Physics of War

FUTURE MAKERS TEACHER RESOURCE

Queensland Museum, Fred Port Collection

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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.

QUEENSLAND MUSEUM NETWORK Queensland Government THE UNIVERSITY OF QUEENSLAND AUSTRALIA

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Contents

Workshop Overview

Within this workshop, students explore the science behind a number of First World War technologies and innovations. They use physics concepts to investigate how light from a source can be reflected, identify and represent energy transfers and transformations, and explore how electrical energy can be used to communicate coded messages. Students apply scientific concepts and engineering skills and principles to design technologies used during the First World War, including periscopes and telegraph machines, and appreciate the stories and scientific contributions associated with the development of these technologies.

This workshop has been structured using the 5E's instructional model.

The following topics and concepts are explored in each aspect of the workshop:

ENGAGE	Use visual literacy skills to explore the conditions of trench warfare.
ENGAGE	Participate in a community of inquiry to consider the ethical implications of scientific knowledge.
EXPLORE **EXPLAIN** **ELABORATE** **EVALUATE**	Apply understandings of the physical sciences to design, build and test a periscope.
EXPLORE **EXPLAIN** **ELABORATE**	Investigate the energy transformations found in the First World War tank, Mephisto.
EXPLORE **EXPLAIN** **ELABORATE** **EVALUATE**	Evaluate the communication technologies used during the war. Apply understandings of the physical sciences to construct a telegraph machine. Develop and use a cipher to send a coded message.
EVALUATE	Students reflect on why it is important to use scientific knowledge responsibly and ethically. They discuss what it means to be an ethical science user in today's world and how they would recognise ethical science use.

ENGAGE

Conditions of Trench Warfare

Teacher Resource

Australian soldiers fought across Europe, Africa and the Middle East. Many soldiers who served in Europe engaged in trench warfare. Trenches acted as a form of defence, designed to provide protection from gunfire and stop enemy lines from advancing. Life in the trenches was tedious and terrifying, involving mud, cramped unsanitary conditions, restricted access to food and water, disease and pests, as well as the constant threat of shellfire, gas attack or hand to hand combat.

In this activity, students use their visual literacy skills and primary sources to explore and develop an understanding of the conditions of trench warfare. This activity is also designed to set the context for future learning, create interest and stimulate curiosity.

The See-Scan-Analyse strategy has been used to structure this activity. Here, students respond to the following questions:

1. State what you see.

2. Scan the image closely. You may like to use a magnifying glass to complete this task.
   What do you notice that you didn't before?
   What does the image make you wonder?

3. Analyse the image.
   What is happening in the image? Why do you think that?
   Why was this image taken?
   How do you feel about this image?

See below for additional information about each photograph used in this activity.

Photograph 1

Description	In the trenches, one soldier prepares to throw a 'cricket ball' or Malta bomb while the observer checks the target through a periscope.
Location	Gallipoli, Turkey
Date	1915

Photograph 2

Description	An Australian sleeping in his trench shelter in the second line of trenches before Riencourt, during the fighting near Bullecourt. His pack and various tools are laid beside the opening of the shelter.
Location	Somme, France
Date	May 1917

Curriculum Links

General Capabilities

Literacy

Visual knowledge

Critical and Creative Thinking

Inquiring: Identifying, exploring and organising information and ideas

Reflecting on thinking and processes

Intercultural Understanding

Interacting and empathising with others

Courtesy of Australian War Memorial

Queensland Museum, Fred Port Collection

Conditions of Trench Warfare

Student Activity

1. State what you see.

2. Scan the image closely.
   You may like to use a magnifying glass to complete this task.

   What do you notice that you didn't before?

   What does the image make you wonder?

3. Analyse the image

What is happening in the image? Why do you think that?

Why was this image taken?

How do you feel about this image?

ENGAGE

Community of Inquiry: First World War Scientific and Technological Advancements and Ethical Considerations

Teacher Resource

In this activity, students participate in a community of inquiry to consider the ethical implications of scientific and technological knowledge within the context of the First World War.

The community of inquiry is a process of discussion where participants pose open-ended questions, listen to the viewpoints of others, and share their own ideas. Disputed or contestable issues and concepts are considered collaboratively within a supportive and respectful classroom environment. It is important that all participants reflect on their thinking.

