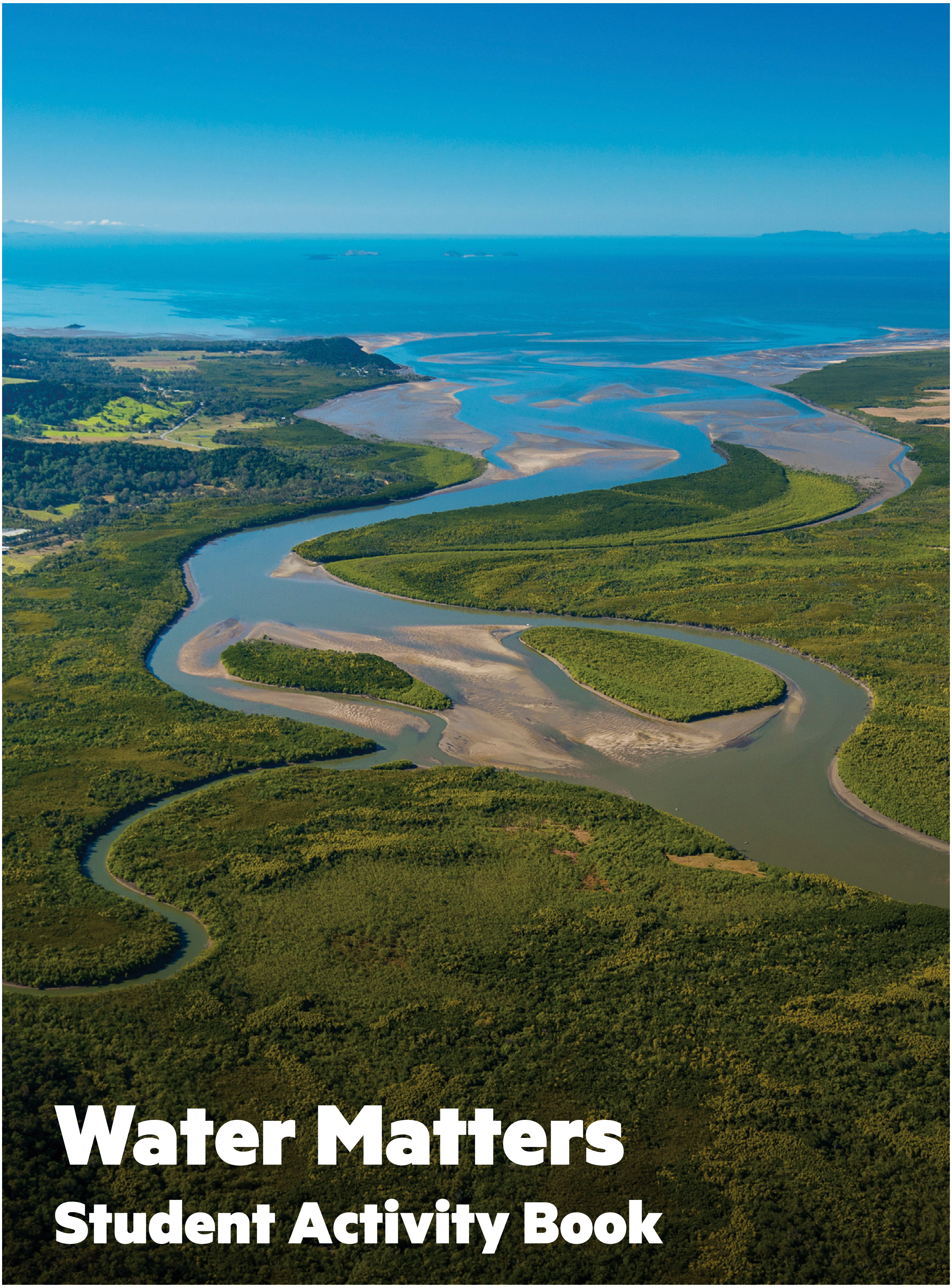

Water Matters

Student Activity Book

QGC | FUTUREMAKERS | QUEENSLAND MUSEUM NETWORK | Queensland Government

Future Makers

Future Makers is an innovative partnership between Queensland Museum Network and Shell's QGC business aiming to increase awareness and understanding of the value of science, technology, engineering and maths (STEM) education and skills in Queensland.

This partnership aims to engage and inspire people with the wonder of science, and increase the participation and performance of students in STEM-related subjects and careers — creating a highly capable workforce for the future.

Cover image: Aerial shot of Proserpine River and surrounding country. QM, Gary Cranitch.

QUEENSLAND MUSEUM NETWORK

Queensland Government

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

This teacher resource is produced by Future Makers, a partnership between Queensland Museum Network and Shell's QGC business, with support from the Australian Research Council and other parties to ARC Linkage Project LP160101374: The University of Queensland, Australian Catholic University Limited and Queensland Department of Education.

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Watson's Tank

Student Activity

Lizard Island

Lizard Island is known as Dyiigurra (Jiigurru) to the Dingaal Aboriginal people, the Traditional Owners of the land. The Dingaal people have lived in this area for tens of thousands of years, and for them, the island is a sacred place with a rich cultural history.

Lizard Island is located 250 km north of Cairns.


Aerial view of Lizard Island (background), Palfrey Island (left) and South Island (right). QM, Gary Cranitch.

The Dingaal people believe that the Lizard group of islands were created in the Dreamtime; the islands form a stingray, with Lizard Island forming the body and the surrounding islands forming the tail.

The Dreamtime is a term coined by English anthropologists. The term refers to the complex network of Aboriginal spiritual beliefs that "permeates all aspects of Aboriginal cultures and societies".[1] This worldview encompasses the past, present and future, and establishes societal structures, rules for social behaviour and rules for interacting with the natural world.[2 3]

Lizard Island is also home to the *manuya*, or sand goanna, whose presence is linked with traditional stories and culture. The presence of the *manuya* on the island makes it a sacred place. Lizard Island was given its Western name when Captain James Cook passed through it on 12 August 1770: "*The only land animals we saw here were lizards, and these seem'd to be pretty plenty, which occasioned my naming the island Lizard Island*".

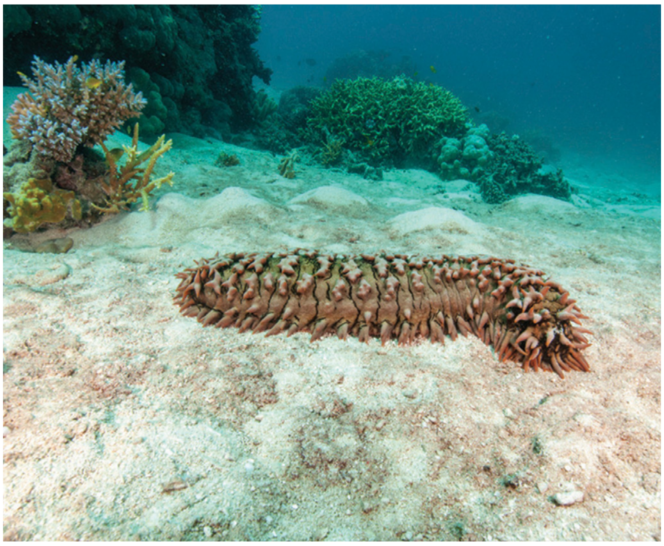
A century later, sea cucumber fishermen began using Lizard Island. Soon after, tragedy struck.

1 Tripcony, P. (2007). Too obvious to see: Explaining the basis of Aboriginal spirituality. Retrieved from https://www.qcaa.qld.edu.au/downloads/approach2/indigenous_read001_0708.pdf
2 University of South Australia. (2013). Respect, relationships, reconciliation. Dreaming. Retrieved from https://rrr.edu.au/glossary/dreaming/
3 Nicholls, C.J. (2014). 'Dreamtime' and 'The Dreaming' – An introduction. Retrieved from https://theconversation.com/dreamtime-and-the-dreaming-an-introduction-20833

Mary Watson

Mary Watson was born in England in 1860. She emigrated with her family to Maryborough, Queensland in 1877. Some time later, Mary moved to Cooktown and subsequently married Captain Robert E. Watson in May 1880. Captain Watson was a sea cucumber fisherman. In June 1880, the couple moved to Lizard Island to set up a fishing station with Captain Watson's business partner, Percy Fuller.

