

// the GIST

The Glasgow Insight into Science and Technology

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BIONICS

WIND ENERGY

TINY SATELLITES

SPACE DIAMONDS

PSEUDO-SCIENCE

SOLITONS

WOLVES



DEAD LIKELY?

THE SCIENCE BEHIND THE ZOMBIE APOCALYPSE

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EDITORIAL

Hello and thanks for picking up your free copy of The Glasgow Insight into Science and Technology, rather snappily shortened to The GIST. In this issue you will find articles on a wide range of scientifically-flavoured topics, from the science behind the (definitely impending) zombie apocalypse to an incredibly important discovery made by an observant Victorian gentleman and his horse. We have a deliberately Glaswegian bias, focusing on the world-class research being carried out in the Greater Glasgow area. We also go as far afield as India to report on their world-leading wind energy sector and lay bare the pseudo-science behind 'Energy Armor™' (coming to a leisure centre near you soon).

So why did we do this?

As a group of post-graduate researchers, we feel that the interesting, enjoyable (and occasionally important) work we get paid to do shouldn't be hidden away in subscription-only journals, wrapped in opaque scientific jargon. The current popularity of scientific programming and festivals shows that there is a public hunger for information about science and technology. We hope to offer a local and early career perspective on all this. In doing so, we're starting a dialogue that will continue through our scientific careers, as public justification for research becomes increasingly important. We also join our fellow student science publications, EUSci in Edinburgh (www.eusci.org) and Au in Aberdeen (www.au.org).

The GIST is an entirely student-run initiative between post-graduate students at the Universities of Glasgow and Strathclyde. Without my fellow GISTers, there would be no website, no magazine and no content. I'd like to thank them for their incredibly hard work on all things GIST, and you once again for picking it up.

If you want to get involved in the next issue of the GIST in any way, from writing to editing to layout and images, email us at editor@the-gist.org

Now go get the GIST about science and technology in Glasgow!

// Alan Boyd is a 2nd year PhD student at the University of Strathclyde

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// 01



DEAD LIKELY?

THE SCIENCE BEHIND THE ZOMBIE APOCALYPSE

Maddy and Gavin team up to discuss the possible agents behind a zombie uprising. A common feature in many sci-fi movies, games and books, is the zombie a scientific possibility?

The zombie apocalypse *will* happen. At least that is what we are led to believe. It may be bioterrorism or an evil pharmaceutical company's twisted experiment gone wrong. Either way, the media has led us to believe that this deadly scenario is not just a possibility but a probability. From the many computer games to the masses of films, this topic has been covered from every angle, but what is the science behind the stories?

The likelihood of reanimated corpses rising to fulfil their bloodlust is minimal but there may be some feasibility in stories involving infections. This has been explored in many movies and videogames including the 28 Days Later franchise, Left 4 Dead, Dead Island and Resident Evil. These plots are still far-fetched but at least have their roots grounded in science. So, how likely is a zombie apocalypse and how may it come about? It's definitely worth exploring – after all, it might just happen.

Zombie ants

Though it may scare some to know, zombies already exist. Carpenter ants in Thailand have recently been discovered to be plagued by zombification caused by a parasitic fungus which infects the ants and manipulates their behaviour in order to increase its own transmission. The fungus, a species of *Ophiocordyceps*, is absorbed in its mycelium form (the vegetative phase) and thrives on the organs of the ant, releasing unidentified chemical signals which penetrate

the central nervous system and allow the fungus full control over behaviour.

The infected ant displays unusual activity, often found astray from the group, wandering on nearby vegetation. When the fungus has found the perfect spot where conditions are ideal for optimal transmission, it induces a 'death grip' response in the ant, which bites down on the stem of a plant, locking its body in place. As the fungus finally starts to feed on its brain, the ant dies. A fungal growth called an ascocarp erupts from its head and releases spores, potentially infecting new victims.

Zombies with a scientific basis

- **Dead Island** - mutated prion
- **Dead Rising** - genetically modified bees
- **Residence Evil** - virus
- **28 Days Later** - RAGE virus
- **Left 4 Dead** - rabies virus

So far the fungus has not made the leap to human transmission and no other known fungus exists that could. However there is always the possibility that on some undiscovered island, a *Cordyceps* fungus exists with the ability to jump the species barrier. Let's hope not.

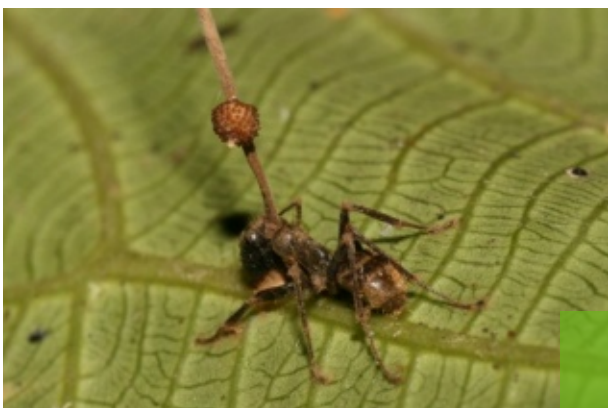
Toxoplasma gondii

Parasites, like the cordyceps above, always have a way of manipulating their host in order to ensure their own continuation. *Toxoplasma gondii*, a small protozoan parasite, is no different and is frighteningly common, affecting one third of the world's population. Although primarily a cat parasite, *T. gondii* has intermediate hosts such as humans, livestock and rodents. However to reproduce, the parasite must be in the definitive host, so it manipulates the behaviour of its intermediate hosts to make this happen.

Rodents are timid creatures, normally averse to cats, their natural predators. Laboratory tests have shown that mice infected at early post-natal timepoints display increased activity and become 'bolder' – more readily exploring new territory and preferring to stay in more open, exposed areas of the testing chamber. Furthermore, mice have an amazing sense of smell and normally avoid areas marked by cat urine. Infection with *T. gondii* can not only cause mice to lose this life-saving instinct but also to become attracted to the smell of cat urine. The mechanism behind the alteration of behaviour is unknown but it makes these mice far more vulnerable to attack from cats, a method the parasite employs in order to breed. The parasite has even been shown to alter the personality of humans but unfortunately not in such a way as to create the flesh eating zombies that we know and love [2].

Prion diseases

As infectious agents go, prions are indeed a novelty. Not a parasite, virus or bacterium, prions are misfolded proteins. These proteins can be transmitted from one person to another through ingestion of, wait for it ... BRAAAIIINS. This major prion protein, or Prp, exists in two

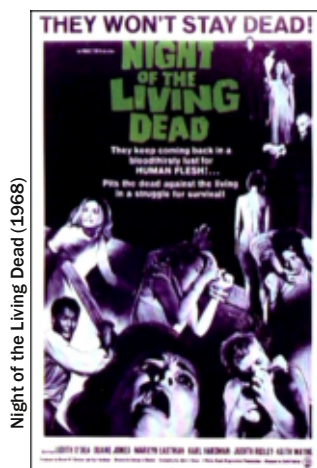


// *Ophiocordyceps* ascocarp emerging from the head of a Carpenter ant [1]

isoforms: the normal physiological isoform, PrP^c and the misfolded form PrP^{Sc}, named after the prion disease scrapie found in sheep. Once the misfolded PrP protein has been ingested, it corrupts all PrP^c production, leading to a build up of the scrapie form which is protease-resistant and cannot be removed by the body. Plaques begin to form in the brain, much like Alzheimer's disease and a similar irreversible neurodegeneration occurs. Clinically, these patients undergo behavioural changes, with symptoms including depression, hallucinations and increased aggression. Muscular abnormalities are also common. Some form of prion outbreak is plausible as history has already shown us, with a UK epidemic of bovine spongiform encephalopathy (BSE, human form termed new variant Creutzfeldt-Jakob disease) beginning in 1987 and killing nearly 200 people over the next 2 decades.

Rabies and rabies related viruses

By far the most used virus in any storyline is rabies. This can be attributed to the virus's ability to transmit between multiple species, how it changes the behaviour of those infected and the fact that there is no definitive cure. The combination of these qualities provides the perfect zombie story, although minor tweaking may be required to produce one of apocalyptic proportion. Both rabies and rabies related viruses fall under the genus *Lyssavirus* and are very closely related, although the latter affects insectivores more than other mammals. The fact that rabies has remained prominent for thousands of years is partially due to its ability to cross between species. Humans



Night of the Living Dead (1968)

// Could this become a reality?



// A zombie mouse

Madeleine Cunningham

often contract the disease via bites from infected animals as the virus is found in high titres in saliva. Once infected the virus may replicate in muscle cells before invading the peripheral nervous system. It does so by binding to acetylcholine receptors, which is similar to the binding mechanism of many snake toxins. Once in the peripheral nervous

Rabies is almost always fatal and treatment is normally preventative

system the virus moves towards the central nervous system where it disseminates into other cells. Victims initially present with flu like symptoms followed by huge behavioural changes, in particular disorientation. This is followed by extreme aggression and intense hydrophobia with an inability to swallow.

Rabies is almost always fatal and treatment is normally preventative. Following a bite by a possibly infected animal, the wound can be cleaned and treated with several doses of rabies vaccine. This must be carried out within 24 hours however or all is lost ... almost. There have been a few cases where people have successfully survived rabies through the implementation of a treatment dubbed the Milwaukee Protocol. A drug-induced coma is used to protect the brain as the immune system mounts its response to destroy the virus. Several people have survived rabies through this treatment but its requirements wouldn't be easy to implement if bitten by a zombie.

In terms of a zombie apocalypse rabies is an excellent candidate for an infectious agent. The localisation of the virus in saliva coupled with the intense aggression experienced by the infected gives rise to the idea of humans running rampant in the streets biting one another. It should be noted that there have been no recorded cases of humans transmitting rabies to one another via bites, however the possibility still remains. The incubation of the virus also differs widely between individuals with some people not experiencing symptoms until at least 2 years after initial infection. However with a few minor modifications, let us say through genetic modification by an evil corporation, this virus would be excellent for bringing down civilisation.

So, what are the chances of all this happening? Well, as expected, they are very slim but the science does exist to make it possible. Who knows, whatever the mechanism, one day this may all occur and the science fiction may become a lot less fictional. Until then, you can prepare yourself using this knowledge and hopefully the scientists of the world can prevent the unthinkable happening — but if you're anything like these two authors you should make your zombie plan now before the zombies start chasing you through George Square and World War Z really does come to Glasgow.

// Gavin Robertson Meehan and Madeleine Cunningham are both PhD students in the Neuroimmunology Group at the University of Glasgow. When not preparing for a zombie invasion they are found in the lab researching Guillain-Barré Syndrome.

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REINTRODUCING THE WILD

// 05

Could reintroducing wolves reinvigorate the landscape of the Scottish Highlands?

Simon Gill investigates the effects of bringing back this icon of the wilderness to modern day Scotland.

Gunnar Ries

COULD WOLVES BE REINTRODUCED TO THE HIGHLANDS?

I'm sat by my tent, dinner cooking while the sun sets away across to the west. The still Highland evening is perfectly quiet up here near the summit of Ben Lomond. The view from my tent door takes in Glasgow and the Clyde estuary to the South and innumerable Highland mountains to the north. And then I hear it, a distant howl. At first just one voice then slowly it is joined by a dozen more. The sound strikes me with terror; it's the singing of the Highland wolves.

There are no wild wolves in Scotland today, but 500 years ago there were and maybe in another 50 they'll be back. The idea of reintroducing wolves to the wild parts of Scotland has been growing over recent decades and since the 1950s several locally extinct animals have been reintroduced: the white tailed eagle, red kites and more recently a trial to reintroduce beavers. With success on these fronts, could the wolf be next?

