**INTERACTIVE: How science works**

**Exploring ideas**

**Observing**

Observing and asking questions is fundamental to the process of science. Scientific knowledge is built as people come up with hypotheses and theories, repeatedly check them against observations of the natural world and continue to refine those explanations based on new ideas and observations.

Sometimes, observation involves relatively simple activities that require little preparation, such as observing that a particular bird species always thumps its foot before foraging. At other times, scientific observation is an extremely complex and challenging activity.

Scientific observations can be made directly with our own senses (for example, seeing, hearing, feeling or smelling) or we can extend and refine our basic senses with tools like microscopes, telescopes, radar, radiation sensors and so on. For example, with our own senses, we can observe that a glass of water is hot, but with a thermometer, we can extend this observation.

Image caption: Science is based on observation

Image acknowledgement: Erion Cuko

**Asking questions**

New questions and new ideas are what keeps scientific research growing. Science continually studies and asks questions about the natural world. The natural world means all the components of the physical universe – atoms, plants, ecosystems, people, galaxies – as well as the natural forces at work on those things, such as gravity, electricity and so on.

For example, with Antarctica becoming an increasingly popular tourist destination, people are asking the question of how the presence of humans affects this isolated and pristine ecosystem. To help answer this question, research is being conducted in Antarctica to find out how humans are specifically affecting penguins. Observing and asking questions are fundamental to the processes of science.

Image caption: Asking questions about human impact in Antarctica

Image acknowledgement: Calum Ninnes

**Inspiration & creativity**

Creativity is the engine of science. The stereotype of scientists is of people in white coats going about very routine procedures over and over again in a boring way, but science actually is a creative endeavour. It begins with thought. It begins with imagination.

In fact, imagination and creativity are needed in every aspect of a scientist’s work – coming up with new ideas, designing investigations, making sense of observations, making the creative leap from data to possible explanation and looking at previous data in a new light. All observations in science require interpretation and inference by scientists because scientists need imagination and creativity to make inferential statements about what they see.

Neurosurgeon Dr Martin Hunn gives us an idea of the creativity scientists need. He wanted to improve the outcome for patients with malignant brain tumours. A creative possibility he has thought of is that it might be possible to harness the power of the body’s immune system, so he has joined the team at the Malaghan Institute to see if, together, they can develop vaccines against brain tumours.

Image caption: Researching a creative treatment for brain tumours

Image acknowledgement: BUTO Productions/TVNZ 7

**Reading the literature**

Sir Isaac Newton, often regarded as the most influential scientist in history, is quoted as saying, “If I have seen further, it is only by standing on the shoulders of giants.” In other words, he was saying that his work would not have been possible without the previous work of other scientists. Science relies on the accumulated knowledge of the scientific community to move forward.

Scientific publications, called journals, contain firsthand reports of research. They provide a cumulative, permanent record of scientific research. Most are published on a regular basis and focus on a particular field of scientific research. Scientists read the journals in order to learn more about research in a field, to find out what is already known about a particular topic and to keep up with new ideas and findings in their fields.

Scientific journals began in 1665, when the French *Journal des Sçavans* and the English *Philosophical Transactions of the Royal Society* first began systematically publishing research results. Now, there are thousands, both in print and electronically, usually reporting new research.

Image caption: Cover of the first volume of the first scientific journal

Image acknowledgement: Wikimedia Commons

**Sharing ideas**

The stereotype is of a scientist working alone in a laboratory. In reality, only rarely does a scientific idea arise in the mind of an individual scientist, to be validated by the individual alone and then accepted by the scientific community. Most research takes too long, is too expensive and needs more knowledge and expertise than an individual scientist working alone, so the process of science is much more often the result of collaboration of a group of scientists.

Because scientists are specialised in their individual fields, they often need to work together on a project to meet the range of knowledge and skills that are needed. This is evident in the wide range of organisations in New Zealand that use a multi-disciplinary approach with scientists from different areas of expertise collaborating to carry out cutting-edge research.

