ScienceWise

SCIENCE MAGAZINE OF THE AUSTRALIAN NATIONAL UNIVERSITY

ANU
THE AUSTRALIAN NATIONAL UNIVERSITY

- March / April 2009

Volume 6 No. 2

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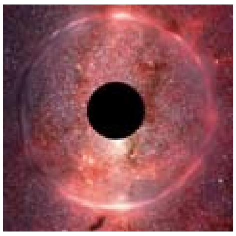

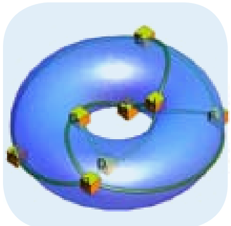

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Cover Image Dr Isaac Sakala
Photo: Karen Edwards, John Curtin School of Medical Research

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The Editor's Corner

Science and environment

Dr Tim Wetherell

In this edition we have a couple of stories relating to the ever growing concerns over the direct and indirect influence of humans on the environment. In one we look at research intended to assess the true impact of the introduced Indian Myna bird population on native birds. And in the other, a team of scientists assisting the Pacific island nation of Kiribati protect it's fresh water supply against the worst effects of climate change and over exploitation. But apart from their environmental content these stories have another thing in common. They both involve scientists who set about solving a problem by first thoroughly investigating and understanding it's nature.

We're all concerned about the impact of human and natural forces on our environment, after all it's where we all have to live. And perhaps for this reason we tend to get very emotional about the politics of environmentalism. But if we're really going to solve the existing problems and avoid even worse ones in the future, we can't approach this from an emotional perspective. We have to clearly understand what's going on and what various courses of action are actually achieving.

All too often we see well intentioned but inadequately researched initiatives fail to achieve any measurable outcome or worse still, create problems greater than the ones they aim to solve. This creates a double problem. It draws resources away from the effective projects and worse still, gives ammunition to cynics. If a highly visible environmental program ends up doing more harm than good, there's a tendency to believe that any attempt to reduce human impact is futile and we may as well not bother.

So how do we make our environmental projects yield maximum benefit? Well in my view by making sure that we get the basic science right first. Make sure we understand the problem, develop a proposed solution, test it and assess the outcome without bias. Of course this is the very essence of the scientific method. Investigate, hypothesise and test.

Science is a great way to address environmental concerns and to solve technical problems but that isn't all science can do. Science can also form the basis for a whole way of thinking. Undertaking an education in science is great way to enhance your ability to problem solve across every aspect of life. So even if you end up perusing a career in business, politics or even retire to the hills to grow grapes, the mental discipline and rigorous methodology of science will serve you equally well.

Mice and men

Tim Wetherell

Helping the immune system fight viral infection

Since the dawn of time all animals have been engaged in a life and death struggle with the microorganisms that infect them. To some extent such infectious diseases in humans have been exasperated by the vast social, technological and cultural changes human society has experienced. For example the mass migration to cities during the European industrial revolution was a factor in building deadly cholera and typhoid infections to epidemic levels. In the modern world infectious diseases are still prevalent and are a cause of much human misery especially in developing countries. But fortunately, today we also have advanced science working towards eliminating many of the worst of them.

Dr Isaac Sakala from the John Curtin School of Medical Research is an immunologist working on the Ectromelia virus that causes mousepox, a disease in mice with a very similar pathology to smallpox in humans. Dr Sakala explains, "Ectromelia is a virus from the genus orthopoxvirus and its infection in mice is an excellent model for other medically important orthopoxvirus infections in humans such as smallpox and monkeypox."

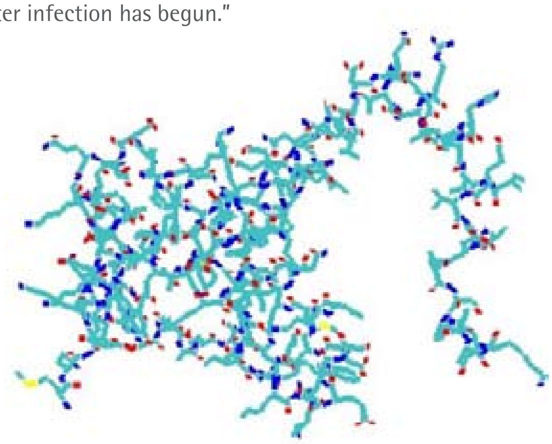
Fortunately, the natural threat of smallpox has been eliminated by a worldwide system of vaccination and quarantine, the last recorded case being in 1977. However, Variola virus, the causative agent of smallpox, still exists in two World Health Organisation controlled repositories. There are concerns that Variola virus may fall into the wrong hands and be genetically engineered into a bioterrorism agent. Given that most countries no longer vaccinate against smallpox, the potential death toll from such a release could be horrendous. However, in addition to these man-made threats, there are also new natural sources of orthopoxvirus disease. There has been an increase in monkeypox outbreaks in recent years. Monkeypox has some similarities to smallpox - and worryingly, is impossible to eliminate by vaccination because it can cross between species. Death rates from human monkeypox can be as high as 10% of those infected. For these practical reasons, scientists continue to work towards a better understanding of the orthopoxvirus family and their modes of operation. In a broader context such work is also vital because a better understanding of the workings of the immune system will also help us combat other diseases ranging from tuberculosis to cancer.