Species reintroduction, particularly with large carnivores, is controversial. Some, such as the White Tailed Eagle reintroduction on the Isle of Mull in the 1980s have now caught the public imagination, but all engender opposition from key groups including farmers and landowners who are concerned about the effect on their way of lives. One thing that eagles, kites, beavers and wolves have in common is that they were wiped out in Scotland by humans. Whether

through hunting or changes to their environment it is us who are responsible for their disappearance. European law now makes it a requirement that governments look at the possibilities and practicality of reintroducing species which have humans responsible for their extinction. Many of these are regarded as 'key-stone' species, an ecological term meaning that their effect on the area's ecology is disproportionately large compared with their number. Understanding these types of ecological effects is a key part of any reintroduction.

The ecological effect of wolf reintroduction in Scotland is, at present, unknown. But the effects of another key-stone species, the beaver, are being teased out by a trial reintroduction at Knapdale in Argyre, about two hours' drive from Glasgow. "There are a number of things we monitor", says Martin Gaywood who works for Scottish Natural Heritage (SNH), "— the beavers themselves — their own ecology and population dynamics, the woodland interest, and the loch systems. Then there are fish populations, otter populations and dragonflies". Martin has been involved in beaver reintroduction since it began. In May 2009 three families of beavers were released into an area of slow moving water, lochs and woodland in an attempt to estimate the effect they would have on the Scottish Highlands if a general reintroduction were undertaken. SNH is in charge of

monitoring beaver reintroduction and of answering some of the ecological questions that it poses [1]. "One of the key reasons why we are interested in beavers is that they do seem to have this possible keystone role in the ecology of woodland and freshwater habitats." It is easy to see why — take an area of small lochs and rivers for example. When beavers arrive they begin engineering works: felling trees, building dams and as a consequence diverting water flow and flooding new areas. These increased areas of shallow standing-water and riparian woodland surrounding the water edge can provide important new habitats. A big effect is on the amount of deadwood in the environment, something that is almost entirely missing from many human-managed woods. "Beaver activity can result in a lot more deadwood", explains Martin, "either standing deadwood, which might come about because they flood certain areas and the trees might die, or fallen dead wood where they have felled a tree". Deadwood is a hive of biodiversity providing perfect habitats for invertebrates, lichens and fungi to name a few. There is a similar effect in the water, where aquatic macrophytes — water dwelling plants — depend on the availability of standing water, and in turn provide sites for dragonflies to lay eggs.

The beaver trials highlight an important difference between direct and indirect ecological effects. Direct effects between beavers and other species, such as willow and aspen, include felling trees for food and dams. These effects are usually easy to study; indirect effects are another matter. The relationship between beavers and dragonflies involves an elaborate chain of cause and effect involving several intermediate species. Quantifying these requires masses of data and advanced statistical techniques.

Indirect effects have often been ignored in studies of ecosystems as it is assumed that the direct effects are more important, but in wolf research that trend is changing. A recent paper discussing Scottish wolf reintroduction quotes new evidence suggesting that indirect and non-lethal effects are at least



Jo Foo
http://www.flickr.com/photos/meiphotography/

// Would the wolf be welcomed back to Scottish forests?



Felicity Carlyle

as important as direct predation [2].

Yellowstone National Park in the USA is a place that knows about wolves. In 1995 a project began which has seen wolves released, packs develop and the ecosystem respond. Today approximately 100 wolves live in an area about one tenth the area of Scotland. Whilst the predation of wolves on elk is significant now, it is the behavioural changes of elk and the resultant effect on vegetation levels that is interesting Yellowstone's researchers. The change in elk habits since wolves arrived comes down to their awareness of danger. Previously, elk were happy feeding in most parts of their habitat, but the wolves have changed that and the elk now move in 'landscapes of fear'. This means that they are more wary when feeding and tend to avoid areas where wolf predation is most likely. The result is an abundance of willow and aspen in areas that were previously browsed clear [3]. The effect of wolves on willow and aspen is a perfect example of an indirect effect known as a trophic cascade, and trophic cascades could also be an important ecological effect when reintroducing wolves to Scotland.

Scotland does not have elk, but the ecology of the highlands is strongly influenced by a similar species – the red deer. Like the extinction of wolves, red deer numbers are high because of human intervention.

Stalking is lucrative for Highland estates, and more deer means more chance that their high paying clients will be able to bag one. But the ecological effect of the deer is massive and has led to barren landscapes, forests which are not regenerating and areas of low biodiversity. Even a small number of wolves in the Highlands could have the capacity to change red deer behaviour in a similar way to the changes observed in Yellowstone's elk. It seems likely that the resulting trophic cascade could reinvigorate Highland biodiversity.

Wolves may be positives in biodiversity terms, but there are other barriers to overcome. "Little Red Riding Hood has created too much bad publicity", says Douglas Richardson, the animal collection manager at the Highland Wildlife park where a pair of captive wolves provide an ambassadorial role for the idea of reintroduction. Beavers are small and cuddly, but wolves tend to create more than a little fear in the public imagination. Will wolves ever roam wild in the Scottish glens again? Douglas thinks so. "Yes! But there will almost certainly be other reintroductions first." If he's right we could look forward to hearing wolves howling from the Campsie Hills to the North Coast and to living with the thought in the back of our minds that maybe, today we could see a wolf. But most importantly from an ecological perspective we could look

// The hills are alive with the sound of... wolves?

forward to a Scotland with more biodiversity and a richer ecology. With the return of low lying vegetation and an expansion of our native forests, the Highlands could over the next 50 years become a greener, less barren place. As Scottish nature writer Jim Crumley put it in a recent BBC radio broadcast: "The wolf that howls in our dusk is a painter of mountains." [4]

// Simon Gill is a PhD student at Strathclyde University studying renewable generation in power systems but he also has a passion for spending time in the wild bits of Scotland.

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BIONICS CAN BE ALL FINGERS AND THUMBS

Paul McCool looks at the rapidly changing world of advanced prosthetics.

Paul Daniels is far from alone. You are more likely to suffer an amputation of all or parts of your fingers than of your entire hand. Think about that next time you try the detachable finger trick with a circular saw, or more plausibly, if you put your thumbs behind the seatbelt across your chest as you sit in the passenger seat.

Until late last decade, there wasn't much that could be done to help you get more use from your damaged hand. Then ProDigits came along in 2009, which replaces missing fingers with dextrous robotics. The system (now called iLimb Digits), along with its full-hand older sister the iLimb, are developed and manufactured in Livingston by Scottish company Touch Bionics.

Most prosthetic hands are passive cosmetics or are body powered, where the user has straps around their torso such that shrugging

opens and closes the hand. The advantage with these is that the user can judge how open the hand is by the position of their shoulders (knowing where your limbs are in relation to your body is called proprioception). Bionic limbs will never replace these seemingly primitive approaches because every amputee is unique, so passive or body-powered might be a better option.

The types of prosthetic commonly called bio-electronic (or 'bionic') are actually myoelectric prostheses. Muscle signals from the arm (called myoelectric signals) are picked up using sensors that sit on the surface of the skin. Two sensors are used: one on each side of the residual limb corresponding to flexor and extensor muscles. To open and close the hand, the user moves the muscles as if to flex or extend the wrist, as this gives stronger and more repeatable signals than if

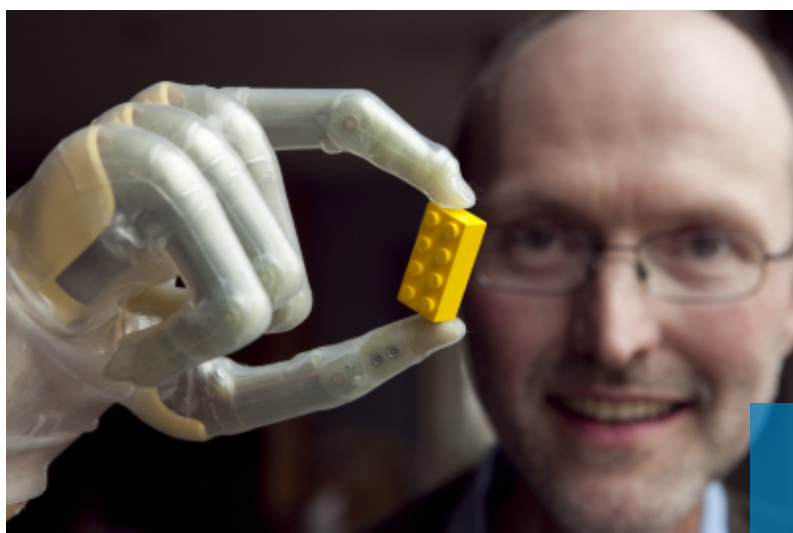


Touch Bionics

actual hand open and close gestures are used.

Most myoelectric prostheses are pincers. This has not changed since the first myoelectric limb was announced by Soviet engineers in 1964. In fact, the only real developments before the 21st century were that the battery and control unit were moved from the user's belt to inside the limb, and variable speed control was implemented. The iLimb is different in that the fingers are individually articulated. The motors can be stalled by obstructing the fingers, meaning that the limb can be contorted into many useful gestures, such as pointing for typing.

Gestures can also be automatically summoned through clever re-use of open and close commands. For example, the user can program their limb over Bluetooth to make a pointing gesture if an 'open' command is held for a few seconds. Custom gestures can be accessed by, for example, a double impulse, which is like a 'double click' using the muscles. This depends on the



Touch Bionics

// iLimbs are capable of incredibly precise user-controlled movements



// iSkin Natural gives prosthetics a very natural look

capabilities of the user.

The iLimb is available in custom colour schemes. Many like the natural and modest appearance of a prosthetic with a convincing silicone skin covering, right down to pores, fingernails and even fingerprints copied from their 'good' hand. Others prefer the more flamboyant robotic appearance of an iLimb with a translucent covering, tattoos or full camouflage.

The iLimb and iLimb Digits are a major progression for prosthetic

limbs. Despite this, there are still many drawbacks, the most obvious of which is the reported cost of about £35,000 (according to The Daily Telegraph). This covers hardware and physiotherapy. It is understandably very rare to get one through the NHS.

All modern prosthetic hands lack the sensation of touch and the ability to address individual fingers as if they were your own. There has been research across the world since the sixties into achieving

better control, but the computing power has not been available for real-time implementation until recently. The most common approach is Pattern Recognition; though even with enough computing power, nobody has yet made a control system with it that is acceptable for commercial implementation.

It will be a long time before prosthetics become proper replacements for natural limbs, and even longer before they become superior to what we were born with, like Luke Skywalker's hand (or the Major's cyborg body in Ghost in the Shell, depending on how much of a geek you are).

Until then, even small developments in prosthetic hands represent huge improvements in quality of life for their users.

// Paul McCool is currently in his second year of an electronic engineering PhD at the University of Strathclyde.

// NEWS SNIPPET: CAFFEINE-NATION

STRONG COFFEE

Researchers at Glasgow University have found a startling range of caffeine levels in high street coffees. Research published in the journal Food and Function [1] has found that levels of caffeine in a cup of high street bought coffee can vary by a factor of six.

Why is this important? The greatest level of caffeine found in a single shot of espresso was 322mg and three other samples (including the University Cafe) contained greater than 200mg. This is above the daily 'safe' level of 200mg set out for pregnant women by the UK Food Standards Agency [2]. The average across all the coffees tested was 140mg, almost three times above the commonly quoted average of 50mg of caffeine in a cup of coffee.