Glass painted portrait of Mary Watson (artist and date unknown). QM, Peter Waddington



The Prickly Redfish (*Thelenota ananas*) is one species of sea cucumber that was harvested during the nineteenth century. QM, Gary Cranitch.

Europeans began to harvest sea cucumbers (otherwise known as trepang or *bêche-de-mer*) in the nineteenth century. Cooktown was the centre of this industry, and was the point from which sea cucumbers were exported to south-east Asia and China. The continuous overfishing of sea cucumbers during this period resulted in the severe depletion of these once plentiful animals, which affected both the ecosystem and the food supply of the Aboriginal and Torres Strait Islander peoples who had been harvesting this resource well before the arrival of European settlers. A further impact of this industry was the abuse of and lack of pay for Aboriginal and Torres Strait Islander workers.[4 5]

On 1 September 1881, Watson and Fuller departed on a fishing trip, leaving Mary, their four month old son, Thomas, and two Chinese workers, Ah Sam and Ah Leung, on the island.

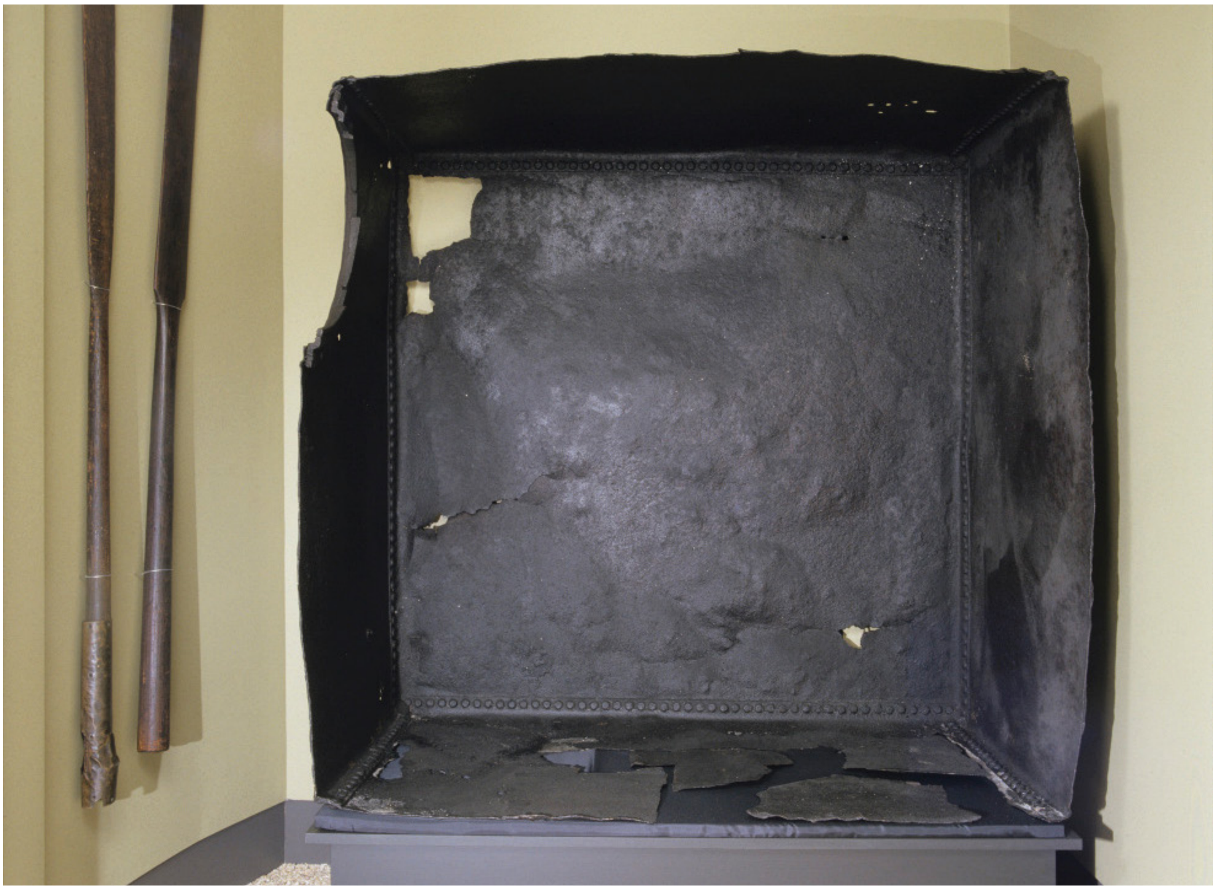
Several weeks later, on 29 September 1881, a group of mainland Aboriginal people of the Guungu Yimmidir group arrived on the island to collect their valued fish oils.

There are different perspectives about what happened next, and why. Conflict broke out between the Guungu Yimmidir people and the settlers. Ah Sam was attacked, and suffered several spear wounds; Ah Leung was killed. Mary shot at the Guungu Yimmidir people.

Most written accounts suggest that Mary Watson accidentally trespassed on ceremonial ground. According to traditional stories, the whole island is a sacred site, which the Watsons, Fuller and their workers should never have been living on.

4 Daley, B. (2014). The Great Barrier Reef: An environmental history. Routledge.
5 Ryle, P. A. (2000). Decline and recovery of a rural coastal town: Cooktown 1873 – 1999 [PhD thesis]. James Cook University.

Following the conflict, Watson, her son and Ah Sam left the island in a cut-down iron tank used to boil sea cucumbers. They took only a few supplies, including some food and water. The date was 2 October 1881.



Cast iron tank and paddles used by Mary Watson to leave Lizard Island. QM, Jeff Wright.

After departing Lizard Island, the group drifted and paddled in and out of reefs and small islands. Watson kept a makeshift diary during this time. She wrote about their journey, their dwindling supplies and their need to find fresh water.

Mary Watson's Diary Entries

4 October 1881: "*Made for the sand bank off the Lizards, but could not reach it. Got on a reef.*"

6 October 1881: "*Able to pull the tank up to an island with three small mountains on it. Ah Sam went ashore to try to get water as ours was done.*"

7 October 1881: "*Made for another island four or five miles from the one spoken of yesterday. Ashore, but could not find any water. Cooked some rice and clam-fish.*"

The group stayed on this island, No 5 Howick Island, awaiting rescue or rain. Unfortunately neither came in time; all three died of thirst between 11 and 12 October.

This was not the only incident of its kind to occur at this time. Reports around the time of Watson and Ah Sam's deaths indicate that the conflicts between the fishermen and Aboriginal land owners were part of a larger conflict also happening on other islands in the reef.

1. Use this information to develop a timeline of events.

Date	Event

2. Express how the Guungu Yimmidir people may have felt in their situation, after discovering European people on their land. Consider knowledge, beliefs and practices, and how these may impact perspectives and points of view.

3. Express how Mary Watson may have felt in her situation, after moving to Lizard Island and experiencing conflict with the Guungu Yimmidir people. Consider knowledge, beliefs and practices, and how these may impact perspectives and points of view.

What Floats Your Boat?

Student Activity

Cast iron is used to make a wide variety of objects. You may like to conduct an internet image search for 'cast iron uses' to take a look at the types of objects that are made with this material.

Based on your observations:

- What physical properties would you associate with cast iron?
- Do you have anything made of cast iron in your home or school?
- Would you expect this material to float on water?

Following conflict with Aboriginal land owners, Mary Watson used a cast iron ship tank to leave Lizard Island with her infant son and a Chinese worker. They travelled over 64 km in the tank, between the reefs and islands of the Great Barrier Reef.

Glass painted portrait of Mary Watson (artist and date unknown). QM, Peter Waddington.

Cast iron tank and paddles used by Mary Watson to leave Lizard Island. QM, Jeff Wright.

How was a cast iron tank able to float with two adults, a baby and a handful of supplies?
How many additional people would have been able to sit in the tank before it began to sink?
You will investigate the answers to these questions below.

Density

What determines whether an object will float or sink in a liquid? Density!

Density is a physical property of matter, and is a measure of the amount of matter in a given space. The density of an object depends on:

- The number and mass of atoms or molecules that make up the object; and,
- How closely the atoms or molecules are 'packed' within the object.

Density is calculated using the equation:

$$\textbf{Density (g/cm}^3\textbf{)} = \frac{\textbf{Mass (g)}}{\textbf{Volume (cm}^3\textbf{)}}$$

If an object is less dense than the liquid it is placed in, then it will float, e.g. a volleyball on the water. If an object is denser than the liquid it is placed in, then it will sink, e.g. a sandstone rock in the water.