During his PhD, Dr Sakala studied the virus-host interaction between mice and the ectromelia virus. During an ectromelia virus infection the virus expresses a molecule that can interfere with the mouse's immune response by binding to a protein

Dr Isaac Sakala in his lab. Photo: Karen Edwards

Dr Isaac Sakala with the 2009 Alan and Elizabeth Finkel Prize. Photo: Karen Edwards, Multimedia Unit, JCSMR

known as Interferon-gamma (IFN-γ). This reduces the ability of the host to mount an efficient and effective antiviral immune response. In this way the virus is able to effectively protect itself against attack by the immune system. However Dr Sakala believes that understanding this mechanism may give us a means to treat infections. "A better understanding of the role of Interferon-gamma in immunology may give the opportunity for therapeutic intervention. By designing a modified Interferon-gamma that retains its role in immune response but won't bind to the virus blocking receptor, we may be able to greatly improve a patient survival rate even after infection has begun."



Line representation of a IFN-γ monomer

Dr Sakala's research has also yielded some surprising results. Generally it has been thought that a host infected with a poxvirus either dies or recovers, eliminating the virus from the body. However, it turns out that ectromelia virus can cause a persistent infection in mice that have a particular genetic makeup. Clearly this has serious implications for eradication of diseases such as human monkeypox. If the same were true of the monkeypox virus in humans, some members of the population who had apparently recovered from the infection may be still able to spread the disease.

Being originally from Zambia, Dr Sakala is more aware of the direct human consequences of viruses than most of us. "From early in my career I've had an interest in the immunology of infectious disease and wanted to work specifically on viruses. Coming from a developing country in which viral infections such as HIV are common, viruses and immunology are very much on my mind."

In recognition of the importance of his recent interferon gamma research Dr Sakala was awarded the prestigious Alan and Elizabeth Finkel Prize in 2008.

Models of time

Guy Micklethwait

The real physics behind time travel in the movies

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Back to the Future, Planet of the Apes and The Terminator are all highly successful movies, but they have something else in common. Each of them involves speculation about the physics and philosophy of time. PhD researcher Guy Micklethwait explores the facts in science fiction about time travel.

Filmmakers have been using ideas about time as plot devices for years. I've found at least 170 movies that involve time travel or other temporal phenomena, and have reviewed over 100 of them including science fiction, psychological and fantasy films. How likely is it that these scenarios will one day become a reality? And if we do find ways of travelling through time, what consequences might we face? These are tricky questions, but first we need to consider the physics of time travel.

Einstein's Special Theory of Relativity argues for the existence of a four-dimensional 'space-time continuum'. This is made up of the three dimensions of space: width, breadth and depth. We can see and touch all of these things. The fourth dimension is time, which we cannot see or touch, but whose passing we can experience. A physicist would say that we are experiencing ourselves passing through the dimension of time. In the 1960 film, The Time Machine, George Wells explains to his learned colleagues what the fourth dimension is and how his newly invented machine can travel backwards or forwards through it.

These four dimensions all relate to a constant. So for example, the faster a rocket moves through the three dimensions of space, the slower it moves through the dimension of time. This means that the rocket's onboard clock is ticking more slowly than a clock back on Earth – a concept known as 'time dilation'. When the rocket returns, less time will have passed for its passengers, so they will have aged less than the people back on Earth. In the extreme case, they may return to the Earth's distant future, as in Planet of the Apes (1968). So forwards time travel is a reality: how far forwards you wish to go in time only depends on how fast your technology will allow you to travel through the three dimensions of space.