So, if you're pregnant then you may want to avoid the coffee shops and make your own (weak) coffee at home or in the office — if you're not pregnant and like your coffee strong, head to one of the top four cafes for caffeine content in Glasgow — Patisserie Francois, University Cafe, Cafe Cinnamon or



Sven Lindner

// How strong is your coffee? Probably too strong.

Paperino's, safe in the knowledge you're getting over four times the caffeine of a supposed 'average' cup!

// Adam Stock is a Research Assistant at the University of Strathclyde

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// REVIEW

// 09

CLASSIC TEXTBOOK: Modern Engineering Mathematics 3rd edition

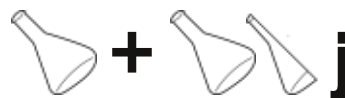
AUTHOR: Glyn James

SUBJECT: Maths

Failure to own this book may result in a life sciences degree or worse. With absolutely no consideration for superstition, these 13 chapters and 977 pages are a furious onslaught of algebra and calculus that provide the most solid and unrelentingly dry foundation for any aspiring physical scientist.

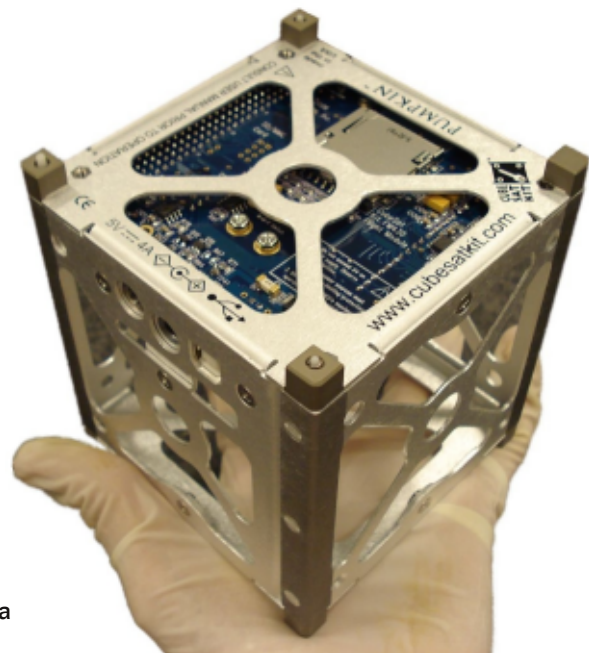
WARNING: Misuse of Section 7.6 on infinite series may result in either permanent disfigurement or transcendental enlightenment.

VERDICT:



TINY SATELLITES, BIG IDEAS

Ruaridh Clark reports on new developments in miniature satellites and research using them at the University of Strathclyde.



Pumpkin, Inc.

// A typical implementation of a CubeSat

Relatively 'affordable' space tourism (i.e. \$200 thousand per trip as opposed to \$20 million) is, if Virgin Galactic can be believed, just around the corner with paid passenger flights beginning in 2013. This is a significant milestone in itself, but it also marks a new era of greater access to space and opportunities to exploit its potential — an era in which space has become accessible for academics and small businesses with the previously insurmountable barriers to space exploitation reduced to manageable and affordable levels.

A major force in removing these obstacles to space has been the development of the CubeSat. CubeSats were first envisaged at California Polytechnic State University, where regulation and standardised requirements were devised and could be utilised in conjunction with low mass and volume satellites to provide cheap spacecraft.

CubeSats, as the name suggests, are small, cuboid-shaped satellites, typically coming in 1U or 3U configurations, with 1U being a 10×10×10cm cube and 3U having the same base but a length of about 30cm. These CubeSats contain electronic boards to carry out their mission and often have external solar panels to keep them powered. Many universities around the world have tried their hand at CubeSat development, aiming to maximise the potential of such a small platform, with the CubeSat also finding a home in Glasgow.

The Glasgow based company Clyde Space has placed a lot of faith in the continued success and

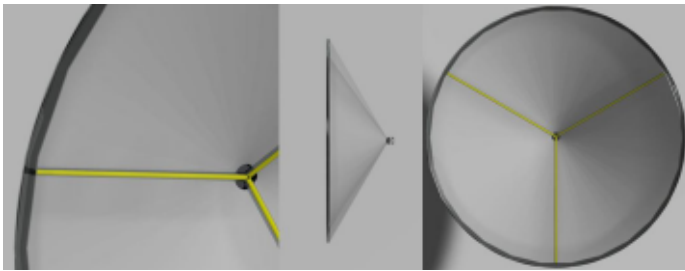
development of CubeSat systems. This faith has been repaid, so far, with Clyde Space inhabiting about 30–40% of the global CubeSat power market and manufacturing the UK Space Agency's first CubeSat. Their online shop provides an opportunity for prospective CubeSat developers to purchase almost everything they would require to build their satellite quickly and easily — with a Clyde Space launch provider service being all that's missing for prospective satellite designers. However, opportunities to launch do exist for those who go looking for them, including the announcement that the International Space Station (ISS) is to be used as a launch pad for CubeSats.

Obviously for CubeSats to achieve the reductions in size and costs that they do when compared with regular satellites, large sacrifices to capabilities have to be made. A few of the main constricting aspects are the lack of volume to work with, power that can be provided on board and the absence of a propulsion system. Conventional propulsion is unavailable for CubeSats due to regulations preventing them from carrying explosive materials, which could potentially damage the rocket or main satellite cargo, and also allows for lower insurance costs. Strathclyde Students for the



// Artist's impression of a CubeSat in orbit

Clydespace



Exploration and Development of Space (StrathSEDS), in conjunction with the Advanced Space Concepts Laboratory at the University of Strathclyde, is also keen to play a role in the development of CubeSats. StrathSEDS has an opportunity to do this after being accepted onto the European, German and Swedish space agency funded REXUS/BEXUS (Rocket Experiments for University Students/Balloon Experiments for University Students) programme. Here the student team plans to build two CubeSats to demonstrate the use of inflatable structures, in near space conditions, for the few minutes they will spend in space before returning to earth.

One of the demonstrators, the Foldable Reflective System for Omni-altitude De-Orbiting (FRODO), will test the deployment and attitude upon re-entry of an inflatable and reflective cone-shaped structure, which is envisaged for de-orbiting CubeSats. The system is designed to utilise the solar radiation pressure acting on the reflective sail structure, which forces the satellite from an initially circular orbit into an increasingly eccentric one. Eventually, part of the orbit passes close enough to the Earth to be captured by

atmospheric drag from where the CubeSat de-orbits completely. This method is promising as an end of life de-orbiting strategy with the sail operating passively, as the solar radiation pressure maintains the CubeSat's orientation towards the sun.

The other technology demonstrator is the Self-inflating Adaptive Membrane (SAM) which consists of two layers of inflated spheres directly on top of and attached to each other. This will test the membrane's shape alternating ability by pumping the air inside of the sphere on top into the one below, which results in folding of the membrane. A possible use for an inflatable structure like this could be the deployment of a curved reflector or maybe an array of solar panels. The future use of inflatable structures like these is an attractive proposition due to their lightweight and low volume. An especially low volume is achieved for these

// CAD renderings of [left] the Foldable Reflective System for Omni-altitude De-Orbiting (FRODO) and [below] the Self-inflating Adaptive Membrane (SAM)



demonstrators by relying solely on residual air inflation for deployment. Residual air inflation occurs when the external pressure usually exerted by the atmosphere is absent; as a result the small quantities of air inside the inflatable elements expands, inflating the structure.

CubeSats seem assured of longevity in at least the university community; whether inflatable structures begin to play a significant role in future CubeSat missions is much less certain. Hopefully, the experiments planned by StrathSEDS will drive more progress and lead to a full CubeSat mission utilising inflatable structure technology.

// Ruaridh Clark studies Aero-Mechanical Engineering at the University of Strathclyde and is the president of StrathSEDS.

// HEAD-TO-HEAD CLASSIC TEXTBOOK REVIEW: ACOUSTICS

CONCERT HALLS AND OPERA HOUSES

AUTHOR: Leo L. Beranek

SUBJECT: Architectural Acoustics

A beautifully typeset and expensive book, Concert Halls and Opera Houses is a compendium of 100 concert halls and opera houses from around the world. Each hall is vividly described and full architectural and acoustic details are given. Accompanying each description are two photographs (disappointingly in black and white) and plan and elevation drawings. The book also includes definitions of many acoustic measures and their optimum values. It is a tour-de-force in acoustics from one of the fathers of the modern discipline.

VERDICT:



FUNDAMENTALS OF ACOUSTICS (4TH EDITION)

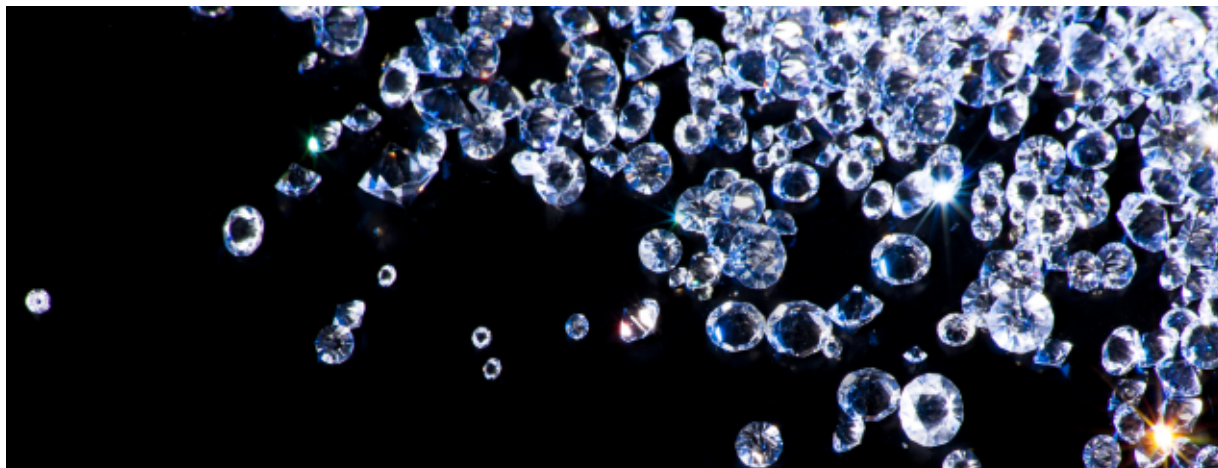
FIRST AUTHOR: Lawrence E. Kinsler

SUBJECT: Acoustics

Despite the quite pungent aroma of vomit that hits you when you open this book (a result of the glue used in its binding), this book is a valid alternative to the perhaps better known Acoustics by Kuttruff. Light on architectural acoustics, it nonetheless covers the underlying mathematics of acoustics, like Helmholtz resonators and the 3d wave equation better than any other. And you do get used to the smell.

VERDICT:





DIAMOND ELECTRONICS

...IN SPACE

Fer Gregory

Diamonds, beyond their notorious rarity and allure as jewellery, may soon form the heart of the electronic systems that will enable next generation satellite communications and deep space exploration missions.

In the harsh environments of space, both mechanical and electrical systems must withstand bombardment from radiation and exposure to a wide range of temperatures from well below freezing to hundreds of degrees centigrade. Engineers then face the challenge of designing systems that must operate reliably in such uniquely hostile conditions. Isolated in the depths of space, even the most minor of system failures can lead to not only the loss of millions of pounds of investment, but also potentially the loss of human life. Overcoming these technological challenges remains the key to the continued exploration of space and the development of crucial future satellite technologies. Only through the identification and investigation of new and robust material systems will such challenges be addressed and the associated benefits to mankind come to fruition.

Why diamonds?

