholic Church's dogmatic opposition to the use of condoms.

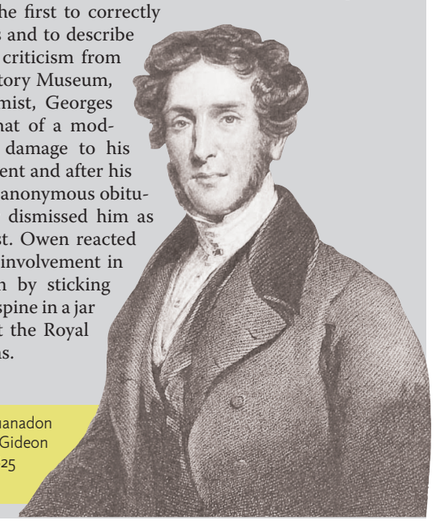
However, the problem isn't just about religion. Our system of government is woefully ill-equipped to deal with problems of this scale. In addition to being inherently short termist, our democratic system means that any political movement advocating limited reproduction rates will inevitably see its relative number of supporters dwindle from one generation to the next. By contrast, those parties advocating unlimited propagation are likely to see their number of supporters increase over time.

UNSEEN HEROES OF SCIENCE

BY KATE HAZLEHURST

6 GIDEON MANTELL
(1790 – 1852)

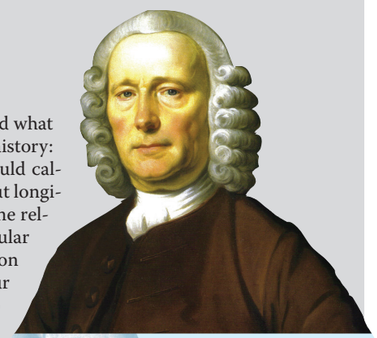
Mantell was a full-time medical doctor, but made some incredible contributions to palaeontology in his spare time. He was the first to correctly identify dinosaur fossils as giant reptiles and to describe Iguanodon, but was constantly fielding criticism from his rival, the founder of the Natural History Museum, Richard Owen. Eminent French anatomist, Georges Cuvier dismissed Mantell's fossils as that of a modern species. Mantell suffered horrific damage to his spine in a carriage accident and after his death a decade later, an anonymous obituary in the local paper dismissed him as an inadequate scientist. Owen reacted to accusations of his involvement in Mantell's defamation by sticking Mantell's deformed spine in a jar and displaying it at the Royal College of Surgeons.



Sketches of fossil Iguanadon teeth and jaw from Gideon Mantell's (right) 1825 seminal paper

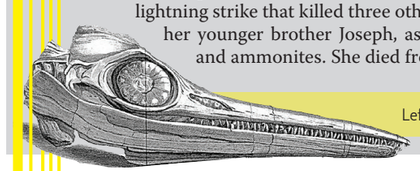
5 JOHN HARRISON
(1693 – 1776)

A Yorkshire-born carpenter, John Harrison solved what was probably the greatest maritime problem in history: finding longitude at sea. In the 1600s, sailors could calculate latitude (N-S) from the angle of the Sun, but longitude (E-W) required accurately tracking local time relative to a meridian (Greenwich Mean Time). Regular pendulum clocks were affected by a ship's motion and humidity, so Harrison designed and built four timepieces (H1-H4), the last of which could keep time so accurately on long voyages that Captain Cook referred to it as "our faithful guide through all the vicissitudes of climates". Harrison didn't receive his deserved payment and recognition from the British government until he was eighty years old.



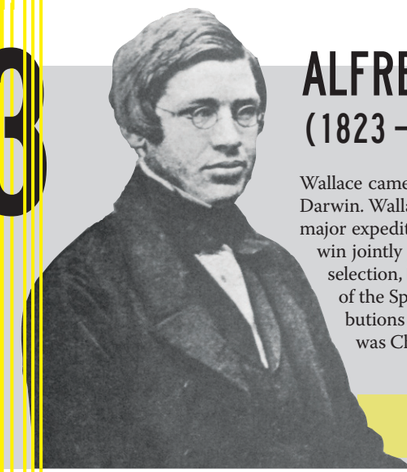
4 MARY ANNING
(1799 – 1847)

One of the most prolific fossil collectors in the history of British palaeontology, Mary Anning taught herself geology and anatomy as a young girl. She was well known for collecting fossils along the Dorset coastline and selling them to tourists, inspiring the tongue-twister, 'she sells sea shells on the sea shore'. Scouring the cliffs for fossils was a dangerous pursuit and Mary's father fell to his death when she was only eleven. Mary herself survived countless falls and slips in bad weather, and was even unscathed when, aged one, she was hit by a lightning strike that killed three others. Mary found the first ichthyosaur fossil with her younger brother Joseph, as well as plesiosaurs, pterodactyls, belemnites and ammonites. She died from breast cancer aged 47.