1. Determine the density of salt water. Explain how you came to this result and record any working out below. (Hint: You can use the density equation above.)

2. Calculate the density of the following. Determine whether each will float or sink in salt water, and explain why this is the case (recall how the size, mass and arrangement of atoms or molecules within an object affects its density).

   a. Mary Watson's Tank
      Use the dimensions provided by Queensland Museum and assume a thickness of 5 mm.
      Use a metal calculator, such as https://www.onealsteel.com/resources/metal-calculator/, to determine the approximate mass of the tank.

b. Mary Watson's tank with two adults, a baby and a handful of supplies.

You may assume the following:

In 1880, the average mass of a woman:	*55 kg*[6]
In 1880, the average mass of a man:	*75 kg*[6]
Average mass of a four-month-old baby:	*6.7 kg*[7]
Mass of supplies:	*5 kg*

c. Mary Watson's tank with the entire sea cucumber camp population, if all were on the island and had survived the conflict. This includes: Mary Watson, Robert Watson, Thomas Watson, Percy Fuller, Ah Leong and Ah Sam.

d. Determine how many additional people would have been able to sit in Mary Watson's tank before it started to sink.

6 Hathaway, M. (1959). Trends in heights and weights. Retrieved from https://naldc.nal.usda.gov/download/IND43861419/PDF
7 WHO. (n.d.). Boys percentiles. Weight-for-age: Birth to 5 years. Retrieved from https://www.who.int/tools/child-growth-standards/standards/weight-for-age

Buoyancy

When an object is placed in a liquid, it displaces (pushes away) some of the liquid. The displaced liquid pushes up on the object. This upward force is called buoyancy.

If the object is equal to or lighter than the amount of liquid it has displaced, it will float. However, if the object is heavier than the amount of liquid it has displaced, it will sink. This is because the liquid is not capable of exerting enough force to keep the object afloat. The buoyancy of an object will also change in liquids of different densities.

3. Draw force diagrams to represent the buoyancy of the tank in each of the previous situations. Use your understanding of forces to explain what is happening in each situation.
   a. Mary Watson's Tank

Force Diagram	**Explanation**

   b. Mary Watson's tank with two adults, a baby and a handful of supplies.

Force Diagram	**Explanation**

c. Mary Watson's tank with the entire sea cucumber camp population.

Force Diagram	Explanation

d. Mary Watson's tank sinking.

Force Diagram	Explanation

4. Imagine an ocean of vegetable oil, honey, detergent or milk! How would you expect the buoyancy of the tank to change in liquids of different densities?

Rust Away

Student Activity

Take a look at Mary Watson's tank.

QM, Jeff Wright

What do you notice about the condition of the tank?

Do you think the tank was in this condition when Mary Watson set off from Lizard Island? Why?

What could have caused these changes?

Seawater contains many dissolved solutes; the main (and most noticeable!) one is sodium chloride, or salt. On average, most seawater has about 35 g of salt in every 1000 g of water. However, the salt content (salinity) of the ocean can vary between places around the globe - especially at the surface of the ocean.

Seawater affects materials in different ways. You will now design an experiment to investigate how the amount of salt in water can affect the rate of rusting (corrosion).

Aim

To investigate the effect of salt concentration on rusting.

Hypothesis

How will salt concentration affect rusting? Write a prediction, giving reasons for your answer.

Variables

Record the variables in the table below.

Independent variable	Dependent variable	Control variable

Materials

List all of the equipment you will use in the experiment. Remember to include numbers and amounts.

Method

List the steps you will take to conduct your experiment.

Risk Assessment

What safety considerations must be made before, during and after this experiment? Identify at least five hazards and how to minimise them.

Hazard	How to minimise hazard

Results

1. Record your observations in a table (you may wish to use Excel for the table and graph).
2. Present your results in a graph.
3. Describe the results in words.

Discussion

1. Explain the results and observations. Do the results support your hypothesis?

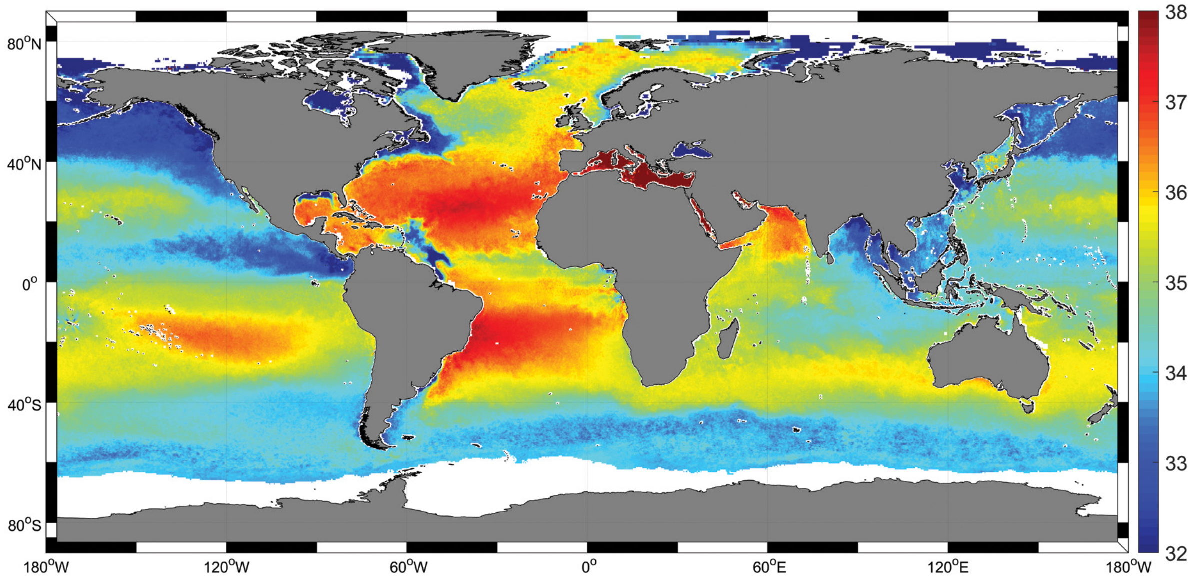
2. Describe which materials in the experiment are elements, compounds and mixtures (include chemical formulas where possible). In the mixture, what is the solution, solute and solvent? **(Year 8)**

3. Draw a labelled diagram of the experiment, showing the materials before and after.

4. Justify the type of change (physical or chemical) that has occurred within this experiment, and whether it is reversible or irreversible.

5. The salt content (salinity) of the ocean can vary between places around the globe. Salinity levels are affected by evaporation, rainfall, thawing ice and the flow of rivers. Explain how these processes affect the salt concentration of the ocean.

6. Observations collected from three satellites (SMOS, SMAP and Aquarius) were used to develop a map of sea surface salinity.



Global sea surface salinity, measured in grams of salt per 1000 mL of water. European Space Agency Climate Change Initiative.

Compare the salinity levels of the following locations: the Mediterranean Sea, the coastline of Alaska and the coastline of eastern Australia. Discuss how these conditions would be likely to affect the state of Mary Watson's tank.

7. Describe any challenges you experienced during the investigation.

8. Explain how you could improve the investigation.

Conclusion

Summarise the experiment and results.

Queensland Museum: The Conservation of Rusting Objects

Queensland Museum has a responsibility to collect, research and promote Queensland's natural, cultural and technological heritage. Our collections provide evidence of changes occurring in our natural and cultural environments.

Cultural and historical collections are comprised of objects that are significant to the people of Queensland. These objects are cared for on behalf of all Queenslanders so that they can be enjoyed by future generations. The people who care for these objects are called conservators. They use chemical and physical tests to determine the age and composition of different objects, and use their understanding of materials science and their problem-solving skills to determine how best to stabilise, restore and preserve the objects.

A Chat with Sue Valis, Conservator, Museum of Tropical Queensland

Sue Valis is a Conservator at the Museum of Tropical Queensland. Learn more about conservation, particularly about the preservation of rusting objects below.

Sue Valis working on one of the diving helmets from the Queensland Museum collection.