For the development of space-based electronic systems, diamond is truly an ideal material system.

The key to diamond's potential success lies at the heart of its amazing and unique physical properties. Many people are aware of the extreme physical hardness of diamond, but fewer are aware of its electrical properties which are equally remarkable. For example, diamond possesses the highest

The University of Glasgow brings new and exciting possibilities for diamonds closer to reality

thermal conductivity of any known solid, which allows heat to flow through it more easily than any other material. It is also extremely robust electrically, which means it can tolerate the high voltages used in spacecraft better than other more commonplace electronic materials such as silicon. Its unique electronic structure means it is also less sensitive to radiation and hence more robust in radiation intensive environments. Electronic charge can also move very fast in diamond, making it ideal for very high frequency applications and high data transfer rates.

Success in the implementation of diamond-based electronics relies heavily on the ability to make a diamond-based transistor, as the transistor remains a key electronic component in modern day electronics. Pioneering work in this area is currently underway at the University of Glasgow in a bid to unlock the revolutionary potential of this material system. Instead of relying on rare, expensive and varied quality diamond mined from the earth's crust, the availability of synthetic high-quality diamond has now made this research possible. To fully maximise the performance of the diamond transistors, their physical size must be reduced to nano-scale dimensions. This challenging feat is accomplished using the unique capabilities of the James Watt Nanofabrication Centre at the University of Glasgow and the expertise of the Nano-Electronic Diamond Devices and Systems group led by David Moran. Recent progress by this team has resulted in the demonstration of the world's smallest and fastest diamond transistor with a feature size of 50nm, or approximately 250 carbon atoms in length.

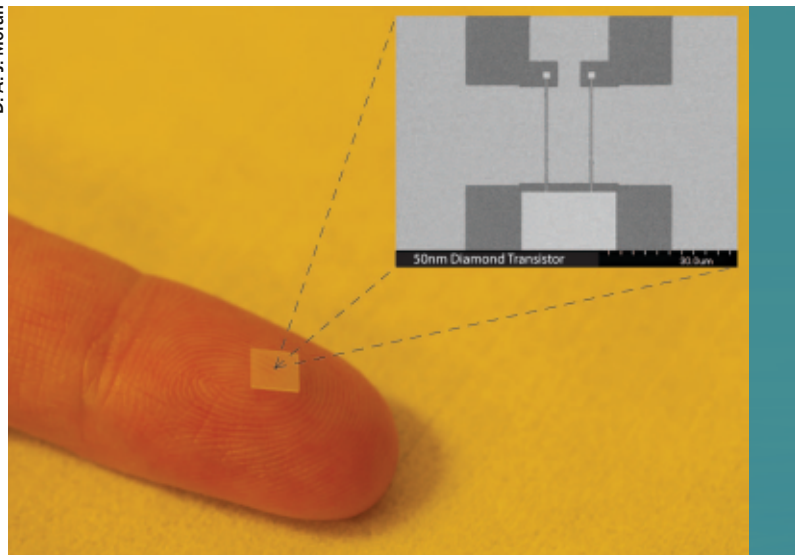
Novel applications

Taming the extreme properties of the diamond material system for inclusion in actual space-based electronic systems remains a

challenging task. Success in bringing this technology to maturity however would lead to future satellite communications for higher data transfer rates and digital media distribution, greater supply of high speed broadband to rural areas and next generation ultra-accurate GPS tracking to name but a few. Diamond electronics may also form part of vital systems to allow manned space exploration missions to other planets, moons and other astronomical bodies where potential system failure due to hazardous environments remains one of the main technological hurdles limiting space exploration.

Cutting edge research underway at the University of Glasgow continues to explore the many and varied scientific and technological opportunities that diamond can provide, to push the boundaries of this emerging technology and to bring these exciting possibilities closer to reality.

D. A. J. Moran



// D. A. J. Moran is an EPSRC Advanced Research Fellow at the University of Glasgow.

// A sliver of high purity synthetic diamond on the end of a finger plus electron microscope image of 50nm transistor

// NEWS SNIPPET: INFERTILITY BREAKTHROUGH

NEW HOPE FOR MALE INFERTILITY TREATMENT

// 13

Sperm production is a complex process. The body's sperm production line begins with stem cells, which develop into spermatids and mature finally into fully-formed spermatozoa. This process lasts over a month, making it one of the longest processes of cell differentiation in the body and a real challenge to replicate in a laboratory. However, scientists have recently managed to do just that by isolating testicular tissue from baby mice and using this tissue to cultivate viable sperm. The laboratory-grown sperm was subsequently used in IVF treatments to produce twelve live mice that then successfully gave birth to young of their own.

Although current legislation makes the procedure illegal in Britain, the discovery carries huge implications for male fertility. Scientists will finally be able to study the process of sperm production in close detail and potentially identify the reasons why some men have problems with deficient or faulty sperm production. By using testicular tissue to create viable sperm, people who are unable to produce their own sperm

may one day have the option of male fertility treatment.

Although the procedure has seemed initially successful, measuring the health of the mice involved by their fertility alone remains a crude indicator of success. Any possibility of subtle genetic changes arising during the process would need to be eliminated and the sperm proved safe before this procedure becomes an acceptable fertility treatment. Importantly, freezing and storing the laboratory-grown sperm did not affect its viability, meaning that boys receiving potentially fertility-damaging treatments for cancer

may also be able to benefit from this research by storing their own testicular tissue for future use.

// Sophie Brennan-Jones is a 5th year medical student at the University of Glasgow.

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// Sperm in action



Mopic

MAKING HYDROGEN FUEL EVEN GREENER



// Gel-like biomaterial used to encapsulate a catalyst

Hydrogen has shown much promise as a green fuel. Pim Frederix investigates how the production of hydrogen can become even more environmentally friendly.

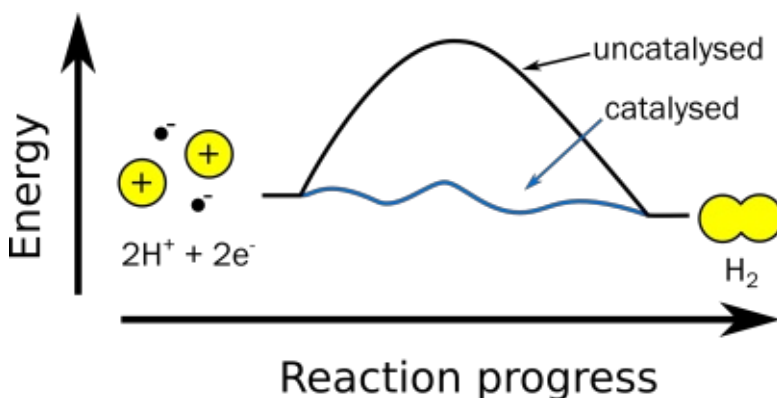
Since humanity realised it cannot keep using our quickly depleting supply of fossil fuels, researchers have been frantically searching for alternatives. Hydrogen (H_2) is attracting more and more attention as a more sustainable fuel (especially useful in cars). H_2 is a clean fuel since its only combustion product is water, rather than greenhouse gases and soot, and would therefore be a good replacement. The energy needed for the production of hydrogen gas can often be drawn from renewable sources like wind and solar power, making it even more attractive. However, the current method for converting hydrogen into energy relies on heavy metal (like platinum) fuel cells, which are environmentally unfriendly, expensive and relatively inefficient. This therefore limits the potential exploitation of H_2 . Moreover, most hydrogen is produced by steam reforming, which still requires fossil fuels (mostly methane). This has prompted the research groups of Rein Ulijn (Department of Chemistry) and Neil Hunt (Department of Physics) at the University of Strathclyde to look into the use of alternative systems to

improve the production and harvesting of hydrogen.

Searching for catalysts

The development of catalysts is a very important research theme within chemistry. Its goal is to lower the energy required for a reaction to proceed so that less heat or electricity is needed to form the products. An ideal situation for hydrogen is depicted below; with a catalyst (blue line) H_2 can be formed without crossing the high energy

barrier in the reaction progress. To achieve this in practice, scientists have once again drawn inspiration from nature. In the late 1990's a type of bacteria was discovered near oceanic volcanoes which was found to produce hydrogen using its own microscopic hydrogen fuel cell. The enzyme responsible for the conversion of the hydrogen (called hydrogenase) has been isolated and can be modelled by a small molecule with two iron atoms. These model systems have already shown that they can produce hydrogen on a small scale [1], but they are generally unstable in the presence



of water, light and oxygen (which are typically quite abundant substances). Moreover, their production rate is often insufficient for commercial applications.

Finding solutions

One way to approach the current problems with the hydrogenase models is to vary the functional groups around the iron atoms in the model or to even replace the iron with a different metal like nickel. Very recently, a US research group has demonstrated that they could

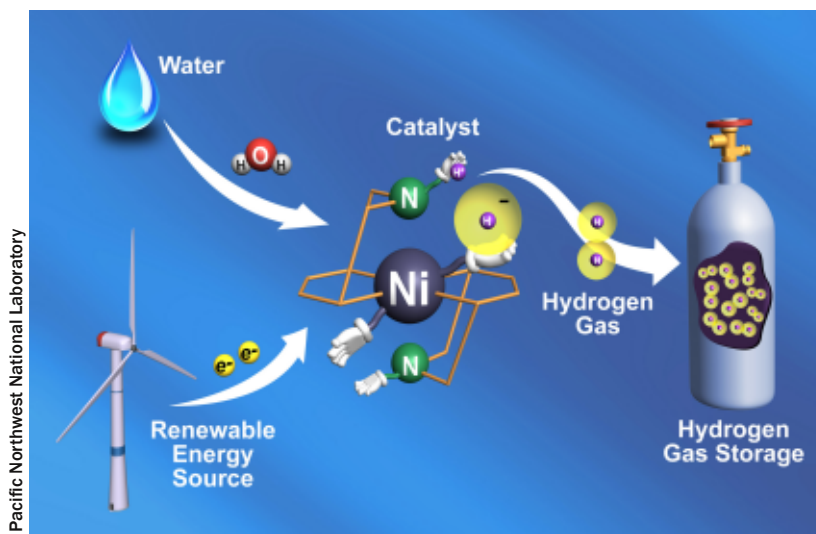
surpass the catalytic rate of the native enzyme by a factor of 10, producing 100,000 molecules of hydrogen per second per catalyst molecule [2]. At the University of Strathclyde, researchers have shown that you can further improve the stability and catalytic rate of existing catalysts by encapsulating them in a biomaterial. These materials have a gel-like nature, as shown in the title picture, comprised of short peptides in water. They are cheap, biocompatible and biodegradable with properties that can easily be modified [3]. Using these materials, the hydrogenase

mimic was much less sensitive to light. They also showed that in the gel it was stable for up to two weeks in an environment of 90% water, while it was completely insoluble in pure water. Water is crucial for hydrogen production; it is a good transporter or source of protons, the starting material in the formation of hydrogen, so that the catalytic rate of the model generally shoots up at least one order of magnitude in the presence of water. Moreover, confining a catalyst to an immobile pocket (the stiff gel material) is generally beneficial for the amount of H_2 produced per second. These results will contribute to a cleaner and more efficient way of making the hydrogen needed for the next generation of energy consumers.

// Pim Frederix is a PhD student in the Departments of Physics and Chemistry at the University of Strathclyde.