The following ways of working are used during the community of inquiry process. These should be put up on a wall for all students to refer to throughout the process:

- Listen attentively to others
- Build upon and connect ideas
- Have respect for others, yourself and place
- Disagree reasonably and respectfully
- Many responses and opinions may be considered to be correct

Detailed step-by-step instructions for this activity can be seen below. It is recommended that you use these instructions to guide your students through the activity as a class.

1. Ask students to brainstorm the various ways in which science and technology were used during the First World War. Students may examine the images used in the previous activity to gather some initial ideas. Students may also need to conduct additional research to assist in the completion of this activity. Examples could include:
    - Communication technologies
    - Chemical weapons
    - Artificial nitrates
    - Medical imaging, including X-ray
    - Underwater acoustics

2. Circle any suggestions that exemplify the tensions between the 'use and misuse' of scientific and technological knowledge during the First World War. Explore these suggestions further by completing the following table:

Use of Science/ Technology	Advantages	Disadvantages	Questions

3. Share the following quotes with students. Quote 1 should be supplied to Years 5, 6 and 7 students. Quotes 1 and 2 should be supplied to Year 8 and 9 students. Students should be provided with time to consider, interpret and discuss the quotes with their peers.

Quote 1

"... technological capabilities, while they may in some sense be morally neutral, have a profound moral impact."

Agar, J. [UCL Lunch Hour Lectures]. (2014, July 1). Science and the First World War [Video File]. Retrieved from *https://www.youtube.com/watch?v=oA1hMahtSKQ*

Quote 2

"... in scale and in intensity alike, this war represents the results of the totality of scientific progress – it is the realisation of all that which the accumulated powers with which science has endowed mankind can effect when used for destruction."

Moulton,J.F. (1919). Science and War. The Rede Lecture. Cambridge: Cambridge University Press.

4. Ask students to consider the quotes and any earlier discussions before responding to the following questions. Please note:

- Not all questions should be used in a single community of inquiry activity. Instead, select the questions that best suit your purpose and student group.
- Ensure ways of working are shared and discussed with students prior to engaging in the community of inquiry.
- When answering questions, students should always provide reasons for their responses.

A 'values continuum' can also be used to implement this activity. After sharing the engagement protocols, pose a question to the student group. Provide students with time to silently consider and reflect on the question, before sharing their thoughts with a partner. Following this, invite students to stand along a continuum ranging from strongly agree to strongly disagree. Students then discuss why they decided to stand where they did along the continuum with the group. After listening to the responses of their peers, provide students with an opportunity to change their position along the continuum. Students who do change their position along the continuum should discuss why they decided to make this change.

Community of Inquiry Questions

- How are scientific/technological progress and war connected?
- Can the use of science/technology within the context of war be considered morally neutral? Why/why not?
- What might have occurred if governments restricted the use of new scientific/technological discoveries during the First World War?

  How might this action have affected the war's outcomes?
- Should society aim for scientific/technological progress, regardless of the consequences of its use?
- Before the First World War, scientists were beginning to share their scientific theories/ideas with others around the world. Would a government be acting ethically if they decided to use these theories/ideas in ways that might cause damage or harm? **(Year 5/7)**
- Is science/technology solely responsible for the atrocities of the First World War? **(Year 8/9)**
- Was the use of internationally accumulated scientific/technological knowledge with the intent of destruction during the First World War ethical? **(Year 8/9)**
- Could the use of this accumulated knowledge during the First World War be considered abuse of power if it was used to:
  - o Destroy en masse
  - o Protect a nation and its citizens **(Year 8/9)**
- If scientific/technological progress was achieved as a result of war, is it ethical to use/further develop that knowledge for use after the conclusion of war? **(Year 8/9)**

Future Impacts:

- Consider the scientific/technological advancements made to date. What impact might these advancements have if a third world war were to happen?
- Has this changed your prior thinking about the connections between scientific/technological progress and war?
- How might the type of scientific/technological advancement influence the ethics of its use during a war? **(Year 8/9)**

Reflection

- What did you take away from this discussion in terms of the progression of science/technology and related ethical considerations?
- How might you use your thinking and learning from this discussion in the future?
- What further questions do you now have about science/technology?