- **How did you become interested in your field of study?**

  While studying Art and Archaeology for my first degree, I worked with a paintings conservator. This exposed me to the principles of conserving cultural materials and its practice. I loved the combination of working with my hands and at the same time having to think about the science and technology behind the making of the object, as well as the ethical issues guiding the treatment. Conservation is about stabilising objects and acknowledging their history and use, rather than 'restoring' them to look new again. This mental and physical combination of skills made me realise that I wanted to make conservation my career. As I had not studied Chemistry in high school, a prerequisite for a conservation degree, I enrolled in evening classes at the local technical college and then went on to complete the three year Bachelor of Applied Science in Conservation at the University of Canberra.

- **What is your favourite part of your work?**

  Probably my second favourite part is to receive an object requiring treatment and having to look at its background: where it comes from, the way it was made, and assess what kind of life it has had in order to explore which conservation treatment would be most suitable. This always varies, because no two objects are the same or are in the same condition. My favourite part is, of course, completing a successful treatment and knowing that the object is stable and preserved for many years to come.

- **Describe some of the objects you have worked on, and the treatments you used to conserve these objects.**

  During my career, I have conserved a variety of objects ranging from meteorites, a famous dress belonging to a wife of one of the Prime Ministers of Australia, to an 1855 Locomotive. Since working at Queensland Museum, my work has been mainly on artefacts recovered from shipwrecks along the Queensland coastline.

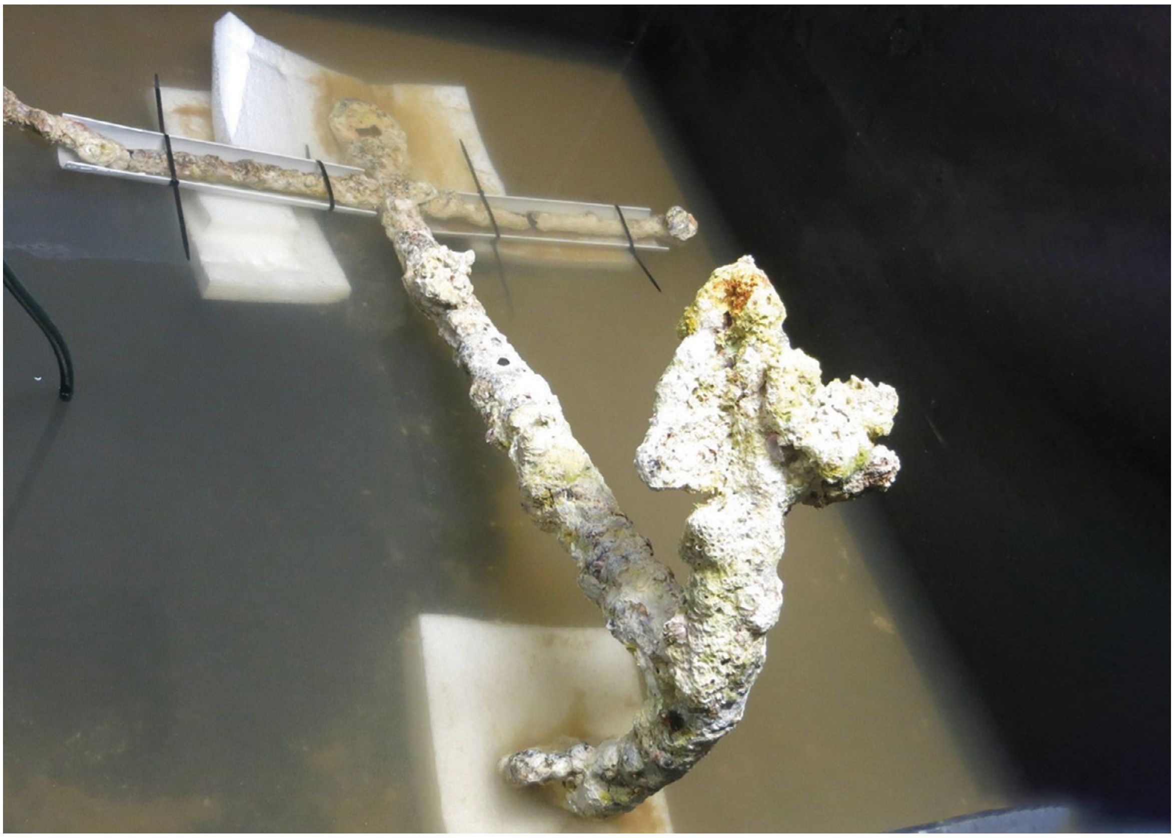
  An example of a treatment on an 'unknown' object was the mass of concretion (a hard, compact mass of mineral matter) from the SS Brinawarr (1918), which was recovered in Mackay's Pioneer River. The mass was deconcreted and the individual items were desalinated and coated with a protective layer of microcrystalline wax to reduce the chance of corrosion. Concretions, such as this one, are usually x-rayed to determine what is hidden inside them.

Before treatment

After treatment

A mass of concretion (left) from the SS Brinawarr and the separate components (right).

Currently I am working on the conservation of a 120 kg iron anchor from the HMCS Mermaid (1829) which was recently recovered from the shipwreck site off the coast of Cairns. The anchor is immersed in a large tub, containing a 2% sodium hydroxide solution, which will draw out the salts from the metal over a long period of time. The solution is tested on a regular basis, and once the salt levels plateau out, it is changed, a new solution is added and the process starts again. All material from the ocean needs to be desalinated prior to being dried; otherwise the dried salt crystals can damage the material and exacerbate corrosion reactions. This process can take years, depending on the size and density of the object.



The tub with the iron anchor from the HMCS Mermaid being refilled with solution during treatment.

- **If we wanted to stop something rusting at home, what is the most important thing to do?**

  Rusting or corrosion occurs in the presence of high humidity and therefore it is important to avoid exposing your objects to moisture. This can be achieved by raising them off the ground to avoid transfer of moisture through the floor or keeping them away from external walls of rooms. Dust can also trap moisture, so maintaining your objects dust-free will also reduce the chance of corrosion.

  Pollution is also attributed to corrosion, although this is not going to be an issue for objects at home. However, some materials emit vapours that have a corrosive effect on certain metals. Avoid placing objects on chipboard, wool or felt fabrics. Lastly, since oils and sweat can enhance corrosion, wash your hands prior to handling your objects or use gloves.

- **What would you recommend for students who would like to work in a similar field?**

  Because conservation is an unusual profession with limited job opportunities, it is extremely important to receive some work experience, before embarking on a degree in conservation. The combination of knowledge and skills required to undertake the work, including the patience needed to carefully approach any treatment does not suit everyone. However, if you are a person with the right qualities, it is an extremely rewarding career.

If you want to learn more about life as a conservator, you can watch Sue Valis talk about her career and how she conserves other objects in Queensland Museum's collection.

You can also learn about how the team at Cobb+Co Museum in Toowoomba conserved a GS (General Service) Wagon used by the British and Australian armies during the First World War. Part of this work involved removing rusted rivets, manufacturing new rivets by hand, and removing and replacing damaged wood.

Thirst Quencher Design Challenge

Student Activity

Mary Watson made landfall on one island after another, but failed to find any fresh drinking water. However, what if it was possible to produce drinking water rather than relying on the possibility of a chance find?

Task:

You are to design a solution that will allow for the reliable production of drinking water on a remote island, using only the surrounding natural materials and supplies brought by Mary Watson.

You must:

- **Investigate** the types and properties of available construction materials and the range of physical separation techniques. Evaluate the viability of using different materials and separation techniques on a remote island. Develop criteria that solutions would need to meet to successfully resolve the problem (success criteria).
- **Design** a solution that will allow for the reliable production of drinking water on a remote island using listed materials and supplies.
- **Create** a prototype of your solution.
- **Test** your solution. How well does your solution produce drinking water? Evaluate your results against the success criteria.
- **Refine** your solution to improve the production of drinking water. Repeat your scientific investigation to determine the impacts of any changes made to your design.
- **Evaluate** your solution continuously against the success criteria, and make changes to improve the design.
- **Collaborate** in teams of two or three. You may also be required to evaluate social interactions to effectively work in a team.

Investigate

You have access to the following materials and supplies:

- Sand
- Rocks
- Vegetation, including the leaves and branches of plants and washed up plant material
- Cotton clothing
- Cotton blanket
- Bonnet
- Umbrella
- Three cans of tinned food
- Saw
- Hammer
- Matches
- Watch
- Book
- Pencil

View from Lizard Island, over the Great Barrier Reef.

1. Investigate the types and properties of materials available for construction. Evaluate the viability of using these materials on a remote island.