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Pacific Northwest National Laboratory

// NEWS SNIPPET: ANIMAL PSYCHOLOGY

MONKEY BUSINESS

Evidence has shown that only humans and great apes have self-recognition – the ability to recognise themselves in a mirror – a cognitive facility that has so far eluded the common monkey. This finding is supported by research spanning over 40 years and is rarely disputed. But how do you actually test which great apes or monkeys can recognise their own reflection? It is fairly easy to tell when a monkey cannot recognise themselves when obvious signs occur such as displays of aggression and intimidating behaviour towards their own reflection. However, confirming whether an ape has recognised their own reflection can be much more difficult. For all we know they may be perfectly aware of their reflection but just take no action. Researchers have tried to overcome this problem by placing small red dots on areas of particular interest

to the apes, primarily on the face, ears and genitals (this is known as a 'marks test'). The identification of these foreign marks and subsequent investigation of these areas of interest implies self-recognition. It had previously been hotly debated whether monkeys possessed these same self-recognition abilities. This debate arose from a group of rhesus monkeys who used a mirror to identify and investigate an acrylic block (taking neurophysiological measurements for another study) which had been implanted in their skull. However, these monkeys failed to show self-recognition on the traditional marks test and it was argued that the monkeys were just interested in the painful weight on

their head (understandably) and that this investigation of the head just happened to coincide with an experiment in front of a mirror. So despite their best efforts, monkeys still seem to be playing cognitive second-fiddle to the great apes and their red-marked heads, ears and genitals.

// Chris Brennan-Jones is studying audiology at Queen Margaret University

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Thomas Lersch

"What you lookin' at?"

HOW A SCOTTISH NAVAL ENGINEER

AND HIS HORSE

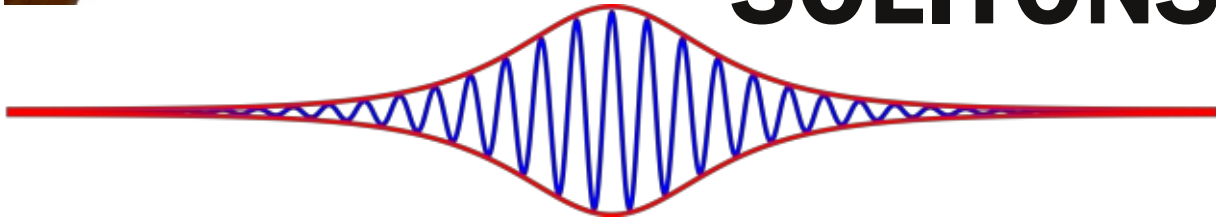


Wiener Weltausstellungs-Zeitung, 1873



Erik Lam

DISCOVERED SOLITONS



Kraaiennest

Daniel Giovannini looks at the incredible contribution that one man and his horse (and the Union Canal) made to modern science.

Although no reliable, easily accessible records are available on this topic, it is probably safe to say that not many mathematical discoveries have ever been made on horseback. It may or may not have been sunny in August 1834. The weather conditions for that fortuitous day are unknown but, for the sake of realism and to set the scene, let us just assume that it was overcast, with a light drizzle. The story takes place in the Scottish countryside, on the Union Canal at Hermiston, near Edinburgh. At the time naval engineer John Scott Russell, born and educated in Glasgow, was working on the design of the keels of canal boats. In Hermiston, Russell was riding his horse, following and observing a boat being rapidly drawn along the canal by a pair of horses. As he later recounted in a nicely penned report for the British Association for the Advancement of Science [1], what he noticed when the boat suddenly

stopped was a most unusual wave that detached from the prow.

The swell quickly moving away from the boat and J. Scott Russell's insight turned out to be surprisingly resilient. It also had a rather unexpected, though tardy, impact on mathematics and applied mathematics. Such a wave would later be dubbed a soliton and, in the following decades and throughout the twentieth century, would play a central role in the theory of nonlinear differential equations, hydrodynamics, nonlinear optics and communications engineering.

What Russell saw was a wave rolling forward "with great velocity, assuming the form of a large solitary elevation, a rounded, smooth and well-defined heap of water". This beautiful but subtly odd phenomenon was enough for him to spur his horse and go on the pursuit. The wave kept travelling

along the canal, at about 14 km/h when Russell overtook it, apparently undisturbed and preserving its form (a bump of about 40 centimetres in height, extending for some 9 metres). At least two of the properties that would later be recognised as defining characteristics of solitons must have been at once apparent to Russell: the shape of the wave remained stable and, although propagating forward, localised at each instant within a certain region without the dispersion that we would usually associate with an ordinary wave, which instead would eventually flatten out or topple over.

The chase lasted for a mile or two, after which Russell lost sight of the persistent wave in the windings of the canal. Following prolonged investigations performed using a tank built in his back garden for this very purpose, Russell concluded that the strange behaviour of what



// The soliton wave
was recreated on the
Scott Russell Aqueduct
in 1995

he called the wave of translation was due to the relative shallowness and narrowness of the canal. The stable waves produced in such a body of water at odds with the principles of hydrodynamics known in the mid-19th century, also showed bizarre particle-like behaviours: a wave of translations too big could split into two, and two waves propagating at different velocities wouldn't merge, but rather overtake each other and carry on undisturbed.

The first full theoretical treatment of Russell's wave of translation also known as solitary wave, or soliton, was only published in the 1870's by Joseph Boussinesq and Lord Rayleigh. The first mathematical model of waves on shallow water surfaces was published much later, in 1895, by Diederik Korteweg and Gustav de Vries. What is now known as the Korteweg-de Vries equation is the prototypical textbook nonlinear partial differential equation whose solutions can be exactly and unambiguously found. Solitons constitute one of its families of solutions. This fact shouldn't surprise us at all, since solitons were in fact first observed as waves propagating along shallow water surfaces, which is just what Korteweg and de Vries had set out to describe.

Russell went on with his life. He single-handedly revolutionised naval design and made the first experimental observation of the Doppler effect. During all this time, though, he was convinced that his wave of translation would one day be considered of fundamental importance.

In many instances, the scientific method is all about accumulating evidence that either supports or refutes existing hypotheses, models and theories that haven't yet been put to the test. Sometimes, those models and theories just have to be put aside, waiting to be picked up at some point in the future by someone who can put those nifty mathematical tools to good use. And in fact, while mathematicians

kept finding soliton solutions popping up everywhere in new, increasingly complex nonlinear systems, during the second half of the 20th century solitons started finding practical applications, for instance, in optics — where solitons' intrinsic stability comes in handy when designing optical fibres for long-distance transmission.

Solitons also appear in the description of many optical phenomena that involve nonlinear crystals (where the optical properties of the crystal do not respond linearly to the electric field of the incoming light), as well as optical fibres. These effects now

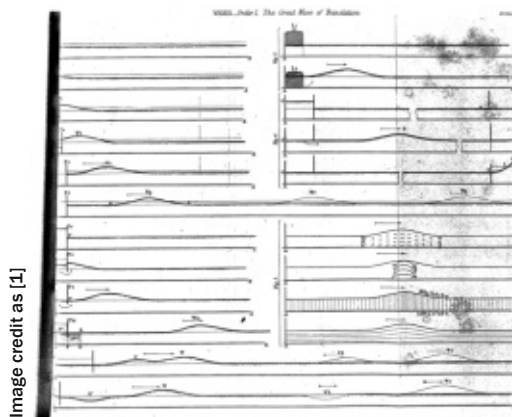


Image credit as [1]

// A diagram from
Russell's original
paper, showing his
recently discovered
"wave of translation"
(1844)

constitute the basic toolbox of modern optics, and have been the subject of active research and countless fundamental and technological applications since the invention of the laser. As the same nonlinear models describe a wide range of physical systems, similar at least from the mathematical side, solitons also appear in the treatment of phenomena as diverse as shock waves and plasma, low-frequency oscillations in complex chemical structures such as DNA and fluid dynamics.

Solitons are, in a way, a recurring trait in the family tree of nonlinear differential equations. Furthermore, they also show up among the families of solutions of other

equations that are directly related to, or nonlinear generalisations of, equations that shaped our understanding of the quantum world. The Schrödinger equation in its most basic form is one of the foundations of quantum mechanics. Introduced by Erwin Schrödinger in 1926, the equation that now goes by his name describes the time evolution of the quantum state associated with a physical system. The nonlinear version of the equation and its soliton solutions, moving through obscure mathematical backdoors, appear in the analysis of the interactions of some classes of subatomic particles. At the same time, however, the nonlinear Schrödinger equation can also help describe rogue waves: unusually large spontaneous ocean surface waves that represent a threat even to bulkier ships and ocean liners.

Solitons are an excellent example of a ubiquitous mathematical concept that, after being modelled over a simple physical system, have turned up in a wide variety of disciplines. If

one day you happen to be cycling along the Union Canal and a barge stops nearby, look out for the solitary wave it may generate and follow it. It could get you far.

// Daniel Giovannini is a Ph.D. student in the optics group at the University of Glasgow. His main field of research is experimental quantum optics.

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LET'S TALK ABOUT (GAY) SEX!

Neil Kirk
examines the
need for gay sex
education in
schools



wtamas

// 18

On the surface, it appears that the United Kingdom in the 21st century is a tolerant and understanding place for people who identify as Lesbian, Gay, Bisexual or Transgender (LGBT) to live. The past decade has seen an amendment to the Sexual Offences Act (2000) which lowered the age of consent for gay and lesbian sexual activity to 16 – the same as heterosexual sexual activity – and the introduction of the Equality Act (2006) which outlaws discrimination on the grounds of sexual orientation. However, one debate which has made headlines for many years is whether it is morally acceptable to teach about homosexuality and to allow schools to educate about homosexual activities as part of safe sex education. In 2003, Section 28 – a piece of government legislation which banned the ‘promotion of homosexuality’ by local councils (including schools) – was lifted in England and Wales; a similar piece of legislation having been removed in Scotland in 2000. This did not happen without protest and even now, the discussion of homosexuality in schools is still a delicate subject.

Does ‘promoting’ homosexuality turn people gay?

One of the underlying arguments in the ‘keep the clause’ campaign was that homosexuality should not be ‘promoted’ in schools. This suggests a viewpoint that homosexuality is an individual’s choice – a choice that could be made by persuasion or through influence. However, the belief that sexual orientation is purely down to individual choice is one that does not hold up to much scrutiny.

Several theories exist to explain same-sex attraction. Evidence for a genetic cause comes from research which shows that if a male is homosexual, his identical twin is much more likely to also be gay than a non-identical twin is, and a non-twin brother or half-brother is significantly less likely to also be gay. One theory – the ‘fraternal birth order effect’ (see box) – suggests that for each older brother a man has, his chances of being gay increase by around 33%, and that 1 in 7 gay men exclusively owe their sexual orientation to the order of their birth.

// If this picture were a man and a woman, would anyone bat an eyelid?

Other theories include the belief that, in evolutionary terms, same-sex sexual behaviour is beneficial as a method of forming, increasing and strengthening social alliances which directly contribute to the survival of the males of the species and indirectly increase male reproduction. There is also research to suggest that male homosexuality, rather than a trait which is incompatible with Darwin’s theory of evolution and natural selection (and as a result, should die out instead of being passed on), is the resulting side-effect of a biological process which increases fertility in females. Obviously, these theories don’t explain female homosexuality, suggesting that male and female same-sex orientation are caused by different factors. So, the evidence hints at a genetic, bio-social or pre-natal environmental influence and doesn’t show any real evidence towards homosexuality being caused by educating about safe gay sex.

Fraternal Birth Order

The fraternal birth order effect is explained as being the result of the progressive immunisation against male-specific antigens the mother is exposed to with each succeeding male foetus she carries. There is no effect on female sexuality.

Interestingly, the effect appears to interact with handedness; the incidence of homosexuality correlated with an increase in older brothers seen only in right-handed males.