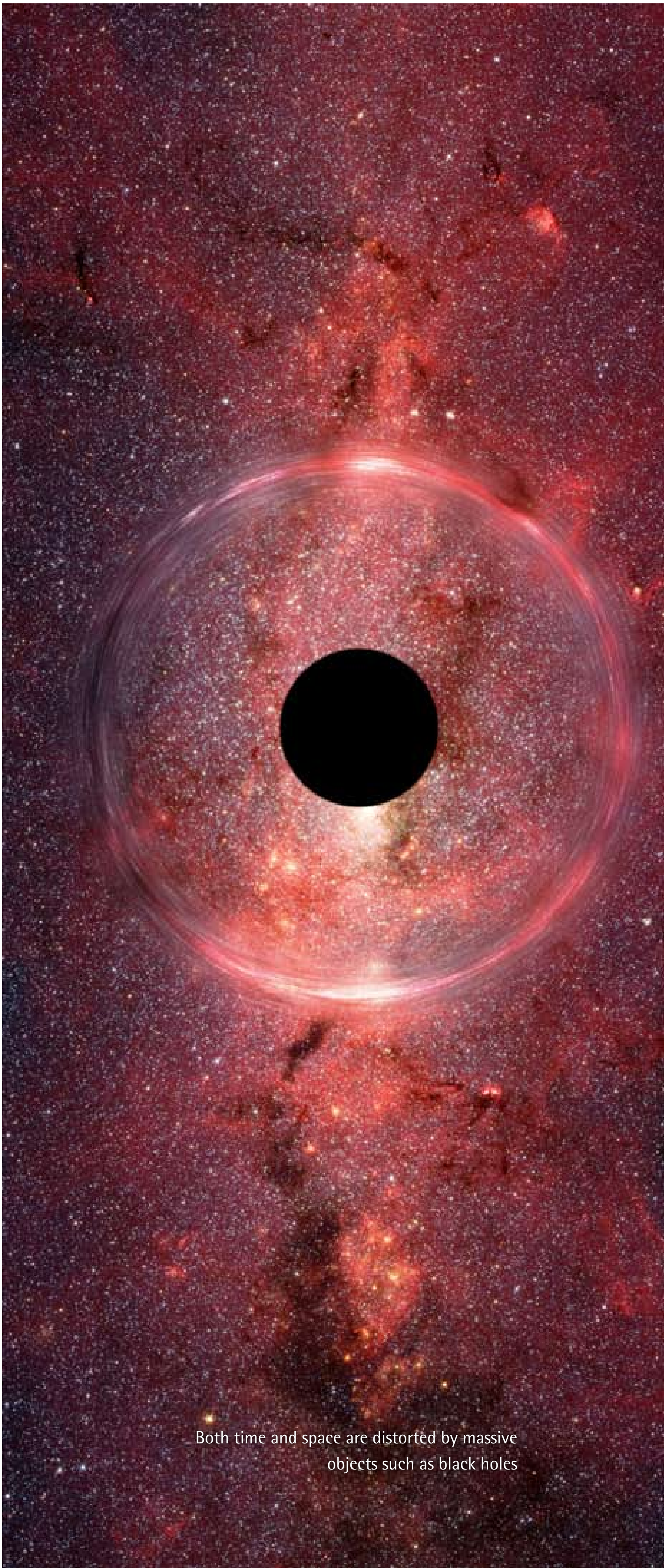
Backwards time travel is a little trickier. Scientists have speculative theories in place, but technology hasn't caught up yet to the point that they can be tested. Creating wormholes is one such theory. If space can be curved enough, and there is no theoretical reason why it can't, then maybe a wormhole could be constructed to shortcut from one side of the universe to the other. If one of the mouths of the wormhole was made to travel very fast compared to the other one, then there would be a time difference between the two. Passing through the hole one way would allow you to move forwards in time and passing back the other way would allow you to move backwards in time. The main limitation with this method is that you would never be able to travel back to any date prior to the construction of the wormhole. Such a wormhole occurs naturally in Donnie Darko (2001), where a jet engine falls off a plane and then passes through a space-time anomaly, which causes it to travel back 20 days before crash landing.

A jet engine is rather large, unlike sub-atomic particles. At that very tiny level, anti-particles moving forwards in time behave like particles moving backwards in time and vice versa. So backwards time travel is unproblematic on microscopic scales. As an aside, the physicist Stephen Hawking suggests that on the macroscopic scale (where we exist) time travel must be impossible. He argues that a 'Chronology Protection Agency' would prevent 'closed time-like curves' from appearing, thus making the universe safe for historians. But what is a closed time-like curve in the first place?

Causes and special effects

If you were able to curve space, then what would happen if you curved it right around to the point where you made a loop? This is theoretically possible using Einstein's equations. Indeed there may be parts of the universe where these loops naturally exist. A 'closed time-like curve' is when you loop right back to a place in space and time that you had previously experienced. You could hypothetically traverse the loop just the once, get stuck in such a loop forever, or go around several times before exiting. This happened to the character Phil Connors in Groundhog Day (1993), who kept waking up each morning to find he had returned to the start of the previous day.

As a weatherman, Connors no doubt would have known the work of Edward Lorenz, who in 1961 created a simple weather forecasting model using a software program with 12 equations. Lorenz noticed that the slightest change in his input data would give very different long-term weather predictions. Such systems are known as 'nonlinear systems' and are normally characterised by long-term unpredictability. Lorenz noted that the flap of a butterfly's wing could cause a tornado in some other part of the planet and thus the term the 'Butterfly Effect' was born. Examples of such systems are seen in the stock market, evolution and even in psychology. In the film The Butterfly Effect (2004) a man goes back in time and makes a few changes at a critical point in his childhood, which causes his original timeline to disappear and a new timeline to form from that point onwards. This new timeline diverges away from where the original used to be, so that when he returns to his adult life, he and all of his friends are following a completely different destiny.



Both time and space are distorted by massive objects such as black holes

One of the most famous temporal paradoxes thrown up by backwards time travel is the 'Grandfather Paradox'. If you went back in time and killed your grandfather when he was a child, this would mean that you would never have been born and would cease to exist. An example of this paradox occurs in Back to the Future (1980), when Marty McFly goes back in a time machine and meets his parents before they were married. His presence causes his mother to fall in love with him and reject his father. Marty fears this will prevent his birth, so spends the rest of the film trying to get his parents back together again.