Image caption: Research collaboration aboard the research vessel Tangaroa

Image acknowledgement: National Institute of Water and Atmospheric Research (NIWA)

New technology

Practical problem

Curiosity

Personal motivation

Serendipity

Surprising observation

**Investigating ideas**

**What is known already?**

**Where are the gaps?**

**Actual observations**

Scientific observations can be made directly with our own senses or by extending and refining our basic senses with tools like microscopes, telescopes, radar, radiation sensors or mass spectrometers. Many of the phenomena that science investigates can’t be directly observed – no amount of staring at this computer screen will ever let you see the atoms that make it up or the UV radiation that it emits – and so we must rely in these cases on indirect observations facilitated by tools. Through these tools, we can make many more observations much more precisely than with our basic senses.

Observations yield what scientists call data. Scientists analyse and interpret data in order to figure out how that data informs their hypotheses and theories. Does the data support one idea over others, help refute an idea or suggest an entirely new explanation? Complex data can be represented by detailed graphs, models or complex statistical analyses, but it’s important to remember that, at the most basic level, they are just recorded observations.

At Baring Head, scientists have been collecting observations measuring carbon dioxide in the atmosphere every month for nearly 40 years. These observations are the longest continuous record of its kind in the world and are contributing to an understanding of global changes in the atmosphere.

Image caption: Recording observations atBaring Head air monitoring station

Image acknowledgement: Dave Allen, NIWA

**Problem-solving**

Dr Mike Williams from NIWA explains what excites him about being a scientist and why he likes problem-solving.

Transcript

DR MIKE WILLIAMS
The thing I like most about doing scientific research is the problem-solving. That you’re sitting there and you don’t actually know the answer, you don’t know if anyone knows the answer. And in fact, there may not even be a sensible answer, and it’s that using your brain and the skills you’ve developed and working with other people to try and solve this problem.

It’s a really positive way to tackle life is that you’re just constantly working on something that’s new and challenging – and if you get a little bit bored with that problem, there’s always another problem that needs working on. So I think it’s the problem-solving that… that I enjoy the most.

**Creativity**

Associate Professor Rod Dunbar (University of Auckland) gives his views on the myth of scientists wearing white coats and discusses the role of creativity and imagination in science.

Transcript

DR ROD DUNBAR

People’s images of science is often that people in white coats going about very routine procedures over and over again in a boring way, but science actually is a creative endeavour. It begins with thought, it begins with imagination, and a lot of science is based on things that have gone before. So you always start your creativity from a basis of learning, but in general, everyone starts their creativity from a basis of learning. You can’t write a brilliant new musical piece unless you really know what has been done before and you know something about the structures of music. The starting of the creative process in science is really knowledge and knowing what has gone before so you don’t repeat things.

But in high-level science, such as the work that Hayley has been doing, once you have assimilated all the knowledge that is out there, the first step in a new project is to imagine something, it’s a creative step, and this is true of Hayley’s project. What we did was we imagined a visualisation system that would enable us to see the patterns of lymphatic drainage, and there was no such thing in existence at the time. Then what we do is, having made that imaginative leap, we work out ways of working towards that.

**Inspire revised/new hypotheses and assumptions**

Science investigations can lead to revising existing ideas or to coming up with new ones entirely.

For hundreds of years, it was assumed that the Earth’s continents have always been where they are now. Then in 1915, Alfred Wegener published his theory that the Earth’s continents were once part of a large supercontinent, but he was unable to give a scientific explanation. Since then, however, many lines of evidence have supported his ideas and led to general acceptance of the theory of continental drift and plate tectonics.

This revision of ideas happens in all areas of science. For example, for a number of years, scientists have noticed that people perk up or have a spurt of energy immediately after drinking a carbohydrate drink or swallowing some carbohydrate foods. But this immediate response is too quick to be explained by our existing understanding of energy being supplied to the muscle, because it would take about 10 minutes for the food or drink to make its way down the throat to the stomach into the intestine and then be absorbed.

So a new hypothesis is needed to explain how carbohydrate can immediately improve performance through a mechanism that doesn’t involve the supply of energy. Dr Nicholas Gant has shown that an energy boost is even created by a carbohydrate rinse in the mouth that doesn’t need to be swallowed. This remarkable discovery is changing our understanding of the way that the brain and the body communicate.

Image caption: Researching a new hypothesis on body/brain communication

Image acknowledgement: BUTO Productions/TNVZ 7

**Oppose/support an existing idea or theory or law or hypothesis**

It is a misconception that science can prove or disprove ideas. Instead, it accepts or rejects ideas based on supporting and refuting evidence and may revise those conclusions if warranted by new evidence or perspectives. A single negative finding, if confirmed, is enough to overturn a scientific hypothesis or theory.