Material	Properties	Plus	Minus	Interesting

2. Investigate the physical separation techniques that will allow you to produce drinking water. Evaluate the viability of using these separation techniques on a remote island using only the available materials and supplies. **(Year 7)**

Separation Technique	Plus	Minus	Interesting

3. Develop criteria your designed solution would need to meet to successfully solve the problem (success criteria).

Design

Draw a labelled diagram of your solution. Make sure you identify and justify the materials you will use to create the solution, and justify reasons for design.

Create

Create a prototype of your solution.

Test

Test the effectiveness of your solution. How well does your solution produce drinking water? Record and discuss your results below.

Recording Results

1. Before you start, what safety considerations must be made before, during and after this test? Identify at least five hazards and how you will minimise them.

Hazard	How to minimise hazard

2. Describe the results of this test.

Discussing Results

1. Explain the results of this test.

2. Explain how you obtained the drinking water. What changes occurred, and how did you make these changes occur? You may like to draw a diagram to help communicate your response.

3. Discuss the effectiveness of your solution. Consider any success criteria in your response.

4. Explain how you could refine your solution to increase its effectiveness.

Refine

Modify your solution based on the ideas discussed in the previous question. Retest your solution to determine how these changes affected your solution's ability to reliably produce drinking water. Evaluate the impact of these modifications.

Evaluate

Reflect on your actions with your team or class after you have completed the design challenge. You might like to think about the following questions to assist with your reflection:

- What scientific knowledge helped you make decisions about your solution?
- What aspects of your solution are you very satisfied with and why?
- Describe any further changes you could make to improve the solution.
- What were the main challenges you experienced during the design process? How did you overcome these challenges?
- What have you learnt about separation techniques and the design process from this activity?
- How could you apply this knowledge and understanding to your learning in other contexts?
- What more would we like to know about how to produce drinking water?

Evaporation Innovation: Design Challenge

Student Activity

Task:

A regional council has selected your engineering company to design a solution that will reduce the rate of evaporation currently experienced by their local dam. The regional council is located in a drought prone area, and by engaging your engineering company they hope to conserve the amount of water available for use by the community and local industry. You will present your final solution to representatives from the regional council (your class and teacher).

You must:

- **Investigate** the local context and factors that may influence the rate of evaporation. Develop criteria that solutions would need to meet to successfully address the problem (success criteria).
- **Design** an innovative solution that will reduce the rate of evaporation experienced by the dam. During the design process, you should consider:
    - o Success criteria
    - o Materials, systems, components, tools and equipment, including their characteristics, properties and cost
    - o The impacts your solution will have in relation to sustainability and the environment
- **Create** a prototype of your designed solution.
- **Test** your designed solution by conducting a scientific investigation. How well does your design reduce evaporation? Evaluate your results against the success criteria.
- **Refine** your designed solution to further reduce the rate of evaporation. Repeat your scientific investigation to determine the impacts of any changes made to your design.
- **Evaluate** your designed solution continuously against the success criteria, and make changes to improve the design.
- **Collaborate** in teams of two or three and pitch your final designed solution to the regional council. You may also be required to evaluate social interactions to effectively work in a team.

Investigate

The regional council (your teacher) has supplied the following information about the local dam.

Dam name	
Surface area (m^2)	
Depth (m)	
Evaporation rate (mm/year)	
Residential water use (per person, per day)	

Use this information to calculate when the dam will run out of water, if the dam is currently at capacity and there is no rainfall from this day forward. Remember to include your working out, as this will help to explain your thinking and support your conclusion.

Keep in mind: Your designed solution should increase this amount of time by decreasing the rate of evaporation experienced by the dam.

What other factors may influence the rate of evaporation experienced by the local dam? Identify these factors and explain how they may increase or decrease the rate of evaporation.

Factor	Effect on rate of evaporation

Develop criteria your designed solution would need to meet to successfully address the problem (success criteria).

Design

Draw a labelled diagram of your designed solution. Make sure you identify and justify the materials you will use to create the solution, and explain and justify reasons for your design.

Create

Create a prototype of your designed solution.

Test

Conduct a scientific investigation to test the effectiveness of your designed solution.

Aim

To investigate how effective the designed solution is in reducing the rate of evaporation.

Materials

List all of the equipment you will use in the experiment. Remember to include numbers and amounts.

Method

List the steps you will take to conduct the experiment.

Risk Assessment

What safety considerations must be made before, during and after this experiment? Identify at least five hazards and how to minimise them.

Hazard	How to minimise hazard

Results

1. Record your results in a table (you may wish to use Excel for the table and graph).
2. Present your results in a graph.
3. Calculate the average rate of evaporation per day for the control test and your designed solution.

Control Test	Designed Solution

4. Use the average rate of evaporation per day for your designed solution to recalculate when the dam will run out of water, if the dam is currently at capacity and there is no rainfall from this day forward.

Discussion

1. Explain the results.

2. Justify the effectiveness of your designed solution in reducing the rate of evaporation. Consider your previous calculations and success criteria in your response.

3. Explain any challenges you experienced when completing this investigation, and how you did or could overcome them.

4. Determine how you could improve the investigation.

5. Discuss how you could refine your designed solution to increase its effectiveness.

Refine

Modify your designed solution based on the ideas discussed in the previous question. Repeat the scientific investigation to determine the impacts of any changes made to your design.

Explain and evaluate the impact of these modifications.

Present your final designed solution to the regional council.

Evaluate

Reflect on your actions with your team or class after you have completed the design challenge. You might like to think about the following questions to assist with your reflection:

- What scientific knowledge helped you make decisions about your designed solution?
- What aspects of your designed solution are you very satisfied with and why?
- Describe any further changes you could make to improve the designed solution.
- What were the main challenges you experienced during the design process? How did you overcome these challenges?
- What have you learnt about evaporation and the design process from this activity?
- How could you apply this knowledge and understanding to your learning in other contexts?
- What more would we like to know about evaporation?

Evaporation Innovation: Innovation Analysis

Student Activity

Innovation Analysis

Research and select an innovation that has been designed to reduce evaporation. Describe the innovation. Include in your description what the innovation is, how it is made and how or where it is likely to be used by people.

Explain how the innovation reduces evaporation.

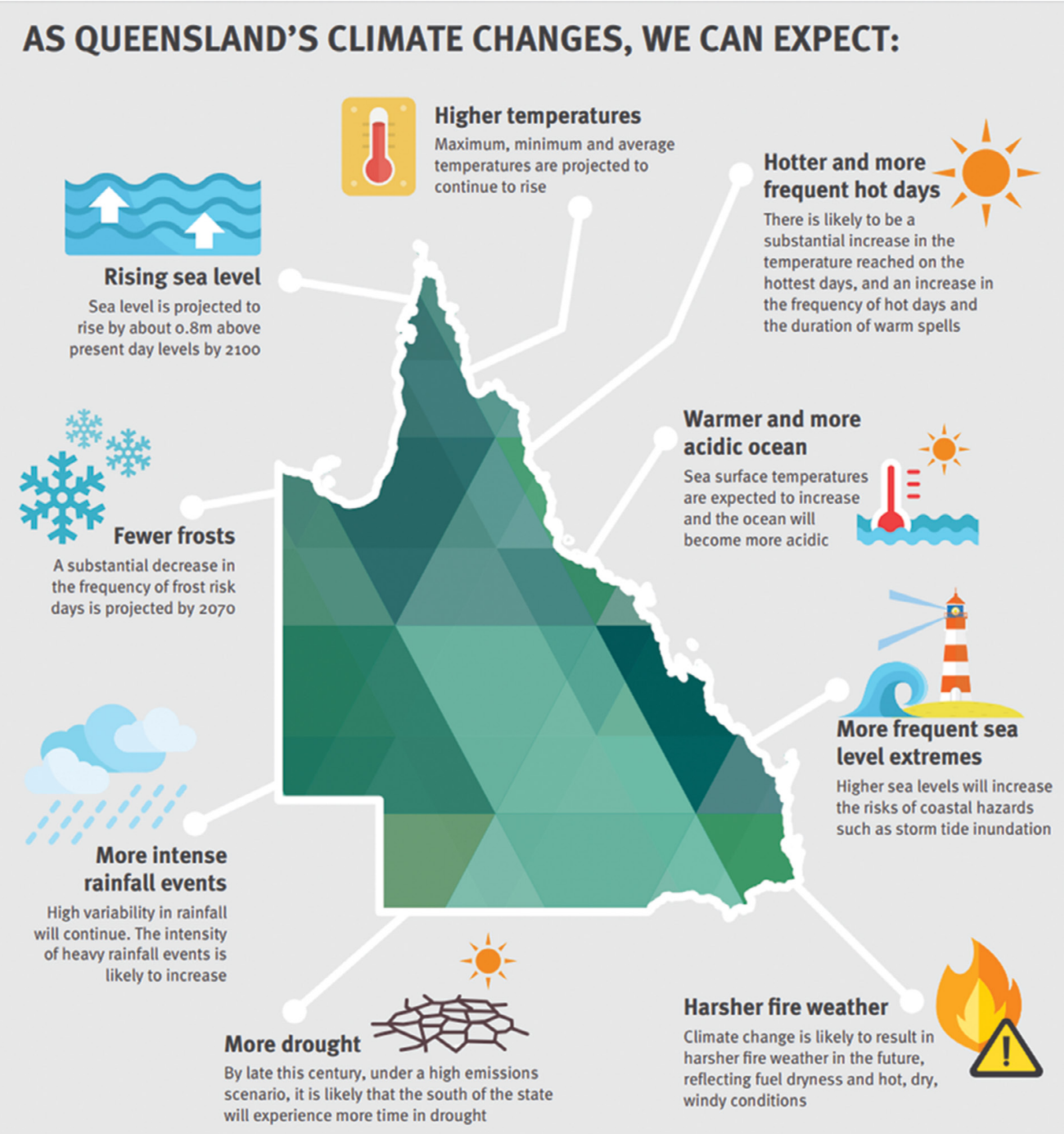
Evaluate the sustainability implications of the innovation. Consider the materials, techniques and technologies used to make the innovation.