If you were to travel back in time and send your grandfather to an untimely grave, there is a possibility your own timeline would continue unharmed. The physicist Hugh Everett III proposed his Many Worlds Interpretation of Quantum Physics in 1955. He suggested that when we measure quantum objects the world actually splits into two parallel realities. In this theory there are no paradoxes, but the idea of an infinite number of timelines scares away many scientists. How does this relate to time travel? Well, if you were to travel back in time, another timeline would be created in which you would begin to interact. You could kill your grandfather, if you wished to do so, and you would continue to live in a world where your grandmother did not marry your dead grandfather, so you would never be born in this timeline, and would not get to meet yourself. In parallel to this, your grandfather would still be alive on the original timeline and you would be born and live to become a time traveller. An example of parallel worlds is seen in the movie, Sliding Doors (1988), which follows two different parallel lives that branch out from each other after a brief time reversal.

Fate of a time traveller

What if you go back in time and your actions cause an event that later becomes the reason why you originally went back in time? This would mean that you would be predestined to go back in time in order to create a self-consistent timeline. This is known as the 'Predestination Paradox'. Any changes you thought you were making in the past would be not be changes at all, as they would be helping to make history just as it was originally written. This happens in The Terminator (1984) when a man is sent back from the future to protect Sarah Conner, the mother of his comrade, John. He gets her pregnant and thus becomes John's father. Therefore John is predestined to send him back in time so that he can be born and keep the timeline self-consistent.

But perhaps we wouldn't have to go to so much trouble to keep our timelines tidy. In the mid-1980s, Dr Igor Novikov developed the Novikov Self-Consistency Conjecture, which stated that if time travel were possible, there must be a law of physics that would prevent time travellers from doing any action that would cause an inconsistency and hence a paradox. This is exactly what happens in Terminator 3 - Rise of the Machines (2003). No matter what they do, or whom they kill, the protagonists can't stop the inevitable rise of the machines. The war has to take place for the robots to be sent back in time and for Sarah Conner to give birth to her son.

So it can be seen that although forwards time travel is a reality and its effects are being used in modern engineering, the technology required for backwards time travel is speculative. In fact, arguments between physicists are ongoing about how likely it is that a wormhole would actually work even if built. That hasn't stopped filmmakers from using wormholes and other time travel techniques as plot devices for their films to inspire audiences to hope that one day they will be able to venture back and change their past, just as people once dreamed of a rocket reaching the moon. As we move into the era of space tourism, who can say if and when backwards time travel will be possible.

Guy Micklethwait is doing his phd, Models of Time: a comparative study using film, jointly at Centre for the Public Awareness of Science and the research School of Physics and Engineering.

Fantastic films

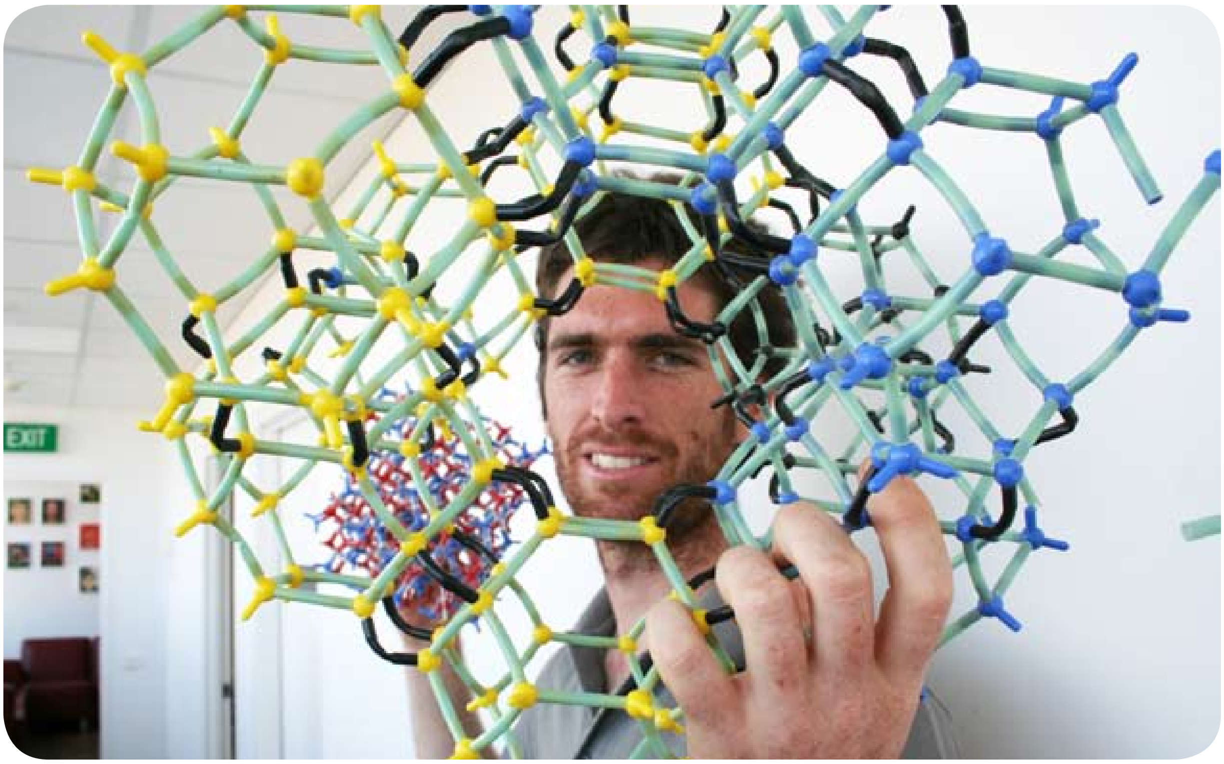
Guy Micklethwait picks five time-bending movies worth watching.