So rather than being proven ‘once and for all’, a hallmark of science is that it is subject to revision when new information is presented or when existing information is viewed in a new light. For example, when geographers first began to document where ice was found on the Earth, they thought that icecaps had always been found only round the North and South Poles, plus a few glaciers and snowfields on particularly high mountains. But finding glacial moraines far from any existing glaciers opposed this view and suggests that glaciers extended much further in the past than was originally believed.

Image caption: Evidence of glacial action

Image acknowledgement: Geography Site

**Finding supportive, contradictory, surprising, inconclusive data**

Scientists typically weigh multiple competing ideas about how something works and try to figure out which idea is most accurate based on the evidence. Data can support, contradict or be unexpected and surprising. Evidence may lend support to one hypothesis over others, may help rule out some hypotheses or may lead to the revision of a hypothesis. Or evidence can be inconclusive, failing to support any particular explanation over another.

For example, many biologists have investigated the anatomy and genetic sequences of the arthropods (crustaceans, insects, millipedes, spiders and their relatives) in order to figure out how these groups are related. So far the results have been inconclusive, not consistently supporting a single view of their inter-relationships. Biologists continue to collect more evidence in order to resolve the question.

Finding evidence in scientific research sometimes involves serendipity, where an unexpected or surprising result leads the research in a whole new direction. This was so for researcher Jenni Stanley who had been playing reef noises through a speaker to a tank containing crab larvae to see if it would disrupt their normal daily patterns of movement. Nothing happened – until the night she forgot to turn the speaker off and returned a couple of days later to find that the crabs had started to settle and moult into their adult form. It seemed that the noise had encouraged the crabs to change from their larval form and develop into adults. This discovery that crabs settle and metamorphose (change into an adult form) in response to sound was surprising and unexpected data.

Image caption: Finding surprising data

**Model-building**

Scientists create many types of models – analogical, mathematical, computer-based, mental, molecular and so on. Some models are perceived representations of reality, scaled up or down, for example, a model of a virus particle or of the Solar System.

Scientists use models to help explain phenomena, and they also often use models to make and test predictions. A good example is the particle theory of matter, which pictures atoms and molecules as tiny discrete balls that have elastic collisions. This is a model that explains a whole range of phenomena, but no one has actually ever seen these tiny balls. The model is useful, and it works as a means to explain and to predict phenomenon.

NIWA scientist Richard Gorman uses mathematics and computer modelling to predict wave conditions in oceans across the whole world. Richard confirms his computer-modelled wave predictions by using data from buoys, radar and satellites.

The Science Learning Hub profiles a wide range of other models, for example, modelling tsunami formation, a melanoma spread pattern model, an evacuation computer model, a 3D model of methane and the adenovirus model.

Image caption: Designing a computer model to predict wave conditions

Image acknowledgement: NIWA

**Questions**

Observing and asking questions is fundamental to the processes of science. In every scientific investigation, there will be questions.

New questions and new ideas are what keep scientific research growing. For example:

* How do volcanoes work? Where do they form? And what does this mean for the people who live near them?
* How will we power New Zealand when fossil fuels are depleted?
* Can antibodies be used to fight a brain tumour instead of removing it?

Image caption: Can we predict when Ruapehu will erupt?

Image acknowledgement: Dougall Gordon

**Predictions/expected observations**

When scientists describe their arguments, they frequently talk about their expectations in terms of what a hypothesis or theory predicts. For example, if smoking causes lung cancer, then we’d predict that countries with higher rates of smoking would have higher rates of lung cancer. So when a scientist talks about the predicted rates of lung cancer, it really means something like “the rates that we’d expect to see if our hypothesis is correct”.

Scientists have recently discovered that sea temperatures around New Zealand 50 million years ago (the Eocene period) were much warmer than they expected – a very warm 30 °C. The new findings are at least 10 °C warmer than scientists had previously predicted. This suggests that climate models tend to underestimate temperatures during past climate warming episodes, and it’s possible that current models are also underestimating future warming projections.

Image caption: Sun’s rays warming the sea

Image acknowledgement: 123RF Limited

**Gathering data**

Science aims to build more accurate and powerful explanations of how the universe works – and requires testing ideas with evidence to build scientific arguments. These arguments form the core of science and must be backed by data that can be used as evidence. In general, raw data is considered evidence only once it has been interpreted in a way that reflects on the accuracy of a scientific idea.