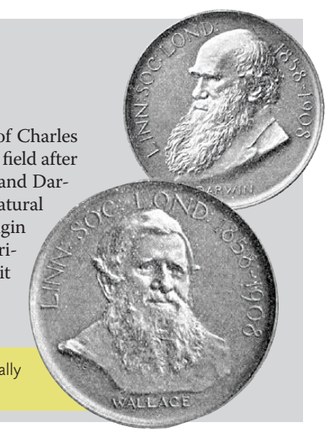


Left: Anning's 1814 drawing of 'Ichthyosaurus' platyodon

3 ALFRED RUSSELL WALLACE
(1823 – 1913)



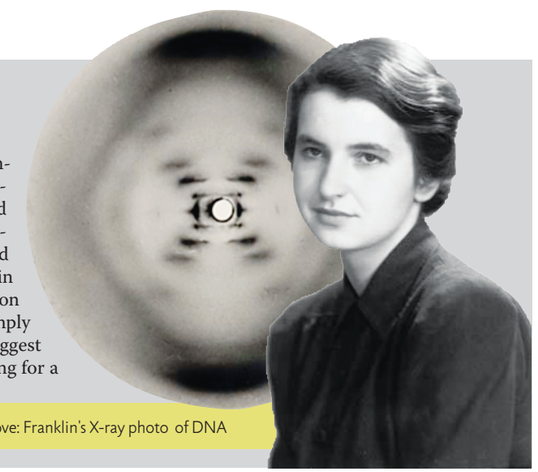
Wallace came up with the theory of natural selection independently of Charles Darwin. Wallace was a self-educated biologist, gaining eminence in the field after major expeditions to South America and South East Asia. In 1858 he and Darwin jointly published a paper detailing the theory of evolution by natural selection, but it had negligible impact compared with Darwin's Origin of the Species one year later. Wallace was well-known for his contributions to evolutionary science in the 1800s, but after his death, it was Charles Darwin who would become a household name.



Right: The Linnean Society award the Darwin-Wallace medal annually for outstanding advances in evolutionary biology.

2 ROSALIND FRANKLIN
(1920 – 1958)

The mid-1900s was a difficult time to be a woman, a Jew, or a scientist, never mind all three. Rosalind Franklin was mistaken for an assistant by her chauvinist colleague at Kings College, London and had to struggle with blatant sexism throughout her career. She was a brilliant biophysicist, taking incredible X-ray photographs of DNA and coming extremely close to solving the helical DNA structure. Franklin was beaten to publication by Watson and Crick in 1953 after Watson viewed some of her photographs. Some accounts suggest Watson simply turned up at the lab insisting to view the images, while others suggest that he had been regularly snooping around her place of work, hoping for a glimpse of the images that would change science forever.