- *Twelve Monkeys* (1995) Time travelling backwards inadvertently causes a closed causal loop.
- *Slaughterhouse* Five (1972) Experiencing life along a fixed timeline, but in a random order.
- *Déjà Vu* (2006) Viewing and trying to change the past using wormhole technology.
- *Frequency* (2000) Changing the present by communicating with people in the past.
- *The Jacket* (2005) Involuntarily travelling to the future brings justice to the present.

Knots and networks

David Salt

The mathematics of entanglement



Toen Castle believes we have much to learn (and gain) by subtlety modifying the connections between the nodes that make up a network, be that network a crystal lattice or a molecular material. His specific interest, which forms the basis of his PhD studies in the Department of Applied Maths (RSPSE), lies in understanding how networks of points can be entangled without changing the basic order of connection.

"This field of research started with people looking at networks that are embedded in space," explains Mr Castle. "These approaches are relevant to a lot of physical systems such as crystals because crystal lattices can be thought of as networks of atoms and bonds in space.

"However, while quite a large amount of interest has been directed towards considering the connections between elements of these networks, not so much attention was given to the more subtle effects of the manner in which connections could be made.

"And when I looked at how connections might vary I began to concentrate on features that these bonds within the network can have. It's possible to conceive of a tangling of complex structures, of things being connected in ways that are knotted or linked.

"A knot is a loop in space that you can't straighten out into a normal circle in space without passing through itself. Knottedness is a fundamental property of a loop in space. Either it's just a simple loop, like a circle, or else it's got some form of structure in it that can never be removed without passing edges through each other.

"Links are related to knots. In the link there are more components and they're joined together and unable to separate, which is a similar phenomenon, but involves two or more components instead of the one."

Knots and links add a whole new dimension to the manner in which a network performs. You can have two networks with the exactly the same connectivity but which are linked or knotted in different ways making them behave in different ways.

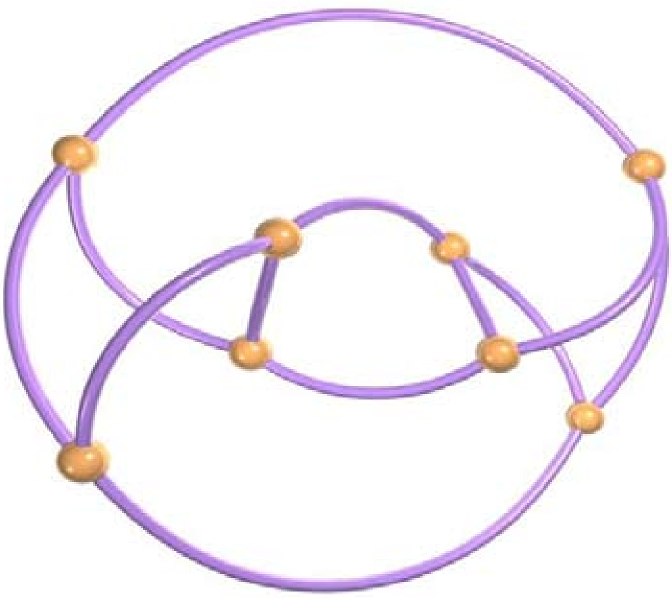
A LANGUAGE OF KNOTS

"It's very difficult to describe this area of tangled networks," observes Mr Castle. "There's no natural language to describe exactly what's going on. You can wave your hands and say 'look its tangled', 'look the layers are interlocked with each other', but in terms of a quantitative science we're really searching for a good description of what's really going on. That doesn't exist at the moment and that's what I'm trying to do with my research.