The only gay in the village?

If time and resources are to be used to educate young people about safe sex, then it's important to establish the prevalence of same sex attraction and how many people may receive this benefit. Several studies have found that the prevalence of homosexuality changes depending on the criteria used to define it. It has been found that when using the most restrictive definitions of homosexuality, 1% of males and females reported exclusive homosexual experience, interest and identity and when using the most inclusive criteria, 10% of males and 25% of females reported having had some homosexual experience or interest. Other sources also estimate the prevalence of homosexuality to be somewhere between 2–6% of the population.

Should we teach young gay men how to avoid getting pregnant?

The experience of many young LGBT people's sex education in school is one which has been less than satisfactory. One study, investigating the outcomes of non-inclusive safe sex education, reports young gay people finding this education to be useless, with many reporting having learned about issues such as pregnancy, STIs, HIV and condom use with a sole focus on vaginal sex. They also found oral or anal sex being discussed exclusively in the context of heterosexual couples engaging in alternative sexual activities to prevent pregnancy. This study also reports that young LGBT people often turned to other sources to find information about sex: for many, this was via the internet and such knowledge was gained through exposure to

pornography. Other individuals ended up learning about gay sexual activity from their first same-sex partner, who may not always have their best interests at heart.

These findings do not address the needs of those who are not heterosexual and thus highlight the need for more inclusive education.

What are the consequences of not providing this education and support?

To not acknowledge anything other than heterosexuality can lead to young LGBT people experiencing feelings of isolation, inadequacy and that there is something inherently wrong with them. Apart from the obvious consequences such as STIs, there are many issues which, although affecting all young people, may be more prevalent amongst young people with same-sex orientation. Such issues include eating disorders, which are higher in homosexual young males than in heterosexual young males; also young LGBT people are more likely to misuse alcohol, suffer alcohol-related illness and are 4 times more likely to commit suicide than their heterosexual counterparts. Domestic abuse is another problem faced by young people in same-sex relationships and may be exacerbated by the fact that victims have no clear indication of who to turn to for support in such matters or do not know what to expect from such relationships.

There are also issues which are more specific towards those with same-sex orientation. Many may be ostracised by their families or communities as a result of beliefs surrounding homosexuality and thus not have adequate support available to them. Many LGBT people also face the added stresses

and pressures which occur as a result of the coming out process and the identification of their own sexuality.

What effect does providing this education have on the heterosexual majority?

It should not be difficult to introduce the topic of homosexual relationships and gay sexual activities into current sex education classes. A Scottish study conducted in 2001 reports that the simple acknowledgement and reference to sexual acts which can be performed by different gender pairings is enough to promote healthy sexual activity and not give preference towards, or discriminate against, one type of relationship. This study also found that acknowledging different types of sexuality helped to reduce prejudice and intolerance towards non-heterosexuals. To devote time and resources to exploring issues relating to the experiences of young gay people need not be at the expense of sex education which benefits their peers who have opposite-sex attraction.

So, in summary — are we doing a disservice to young LGBT people by not providing any information about safe sex education to those who will have same-sex relationships? We're all likely to know someone that's LGBT — ask them if learning about gay sex at school made them that way. The likelihood is they were never taught about it at all...

// Neil Kirk is a Research Assistant at the MRC Institute of Hearing Research (Scottish Section).

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WINDIA: THE NEW WIND NATION

Conaill Soraghan explores how a country beset by power cuts has emerged as a world-leader in the wind energy sector.



Land Rober Our Planet

// Workers manually shift gravel in the shadow of a wind turbine

In December 2009, the MNRE approved a generation based incentives (GBI) scheme that pays suppliers for every unit of energy that is generated from a renewable source for a ten year period. This is a much more effective incentive that encourages the developer to produce output once the turbines are installed. The scheme pays 0.5 Indian rupees for every kilowatt hour of energy produced from renewable sources. This means that a state of the art wind turbine in India rated at 2 megawatts would generate roughly £50,000 annually from the subsidy alone.

Despite the experience that European and American companies have gained through building wind turbines since the 70s, the Indian manufacturer Suzlon has become the sixth largest manufacturer in the world in the 15 years that they have been doing business. They have developed a world-leading global innovation network. Among many other overseas subsidiaries, they own German-based Hansen, the second largest gearbox manufacturer in the world. They have research centres across Europe and manufacturing facilities in China and the USA to support deployment in high growth regions. In spite of the aggressive global expansion, Suzlon still manufactures most of its wind turbines in India, and India makes up most of its annual sales [2].

Danish wind power consultants BTM forecast in 2010 that demand in India for wind capacity would grow by between 2.5 and 4 GW annually for the next few years [3] – that means every year building more than the complete installed wind capacity of Scotland. There may be

With their population set to overtake China's by 2020 according to the population reference bureau, India will become the world's most populous country. Powering a nation of this scale is an almighty task and in order to do so the country has emerged as world-leader in the wind energy sector. How has India done this and what lessons can be learned from the meteoric rise?

India ranks fifth in the world in terms of total installed wind energy capacity and for the past three years has had the highest growth of these top five countries. Only ten years ago there were very few wind turbines in India but since then a period of incredible expansion has led to over 300 times as much electricity being generated from wind turbines. While the debate in Europe and the Americas is about how to meet national demand, India still struggles to even meet demand. The priority for the Indian government is captured by their National Electricity Policy target of 'Electricity for all by 2012' which aims to make up the 12.7% gap between electricity demanded and electricity generated at peak times [1]. This makes their rise in the wind energy sector all the more impressive and reveals how the Indian wind sector is growing.

The key driver of this persistent growth has been the government's robust public policy regime. The Ministry for New and Renewable Energy (MNRE) was created to develop and deploy new and renewable energy sources. The main piece of policy they have developed supporting wind power is the Electricity Act 2003, which provides a framework for investment in renewable energy technologies. The act aims to revolutionise the entire power sector in India by addressing generation, distribution, transmission and trading in power. In accordance with the act, 10% of the power supplied to consumers has to be generated using renewable sources of energy. Furthermore generation has been de-licensed; this allows any company to enter the generation market without permission from some central authority. The result has been increased competition and foreign investment.

A tax-driven policy was the key financial incentive for wind power development which rewards installing wind turbines. However, as the great wind rush of California taught us, incentives based on installed capacity are fundamentally flawed (see box). The lack of emphasis on operation can lead to installation of inefficient machines.

The great California wind rush

In 1980 the state of California developed a scheme which rewarded wind turbine developers per installed kilowatt. This led to a rush of activity with thousands of 50 kilowatt machines being built across the Californian hills.

These machines did not operate at full capacity and the government could not maintain the ineffective incentive. The market for wind energy collapsed in 1985 with the closure of the Californian support scheme. The hills were left with many poor quality, and in some cases unused, turbines.

no sign that this strong growth in India will settle soon, however many barriers still exist. According to a 2010 report on the state of the Indian wind industry, the two most pressing issues are the need for grid infrastructure improvement and lack of long term policy to increase investor confidence [3].

If India, one of the G20 developing nations, can make renewable energy a national priority while they struggle to even keep the lights on in major cities, it will be clear that



Stan Shebs

the global power industry is evolving towards a cleaner and more sustainable future. The case study of Suzlon illustrates that conditions in the Indian wind market are well suited for private interests. In terms of the public interests, government policy has helped Suzlon go global whilst building up a strong manufacturing base within India. This provides employment and means that investments in clean energy not only help meet renewable targets, but keep the investments within the Indian economy.

// Conail Soraghan is a 2nd year PhD student in the Wind Energy DTC at Strathclyde University

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// NEWS SNIPPET: GOOD BACTERIA

USING BIOLOGY TO SOLVE THE PROBLEM OF WATER SHORTAGE

// 21

A UK-wide research project aiming to make fresh water by removing the salt from sea water was launched at the University of Glasgow in October [1]. Project leader Anna Amtmann and her team plan to use sunlight-powered microorganisms to extract the salt from seawater.

"World-agriculture uses 70% of the fresh water resources," Amtmann says. "Irrigation of fields with seawater – even if diluted – leads to the build up of salt levels in the soil that are toxic to common crops."

Salt is toxic because it causes dehydration of cells in most living organisms, explains Amtmann. For example, when we sprinkle salt on spilled wine we take advantage of its ability to suck up water. Salt can also damage cells by distorting the shape of their proteins, preventing them from functioning normally.

"Marine organisms have evolved strategies to adapt and avoid toxicity," says Amtmann. The team will grow these organisms in sea water and fit them with a set of



Torsten Henning

molecular engines to take up salt until they are packed with it. The salt-packed cells will die, leaving fresh water, and a salty waste product that could be used to produce biofuel, biopharmaceuticals or biocosmetics.

"There is a global water crisis out there," says Bill Sloan, Professor of Environmental Engineering at the University of Glasgow, "for example in the Horn of Africa, where the worst drought in decades is causing

// High salt levels are a major cause of undrinkable water supplies globally

malnutrition and starvation" [2]. There are also problems closer to home, Sloan points out, with the south-east of England suffering periodic water shortages.

While the potential benefits of the project are clear, there are risks such as environmental contamination by the de-salting organisms. That is why the team also includes researchers in environmental policy and risk assessment. "Understanding social acceptance is absolutely crucial," says Amtmann. "Scientists should know from the beginning what might actually be acceptable to potential clients."

//Cornelia Eisenach is an RA at UoG

//References

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[2] www.un.org, accessed 21/10/2011

WHY SHOULD WE ASK FOR EVIDENCE?

Lindsay Hogg explains why you should ask for evidence to back up a company's claims.

You only have to walk down the high street to see a plethora of beautifying products on offer: tablets for a thinner you, powders for flawless skin, and creams for pert bods. Then there are the health products which detox, balance or nourish. These claims are everywhere and they all sound so appealing. We spend millions of pounds a year in the UK on health and beauty products yet many of the promises made on the products are never delivered. Does it really matter though? People don't buy an anti-wrinkle cream in the real hope that it will take years off them; sometimes it's about treating yourself and that may well be worth the price tag.

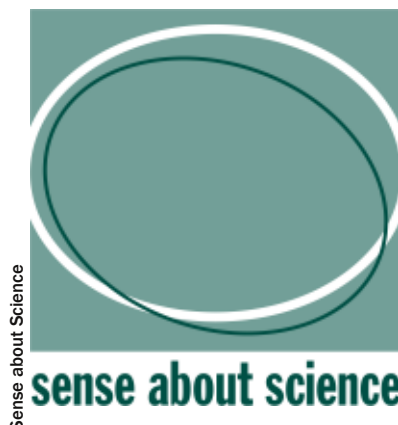
But what about the false claims that cost more than just a few quid? Sense About Science is a small charity whose remit is to equip the public to make sense of science and evidence. While working with patient groups to develop the publication 'I've got nothing to lose by trying it', we heard stories from real people who had been given hope by 'miracle cures' advertised on websites and patient forums. People dressed in lab coats talking about complex biological molecules, the personal testimonies from 'real patients' and scientific terminology give these claims an air of legitimacy, making people feel pressured into trying 'miracle cures' for themselves. The husband of a multiple sclerosis sufferer told us that he would rather have spent the last few months of his wife's life and thousands of pounds on a holiday rather than chasing false hope in clinics offering unproven stem cell treatments.

Regulators such as the Advertising Standards Agency, or Trading Standards, are working towards chasing down products that make these claims, but it's impossible to tackle them all. As soon as one claim has been taken down, another

one pops up. The only solution is to make a permanent difference. Last September, Sense About Science launched the 'Ask for evidence' campaign to do just that (<http://www.senseaboutscience.org/pages/a4e.html>). It doesn't always have to be the regulators knocking on the door of those making false claims, everyone can do it. By giving people the questions, they can ask for themselves.