Evaluate the impacts of the innovation on society. Consider any ethical impacts, as well as impacts at a local, regional and global scale.

Changing Climates, Changing Waters

Student Activity

One of the biggest environmental challenges to face Queensland (and the world) is climate change. Human societies and natural environments are already experiencing its impacts. Amongst other changes, we are observing higher temperatures, hotter and more frequent hot days, warmer and more acidic oceans, rising sea levels, harsher fire weather and more drought. These changes are expected to continue and intensify in the future if greenhouse gas emissions are not reduced.



How Queensland's environment is predicted to change with climate change. Image: The State of Queensland 2017.

Our changing climate is also affecting how water cycles through the environment, influencing both water quantity (too little and too much) and water quality.

Taking Action: Designing Solutions

You are a climate scientist, specialising in the impact of climate change on the availability of water. The State Government has asked you and two of your colleagues, who are also climate scientists, to provide advice on how climate change will affect the water cycle and how we can best protect our ecosystems and communities from these changes.

In order to respond to the government's request, you must:

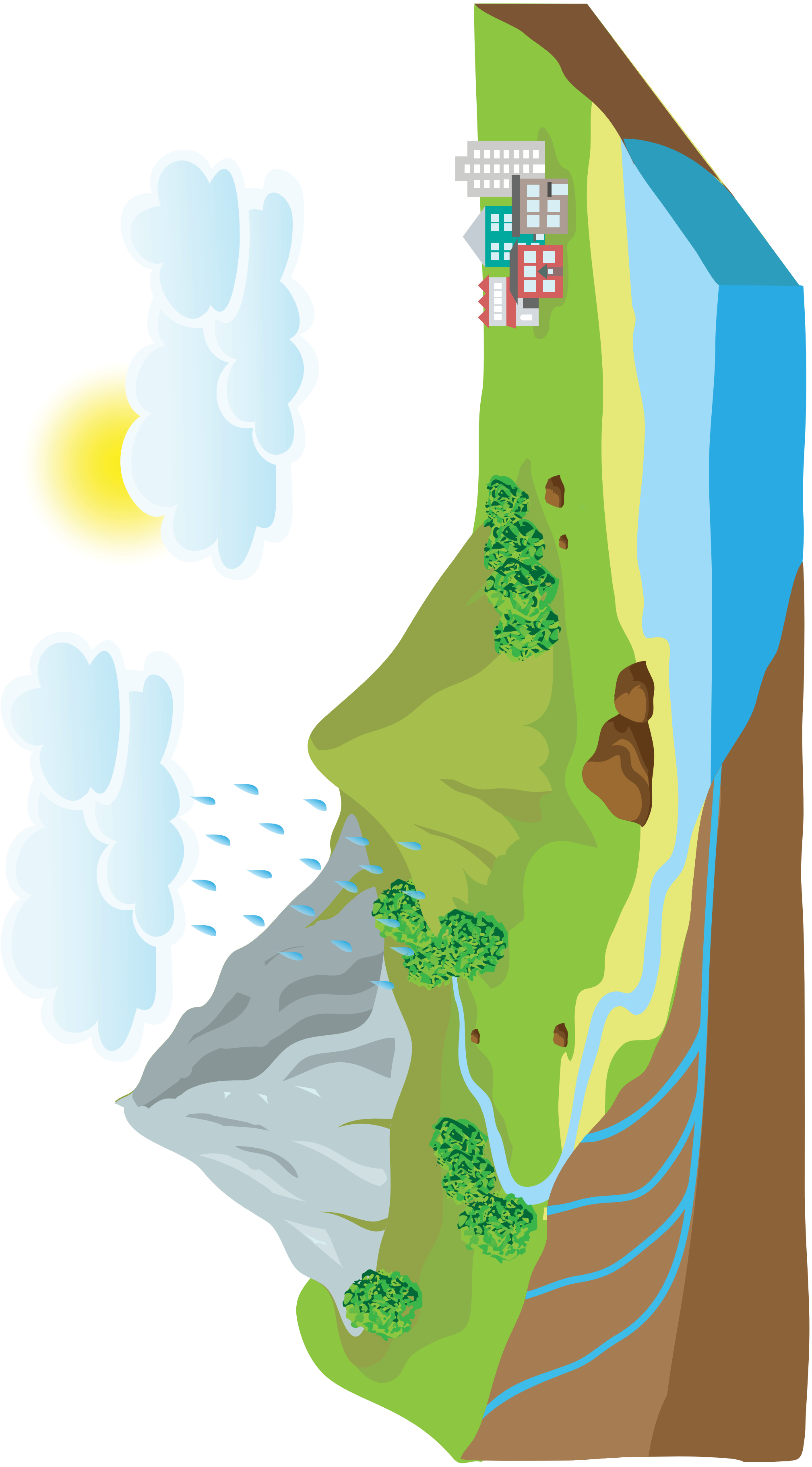
- Determine how climate change will affect the water cycle;
- Identify the likely impacts of these changes; and,
- Develop a designed solution that will minimise the impacts of these changes.

Part A: Climate Change and the Water Cycle

Justify how climate change may affect each stage of the water cycle. Record your thoughts below, and then represent these changes in the diagram on the following page.

Your teacher may ask you to conduct online research to complete this task.

Our Changing Water Cycle



Part B: Impacts

Select one change to investigate further. Justify the impact this change may have on ecosystems, communities and industry, and explain how this change may affect the quantity and quality of water. Your teacher may ask you to conduct online research to complete this task.

<table>
<tr><th colspan="2">Ecosystems</th><th colspan="2">Communities</th><th colspan="2">Industry</th></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="6">Water cycle change:</td></tr>
<tr><td colspan="3">How will this change affect the QUANTITY of water?</td><td colspan="3">How will this change affect the QUALITY of water?</td></tr>
<tr><td colspan="3"></td><td colspan="3"></td></tr>
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Part C: Designed Solutions

Develop a designed solution that will minimise the impacts of this change on ecosystems, communities or industry. You will present your final solution to representatives from the State Government (your class and teacher).

You must:

- Investigate current solutions to improve this problem. Critique two current solutions by conducting a SWOT analysis. To complete the SWOT analysis, you will need to consider:
  - What are the best aspects of the solution? (Strengths)
  - What will not work so well with the solution? (Weaknesses)
  - What might you do differently if you designed the solution? (Opportunities)
  - What potential problems are there with the solution? (Threats)

  Develop criteria that solutions would need to meet in order to successfully improve the problem (success criteria).
- Design an innovative solution that will minimise the impacts of the water cycle change on ecosystems, communities or industry. During the design process, you should consider:
  - Success criteria
  - Materials, systems, components, tools and equipment, including their characteristics and properties
  - Ethical, economic, environmental and/or social sustainability factors and impacts
- Create a prototype of your solution.
- Test your designed solution and evaluate it against the success criteria.
- Refine your designed solution to better solve the problem and meet the success criteria.
- Evaluate the designed solution continuously against the success criteria, and make changes to improve the design.
- Collaborate with your team members, pitch your design and respond to feedback from other teams. You may also be required to evaluate social interactions to effectively work in a team.