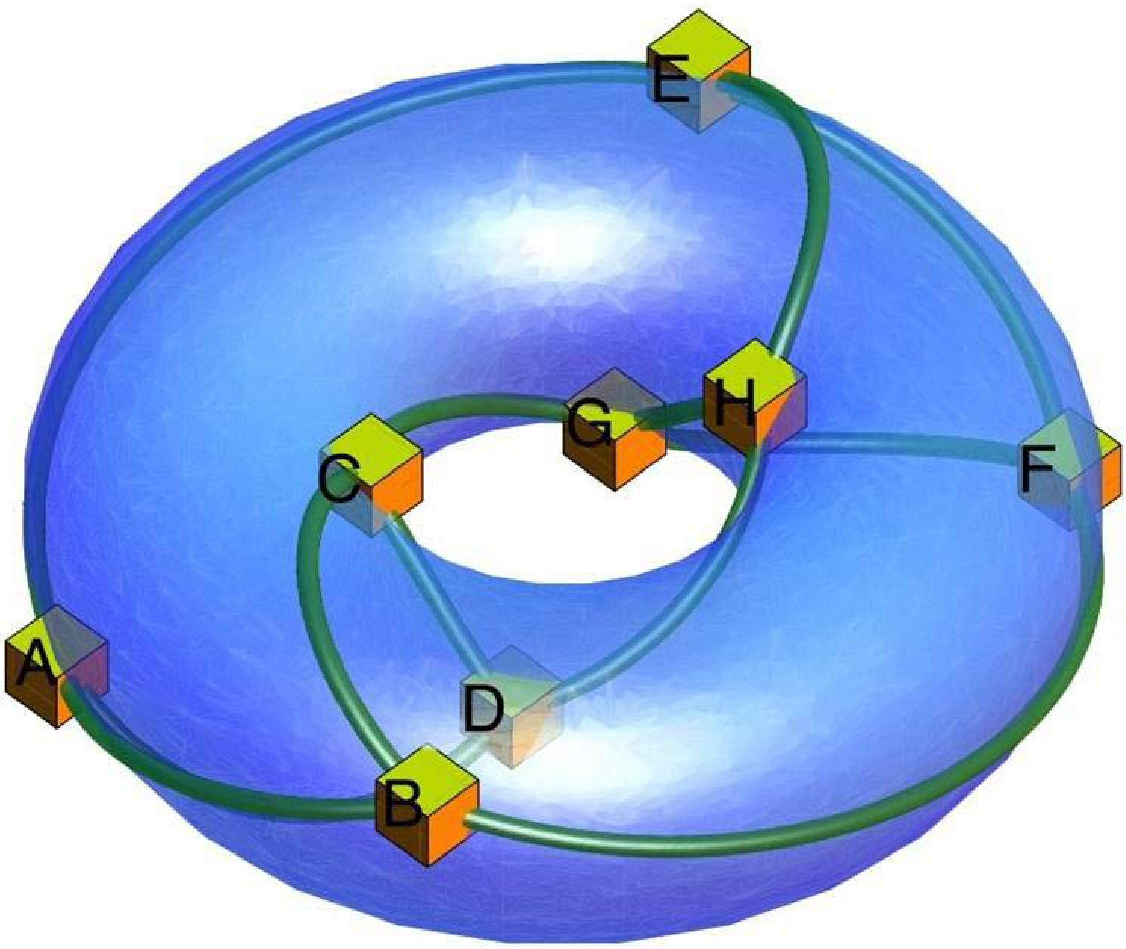
"The aim is to come up with a framework or language by which this understanding of entanglement can be taken further and applied to different networks. And to be a good language, it must describe the fundamental tangling features that can be present in a network. So, by finding a conceptual language that can describe the tangling you can put together words from this language and generate novel structures.

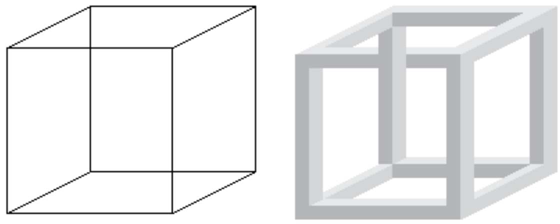
"The language we're generating is still rudimentary but we've made some real progress."

To build a language of entanglement, a language of network knots, you ideally begin with a basic structure and explore what's possible in terms of entangling it without changing its connectivity. And for Toen Castle, that structure is a cube.



This structure - shown (below) on the surface of a doughnut and (above) without the surface - have the same connectivity as the cube (8 nodes connected by 12 edges) but are structurally tangled. By understanding the language of loops and knots Toen Castle believes we can create materials with new properties.





The optical illusion of 'the impossible cube' (above), with a wire-frame version of the cube (left) and the 'impossible cube' (right). An impossible cube is really a form of a knotted cube. You can't embed an impossible cube into a sphere as you can with a normal cube. However, you can embed it into a doughnut as shown on the previous page. By figuring out ways that simple arrangements can be knotted in different arrangements you open up rich new possibilities for networks.

"Most people conceive of a cube as a solid square block with six sides," says Mr Castle. "For our purposes, ignore its volume and surface and think just of the edges as a wire frame with eight corners. The cube is a very interesting structure because it's so common and hence we have a good intuitive link with it. However, it's also complicated enough to start to display some interesting properties in terms of the potential ways to tangle it.

"It's also a common building block in crystal lattices. In complex structures, modern crystallographers may find certain repeating cubic and tetrahedral units inside the crystal structure and then represent the structure in terms of those cubes and tetrahedra or prisms just to simplify their work."

To understand how you might tangle a cube it's helpful to consider the impossible cube. It has the same connectivity as your normal cube and yet it's completely different. It's tangled.

"Many people will have seen the impossible cube in books of optical illusions," says Mr Castle. "It's an optical enigma in which the lines and perspectives seem wrong. It seems impossible because there's no way you could embed this version of the cube onto a sphere. By that I mean that there is no way to deform the wire-frame cube onto the surface of a sphere. The cube embedded on a sphere - a normal cube - can't have any knots or links.

"If you consider every way of starting at a certain vertex of the cube, travelling along edges and coming back to your original vertex without doubling up, there's no way that you can make a cycle that will be anything other than a simple loop; there's no way it can have a knot in it, being embedded on the sphere just prohibits it. In terms of tangling, the sphere isn't an exciting place to live. Similarly, there's no way to find two distinct cycles that actually link together, they're always just on opposite sides of the sphere.