Are you frustrated by distorted and misleading scientific claims pulling the wool over people's eyes and undermining science? You can do something about it. Just pick up the phone, write an email, or fill out one of the handy 'Ask for Evidence' postcards you can find on the Sense About Science website and ask for the evidence. You might find the person making the claim has good evidence to back it up.

Voice of Young Science (VoYS) is a network run by Sense About Science, which encourages early career researchers to play an active role in public debates about science. Since 2005, participants of VoYS have been running myth-busting campaigns and chasing down pseudoscience. Their campaigns have received wide media coverage and highlight the need to question the evidence, promote scientific reasoning and stand up against bad science.



Sense about Science



Ask for evidence

// Celebrities outside the scientific community have been supporting Ask for Evidence

VoYS members from around the world have been asking for evidence:

Rita asked a shop for evidence behind their claims on a leaflet that wheatgrass juice was a 'natural healer'. The following day the leaflet was removed from the shop floor while the content was reviewed.

Jennifer got in touch with Marks & Spencer about their 'MRSA resistant' pyjamas and was told that there is a trial underway.

Rhys came across a miracle cure product advertised on a Crohn's disease forum and decided to investigate further. He found out that the 'cure' could cause serious harm to health so reported it to Trading Standards. The product has now been banned in the UK.

These stories show just how easy it is. If enough people ask for evidence, companies will come to expect it and make the evidence more available. Perhaps they will also think twice before making false claims.

// Lindsay Hogg is a Senior Public Engagement Officer for the Medical Research Council

// Do you have a desire to stand up for science in public life? To find out more about Sense About Science and VoYS in Scotland contact Lindsay Hogg at lhogg@senseaboutscience.org.

TALKING SCIENCE



Andrew Farrell

The GIST's Cornelia Eisenach, Andrew Farrell and Lydia Murray met the organisers of Glasgow's Café Scientifique to talk science, the public and the media.

Café Scientifique, or Café Sci as it has come to be known, has become a Glaswegian institution. Running for over 7 years now, on the first Monday of every month, invited speakers take to the stage to illuminate weird, wonderful and often controversial science topics. From British author Simon Singh discussing the Big Bang to Nobel Laureate Sir James Black on drug discovery — via talks on climate change, stem cell research and designer babies — Café Sci is not your typical academic lecture. Speakers take to the stage without props or flashy technology. Much like a stand-up comedian, their job is to captivate the audience in Glasgow's Tron Theatre Bar using words alone. After a half hour introductory talk from the speaker there is a short break to allow glasses to be refilled, then it's over to the audience to ask questions and offer their own opinions. This is the core of the Café Sci experience. "On some nights we have kids from the age of about nine up to old people at the age of ninety. Some are scientists, some are non-

scientists," says Glasgow Café Sci co-founder Mandy MacLean. "Whilst it's nice to have some scientists in there coming along to support questions, it really is aimed at your public on the street. We always try and do things that are not too obscure that are of public interest or have been in the press." MacLean is Professor of Pulmonary Pharmacology and Dean of Graduate Studies at the College of Medical, Veterinary and Life Science, University of Glasgow. She was inspired by a Café Sci experience in Edinburgh to set one up herself, here in Glasgow.

Tonight, she and organisers Kevin O'Dell and Martin Hendry have enlisted Phil Hanlon to talk about the 'Scottish Effect' — the observed widening of the gap in life expectancy between Scotland and England, which cannot be attributed to deprivation or differences in social class. Hanlon is Professor of Public Health at the University of Glasgow. In common with previous speakers he does not use PowerPoint; instead he describes a

graph of rising alcohol consumption over the decades by slowly raising his hand while walking from left to right, turning the stage into an imaginary x-axis. "If the speakers insist on PowerPoint," says MacLean, "they wouldn't be asked to come." Hanlon does a good job, drawing stunned exclamations and laughs from the audience. "I think Phil made it very accessible so that everybody in the audience would understand exactly what he was talking about", says audience member and Café Sci first-timer Christine Cooper. Her companion and fellow lecturer Lesley Catchpole adds, "But you've got to have really good speakers. There's nothing worse than having a poor speaker, being lost. [PowerPoint] does sometimes help, but if you've got good speakers then it's not an issue."

We spoke to MacLean and O'Dell as they made final preparations for the evening's event. O'Dell is a lecturer in Biomolecular Science at the University of Glasgow. How do they feel about the effectiveness of Café Scientifique in bringing science to a wider audience? "It gives the opportunity to the public of actually

// ABOVE: Glasgow Café Sci organisers Mandy MacLean & Kevin O'Dell

coming and asking a question directly to a scientist", notes MacLean. "The only other option is to email people maybe, or attend university lectures where they wouldn't want to ask a question." Audience member Siobhán Hoy, a life sciences student at Glasgow University, agrees: "The science world can be quite exclusive to people who know what they're talking about. And unless you're really confident about your interest, you don't get the chance to hear about it. You can't pick up a physics journal and have a wee read because you don't understand the terms, you don't know the jargon. So this is just really accessible and it is for all ages as well. I think that's what I quite like about the Café Scientifique."

Public acceptance of scientific evidence and key theories has suffered some serious set-backs over the last few years. As Nobel Laureate Sir Paul Nurse explored in the recent BBC Horizon programme, 'Science Under Attack', the public is losing faith in scientific theories such as Darwinian evolution, the link between HIV and AIDS and the impact of man on global warming. The organisers quickly warm to the subject. "I think there's a kind of disbelief in anything that experts say, I don't think it's particularly science", says Kevin O'Dell. Mandy adds, "I mean we have working against us the media, because the media always get it wrong. What they actually put out there is either inaccurate or sensational. Then it becomes unbelievable to the public." Can Café Sci readdress the balance? "Café Sci is one good way of several ways of getting it across. No one route is going to do that", answers Kevin. "I think there is a strong thing that scientists are almost a different species. I think just coming along and seeing real people who work in this area, so they see that — underneath it all — we're normal people, really." "Yeah



Andrew Farrell

Paul Hanlon in action.

we're normal", Mandy laughs, "we're not people with big pointy heads." "And", Kevin adds seriously, "obviously we're making a great deal of effort in trying to get speakers in who will be able to communicate with people in general."

In the last decade science has enjoyed increased exposure in the media, helped by the charm of physics superstar and one-time D-Ream keyboard player Brian Cox amongst others. Science is cool and geeks are the new popstars. Isn't this a positive development in the media, we ask? "I think there's two differences there", says Mandy. "I mean [Cox] has been great at interesting young people in science but it's when it's inaccurate sensationalism of science that it becomes dangerous and even our politicians work against us. I mean Vince Cable undid 7 years of my work recently. He made some quote about 'we have to stop scientists hiding away in basement labs wearing woolly cardigans' or something and I'm thinking: 'I just spent seven years trying to stop the public thinking that that's what we're like. And then a careless word by one politician and we're back to

square one with all the public thinking we're hidden down in basement labs poring over sort of steaming things."

To help improve understanding of science in the public the organisers frequently cover controversial topics, making for some heated discussions. Says Kevin O'Dell: "You can't always necessarily tell whether something is going to turn out to be controversial. You only need one or two people in your audience to be very anti-something. Evolution, for example — there will always be somebody that perhaps just does not believe." But whether it's evolution, stem cell research or euthanasia, Kevin believes that "it's perfectly reasonable to be pro or anti, but what you want to be is informed on that thing." Mandy agrees. "It is about educating accurately" — that is one of the things that Café Sci can contribute to and help us to separate fact from fiction and myth from reality.

// Cornelia Eisenach is a post-doctoral Research Assistant at the University of Glasgow doing research in Plant Cell Biology and Physiology.

The next Cafe Sci will be at 7pm, Monday 14th May 2012

The Victorian Bar, Tron Theatre, Trongate, Glasgow

TITLE: Science Education in Scotland

SPEAKER: Heather Reid



// SCAN FOR MORE
INFORMATION

ENERGY ARMOR ...REALLY?

Craig McInnes dissects Energy Armor™, with a contribution from Scott McKellar. They try keeping a straight face when they talk about yet another pseudo-scientific craze that's hitting the nation.

I almost choked. I actually (not actually) almost died from a lethal overdose of cynicism, disbelief and self-righteousness. My brother-in-law recently informed me that he paid £20 for a new 'invention' that can (maybe) enhance one's fitness, flexibility, agility and balance. "What is this magical invention?" I hear you ask. The answer dear reader, is Energy Armor [1].

Sounds pretty impressive, huh? Well no - it is just placebo-infused silicone in the shape of a wristband. Volcanic placebo at that. But that's not stopped it from being sold, unregulated and under a pseudo-scientific haze of gibberish, to the ill-informed and the gullible like my unfortunate brother-in-law. Oh wait, did I mention that the wristband has a hologram on there too? If there's one thing worse than pseudo-science, it's pseudo-science with shiny on it.

The proliferation of US-based Energy Armor is mainly a result of a stupid-clever marketing campaign - one where its cringe-inducing awfulness is almost matched by its bravado. Think of the Iggy Pop insurance adverts and you're on the right lines. The Energy Armor website is

full of science words. Old favourites like 'ion' and 'serotonin' are there, but they're in sentences such as, "Negative ions are believed to produce biochemical reactions that increase levels of the mood chemical serotonin, helping to alleviate depression, relieve stress and boost our daytime energy". So subtly phrased is this unsubstantiated assertion that I'll call it a McKeithism, in a tribute to everyone's favourite home-grown, poo-sifting television personality, Dr. Gillian.

The dishonest exploitation of the

Some Energy Armor claims

- Improved flexibility
- Improved balance
- A better night's sleep
- Higher mental awareness
- Elevated mood and serenity
- Improved athletic performance

misinformed notwithstanding, the sale of Energy Armor is ridiculous for a few reasons. 1) The claims of the 'inventors'. 2) How it's sold. 3) The fact that a lot of people really just don't seem to give a damn. Let's face it, tat has been sold to morons since tat and morons were invented. But the fact that the makers of Energy Armor make quasi-medical claims in particular compounds the ghastliness of the product.

How it "works"...

The inventors have taken volcanic ash, which is apparently high in negative ions, and infused it with medical-grade silicone because "scientists have studied negative ions and their effect on human health for more than 100 years". The discerning eye of the GIST reader will, I am sure, have noticed the conspicuous absence of a qualifying statement here, but let's roll with it.

First of all, ions are charged atoms or molecules - either positive or negative - that exist as a charge-balanced ion pair. Now, according to Energy Armor, exposure to negative

// 25

Craig McInnes



// It looks so innocuous but inspires so much rage

ions helps improve one's 'energy field'. So far, so questionable. But wait – we already know what happens when we are exposed to a negative charge: have you ever used a Van der Graaf generator? If only Energy Armor worked in the same way, static hair would give the consumer the deservedly laughable look that their investment warrants.

So, do you want to know about this 'energy field' everyone has? Yeah, me too. Here's everything you need to know – it doesn't exist. OK so, what about all the painstaking research that's been carried out to prove the efficacy of this miracle of science? Oh, there's nothing in a peer reviewed journal to support these claims? So what's scientific about it? Ah, I see: nothing.

From this writer's point of view it seems that the only legitimate use of negative ions in a medical product (excluding drugs) has been in air purifiers. Here, a static charge forces dust particles to clump together making them fall to the ground - but let's be clear, this is to help allergy sufferers. It doesn't make the audacious promise of serenity or biomechanical enhancement. Moreover, it requires a high voltage to produce its ionic charge. I wonder, what is the voltage of volcanic ash?