Taking Action: Queensland Museum

Museums play a critical role in describing and conserving our natural history, and consequently can provide a unique insight into how climate change is affecting our biodiversity.

Queensland Museum collections and research demonstrate how species respond and adapt to climate change. Our collections provide information about changes in the population and distribution of species over time; the research of our scientists helps us to better understand how species are being affected by and are responding to changing climates.

A Chat with Dr Paul Oliver, Senior Curator of Mammals and Birds, Queensland Museum

Paul is the Senior Curator of Mammals and Birds at Queensland Museum. Learn about how Paul's research demonstrates the effects of changing climates below.

- **How did you become interested in your field of study?**

  The diversity and story of life on Earth simply blows my mind. I am a Systematist and Biogeographer; basically, this means I document the world's biological diversity (by discovering and naming new species), and I try to understand the processes that have shaped this diversity (by exploring why animals live where they do).

Dr Paul Oliver, working in the field.

- **What is your favourite part of your work?**

  Richard Dawkins, a famous British evolutionary biologist, once described evolution and biodiversity as, 'The greatest show on Earth.' And he was right. My job is to document and tell little tiny portions of a story that spans millions of species and billions of years. It is truly a privilege to be able to document completely new species, and then to try and understand the remarkable confluence of environmental and biological processes that have shaped them. Hopefully this information also inspires and informs efforts to conserve biodiversity.

- **Describe some of the projects you are currently working on.**

  I am working on a lot of things, to say the least. In terms of climate change, one of my big foci is trying to use genetic information to understand how species have responded to past climatic changes, especially across the rainforests and open woodlands of eastern Queensland.

Paul has been investigating how the animals and environments of central Queensland have responded to environmental change. Through this research, Paul has discovered that the distribution of the Brigalow Scaly-foot legless gecko (*Paradelma orientalis*) (left) has changed over time in response to climate change and the clearing of vegetation in the Brigalow Belt (right). Images: © Steve K Wilson.

- **Why did you decide to undertake these projects?**

  Climates have cooled and warmed over past glacial cycles. Understanding how animals have been affected by these past changes is potentially really important for predicting the consequences of the rapid climatic change we are currently experiencing.

  It is important here to emphasise that while the climate has changed for other reasons in the past, there is no doubt that the warming of over one degree we have seen over the last century is due to the greenhouse gases we have been pumping out into the atmosphere. Scientists can show a clear link between past climate change and the amount of carbon dioxide in the atmosphere; the source of the increase in carbon dioxide in the atmosphere over the last century is unequivocally people.

- **What have you learnt from these projects?**

  To be honest, the results of this work are deeply concerning. Lots of populations of animals and plants seem to have responded to past climatic change in a very dynamic way, with major expansions and contractions over hundreds or even thousands of kilometres of Queensland. However, the 2 - 3 degrees of warming we are expecting to see in my lifetime will be devastating for both biodiversity and the biological systems that sustain our society. The current climate is heading in a direction that most species have not previously experienced. Many species will simply have nowhere to retreat to as the climate warms; and for some of these species, pathways for dispersal into new habitats have already been decimated by human activities. It is clear that if we continue on current trends, the already high rate of species extinction we are currently experiencing is likely to increase significantly in the coming decades.

- **What actions do you take to reduce your carbon footprint?**

  We live in a society that is based around burning carbon-based fuels. This means we all have opportunities to reduce our carbon footprint. I drive a small car (as little as possible) and pay extra for electricity generated from renewable zero-carbon sources. My family try to buy food that has a lower carbon footprint. When voting, I pay a lot of attention to climate change policies, but also try to look for realistic pathways to transition away from carbon intensive industries. I am also increasingly reluctant to travel overseas or fly generally, and if I do, try and make the most of each trip, rather than having lots of short trips.

- **What would you recommend for students who would like to work in a similar field?**

  Be flexible and adaptable; it is highly unlikely that the pathway I took to get my job will be the same pathway that people take in 10 years' time. It is not even clear that jobs like mine will exist. The rate at which the economy and society is changing is unprecedented, and many of the key opportunities and challenges which are going to emerge over the next few years may not even be apparent now. All I can say is that if you think something is important and you want to do it, you are going to need to present clear arguments as to why it needs to be done, and get creative about seeking support to do it. I would also emphasise that education matters. Having a good education and a broad and considered worldview is critical to effectively addressing many of the key challenges we face.

What actions could you take to reduce your carbon footprint? Record your thoughts and ideas below.

A Chat with Dr Michael Rix, Principal Curator (Arachnology) and Head of Terrestrial Biodiversity, Queensland Museum

- **How did you become interested in your field of study?**

  I first became interested in spiders at the age of 10, when I saw what I thought to be an ant in some bushland near Brisbane. I realised it was *not* an ant when it looked up at me, and then abseiled down to a leaf on a line of silk! What I had found was actually an Ant-Mimicking Jumping Spider and from that moment on I was hooked! I soon discovered that spiders were endlessly fascinating, poorly known and terribly misunderstood, and I decided by about the age of 12 that I wanted to pursue a scientific career in arachnology. I've never looked back since!

Master of deception: an Ant-Mimicking Jumping Spider (genus *Myrmarachne*). Image: Caitlin Henderson.

- **What is your favourite part of your work?**

  As a spider taxonomist (someone who classifies and names new species) and evolutionary biologist (someone who studies the evolution of those species), the part of my work that I love the most is the process of discovery. Discovering species which are new to science never gets old, and in Australia, we have lots of new and amazing invertebrate species needing to be discovered and described. Indeed, some of my career-favourite moments have been those times in the field where I have encountered an especially exciting, rare or important species. But the process of discovery does not end in the field; back in the lab, when we do our scientific work, we can make other exciting discoveries as a result of careful research or astute observation. In the end, discovering new things is what science is all about, and I love it!

- **Describe some of the projects you are currently working on.**

  I have a number of research projects that I am currently working on, most of them related to a real passion of mine – Australia's trapdoor spiders. Australia is home to lots of amazing trapdoor spiders, and remarkably, the vast majority of these are scientifically undescribed; that is, they don't have a proper scientific name and are in most cases completely unstudied.

  Trapdoor spiders are amazing animals in their own right, and are incredibly important predators in our rainforests, eucalypt forests and inland desert ecosystems. Some can even live to over 40 years of age in the wild! Trapdoor spiders are also excellent indicator species for the health of the environment, especially in the face of climate change and environmental degradation.

Michael studying trapdoor spiders in the field. He spends a lot of time looking at the ground! Image: Alan Rix.

My main taxonomic project at present is all about a particular group of trapdoor spiders that live in Queensland's rainforests. These are commonly called Eastern Wishbone Spiders, and belong to the genus *Namea*. Only 15 species are currently described, but the Queensland Museum collection has specimens of many more additional species, and it is my job to name these.

Eastern Wishbone Spiders are really interesting animals. Unlike most trapdoor spiders, they don't build a little door at the entrance to their underground burrows and they are almost entirely restricted to rainforests. Because Australia's rainforests are themselves now only found in certain special places (usually the tops of mountains), some species of *Namea* have extremely small natural ranges. For these sorts of rare species, their continued survival requires first naming them (so that we know what they are), and then protecting the rainforests in which they live. In this respect, the process of taxonomy (i.e. naming species) has a crucial role to play in our efforts to also conserve biodiversity for future generations.

Unfortunately, rainforest organisms are among the most at risk from environmental changes resulting from climate change, especially those species with extremely small natural distributions and/or very specific habitat preferences. The recent fires during the 'black summer' of 2019/20 were a case in point: vast areas of rainforest burnt during this period, and it is still unclear just how big an impact these fires had on restricted invertebrates such as trapdoor spiders. To address this question, my colleagues and I are currently combining our taxonomic research (to ascertain what the species are, and where they are found), with detailed ecological field surveys (to ascertain where in the environment they can continue to survive, post-fire).

Two species of Eastern Wishbone Spider of the genus *Namea*. These spiders are at home in Queensland's tropical and subtropical rainforests. Images: Michael Rix.

