Climate Change: prepare today, live well tomorrow

Huringa Āhuarangi

WHAKARERI MAI KIA HAUMARU ĀPŌPŌ

MODULE THREE

How do we know? The role of science and indigenous knowledge system

Introduction

The term 'wicked problem' is used in science, planning and education to describe problems that are extremely complex in nature. Anthropogenic climate change is one such problem. Because there is no one-size-fits-all solution, no quick fix, climate change can be difficult to get your head around, let alone teach or respond to. This resource aims to help teachers/kaiako and their learners to understand the immediacy and complexity of this 'wicked problem'. It offers a range of practical and proactive strategies for responding to the challenges.

A collective and inclusive response is needed to mitigate and adapt to the predicted impacts of climate change. This response asks that we recognise the interconnectedness of all life on earth, as the impacts of climate change will be widely and diversely felt by all living things. Also essential to this response is the ability to communicate, listen to and respect varying perspectives and ideas. We are all in this together and can all be part of the solution.

'Huringa Āhuarangi: whakareri mai kia haumaru āpōpō | Climate Change: prepare today, live well tomorrow' is a science-based, integrated learning programme. It focuses on Earth's systems, the interconnectedness of the living world, and the impacts of anthropogenic climate change.

It encourages learners to interpret, analyse and engage with science, and to understand that science knowledge changes over time.

There is opportunity to consider a mātauranga Māori perspective in the learning programme, particularly around the interconnectedness of life on earth as expressed through the relationship between Papatūānuku and Ranginui. Other indigenous knowledge bases will contribute to a broader understanding of the interconnectedness of life on earth and help to inform possible responses.

The programme builds understanding of climate change through an exploration of critical global, national, and local responses aimed at mitigating and adapting to predicted impacts. It is critical to consider indigenous responses, and – in particular for Aotearoa – to include those of whānau, hapū and iwi.

In exploring the challenges of climate change, ākonga are encouraged to develop and apply key competencies. They are prompted to think beyond themselves, to tautoko | support others, and to connect with the intergenerational community responding to the problem.

Most importantly, the resource supports and empowers all learners to have a voice, to take action, and to play their part in a larger, systematic response.

Teaching and learning modules

The modules can be applied in sequence or independently, depending on learners' existing awareness of climate change. For those who have limited prior learning it is suggested that the programme be followed in its entirety, and in the order suggested in the 'User guide'. This will encourage a sound understanding of climate change science and explore potential responses to the challenges of climate change, whilst also supporting wellbeing.

Climate change wellbeing guide

Teachers/kaiako and ākonga will have different reactions when learning about and responding to climate change, with some experiencing strong emotions. Background information and activities to support wellbeing are included. Look for ☺ to connect to the 'Climate Change Wellbeing Guide', a companion resource to the learning programme.


“Your life matters. But so do all the generations after you. STOP CLIMATE CHANGE!”
EMILY

MODULE THREE

How do we know? Climate change and the role of science and indigenous knowledge systems

Specific learning intentions

Learners will:

- develop an understanding of the role of science and indigenous knowledge systems in understanding climate change and explore how knowledge evolves and informs over time
- investigate the impact that increased heat trapping gases in the atmosphere have on Earth's systems through experimentation (making predictions, observing, recording results and drawing conclusions)
- analyse the nature of individual heat trapping gases, the relationships between each gas and the links to human behaviour.

Success criteria

Learners will be able to:

- relate how science and indigenous knowledge systems help us to understand how and why the climate is changing
- understand how these changes in climate impact upon Earth's systems
- appreciate how science and indigenous knowledge evolves and informs over time
- explore the nature of experimentation through making predictions, observing, recording results and drawing conclusions
- record and sort information and apply through presentation.

Background information for teachers and kaiako

There are many medical, technical and environmental developments that are now considered fundamental to human health, wellbeing, and livelihoods. Many have become so embedded that we take them for granted – phones, transport, painkillers and computers, to name only a few. These developments also have consequences for the protection, restoration and/or enhancement of the natural environment and other living things.

Science and indigenous knowledge is essential to these advances, both in design and implementation. The intimate relationship indigenous people have with their environments for their survival and wellbeing is an important knowledge and understanding to also consider.

For example, if your worldview includes understanding the whakapapa of Ranginui and Papatūānuku, separated by their 'son' Tane, the god of the forest, who in the act of separation let light into forests, you have a completely different awareness and viewpoint to the one held by someone who primarily views trees as a resource. For more information, visit 'Te Whare a Māui – The Māori Innovation Hub' on Callaghan Innovation (2018) website.