Scientists gather data in all sorts of ways. Some depend on experiments, some on observational studies (such as astronomy) and some on historical exploration (such as paleontology and evolutionary biology).

For example, this graph shows acoustic data collected on the research vessel Tangaroa steaming from Wellington to the Ross Sea. Each ‘pixel’ is 20 km long by 50 m deep. The colour represents the average amount of sound coming back from each depth (red = strong, blue = weak). Now, the task is to interpret or make sense of and explain this data.

Image caption: Acoustic marine data from the research vessel Tangaroa

Image acknowledgement: National Institute of Water and Atmospheric Research (NIWA)

**Interpreting data**

While observation and gathering data is essential to the process of science, it is only half the picture. Interpreting those observations and data is the other half. Scientists’ observations can’t directly tell them how things work, for example, no matter how many times and how carefully a scientist observes a ball falling, observing it will not directly tell them how gravity works. Instead, observations inspire, lend support to and help refute scientific hypotheses and theories. Scientific knowledge is built as people come up with hypotheses and theories, repeatedly test them against observations of the natural world and continue to refine those explanations based on new ideas and observations.

Dr Willem de Lange describes science as being like crime-solving – looking at the evidence and coming up with the most plausible explanation for it. Scientists observe what’s happening and try to explain it. He says that testing a hypothesis means making a prediction where you have to think, “This is what happened so far. In the future, I expect this is what’s going to happen.” Of course, predictions aren’t always right – but that’s the nature of science!

Image caption: Willem de Lange ‘crime-solving’ tsunamis

Image acknowledgement: Dr Willem de Lange

**Community analysis and feedback**

**Replication**

Scientists’ studies should be replicable, meaning that another researcher could perform a similar investigation and obtain the same basic results. If a study can’t be replicated, it suggests that our current understanding or our methods of testing are insufficient.

Does this mean that scientists are constantly repeating what others before them have already done? No, they would never get anywhere at all. The process of science doesn’t require that every experiment and every study be repeated, but many are, especially those that produce surprising or particularly important results. In some fields, it is standard procedure for a scientist to replicate their own results before publication in order to ensure that the findings were not due to some fluke or factors outside the experimental design.

The desire for replicability is part of the reason that scientific papers almost always include a methods section, which describes exactly how the researchers performed the study. That information allows other scientists to evaluate its quality and to replicate the study if needed, and it helps ensure that occasional cases of fraud or sloppy scientific work are weeded out and corrected.

Image caption: Craig Radford testing replicability of his sound model

**Publication**

In order for science to progress, researchers must share their ideas and findings. They do this in many ways – informally communicating with colleagues, making presentations at conferences, writing books and publishing peer-reviewed articles in scientific journals.

Scientific journals are especially important. There are thousands of scientific journals in publication. Most journals are highly specialised. Journal articles contain firsthand reports of research – detailed descriptions of scientific studies so that other scientists can evaluate the investigations and their results. Journals distribute scientific information to researchers all around the world so that they can keep current in their fields and evaluate the work of their peers.

Journal articles need to be written in a logical way so that they can be followed. The way science investigations and findings are reported can reinforce the myth that the process of building knowledge in science is straightforward, procedural, routine and unproblematic – rather than the messy, complicated and circuitous process it more often is. Each journal article becomes part of the permanent scientific record.

Image caption: Scientific journals publish research

Image acknowledgement: Science journal covers reproduced with permission from publishers, the Royal Society of New Zealand and Taylor and Francis

**Developing explanations**

Scientific knowledge represents our best explanations yet for phenomena in the natural world. It is a misconception that scientific ideas are absolute and unchanging. It is equally wrong to say that, because scientific ideas are tentative and subject to change, they can’t be trusted.

In fact, accepted scientific ideas and explanations are well supported and reliable, but could be revised if warranted by the evidence. A good example of this is plate tectonics and how these plates interact at boundaries, which is science’s best explanation for phenomena such as continental drift, earthquakes and volcanic activity, and the formation of mountain ranges and volcanoes.