A second project that I am currently working on concerns another group of trapdoor spiders, members of the genus *Aname*, which are more at home in Australia's inland deserts. These spiders also live in open-holed burrows, and like *Namea*, the vast majority of Aname species are still scientifically undescribed. However, our aim in this project is to try and understand how Australia's arid zone has evolved over time by studying the spiders that live there. This is a field known broadly as 'biogeography'.

Two species of *Aname* from inland Australia. These spiders are at home in Australia's driest and hottest environments. Images: Michael Rix.

For our project, we have used genetic information from the spiders to try and understand when and where different groups of species evolved over time, and how these patterns correlate to past climatic changes (e.g. the Australian arid zone only formed relatively recently, in response to successive phases of severe climatic aridification). This information then provides a 'window' into the past.

Indeed, the genes of all species (including ourselves) can tell scientists a lot about the evolutionary process, and museum scientists now use genetic information routinely to help them understand the species they work on. In the case of studying the evolutionary history of species from the arid zone, we learn about how the Australian fauna has adapted to past climatic shifts, which in turn can help us to understand how current climatic changes may drive future biotic change.

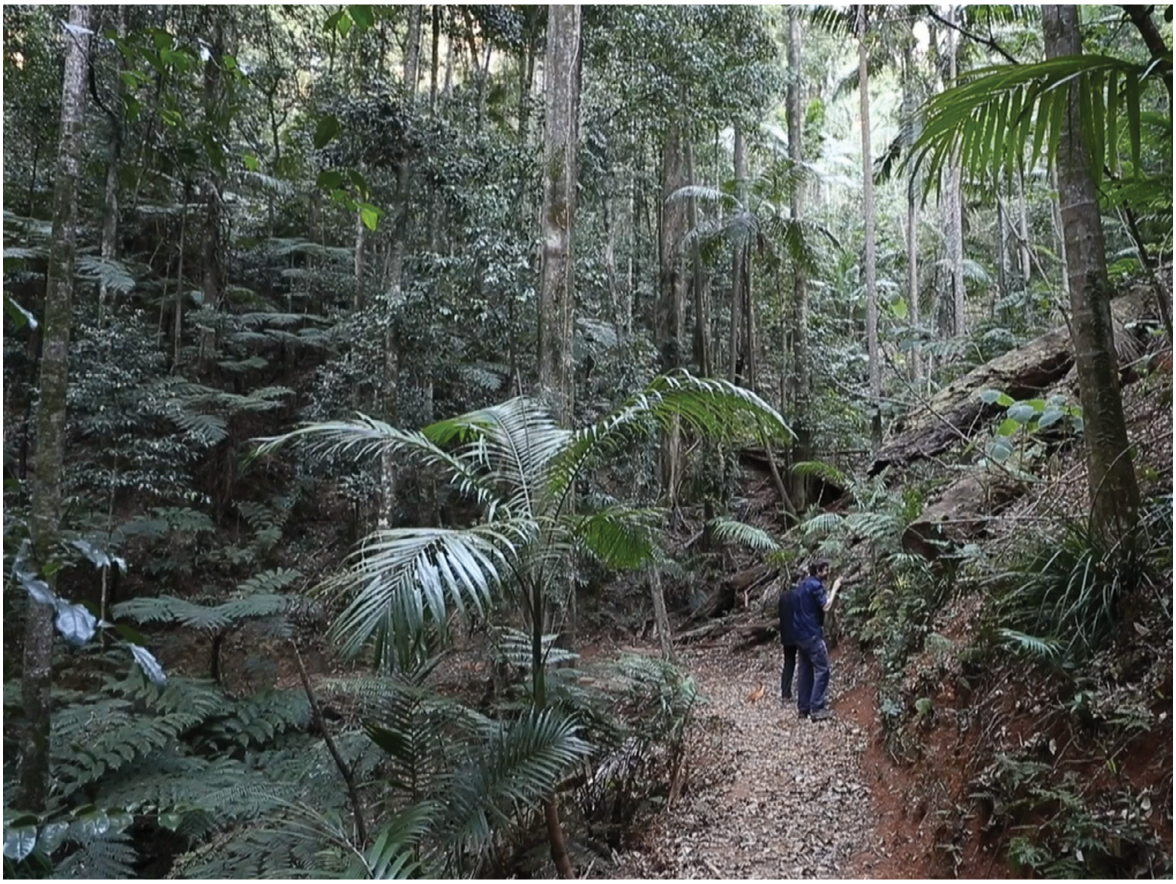
- **Why did you decide to undertake these projects?**

  Biodiversity amazes and inspires me, as planet Earth is still the only place in the universe we know of with organic life. And today we are all surrounded by a myriad of species which have evolved over millions of years. Understanding the origins of that biological diversity, and therefore generating the scientific information we need to conserve it for future generations in the face of unprecedented environmental change, is what drives me to do my research. However, I am also genuinely fascinated by the spiders themselves, and their role in the environment. Australia is home to remarkable spider fauna, and it is a privilege to be able to study them (and hopefully also help preserve them).

- **What have you learnt from these projects?**

  Studying the natural world is endlessly fascinating, and it never ceases to amaze me just how much we still have to learn about biodiversity. Australia itself is one of the most biodiverse countries on Earth, and over the last 10 years we have begun to realise just how remarkably diverse the Australian trapdoor spider fauna really are. Indeed, these projects have now revealed several hundred new and undescribed species in Australia.

For example, in Queensland, we have known for a long time that our rainforests are special places – cradles of biodiversity – and working on Eastern Wishbone Spiders has shown yet again that these rainforest habitats are home to numerous species found nowhere else. The job of discovering and describing these species is not an easy one, but it is essential that we understand what wildlife we are protecting in our national parks and native forests. In essence, if we do not know what lives in the environment, we cannot hope to prevent future extinctions.



Searching for trapdoor spiders in rainforest at Mount Glorious. Image: Peter Wallis.

With our genetic work on *Aname*, we have also discovered that the inland arid zone is far more interesting and diverse than it looks. As the Australian deserts formed over millions of years, trapdoor spiders moved into these habitats, where they then diversified and evolved into the species we see today. Places like the Pilbara and 'Wheatbelt' in Western Australia, and the Eyre Peninsula of South Australia, are home to an amazing diversity of arid-adapted trapdoor spiders, living out their lives in some of the harshest of environments.

However, some trapdoor spiders have a trick up their sleeves… they can burrow, deep underground, thereby avoiding the worst of conditions on the surface. Here they can spend decades, living for long periods with only small amounts of food. In this respect, in the face of severe climatic change, arid zone trapdoor spiders may be more adaptable and better survivors than their rainforest relatives. But we have also discovered that arid zone species are declining due to other factors, e.g. land clearing, grazing and dryland salinity. So, while they are indeed great survivors, they teach us that climate change and environmental destruction caused by humans are two sides of the same coin. For biodiversity to survive long-term, we must protect species, their habitats and Earth's climate system.

- **What actions do you take to reduce your carbon footprint?**

  As a biologist, I see the effects of climate change and environmental degradation all too clearly as part of my own research. In our family, we work hard to reduce our overall carbon footprint as much as possible, by recycling all of our soft plastics (through REDCycle), using a bokashi bin composting system for most of our food waste and growing our own vegetables. We also have solar panels on our roof to reduce our energy consumption, and we recently invested in building a new home which is designed to be as energy efficient as possible. Whenever we can, we also buy local and organic groceries, and I travel to and from the Museum on public transport as much as possible. It's not easy reducing one's carbon footprint, but it is important.

- **What would you recommend for students who would like to work in a similar field?**

  In my view, there has never been a more important time to be a biologist. The threats to our natural world are significant, and we therefore need dedicated, passionate young scientists to help understand and conserve our biodiversity for future generations.

  For students who are interested in a career in the natural sciences, my advice would be – what are you waiting for?! All of us can be students of science in our own right, and the best way to appreciate and learn about biodiversity is to immerse yourself in nature; by getting out into our stunning natural environments, by observing animals and plants up close, by reading amazing natural history books and reference guides, and by seeking out extra information online. This is the best preparation you could wish for prior to formal study.

  For those specifically interested in a career in taxonomy or evolutionary biology, the same rules apply: get out into nature, launch yourself into your studies and never look back. A scientific career can be a hard slog and requires lengthy study (which never really ends), but it is undoubtedly worth it.

What surprised or fascinated you the most about Michael's research? Record your thoughts and ideas below.