Through gathering and interpreting data over many decades, scientists have made careful observations and differentiated between observation and inference. They have gathered wide-ranging evidence to support observations and explanations regarding the causes and effects of a rapidly changing climate. This evidence has been critiqued and interpreted using models, graphs, charts, diagrams and written texts. It all comes to the same conclusion – namely, that the cause of the unprecedented change in Earth's climate is due to anthropogenic/human activity.

Achieving an evidence-based consensus about the cause of climate change empowers us to take action in a real life context. We can use what we know to plan for, mitigate, and adapt to the forecasted impacts of climate change – impacts that will affect all living things, including us.

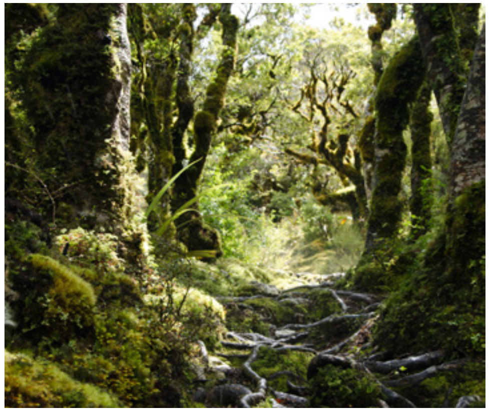
Mātauranga Māori *Pauline Waiti, Ahu Whakamua Ltd (personal communication, 2021)*

Mātauranga Māori informs the understandings and perspectives Māori have of the natural world, a consciousness that is framed in the whakapapa of Ranginui and Papatūānuku. This knowledge is discoverable as ngā kōrero tuku iho and encoded in karakia, mōteatea, waiata, whakatauki, pūrakau, whakairo, tukutuku and so on, and often in the naming of places. Mātauranga Pūtaiao focuses particularly on the natural world, te ao tūroa, and the many taiao (environments) within it. Mātauranga Pūtaiao offers the opportunity for ākonga to consider changes in the environment by understanding the kōrero of our tūpuna and how environments were then, how they are now, and how they could be in the future.

It is timely that scientists are recognising the value of mātauranga Māori as a knowledge base that can inform possible solutions for the future of our planet. Collaboration with hapū and iwi is becoming an important part of environmental science as we all endeavour to make our environment sustainable.

A Mātauranga Pūtaiao perspective of te ao tūroa informs solutions proposed for the future. For example, our tūpuna considered Papatūānuku to be our 'Earth mother', our sustainer of life, and this plays an important part in the actions that impact her wellbeing.

Other indigenous knowledge bases also have similar understandings and perspectives derived from their ancestors' consideration of the world.



Monitor + observe = evidence

Scientists monitor the Earth's climate in various ways. Evidence gathered over many decades shows conclusively that climate change is occurring. For example, there is substantial evidence showing that average temperatures in the atmosphere and oceans have increased over the past 150 years. Scientists have also observed that global levels of carbon dioxide (CO_2) in the atmosphere are now at their highest level for the past 3 million years at least.

The evidence includes:

- changes to the time of year at which lakes and rivers freeze and then melt again
- extended growing seasons of plants
- changes in heat stored in the ocean
- records of historical concentrations of carbon dioxide (CO_2) in the atmosphere derived from gas measurements in deep ice cores
- ice melting worldwide – at the Earth's poles, in Arctic sea ice, mountain glaciers, and in ice sheets covering West Antarctica and Greenland
- global sea levels rising by 3.8 millimetres a year, and an acceleration in the rate at which this rise is occurring (EEA, 2021)
- rising temperatures impacting on wildlife and habitats, (e.g., vanishing ice has seen linked to the decline of populations of Adélie penguins in Antarctica) (Weimerskirch et al., 2018)
- increases in average global precipitation rates (rain and snowfall)
- some regions experiencing more severe drought, increasing the risk of wildfires, lost crops, and drinking water shortages.

Several biological changes have also been observed, e.g., shifts in the ranges of some plant and animal species, earlier timing of spring events such as leaf unfolding, and migration and egg laying for some bird species. Together, these indicators provide clear evidence that the climate is changing.

The Intergovernmental Panel on Climate Change (IPCC), the United Nations Environment Programme's climate body, has said for over a decade that there is "unequivocal" evidence that the planet is warming, and that the temperature increase is "very likely" due to human-made heat trapping gas emissions. The IPCC does not carry out research itself but bases its assessment on peer reviewed and published technical information.