Image caption: Plate tectonics provide a convincing explanation

Image acknowledgement: U.S. Geological Survey (USGS)

**Theory-building**

‘Hypothesis’, ‘theory’ and ‘law’ are three terms that are often confused. Many people mistakenly believe that facts and observations produce hypotheses, which then become theories, which, in turn, produce laws if sufficient evidence is amassed – so a law would be a theory that had been proved true.

Actually, hypotheses, theories and laws are as unalike as apples, oranges and bananas. They can’t grow into each other. Theories and laws are very different types of knowledge. Laws are generalisations, principles, relationships or patterns in nature that have been established by empirical data. Theories are explanations of those generalisations (also corroborated by empirical data).

Accepted theories are the best explanations available so far for how the world works. They have been thoroughly tested, are supported by multiple lines of evidence and have proven useful in generating explanations and opening up new areas for research. However, science is always a work in progress, and even theories change.

For example, Richard Price has proposed a new theory concerning magma chambers beneath andesite volcanoes – pockets of crystal mush rather than a single magma chamber.

Image caption: A new theoretical model for andesite volcanoes

Image acknowledgement: Public domain

**Coming up with new questions/ideas**

Science is an on-going endeavour. Answering one scientific question often leads to deeper and more detailed questions for further research, So in a sense, the more we know, the more we know what we don’t yet know. As our knowledge expands, so too does our awareness of what we don’t yet understand. As long as there are unexplored and unexplained parts of the natural world, science will continue to investigate them.

Image caption: Answering one question often leads to another

Image acknowledgement: 123RF Limited

**Discussion with others**

Associate Professor Rod Dunbar (University of Auckland) discusses science research as a collective rather than a solitary endeavour and looks at the myth of truth in science.

Transcript

DR ROD DUNBAR
Science can’t exist without interactions between people. There are some fields of science where you can be successful with pure thought – Einstein was largely working on his own, based on conversations with other people, obviously – but in general, science these days is intensely social, and particularly in the work that I do, I meet hundreds of people per week and talk to an awful lot of people about scientific endeavours.

And one of the great things about science is that, to understand it, you have to understand the kinds of personalities that are driving the science. I think, again, people think that science is absolutely dispassionate and that we only chase the thing that is true. We know from a lot of philosophical studies that the definition of truth is problematic, and in science, we recognise that many of the things that we say are absolutely true today are not absolutely true tomorrow. In modern science, we don’t tend to talk about whether something is true – we talk about whether something fits a model or gives us the capacity to move forward with a particular therapy.

**Feedback and peer review**

In science, peer review is the process of subjecting scholarly work, research or ideas to the scrutiny of others who are experts in the same field before a paper describing this work is published in a scientific journal. It is this process that helps to make science ‘self-correcting’. Peer review helps to prevent the publication of irrelevant findings, unwarranted claims, unacceptable interpretations and personal views.

Peer-reviewed articles provide a trusted form of scientific communication. Peer-reviewed work isn’t necessarily correct or conclusive, but it does meet the standards of science. Once a piece of scientific research passes through peer review and is published, science must deal with it somehow – perhaps by incorporating it into the established body of scientific knowledge, building on it further, figuring out why it is wrong or trying to replicate its results.

Many fields outside of science also use peer review to ensure quality. Scholarly journals on topics as diverse as law, art and ethics all use peer review to ensure quality. Even those outside the research community often use some form of peer review – figure-skating championships may be judged by former skaters and coaches, wine-makers may help evaluate wine in competitions, artists may help judge art contests – so while peer review is a hallmark of science, it is not unique to science.

Image caption: Jo Kavanagh’s research will be peer-reviewed before publication

Image acknowledgement: BUTO Productions/TVNZ 7

**Benefits and outcomes**

**Address societal issues**

Scientific knowledge can inform issues in society. For example, how we will power New Zealand going into the future when fossil fuels are depleted? Scientists in New Zealand are addressing this pressing issue by researching a range of alternative sustainable power sources – biofuels, geothermal power, ocean waves and wind power.

Another societal issue scientists are addressing is pollution. Air quality in South Island towns is greatly affected by wood burning in the winter, whereas in Auckland and to some degree Wellington, pollution is mainly associated with motor vehicles and a growing volume of traffic. The Healthy Urban Atmosphere project aims to identify the potential hazards to our health from our air quality to find out to what degree we’re exposed to these hazards and then look at how we might design our cities in the future so we don’t have an air-quality problem.

Science doesn’t tell us that we ought to prevent societal issues such as these, but it does provide the research so that we can make decisions that are more informed.