Above: Franklin's X-ray photo of DNA

UNSEEN HEROES OF SCIENCE

1 NIKOLA TESLA
(1856 – 1943)

BY JOVAN NEDIC

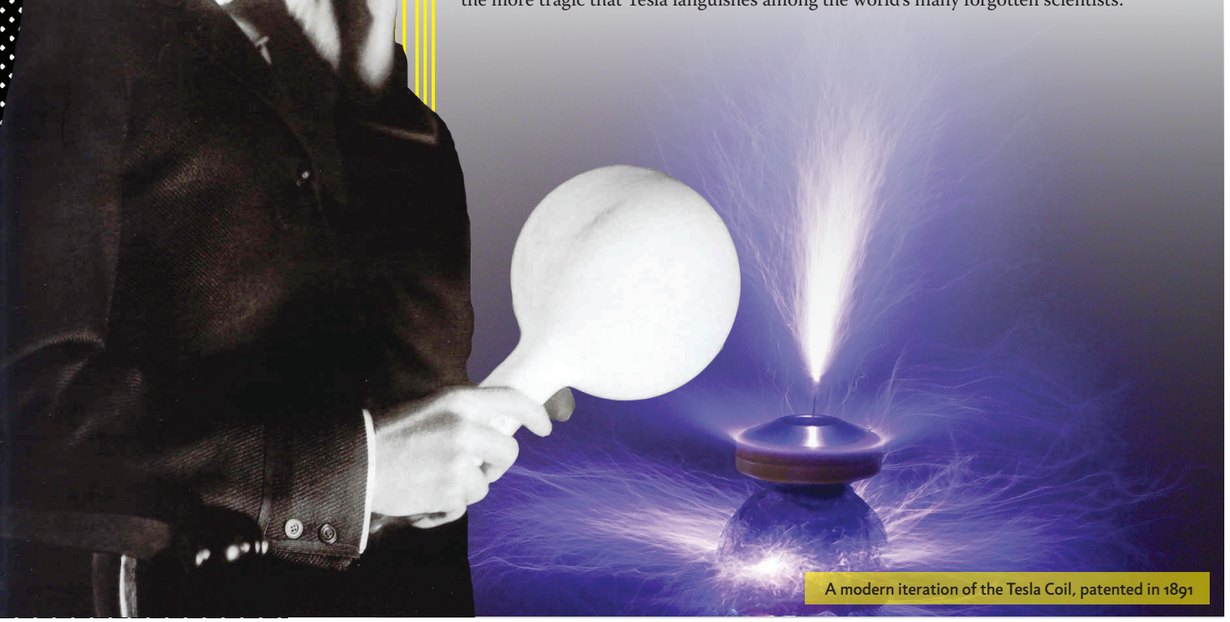
Nikola Tesla was born in Smiljan, then part of the Austrian Empire, in 1856. At the age of 28, he sailed to New York City with four cents in his pocket and a letter from Charles Batchelor addressed to Thomas Edison, in which he apparently wrote "I know of two great men and you are one of them; the other is this young man." Edison had Tesla initially working on some simple problems but soon had him working on improving the company's direct current generators. After not receiving the $50,000 he had been promised by Edison to carry out this work, Tesla quit in 1885 and thus began a life-long animosity between the two men.

One of the fundamental sources of the rivalry between Edison and Tesla was their difference in opinion about the merits of the two possible electrical currents. Tesla believed that the concept of 'direct' current, or DC, that Edison was pushing was inefficient and that 'alternating' current, AC, was the future in both power and efficiency. As we can clearly see today, it is Tesla's AC that has prevailed and stood the test of time. But this is just one of the many great things which Tesla achieved during his life-time. He discovered ways to light bulbs wirelessly, and how X rays could be used safely for the first time.

In 1891 Tesla patented the 'Tesla Coil', a mechanism that allows for wireless transmission. Two years later, he demonstrated a wireless transmitter and receiver over which information could be sent, gaining a patent for his radio in 1897.

Tesla was devastated when Marconi patented the wireless radio in 1904, and thus began another bitter feud. The battle took the two men to a long-running court case into which Tesla ploughed all of his personal savings. In 1944, after an excruciating 40 years, the US Supreme Court came to a decision; the patent was awarded to Tesla after they discovered that Marconi had used a number of Tesla's inventions in making his radio. Tesla died a year before the final decision was made, penniless and alone in a New York hotel.

By the time of his death, Tesla had roughly 300 patents around the world. His inventions allowed us to use electricity safely, and to transport it great distances without losing any of its power. This is why, to me at least, he is the real father of modern electricity. Thus, it is all the more tragic that Tesla languishes among the world's many forgotten scientists.



A modern iteration of the Tesla Coil, patented in 1891

NATURE

In our Nature

Thea Cunningham explores the inner workings of the world's most respected scientific journal

Nature, one of the world's most prestigious science journals, was launched in 1869. Nearly a century and a half later, it is still dishing up the very best peer-reviewed research in science and technology.

All the editing and production takes place at Nature Towers in the heart of King's Cross, London. Here, editors, writers, designers, and a whole host of others work around the clock to produce each copy. Like most media, *Nature* has moved with the times and now much of the process, from submission through to publication, is done online.

Scientists, or 'authors' as they're known to the editors, can submit either an 'article' (report with immediate, far-reaching implications), or a 'letter' (a shorter paper reporting an outstanding finding). Initially, each team has to submit a 100-word summary to see if the editor approves.

Getting your work published in *Nature* is no easy feat though. The journal only has space to publish around 8% of the 200 plus papers it gets sent each week, meaning many papers are declined without being sent out for peer-review. In 2009 alone, *Nature*'s editors received nearly 12,000 papers from hopeful scientists, yet just 803 of these were published. Tough stuff!

To be accepted, research needs to be novel, original, elegant…the list goes on. What's more, the findings need to be interesting to scientists across different disciplines. If the research ticks all of these boxes, the editor will send the whole paper out to review.