The Panel is made up of representatives from 195 member nations, and accesses scientific expertise from throughout the world. It regularly produces a range of reports, including special reports and guidelines. The major IPCC outputs are Assessment Reports, produced every five to 10 years. Each report has many hundreds of authors and reviewers. For the most recent of these, a total of 234 scientists from 66 countries contributed to this first of three working group reports. The report's authors built on more than 14,000 scientific papers to produce a 3,949 page report, which was then approved by 195 governments. University and Crown Research Institute scientists from Aotearoa New Zealand contribute regularly as authors and reviewers of IPCC reports.

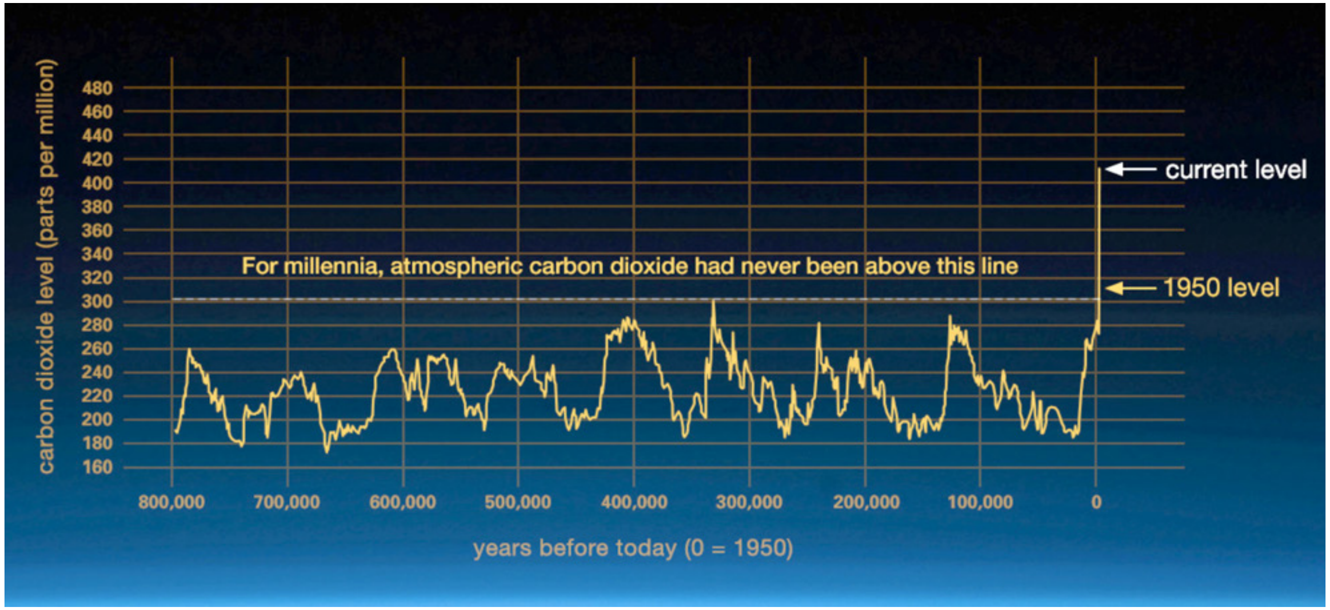


Figure 1: Evidence that atmospheric CO_2 has increased since the Industrial Revolution *(Earth Science Communications Team, n.d.; Global Monitoring Laboratory, 2022).*

Climate change understanding: past and present

Although we tend to think that climate change is only a recently observed phenomenon, scientists have been studying the connections between the energy from the sun, the Earth, and our atmosphere for many years. Nearly two hundred years ago, scientists recognised that something in the atmosphere was acting like an insulating blanket, otherwise the Earth would be much colder than it was. In 1856, Eunice Foote, an American botanist, discovered that the atmosphere 'blanket' comprised carbon dioxide (CO_2) and water (vapour) (H_2O) and that these gasses trapped infrared radiation from the Earth that would otherwise escape from the atmosphere (Huddleston, 2019).

Forty years later, scientists were predicting that changes in atmospheric carbon dioxide (CO_2) levels could substantially alter the Earth's surface temperature through the greenhouse effect. Much of this research was prompted by scientists wanting to understand why the Earth has historically gone through cycles of cooling and warming, resulting in ice ages. However, at that time, scientists were not aware that changes in atmospheric carbon dioxide (CO_2) were already taking place.