"However, it's quite easy to embed an impossible cube onto the surface of a doughnut. Another way of saying that is that there's only one way you can embed a cube into a blob but there are many interesting ways you can embed that cube into a blob with a hole in it (that is, embed it into a doughnut or torus). And this is the beginning of how you build your language of entanglement."

KNOTS BEYOND THE DOUGHNUT

Having worked out a method to tangle basic structures by embedding them in doughnuts, Mr Castle is now looking to explore more complex entanglements.

"The next step in this process is to step up from the simple donut, a torus with one hole, to more complicated shapes like a donut with many holes," says Mr Castle. "This is a very big challenge because the mathematics of multiple-holed donuts is quite different to single holed donuts.

"You get a vastly more structural complexity when you use multiple-holed donuts. You can chop them up and peel them open into repeating units in any number of ways giving you very interesting twisting and tangling patterns."

While conceiving a language of entanglement might sound a little abstract, Mr Castle is a firm believer in the real world application of this work.

"While this work engages with some very sophisticated concepts, there's real potential for applying this work," he says. "Possible applications of this work include the creation of new crystal structures and new materials."

"Hydrogen storage is another big application of this work because hydrogen, being a gas, takes a lot room to store but hydrogen has an affinity to stay at the surface of some materials. So, some mineral structures like zeolites, have lots of big rings in their structure, and are excellent for hydrogen storage. Materials engineers are trying to improve this storage structure and scale it up, however when they do this, the rings are prone to collapse around each other – and entangle. So, researchers are now looking to build similar structures that have the same features, but which are more stable and avoid tangling.

"And there are other ideas as well for how we might employ tangled networks and structures. Though I suspect that the best ideas on how to use this knowledge haven't even occurred to us yet."

Rats of the sky?

David Salt

Just how damaging are Indian Myna birds to the Australian environment?

Indian mynas are an introduced species that many people love to loathe. In a recent ABC poll, they were voted "the Most Significant Pest/Problem" in Australia. They've also been placed on the IUCN's world's 100 worst invasive species list. Some people even call them the "rats of the sky." But just how damaging are these pests, and what can we do about them? Kate Grarock at the Fenner School of the Environment and Society is undertaking the research to come up with the answers.

The Indian myna (Acridotheres tristis) is native to India and southern Asia. In the 19th Century mynas were introduced to many countries as a form of biological control for insect pests in agricultural areas, and they have proved amazingly adaptable. In 1863, 42 birds were released in Melbourne, and then later mynas were released in Sydney and north Queensland. Now they're common throughout the eastern states, often in high densities in urban areas.

They were released in Canberra in 1968. In 20 years they were in half of Canberra's suburbs. By the year 2000 they were judged to be the most common feral bird in the ACT. Today they are in every suburb, sometimes in densities over 100 birds per square kilometers, and numbers are still increasing in some areas.

Indian Myna bird in an urban environment
Photo: Benjamint444, Wikipedia

Kate Grarock is building nest boxes and removing pest birds from Canberra's suburbs to measure the impact of Indian mynas

"Many people hate Indian mynas because they're so visible in our suburbs and backyards," says Kate Grarock. "They prey on native birds, take over precious tree hollows, steal food from our tables, and create noise and mess when they come together in roost trees – often in their hundreds. They've got a high profile but most of the evidence against the Indian myna is anecdotal. Some people question whether they really are having an impact on native species."

But the lack of hard evidence hasn't stopped people hating them and getting together to try and stop them. There are several anti-myna groups around Australia and in the ACT there's the Canberra Indian Myna Action Group (CIMAG) with several hundred members. CIMAG has trapped and removed almost 20,000 mynas but some have questioned whether this is actually achieves anything.

"So here are some important issues that need attention: How many mynas do you need to remove to make a difference? How quickly do mynas recover from removal? Does removal of myanas have a positive effect on native species?"

To answer these questions Kate is conducting a major myna bird removal experiment across Canberra as part of her PhD research. With the help of CIMAG she is removing high numbers of mynas in five suburbs, medium numbers in another five, and comparing this with five control suburbs in which none are removed.

Each of the 15 suburbs will be monitored by transect counts of all bird species present, and through the establishment of over 200 nesting boxes (to monitor nesting success of both natives and mynas). This will be one of the largest myna removal experiments ever attempted in Australia.

"By undertaking this experiment at this scale and with this level of replication we're hoping we can clearly and scientifically demonstrate the impact mynas are having on native species," Kate explains. "To date, the impact mynas have on our natives is largely unqualified. We know it occurs, but not to what extent and which native species are most impacted."

"We're also hoping to establish the level of myna removal required to meaningfully reduce overall numbers. Is it feasible to just concentrate on trapping one suburb at a time or do you need to focus on a much larger area?"

"We're also hoping to learn how Indian mynas respond when you start removing them from the area. An understanding of how mynas adapt to a reduction in numbers may hold the key to ensuring that reductions are long lasting. It's hypothesised, for example, that mynas will rear more chicks in removal areas, than those in non-removal areas."