Most papers are sent to two or three referees, who are normally experts within the same field, but not connected to the authors or their work. The editor will ask the referees to note any technical errors and suggest who they think will be interested in the new results and why.

The peer-review process is rigorous and authors will often be asked to revise their work several times. Sometimes the work isn't as significant as the editor first thought and the paper might be rejected at a later date. However, a bit of rejection along the way isn't necessarily a bad thing and it's not uncommon for a paper to be rejected two, sometimes three, times before it finally gets the seal of approval.

If, despite the authors' perseverance, the work still doesn't cut it, editors might advise the authors to try *Nature*'s more specialised, sister journals, such as *Nature* Genetics, *Nature* Immunology, or the *Nature* Reviews series. Understandably, teams are often disappointed when they receive the bad news and many dissatisfied authors will appeal against the decision, more often than not without success.

Once a paper is officially accepted, it is passed on to the sub-editors, who make sure all the scientific jargon is accurate and readable so that journalists will want to cover it. Since space in *Nature* is tight (each paper gets just four to five pages), authors are often forced to cut out chunks of text and jiggle their wording to ensure it all fits in. The art team will then come up with drawings and diagrams to illustrate the findings.

Because *Nature* is published weekly, deadlines are tight. A fortnight before the issue goes to press, the production team decide which papers to feature in the issue and many papers are published online in advance. One week before the issue is published, the press office will issue a press release highlighting interesting upcoming papers. The press officers work closely with mainstream journalists and provide them with contact details for the authors.

For most authors, seeing their work in print is a proud moment. It's often been months since they first submitted their summaries, so it comes as somewhat of a relief when they finally get their hands on the real deal. Although *Nature*'s peer-review process and production system might be long and tough to crack, with a global readership and an impact factor higher than that of any other scientific journal, it's usually worth the wait.

CRAZY THEORIES

MORPHIC RESONANCE

Most people usually dismiss the feeling that someone is watching them as irrational. However, the theory of morphic resonance may offer a scientific explanation other than just pure paranoia. Or, maybe not.

The well-respected biologist Robert Sheldrake first postulated his theory in 1981, stating that all living things share a common bond, connected by a mysterious morphic field. This field supposedly acts as a library of experience that individuals can access and share. So when you feel you feel the hairs on the back of your neck tingle, it may be that you are sensing someone else's consciousness focused on you. Although Sheldrake claims that participants can guess with 60% accuracy if someone is looking at them, not one experiment of his has been replicated.

With this field of shared consciousness, tasks should become easier as they are attempted by more individuals within this group. In theory, successive generations of rats will become increasingly competent at navigating a maze because they are affected by the collective memories of their predecessors. Or, to use Sheldrake's example, crosswords tend to get easier later in the day. He obviously hasn't ever tried *The Sunday Times*' cryptic crossword: an impossibly difficult task regardless of the time of day. Fact.

Other tests have focused on telepathy, and if your pet knows when you are coming home. Remarkably, it turns out that dogs do show signs of awareness before their owner arrives – well before humans can hear the car. However, by failing to take account of dogs' acute hearing, the tests proved nothing – except, perhaps, Sheldrake's poor knowledge of animals' perceptual abilities.

Despite these massive flaws, morphic resonance still enjoys a modest level of support, perhaps due to Sheldrake's credibility as a scientist early in his career. Believing that there are forces that science cannot explain is a defensible viewpoint. However, as soon as claims are made on the basis of scientific evidence, the theory must play by the rules. With no replicability and poor experimental design, morphic resonance violates many of these scientific rules. Whilst it could be described as a theory, it certainly is not a scientific one.

BY JAN PIOTROWSKI

INTERVIEW

Please Sir, can I have some Moore?

Arthur Turell catches up with world-renowned astronomer and long-time presenter of *The Sky at Night*, Sir Patrick Moore.

Few have done more for popular science than Sir Patrick Moore. Now approaching his 88th birthday, he has been the somewhat eccentric face of science for decades. The chance to go and meet the great man at his home in West Sussex was too good to pass up. As I walk in to see him, waiting for the interview to start, I am surprisingly, and perhaps appropriately, a little star-struck. We sit in his office, surrounded by books, pictures, awards and an entire rail of honorary degrees. For a man who never went to university, or even for one who did, he has an astonishing number of them. When I address him as 'Sir Patrick' he shakes his head,

"Nice to talk to you, it's just Patrick – no-one ever called me Sir Patrick!" he laughs.