It was not until the 1950s, as scientists developed a better understanding of the chemical relationship between oceans and atmosphere, that the impact of carbon dioxide (CO_2) release from fossil fuels on our climate was recognised. At this point, predictions began to be made as to the magnitude of the effect. In 1960, American scientist Charles Keeling was able to show for the first time that concentrations of atmospheric carbon dioxide (CO_2) were actually rising. From then on, the evidence linking human activity to changes in the climate grew rapidly, greatly enabled by the development of computer technology, new analytical techniques, and new ways of thinking about the Earth and its atmosphere as interdependent parts of a system.

However, even in the 1970s scientists weren't in agreement as to the direction or magnitude of climate change, with a minority arguing that the climate might actually be susceptible to cooling. However, scientific evidence of climate warming continued to mount. By the mid-1980s there was a high level of scientific consensus, a trend that has continued through to the present day, in which agreement is very close to unanimous.

Heat trapping gas measurements in Aotearoa New Zealand

In Aotearoa New Zealand the Taihora Nukurangi National Institute of Water and Atmospheric Research (NIWA) makes high-precision measurements of the three main heat trapping gases. Carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are measured at the Baring Head Atmospheric Research Station near Te Whanganui-a-Tara Wellington, at Scott Base (Te Tiri o Te Moana Antarctica), and from ships and aircraft in the Te Moana-nui-a-Kiwa Pacific Ocean and Te Moana-tāpokopoko-a-Tāwhaki Southern Ocean.

The institute has measured the background levels of atmospheric carbon dioxide (CO_2) since 1973, methane (CH_4) since 1989, and nitrous oxide (N_2O) since 1997. Most of the data is from clean-air samples collected at Baring Head.

The measurements record a steady rise in heat trapping gas levels over that period. For example, the release of methane (CH_4) into the atmosphere has increased from natural levels of about 250 million tonnes per year to about 600 million tonnes per year in the early 2000s as a result of human activities.

The concentration of carbon dioxide (CO_2) in the atmosphere measured at Baring Head near Te Whanganui-a-Tara Wellington reached 409 parts per million in September 2019. (See indicator: Greenhouse gas concentrations.) This is about 46% higher than the pre-industrial (pre 1720–1800) level of 280 ppm (Hawkins, 2021).

Session one: Science, climate change and oceans

Learning intentions

In this session ākonga will explore the role of science in understanding the causes and effects of climate change, and the importance of the oceans in stabilising the climate. By the end of the session ākonga will be able to describe how temperature and salinity affects water density and offer simple explanations about the ways in which climate change may impact the oceans' chemical and physical properties.

Activity 1a: Video – 'A day in the life of a climate scientist: Annette Bolton, Senior Scientist, Institute of Environmental Science and Research Ltd (ESR)'

The video covers: The role of science in understanding climate change; the causes of climate change; how change is measured (with a specific focus on carbon dioxide (CO_2)). It explains where the heat and carbon dioxide (CO_2) go, explores the importance of the oceans in stabilizing our climate (ocean conveyor, carbon sink, ocean acidification, heat movement, polar ice caps), and asks what the changes mean. Finally, it explores potential future scenarios. Watch the video on Vimeo.

The video also introduces 'Activity 1b: Experiment – 'Temperature, salinity and water density', and includes a discussion about outcomes at the end.

What you need:

- two glasses – one labelled 'freshwater', the other 'saltwater'
- blue food colouring
- two large 'blue' ice cubes, made with fresh (tap) water using a few drops of the blue food colouring
- fresh (tap) water at room temperature
- salt water at room temperature (approximately 7 teaspoons of salt added to 1 litre of tap water)
- a camera or another recording device, such as phone or pen and paper.

Teacher/Kaiako reflection and wellbeing check.

Activity 1b: Experiment – Temperature, salinity and water density

You can find additional support and understanding of key concepts on the Science Learning Hub Pokapū Akoranga Pūtaiao website.

Experiment information for teachers/kaiako

The experiment supports ākonga to investigate the impact of temperature and salinity on water density. Cold water is denser than warm water, so it tends to sink. This is because water expands when it warms up due to heat energy causing molecules to move around more and take up more space. When water cools it contracts, becomes denser and sinks. By the end of the experiment, ākonga should be able to: describe how temperature affects water density; describe how salinity affects water density; offer simple explanations as to how climate change may impact the oceans' chemical and physical properties.