To assist in monitoring the impacts of the removal experiment, Kate has built and deployed over 200 wooden nest boxes through the treatment suburbs. The nest boxes provide preferred habitat to a number of different native species and are also sought after as homes by the Indian mynas.

"The nest boxes are easy to locate and check on a regular basis," says Kate. "We're expecting to find them used by quite a few mynas in the control suburbs but it'll be interesting to see what's using them in the medium- and high-myna bird removal sites."

It's still too early to say whether the removal treatments have worked and if removal has led to an increase in native species. However, whatever results turn up in the coming year, this study will give us a much improved understanding of the real impact of myna birds. And we'll be better placed to effectively manage them in future.

Myna eggs and a baby found in one of the next boxes.

Two hundred and ten nest boxes were constructed for Kate's experiment. That's a lot of ply board and several bruised fingers!

Rising tide

Tim Wetherell

Developing policies to help protect Kiribati's water supply

As part of growing concerns over the effects of climate change on developing nations, The World Bank recently implemented an Adaptation Program for the multi-island Pacific nation of Kiribati, which has been supported by both AusAID and NZAID. As part of this program, Professor Ian White of the Fenner School of Environment and Society has been leading a team of scientists in helping Kiribati develop strategies to lessen the impact of climate change.

Professor White's long experience of working in the region has led him to believe that "Understanding the local people and their lifestyle is vital to achieving success in any scheme like this. You have to build relationships and take the time to understand local culture. So rather than looking at this from a purely science perspective, we began by speaking to the locals and trying to build up a picture of what their concerns actually were." One might imagine that in a nation of islands and lagoons, many of which don't rise more than 6 metres above mean sea level, increasing sea levels would be the greatest worry to them. However, asked to rank priorities 7 out of the top 10 adaptation strategies concerned the far more immediate problem of fresh water supply.

The northern islands of Kiribati receive an average annual rainfall of between 2000 to 6000mm so outwardly it seems there should be no shortage of water. But the local soil is sandy and highly permeable, so in spite of the high rainfall, there is little run-off water. Instead, the rain permeates down into the ground, through the upper layers of corral sands and into the underlying karst limestone. The low terrain surrounded by ocean and the porosity of the system to tidal saltwater movement create a situation in which the underground fresh water tends to become saline. There is a layer of fresh ground water about 5 to 20 metres thick below which is 15 metres of intermixed water, then salt water.

Almost all the water for human consumption is extracted from this groundwater reservoir using wells or specially designed pumping systems. If a conventional vertical bore is pumped the suction tends to cause intermixing of the salt and fresh water, contaminating both the well and reservoir. So up to 300m long horizontal skimming wells are used instead. However the number and placement of such wells is critically important if the reservoir is not to become intermixed, so effective Government regulation and planning is vital.

Most of the islands of Kiribati are low and flat making them highly vulnerable to major sea level rises. Photo: NASA

Professor Ian White

Ironically, if sea levels do rise due to polar melting the initial effects will be positive for Kiribati. A small rise such as 0.5 m would tend to raise the fresh groundwater level into the coral sands and out of the karst limestone. This would reduce the tidal mixing process and in effect, increase the volume of fresh water available. However a rise of more than 0.5m would spell disaster for both the water reserves and the availability of land on these low flat islands.

But it's not just geographical factors that influence the availability of water. Like many parts of the world including Australia, Kiribati is experiencing large scale migration of population from the outlying rural regions to the major centres of population where there are roads, schools, electricity and hospitals. In the small pacific island nation, this migratory population growth is exacerbating the water resource issue. Population densities in the capital Betio (pronounced Basio) are 12,000 people per square kilometre, something similar to central London! And more people mean more demand for water and more sewage to remove.

One of Professor White's major concerns is the oceanography of the region. "Kiribati is even more susceptible to the whims of the Pacific El Niño Cycle than Australia, so we sometimes see a shift from the normal high rainfall to a situation of extreme drought." Storms also pose a significant threat because even though most of the islands of Kiribati are outside the Pacific typhoon belt, there remains the possibility of a storm surge dumping vast quantities of sea water over the low terrain. "We know from experience on similar islands that when surge waves do pass right over the island, the ground water becomes highly saline and it can take the system up to 19 months to recover." For all these reasons, Kiribati needs a national water policy and implementation plan to diversify the water harvesting methods and protect the future supply.

Professor White's team have been able to help the government develop just such a comprehensive plan to secure Kiribati's water resources over the coming decade. "But this has had to be a plan that works harmoniously with the local people and their traditions." Professor White explains. "In Pacific communities things don't happen overnight. In terms of communication, the people of Kiribati don't naturally use the written word, preferring verbal communication or dance. It's important to know these things in preparing effective policies and especially in developing appropriate plans of action."

Although most of the residents of Kiribati have few of the material possessions that Westerners would associate with wealth, they don't consider themselves poor. They place great value in family and in ownership of land, which provides produce such as coconuts and is also tied to local fishing rights. If the residents can be cushioned from impacts of climate change, in many ways the human experience of living in Kiribati is very positive.

THE AUSTRALIAN NATIONAL UNIVERSITY

ScienceWise is published by the
Australian National University
Editor: Dr Tim Wetherell

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