On the way in to the house, I had spotted an observatory in his garden, which I ask him about. Patrick built it himself. The octogenarian regretfully tells me that he can no longer use it,

"Others use it, it's used the whole time, but, very sadly, I can't."

As we get chatting, he reveals that there was an exact moment, at the age of seven and a half, when he first became interested in astronomy.

"My mother was always vaguely interested and had some books on it. I picked up a small book belonging to her called 'The Story of The Solar System', and there it is."

He points toward the shelf opposite and there it is, amongst the many books, their spines labelled by a home-made referencing system. He continues,

"I read this and thought, this is interesting, I'll follow this up."

He did, buying binoculars and then a beautiful brass telescope, which still stands proudly in the hall outside of his office. Eventually he began to spend time at a nearby observatory, under an astronomer named W. S. Franks.

"Franks suddenly died, which was very sad."

But this turned out to be a break for the then very young Patrick Moore, since the man who owned the observatory, Hamley, was looking for a replacement.

"Hamley gave me the shock of my life [by] saying 'You're 13, my astronomer is dead, would you run my observatory for me?'"

Despite being only 13, Patrick just got on with the job. He ran the observatory right up until the start of the Second World War.

When the war came, Patrick flew in the RAF. He tells me what his Commanding Officer said when he found out that Patrick was underage,

"You've faked your age and you've fiddled your medical. You are now 18, and you were a commissioned officer when you were just 17. Oh well, gin and tonic I suppose!"

He laughs at the memory but it is evident that he is recalling events from an emotional time. It is no secret that he has no love for Germans, even today:

"It makes me so cross that we are making friends with them."

He recognises that this is a controversial attitude and not one which sits well with modern sensibilities. I agree with him that I cannot hope to understand what it must have been like to have had friends killed in the war. Wistfully, he talks about one person he lost in the war,

"At the age of 20, my girl was killed. And that, for me, was it. I knew then that I would never have any children. I'd never marry."

> "AT THE AGE OF 20, MY GIRL WAS KILLED. AND THAT, FOR ME, WAS IT. I KNEW THEN THAT I WOULD NEVER HAVE ANY CHILDREN. I'D NEVER MARRY."

Like most people, I know of Patrick because of what he has done in bringing astronomy to the general public, through the many books and television shows in which he has appeared. Actually, if I'm honest, my first television experience of Patrick was when he played the GamesMaster in the eponymously titled show.

Popularising science, particularly astronomy, has long been his *raison d'être*. He holds the world record for the longest serving television presenter for *The Sky At Night*, which first began broadcasting in 1957 and continues to this day. As he is no longer mobile, he presents it from his home. Patrick has also tried to tackle the stuffy science stereotype by parodying himself many times – and what a character to parody! His rapid, old-fashioned diction and trademark monocle are easily recognisable, though I sometimes have trouble following what he is saying.

He tells me about some great moments from *The Sky At Night*, the highlight being when the crew of Apollo 8 sent him the first ever pictures of the far side of the moon during a live broadcast,

"I said something like this, 'the men of Apollo 8 are now on the far side of the Moon. We can't see them, we can't hear them... but in a few seconds they'll come around the edge and we'll hear them. In a few seconds we'll hear the voices of the first men round the Moon, and this is one of the great moments in human history'. And then the BBC changed over to Jackanory!"

> "AT THE MOMENT, WE ARE RATHER LESS CIVILIZED THAN THE ATHENS OF PERICLES; WE HAVE THE MEANS TO DESTROY OURSELVES, DO WE HAVE THE CIVILIZATION NOT TO DO IT?"

He laughs uproariously at this.

Patrick is not just respected for his work popularising science. He has made significant contributions to academia, particularly in moon mapping. Both NASA and the Soviets used his maps of the moon for their space programmes – and NASA were so grateful that they chose to send the images from the Apollo 8 mission straight to him.

Over the last ten years, he's been compiling an enormous data book of astronomy, which is due to be published by Cambridge University Press in February. I ask him if our exploration of space has stalled since the days of the moon landings, but he is upbeat about our progress.

"People think things have slowed down. In a way they have, and in a way they haven't. So far as manned research is concerned, yes, they have most certainly. But unmanned research, now, think what's been happening with various space telescopes – as a physicist you will know. The Spitzer telescope, for example. And they're all sending observations back all the time."