Experiment discussion

- As we set up the activity, what parts are set up the same?
  The glasses, ice cubes and the amount and temperature of the water.
- What part of the activity set-up is different?
  One glass has freshwater, the other has saltwater.
- Why do you think we have changed this one thing (a variable)?
  To demonstrate the impact of temperature and salinity on water density.
- We are using the equipment to model the impacts of temperature and salinity on water density. What do the different parts of the model represent?
  The glasses = bodies of water. The ice = glacier, iceberg or another source of freshwater. Tap water = freshwater body/lake. Saltwater = seawater body/ocean.
- What do you think will happen in each model?
  Answers will vary.
- Were the predictions correct?
  Answers will vary.
- What differences did you observe in each glass?
  Freshwater model: as the ice melted, the cold water (blue dye) sank to the bottom of the glass.
  Saltwater model: as the ice melted, the freshwater (blue dye) floated on top of the saltwater.
  Also, the water level in the glass will increase a little in both glasses when the ice cube is added to the water in the glass.
  This is what happens when grounded ice (ice on land) melts.
- Why did the cold water sink to the bottom of the freshwater glass?
  Cold water is denser than warm water.
- How could you tell the cold water was sinking?
  Darker currents of coloured water moved down through the water.
- Why did the freshwater float on top of the saltwater even though the freshwater was colder?
  Freshwater is less dense than saltwater.
- What difference does freshwater make to the chemistry of the oceans?
  It dilutes the seawater, making it less dense.
- What difference may this make to the Global Ocean Conveyor?
  Dense water sinking below less dense water drives the Global Ocean Conveyor. The flow of warm freshwater onto the ocean surface warms the oceans, melts sea ice and disrupts the sinking of the cold, salty water. This may slow and/or alter the Global Ocean Conveyor.
- Why is climate change a factor in these changes?
  Warmer temperatures lead to melting land ice and changes in rainfall, which add freshwater to the oceans. Sea ice reflects heat back into the atmosphere. Melting sea ice allows the darker ocean water to absorb the heat, warming the seawater. These changes in temperature and salinity affect density, which then affects the Global Ocean Conveyor.

Experiment method

1. Label one glass 'freshwater' and the other 'saltwater' and add equal amounts of water to the appropriate glasses.
2. Place a blue ice cube in each glass.
3. Observe, photograph and discuss what is happening in each glass at regular intervals.

Session two: Maramataka

Pauline Waiti, Ahu Whakamua Ltd (personal communication, 2021)

Learning intentions

Ākonga become familiar with maramataka, to see how they are important for the people who use them, and to gain understanding of the knowledge from which they were developed. By the end of the activity, ākonga have understandings of maramataka as a tool, based on knowledge of the phases of the moon. This means they will be able to name the phases of the moon and link these to the activities of the taiao our tūpuna engaged in for their wellbeing and survival. They will also consider the changes in the taiao that have happened over time due to climate change, that are no longer able to be carried out according to the maramataka.

Before the activity

Kaiako and teachers will need to become familiar with the idea of maramataka and possibly find one that is locally applicable. The Museum of New Zealand Te Papa Tongarewa has developed the resource 'Nights in the Maramataka | the Māori lunar month'. The resource provides information about the nights in the Maramataka, and about the activities associated with each part of the lunar cycle. Visit Museum of New Zealand Te Papa Tongarewa (n.d.) website.

Activity: Exploring maramataka

Ākonga will use the maramataka provided by the teacher or kaiako, or one they are familiar with. Through this, they will become familiar with the Māori names for the nights of the typical lunar calendar they are engaging with and think about how our tūpuna actually recorded their observations of the moon prior to any technological developments.

Ākonga will explore the activities that are associated with each of the nights and discuss why they think these activities are associated with the particular phase of the moon. They will consider if these activities can be carried out today and, if not, why not? They will discuss the meanings of the various terms used in the maramataka. This may lead to a practical experience of observing the phases of the moon or an interactive experience at an observatory or planetarium.

Activity: Video – Mātauranga Māori

Watch Weno Iti and Apanui Skipper describe their views on mātauranga Māori on the Science Learning Hub Pokapū Akoranga Pūtaiao website.

Teacher/Kaiako reflection and wellbeing check.

Session three: Heat trapping gases – up close and personal

Learning intentions

Ākonga become familiar with the nature and properties of heat trapping gases. They investigate how these gasses occur and behave through a process of recording and sorting information and applying through presentation.