Why do people buy this?

I've been lucky enough to watch the Energy Armor sales pitch on several occasions, and they always comprise an eye-catching stall (a

By the way...

- Negative ions are not known as 'good ions'. This is designed to make you think of 'good bacteria'.
- Even if volcanic ash is high in negative ions, you can be sure that it's high in positive ions too: you can't have one without the other unless there's some serious voltage.
- The product is not based in science. The claims are vague at best and cite no scientific references anywhere on their literature. You should always beware of science without references.

glorified vending machine with an integrated flat-screen TV) and an "expert" who can do an "experiment" (a trick, to use the technical terminology) to wow the crowd. Capitalise on the fact that people like wristbands and job done. Seriously, that's it. That's all you need to peddle stupidity in a wristband to the unquestioning masses. The experiment may look convincing to some but it's nothing more than the placebo effect in all its glory. If you happen to see this, I openly encourage you to stop and laugh.

Of course, your local shopping centre or friendly sports shop isn't the only place where you can buy Energy Armor. After all, if any self-respecting, placebo-peddling scam of a company wants to look credible, they really need a ~~cash~~ ~~cow~~ website where they can ~~immorally~~ ~~sell~~ explain the product to the curious masses. Again, with credibility in mind, it might be helpful to have testimonials of some satisfied customers. Let's take the first example from the webpage and

see if it alleviates our scientific concerns.

"As a conservative Family Physician, I try to balance scientific objectivity with an open mind. As an athlete, one is always looking for ways to improve performance. For this reason, I purchased an Energy Armor Wristband several months ago figuring 'hey, it can't hurt to try'. Well, ever since I started wearing the band my tournament performance has significantly improved as measured by round ratings over the last three tournaments. Is it coincidence or the EA Wristband? Frankly, I really don't care... but I'm going to keep wearing the wristband just in case. Charlie B., MD, FAAFP"

Wow! Charlie B the family physician, if he even exists, really does have an open mind. So open that he doesn't care if he's being exploited or not. Take that, scientific objectivity! It's also comforting that Charlie feels the need to tell us he is conservative, lest we forget that American conservatism is a



Craig McInnes

// The flashy vending machine being a lot less obnoxious with the flat-screen turned off

stronghold of rationality and scientific reasoning (just think of global warming or evolution).

So why do some people not care?

Anyone who has invested their time and money into a product or endeavour doesn't want to feel like it has been a giant waste of time. By doing so they often tend to

perpetuate the myth and before you know it, your brother-in-law and all his friends are wearing Energy Armor. Non-scientists often don't have the inclination or the know-how to question the science they hear or read, and all too often it feels like science is exclusively the realm of the geek.

But it doesn't need to be like that. Science is just an extension of common sense. Question and test what you are hearing. Think it

through. Don't buy a bracelet that claims to help your balance. I mean, if nothing else, surely you would need one on each wrist?

// Craig and Scott are research chemists hailing from The University of Strathclyde. Neither is negatively charged.

P.S Some people do care – there is now a class action lawsuit against the analogous Power Balance™ wristbands. [2]

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[1] www.energy-armor.com

[2] www.powerbalanceclassaction.com

// NEWS SNIPPET: GENRE SUPERNOVA

ASTROCHEMISTRY: AN EMERGING SCIENCE

Our understanding of the universe relies on many scientific disciplines to explain its structure and evolutionary mechanisms. Over the last few decades, the emerging science of 'astrochemistry' has begun to gain momentum in the field of astronomy. This new science aims to detect and identify molecular compounds outside our planet[1]. In the last few years, this research area has expanded to tackle some tough questions such as explaining the formation of solar systems and even the origin of life in the universe.

Astrochemistry utilises a range of advanced telescopes and detection techniques and has led to a number of unique discoveries. Since the first detection of water in interstellar space, many molecules have been discovered which support the conclusion that hydrogen and carbon monoxide are the most abundant molecules in the universe[2]. Astrochemistry has also shown that the presence of dust clouds may enable new chemical reactions in space to take place. It is hoped that this will lead to the discovery of nanoparticles that are able to catalyse oxidizing reactions of organic compounds to produce important molecules such as amino acids[3].

The recent discovery of complex chemical systems in space has been revolutionary for astrochemists. Many of these chemical systems are made of carbon-based structures such as polycyclic aromatic hydrocarbons (PAHs), polyines (carbon chains) and fullerenes. Since fullerenes

were discovered by Kroto and colleagues[4], there have been several publications trying to find ways to detect these compounds in space. Fullerenes demonstrate the complexity of chemical systems in space and were finally identified by scientists from the University of Western Ontario[5,6]. A large network of chemical reactions was also found, allowing connections between different molecules important for the origin of life. The study of these initial molecules (or 'building blocks') for creating life could be based on organic and inorganic chemical structures. By harnessing astrochemical techniques Leroy Cronin, a Professor of Chemistry at the University of Glasgow, is starting to give the first hints to explain how matter may evolve and to describe these important first steps of live matter[7]. A combination of organic

molecules, which are appearing in the interstellar space, and inorganic structures found on the surface of planets, could provide the right conditions for life. It is hoped that the emerging field of astrochemistry can work together with other sciences such as fundamental chemistry and astrobiology to detect the first evidence of life in other planets or galaxies.

// Andreu Ruiz de la Oliva is a PhD student in inorganic chemistry at the University of Glasgow.

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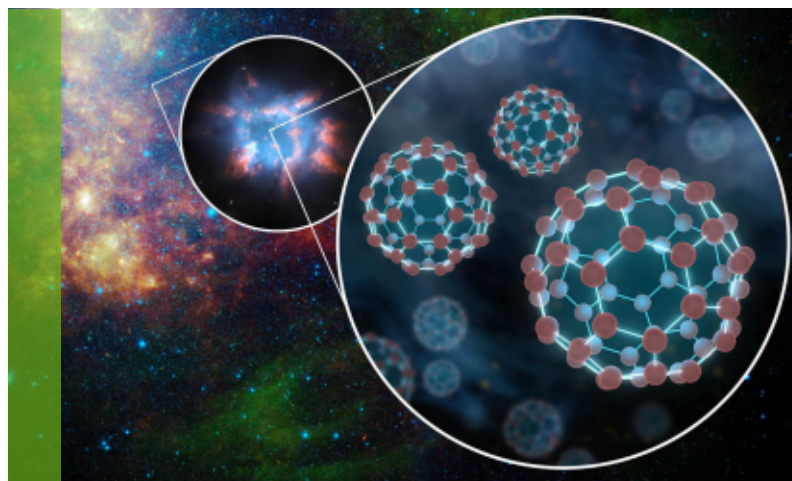
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[6] www.youtube.com/watch?v=tvnBCvs878c

[7] www.ted.com/talks/lee_cronin_making_matter_come_alive.html

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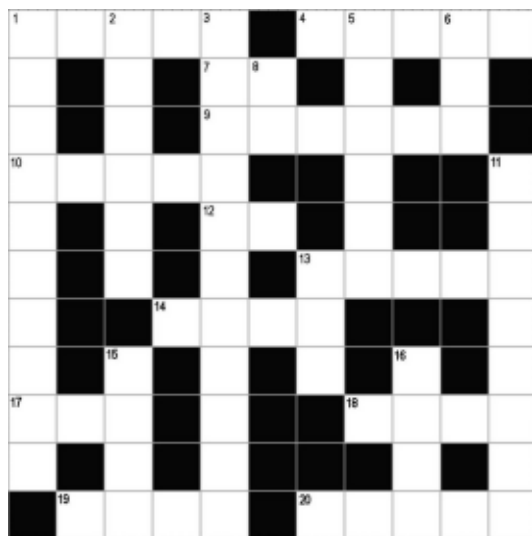


NASA/jpl-caltech/t.pyre

// Representation of fullerenes flowing out from the planetary nebula NGC2440

CROSSWORD

// by Sophie Brennan-Jones



Across

- 1 Non-crystalline solid
- 4 Type of boson
- 7 Symbol of element first discovered in California
- 9 Noble gas
- 10 (see 13 down)
- 12 External opening of the body
- 13 Creator of exclusion principle
- 14 Flightless bird in New Zealand
- 17 Single stranded group of nucleic acids (abbrev.)
- 18 Electrically charged atoms
- 19 Celestial body that begins as a nebula
- 20 Father of antimatter

Down

- 1 Hypothesis that microorganisms are the cause of disease (4,6)
- 2 Type of acid in vinegar
- 3 Austrian cat owner
- 5 WWII cipher machine
- 6 Unit of electrical resistance
- 8 Symbol of metallic element found in haemoglobin
- 11 Period when dinosaurs first evolved
- 13 Innermost layer of the meninges (3,4)
- 15 Product of chemical reaction between acid and base
- 16 Model of atomic structure

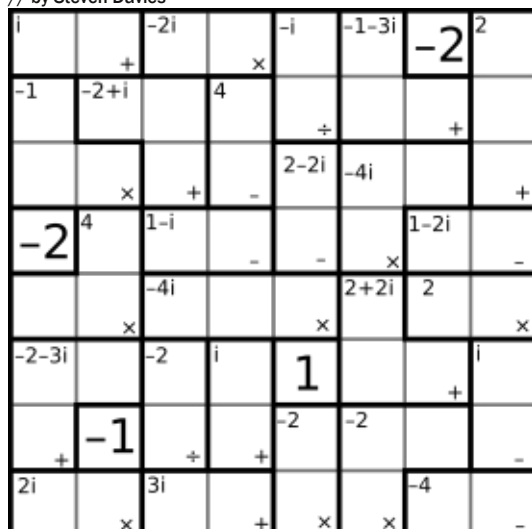
FIGURE 1

// by Johnny Stormonth-Darling



COMPLEXDOKU

// by Steven Davies

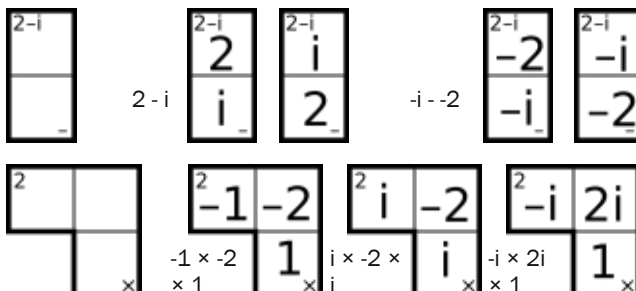


Fill each cell with either -2, -1, 1, 2, -2i, -i, i or 2i.

Each bold cage shows a target and an operator. Using that operator and the numbers in the cage you must be able to form an equation to give you the target.

Numbers can repeat within cages but not rows or columns.

Some examples, with (some) possible solutions:



THE GIST SEMINAR - "ENERGY PRODUCTION IN 2050 - PATHWAYS TO A GREENER FUTURE"

The GIST proudly present the first GIST seminar.

Wednesday May 2nd 2012 @19:30
The Debates Chamber - Strathclyde
University Union

This is an opportunity for the public to engage with leading scientists and engineers to see where science may lead us in the future.

This first seminar focuses on the 2050 pathways calculator (found at <http://2050-calculator-tool.decc.gov.uk>). Leading experts from the world of energy production and distribution will present their vision for the future of energy in the UK. It will then be over to you, the audience, to lead the discussion - ask the questions about the future of energy that you've always wanted to ask...

- Do we need nuclear power?**
- Will we all drive electric cars in 2050?**
- Can't we just keep doing what we're doing now?**

Attendance is FREE, simply contact the GIST via editor@the-gist.org to register