> "ALL THIS RUBBISH ABOUT GLOBAL WARMING, WHICH IS NOTHING WHATEVER TO DO WITH US, IT'S PURELY THE SUN. BUT WE ARE GETTING OVER-POPULATED"

As our talk turns to the terrestrial, he is less than positive about the world as it is,

"At the moment, we are rather less civilized than the Athens of Pericles; we have the means to destroy ourselves, do we have the civilization not to do it?"

I press him on what challenges are facing our civilization.

"Various problems are facing us here, the worst being over-population. All this rubbish about global warming, which is nothing whatever to do with us, it's purely the sun. But we are getting over-populated, we are using up our resources which you can't renew and there's got to be some change there."

So what, I ask, are his dreams for the future of mankind?

"A united world, a peaceful world working together. That sounds idyllic; it is. It may not happen. I would like to think that it will. I won't see it. You'll see more than I do, but even you won't really see it. Your children and grandchildren may."

Our time runs short, but Patrick still has a few surprises. He speaks fluent French and passable Norwegian; he is an accomplished musician and once played the piano in a duet with Albert Einstein on the violin. He once played and drew against one of the greatest chess players in the world, Nigel Short. Patrick Moore, I realised, was a genuine polymath. He doesn't believe he'll be around much longer, but I hope he keeps going for some time yet.

Sir Patrick Moore at his home in West Sussex

The impression I get is of a charismatic man who has had a rich and interesting life, and who has inspired others. Not only that, but he is generous; he invites me back to use his telescope and offers me a gin and tonic before I leave. However, before leaving, I ask him one final question: I ask him what he wants to be remembered for.

"The only thing I've tried to do, I've tried to interest others in astronomy. And bring people in on it, particularly youngsters. If I've done that at all, that'll be the only thing I've done of any use to anybody. And that's how I'd like to be remembered, if I'm remembered at all, which of course I won't be."

REVIEWS

EXHIBITIONS & EVENTS

Museum metamorphosis

COCKROACH TOUR, SCIENCE MUSUEM
SATURDAYS & SUNDAYS

ATTENDED BY DAVID ROBERTSON

I strapped on my exoskeleton, waved my antennae and hissed at my friends. A little kid walking past did a double-take, latched onto his mum and pointed in amazement. I was about to embark on one of the Science Museum's brand new cockroach tours.

The tours take about an hour and are costumed, themed tours, pitched at families but perfect for anyone with an inner child.

Our tour guide, John, did an outstanding job, bringing a new perspective to a selection of the exhibits in the museum. The best thing, though, is running around the museum in a giant cockroach outfit: if you can learn a bit along the way, all the better!

Book in advance from *www.sciencemusuem.org.uk.*

HIPSTER SCIENCE

ATTENDED BY ROSIE WALDRON

SUPER/COLLIDER, THE BOOK CLUB, SHOREDITCH, MONTHLY

One evening a month science collective 'super/collider' invades the basement of trendy Shoreditch bar The Book Club and set up Science Fair; a creative look at all that is cool about science. To commemorate the 40th anniversary of the Apollo 14 blast off, January's Science Fair featured Sundance award winning film-maker Dr Christopher Riley – expert on all things Apollo.

Bright Star Collective provided space-inspired music as the room filled with chic geeks, pints in hand, until there was standing space only. Appropriately, the evening began with a countdown to blast off. Dr Riley then brought to life the quirky and human aspects of space travel, interspersed with audio from the actual moon. These remarkable recordings, documenting Apollo 14 astronauts Alan Shepherd and Edgar Mitchell getting lost on the moon, are taken from Riley's Cone Crater installation. After a quick Q&A session, where we learned why Astronauts get jet lag, the DJs resumed and everyone got another drink.

The next Science Fair will be a night of films, with experts exposing the fact from the fiction, and popcorn and music. They don't usually sell out in advance but judging by January's turn out, get there early if you want a seat!

RADIO & PODCASTS

BY ANNA PERMAN

GUARDIAN SCIENCE
PODCAST, WEEKLY

From a fairly conventional studio-based spoken podcast, Guardian science weekly has grown into something a bit more inventive of late. With more and more outside broadcasts, they've started to use background sound effects and layering voices to sound a bit more experimental. They also talk about science – Alok Jha (above) and the *Guardian* team take you through the week's science news in a playful way, from what it's like to spend Christmas at CERN to Isabella Rossellini's 'Green Porno' films.

STRANGE QUARKS
PODCAST, WEEKLY

Sometimes, you just want to love something so badly, yet can't. Martin Robbins' blogs are pointed, witty analyses of contemporary science, and science writing. Yet his podcasts, aside from the inexplicably terrible audio quality, have an unfortunately self-righteous tone. His interview with David Aaronovitch from December is the epitome of this – two admirable writers who in person sound pompous and arrogant. Lesson: Just because you can write on paper doesn't mean you can speak on radio.