Before the activity:

Teacher and kaiako PLD: The useful webinar 'Chemistry made simple – Atoms', by Greta Dromgool (on the Science Learning Hub Pokapū Akoranga Pūtaiao website) supports teachers and kaiako to teach the particle nature of matter – a key concept in the Aotearoa New Zealand science curriculum. Greta breaks down the science, providing useful hands-on strategies for grappling with this notoriously tricky concept. Watch the webinar 'Chemistry made simple – atoms'.

Important concepts to share with ākonga

Heat trapping, greenhouse gases are made up of molecules. To understand what a **molecule** is, ākonga need to understand what is meant, in science, by the terms '**atoms**', '**substance**', and '**matter**'.

Molecule: A molecule is two or more atoms joined (or "bonded") tightly together. The number and types of atoms in a molecule, and the way in which these atoms are arranged, determines what substance they make. A water molecule can be divided into tiny parts called atoms. This produces two hydrogen atoms and one oxygen atom – H_2O. But these atoms alone do not have the properties of water.

Atoms: Atoms are the basic building blocks of matter that make up everyday objects – including the air you breathe, and you!

Substance: Substance is the material, or matter, of which something is made. Substances are physical things that can be seen, touched, or measured. They are made up of one or more elemental parts. Iron, aluminium, water and air are examples of substances.

Matter: Matter is anything that takes up space. Air, water, rocks, and even people are examples of matter. Different types of matter can be described by their mass. The mass of an object is the amount of material that makes up the object. A bowling ball, for example, has more mass than a beach ball.

Activity: Research – Heat trapping gases

Heat trapping gases and their chemical formula: Carbon Dioxide – CO_2, Methane – CH_4, Water Vapour – H_2O, Nitrous oxide – N_2O.

Invite the ākonga to research one of the heat trapping gases, developing a short presentation either to share as a class or as small groups. The presentation could include models, art, slide show, recorded narration, written word in the form of an article, poetry, etc. The presentation should cover the name of their heat trapping gas, including its chemical formula and what it means, and explain how the gas is produced – both naturally, and through anthropogenic/human activity. This can include a diagram of the gas formula.

Ākonga learning support

Following is a list of useful resources and links for the ākonga to safely learn about molecules, atoms, substance, and matter, including heat trapping gases:

'The Molecularium Project': An interactive site designed for ākonga to learn science facts. It enables them to explore at the molecular level, build molecules from atoms, and learn about states of matter. It includes information for teachers and parents. Connect with the activities ('The Molecularium Project' website).

'Greenhouse gases and the Atmosphere': On the Science Learning Hub, ākonga can learn more about their chosen gas via articles and videos. Science Learning Hub website, 'Greenhouse gases and the atmosphere'.

'Climate change: the science' | NIWA: Helping ākonga understand the science of climate change. Visit the NIWA website.

Ducksters – 'Chemistry for kids': Considered as a physical science, 'Chemistry (for Kids)' provides a wealth of information into the study of the properties of matter and how matter interacts with energy. Visit the Ducksters website.

Wellbeing check

Activity 3: Feelings Thermometer. Can we measure our feelings?

Additional resources and activities to support all sessions

'Captured in Ice' by Veronika Meduna, *Connected 2017 Level 3 – Mahi Tahi.* Nancy Bertler is a scientist who studies the ice. She's been examining Antarctic ice cores to discover what Earth's climate was like in the past – and how it might change in the future. Read the article 'Captured in Ice'.

'Science on the Ice' by Neil Silverwood, *School Journal Level 4 November 2018.* Read the article 'Science on the Ice'.

'You Can Count on It' by Ian Stevens, *Connected 2013 Level 3 – Food for Thought.* Fa'aea's Mum is a meteorologist. She talked to Fa'aea's class about sorting and displaying data in different ways. Read the article 'You Can Count on It'.

'Betty Batham: Biologist' *Connected 2019 Level 3 – Shifting Views.* This biography presented in the form of a comic tells the story of Betty Batham, a pioneering marine biologist. Born in an era when a woman's place in society was largely limited to home and family, Betty rose to become a noted scientist whose legacy in the sciences lives on. Read the article 'Betty Batham: Biologist'.

'Winning Ways: Presenting Scientific Data' by Renata Hopkins, *Connected 2016 Level 4 – Getting the Message.* Grace is on a mission to win the science fair – but to do so she must structure and present her investigation in the most informative and thought-provoking way possible. Grace uses diagrams, photographs, tables, graphs, infographics, and clear science writing to present her data and blow the judges away! Read the article 'Winning Ways: Presenting Scientific Data'.

Teacher/Kaiako reflection and wellbeing check.

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