Image caption: Wind power as an alternative fuel source

Image acknowledgement: 123RF Limited

**Inform policy**

Associate Professor Simon Kingham, of the University of Canterbury, is excited to think that his research can influence government policy on environmental issues. He likes to do research that addresses real problems.

Transcript

DR SIMON KINGHAM
The thing that excites me about my work I think is actually… I would say I am an applied geographer. I’m not really into theoretical questions, I’m more into how can we use research to address real problems. So to me, doing research that actually tells… the government can use to formulate environmental policy is fantastic. So if my research can help make New Zealand cleaner, and it can clean up the air in Christchurch, and people can walk around without getting asthma, then that’s fantastic. You know – that is what I want to do.

**Solve everyday problems**

Science has implications for issues we face every day – and while science doesn’t dictate which choice is the right one, it does give us important background knowledge to inform our decisions. It can help us make decisions on questions such as: Will eating organic vegetables make me live longer? Are sunbeds a safe or unsafe way to tan? Will using my cellphone increase my chances of a brain tumour?

Much of the scientific research carried out today is to address specific everyday needs or problems, such as our need for fresh drinking water. At the Māngere Wastewater Treatment Plant in Auckland, they use UVC light to disinfect wastewater. Research has found that the energy in the UV light is able to inactivate the bacteria and viruses that are present in the water. NASA researchers have found ways to turn wastewater from respiration, sweat and urine into drinkable water. Coupled with the right technology, this research could solve this everyday problem of getting safe, drinkable water from the most challenging sources, such as in underdeveloped regions where well water may be heavily contaminated.

Image caption: Solving our everyday problem of the need for clean water

Image acknowledgement: Watercare Services Ltd

**Satisfy curiosity**

Science helps satisfy our natural curiosity – our desire to know why, what and how. Why doesn’t a kiwi fly? How does a bumble-bee fly? What is a solar eclipse? Science can explore all these questions.

Sometimes questions that are explored just out of pure curiosity can become extremely useful. For example, the research Associate Professor Abby Smith did for her PhD 21 years ago, purely out of intellectual curiosity, looked at how bryozoans dissolve in acidic water. This research is now providing valuable information about the potential impacts of ocean acidification. Oceans are becoming more acidic due to increased levels of carbon dioxide in the atmosphere, and these tiny marine animals may help monitor the impact of ocean acidification on the marine ecosystem.

Image caption: Abby Smith researched bryozoans to satisfy her curiosity

Image acknowledgement: Ken-ichi Ueda

**Build knowledge**

Science seeks to build knowledge about the natural world. A hallmark of science is that this knowledge is subject to revision when new information is presented or when existing information is viewed in a new light. This can be most easily seen at the cutting edge of research and in areas like health and medicine where ideas may change as scientists try to figure out which explanations are the most accurate.

Some ideas in science are so well established and reliable and so well supported by many lines of accumulated evidence that they are unlikely to be thrown out, but even these ideas may be modified by new evidence or by the reinterpretation of existing evidence. Science knowledge is durable, but not absolute or fixed.

Classically, science’s main goal has been building knowledge and understanding, regardless of its potential applications, for example, investigating the chemical reactions that an organic compound undergoes in order to learn about its structure. However, increasingly, much scientific research is undertaken with the explicit goal of solving a problem or developing a technology, and along the path to that goal, new knowledge and explanations are constructed. Either way, science aims to increase our understanding of how the natural world works.

Image caption: The timelines show how knowledge has built over time

**Develop technology**

It’s a myth that science and technology are the same. The purpose of science is to understand and explain the natural world, whereas the purpose of technology is to extend people’s abilities to modify that world. Science and technology do inform each other. Scientific knowledge contributes to many different sorts of new technologies, which often allow us to make new observations about the world, which, in turn, allow us to build even more scientific knowledge, which then inspires another technology and so on.

As an example, knowledge about lymph drainage from melanoma sites led researcher Hayley Reynolds to design a 3D computer model to visualise the spread patterns of melanoma. This new technology will enable doctors to predict where a patient’s melanoma is most likely to have spread and then target those areas in treatment. This, in turn, will likely give rise to new scientific knowledge and further research.

Image caption: Using technology to develop a melanoma spread pattern model

Image acknowledgement: Hayley Reynolds

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