REVIEWS

BOOKS

AN OPTIMIST'S TOUR OF THE FUTURE
BY MARK STEVENSON, OUT NOW

A whistle stop tour of Mark Stevenson's vision of the future, this book is a crash course in some of science's hottest topics.

Taking a journey around the world, Stevenson tries to get to grips with how science is set to change our lives beyond all recognition. Each pitstop along his journey introduces a new topic: nanotechnology, genetics, climate change, space travel, even robots, they are all covered here at a rattling pace.

His love for science comes through clearly in his writing, helping to make it a very lively read. The pace of the book however, is at times a little too fast for its own good, and by the end even Stevenson seems exhausted by the huge amount of information he's had to process. The topics covered also raise some fundamental questions such as "What is intelligence?" and "What does it mean to be alive?" He even mentions the big one: "What does it really mean to be human?" but he only has just enough time to scratch the surface of the issue. Rather than going into greater depth on any one question, Stevenson prefers to skip on to the next glorious image of the future. It is hard though not to get swept away by his optimism and each story that he tells is full of both enthusiasm and humour.

What comes across most strongly is the respect that Stevenson feels for the people that he meets on his trip. Science may underpin the whole book but it really is the characters that hold it together. There are some seriously impressive people in this story and they are undoubtedly the root of all of Stevenson's optimism. The overall message of the book is clear: humans are resourceful enough to get over anything, and if the people in this book are anything to go by, our future may be brighter than we think.

TELEVISION

BY LIZZIE CROUCH

It's been interesting to see what subject matter channels have tackled in the last few months. Channel 4 has covered a lot of environmental topics, from explaining the reasons behind the big chill of 2010 in *The Year Britain Froze* to tenuously exploring the environmental impact of the seafood industry in *Gordon Ramsey: Shark Bait* and *Heston's Fishy Feast.* The BBC on the other hand, alongside its epic series *Human Planet*, looked backwards to examine scientific progress in the last century. Programmes such as Robert Winston's 10 life changing breakthroughs in *How Science Changed Our World* and *Mad and Bad: 60 Years of Science on TV* gave us an interesting perspective on how science, and its place in society, has developed in recent years.

However, my personal favourite from the last few months has to be *The Joy of Stats* shown on BBC4 in January.

The wonderfully quirky Professor Hans Rosling (above) tackled the seemingly dry world of number crunching statistics and actually turned it into an engaging subject. The programme demonstrated the importance of the field, and how statistics will increasingly shape the way we live.

ALSO OUT NOW

Periodic Tales: The Curious Lives of the Elements *by Hugh Aldersey-Williams*
RRP: £11.39 (Hardback)
Thought you knew the periodic table? Not like this you don't. This book is an immensely engaging tour of the stories behind the elements.

The Immortal Life of Henrietta Lacks *by Rebecca Skloot*
RRP: £4.79 (Paperback)
The story of Henrietta Lacks, a black woman born in the 1920s, whose cancer cells were taken without her knowledge to become one of the most important tools in medicine and the basis of a multimillion-dollar industry.

LISTINGS

AUDIO

Science Café
BBC Radio Wales, Tuesday 19.00
OK, it may be about science in Wales, but Adam Walton looks at science news with a surprisingly wide reach, taking in everything from Treborth Botanical Gardens to antimatter.

Genius Unrecognised
BBC Radio 4, Sunday 14.45
Sometimes an invention comes along before the world is quite ready for them. Tony Hill looks at five technologies that are crucial to our way of life now, but were written off when they first came along.

David Attenborough's Life Stories
BBC Radio 4,
Friday 20.50 (repeated on Sundays at 08.50)
David Attenborough's ten-minute audio bites showcase the silky-soft tones of his voice to full effect, as he tells of delightful stories from a life in natural history programme making. Warning: may induce major lifestyle jealousy.

The wired.co.uk podcast
Available on iTunes
A weekly round up of the world in technology, gadgets and gaming from the uber-cool team at *wired.co.uk*.

EVENTS & EXHIBITIONS

Super/Collider Science Cinema Nite
The Book Club – £5
Monday 21st March, 7–11pm
Popcorn, music, drinks and a night separating the facts of science from fiction in films!

Treetop Walkway at Kew Gardens
Kew Botanical Gardens – £11.90 admission
Visit Kew in the spring and check out the spectacular recent addition, the Treetop Walk (pictured above).

Age of the Dinosaur
Natural History Museum – £6
Opens 22nd April
A blockbuster temporary exhibition, complete with lifesize animatronic dinosaurs to excite your inner child!

Astronomy Galleries
Royal Observatory, Greenwich
Free exhibition
Open daily
Touch a 4.5 billion year old meteorite at the home of Greenwich Mean Time.

Big Wild Cats
Dana Centre – Free Event
Tuesday 15th March, 19:00-21:00
Hear a psychoanalyst discuss our fascination with big cats, plus the latest wildlife documentary clips. Book at *danacentre.org.uk*.

A Climate of Fear: Joe Flatman
British Museum – Free event
Thursday 9th June, 13:15
Join a UCL archaeologist as he explains how objects reveal past human responses to climate change.

Senseable Cities
London Transport Museum – £6
Opens 1st May
An artistic and high-tech display showing how advanced sensing systems allow us to access an old city in new ways.

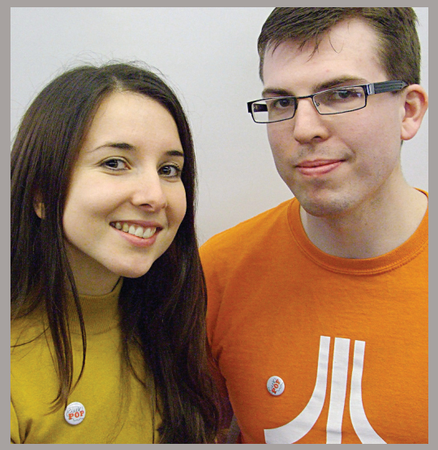
Dirt: The filthy reality of everyday life
Wellcome Collection Free exhibition
Opens 24th March
Explore the fascinating world of filth; one of society's last taboos.

Sexual Nature
Natural History Museum – Cost £4
Open until 2nd October, 2011
Undress the science of sex in a 'stimulating' exhibition.

Wellcome Image Awards Insight
Wellcome Library –Event/Exhibition
Thursday 24th March, 7-8pm
Hear the stories and techniques behind the incredible Wellcome Image Awards display, currently exhibited at the Wellcome Library.

A PITSTOP AT GEEKPOP

Since Geekpop, the UK's only online science music festival, was born in 2007, it has grown exponentially. This year, it is being launched in London at Wilton's Music Hall. Keep an eye on the *I,SCIENCE* website for the gossip from the launch party on March 10th. Anna Perman caught up with Hayley Birch to find out more about what's in-store for them this year.



WHAT WAS YOUR INSPIRATION FOR SETTING UP GEEKPOP?

I'd been listening to Jonny Berliner playing his song *Dark Matter* on the *Guardian*'s science podcast and I sent him an email to ask if I could use it on a website I was writing for at the time. To my surprise, he said yes, and that he would record a new version especially for us. I got in contact with a few more people who had songs about science and the festival just grew from there. Now we have a website and a podcast, and we're organising live gigs of our own and in partnership with other festivals.

AN ONLINE MUSIC FESTIVAL? HOW ON EARTH DOES THAT WORK THEN?

Well, you get to visit the various stages and listen to bands, just like at a normal music festival, except they're virtual stages and virtual gigs. All the tracks you'll hear are downloadable and you don't even have to set up a tent or slop around in wellies – just sit in the comfort of your own home and enjoy the music.

SO WHAT CAN WE LOOK FORWARD TO THIS YEAR?

Usually we know pretty much what's going to be in each artist's set by the time we get this close to the festival. But this year lots of our artists wanted to write new songs especially for the festival, so I'm really excited but a bit anxious about what's going to come in! There's definitely a song about animal sex, so listen out for that, and we've been lucky enough to get *Amateur Transplants* to play at our live launch gig. Not only that but we've got one of the best music venues in London – Wilton's Music Hall.

TELL US ABOUT YOUR FAVOURITE PIECE OF UNSEEN SCIENCE.

I'm personally a bit of a geek about nanotech, which is sort of unseen – in that you can't see it without a super-powerful microscope. If you check out the Geek Pop '09 festival, which is all still online, you'll be able to download a brilliant song called Nanobot by Alatinpunkcircle, from the Tesla Tent. I think it encapsulates many of the hopes and fears and misunderstandings that a lot of people have about nanotechnology, especially in the context of medicine. But it also touches on the idea that even if something is so small you can't even see it, it can have huge potential.