Curriculum Links

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

ICT Capability

Investigating with ICT

Critical and Creative Thinking

Inquiring: Identifying, exploring and organising information and ideas

Reflecting on thinking and processes

Personal and Social Capability

Social awareness

Ethical Understanding

Understanding ethical concepts and issues

Reasoning in decision making and actions

Intercultural Understanding

Interacting and empathising with others

Community of Inquiry: First World War Scientific and Technological Advancements and Ethical Considerations

Student Activity

Use of Science/ Technology	Advantages	Disadvantages	Questions Arising

Periscope Design Challenge

Teacher Resource

In this activity, students design, build and test a periscope with features that allow for the adjustment of height and mirror angle to see beyond a trench and identify approaching threats. Students apply their understanding of the physical sciences and follow the design-thinking framework to investigate relevant aspects of the design challenge.

Periscopes are instruments that are used to view something that is not in a direct line of sight. The earliest periscopes were used to see over the heads of others at religious festivals. During the First World War periscopes were commonly used by the troops to see around them while remaining behind shelter, thus reducing the risk of being shot. The trench periscope is an example of the simplest type of periscope, comprising of mirrors that allow the observer to see objects at a distance. As the name suggests, ***trench periscopes*** allowed the troops to see over the walls of their trench while remaining safe from snipers. The Queensland Museum holds a trench periscope (registration number H14724) in its collection. This object was owned by First World War veteran John McGuirk.

Building a Periscope

Materials

Students can be provided with a variety of materials to construct the periscope. These could include:

- Packing boxes, empty milk cartons, cardboard tubes etc.
- PVC pipes and joiners etc.
- Mirrors
- Skewers
- Pencils or pieces of wooden dowel
- String or twine
- Rubber bands
- Paper clips
- Scissors
- Masking tape
- Ruler

Please note: Total number of materials required to implement the design challenge will depend on the number of student groups completing the task. You may also wish to provide students with only the necessary materials needed to make a periscope (i.e. cardboard, mirrors, pencils or dowel and tape).

Constructing a Trench Wall

To further engage students in the development of their periscope, you may wish to construct a trench wall within the classroom. In replicating the depth of a trench, students are able to test their periscope according to the conditions experienced by soldiers who were stationed in similar locations. They are also able to develop an understanding of how deep trenches were and the effort it would have taken to dig these holes in the ground.

The trench wall could be constructed from PVC pipes and covered with a hessian-like material. Alternatively, freestanding noticeboards, whiteboards, room dividers or an alternative design could be used to make the wall.

Print a copy of the trench panorama and stick this on a wall or other supporting structure behind the trench wall. The trench panorama depicts a wartime scene from the First World War, including the threats students are required to identify during this activity: a tank (Mephisto), bombs and hidden enemy soldiers. Students should be able to see the panorama when looking over the trench wall with their periscopes.

Implementing the Design Challenge

1. Revisit the image of the soldier sleeping in the trench. Ask the students to close their eyes and read the 'Imagine' scenario out loud to the class.

2. Introduce students to the design challenge:
   Design, build and test a periscope that will let you see beyond the trench and identify approaching threats. The height and mirrors of the periscope must be adjustable.

3. Share or negotiate any specific challenge requirements, restrictions or criteria for success with students. These may include:

   - Size of student groups (two students per group)
   - Student roles
   - Materials to complete the challenge
   - Time limit to complete the challenge
   - Identifying the approaching threats

4. Divide students into their groups, ensuring each student knows their individual role, if assigned.

   Provide students with time to conduct research to gather additional ideas and information that will inform the design of their periscope. Students will use this information to write a design proposal and gain approval from their supervisor (the classroom teacher) before constructing. The proposal should include:

   - Information about the development of the periscope
   - Labelled sketch or digital representation of the periscope
   - Justification for design
   - Materials required to build the periscope

5. Following approval from the supervisor, students create their periscopes. Students may like to play a game of eye spy to test how well the periscope works before moving on to the trench wall.

6. Students test their periscope at the trench wall. They record their observations, including how well they can adjust the height and mirrors of their periscope and what happens when they do. You may like to open up a periscope and demonstrate how light travels through the device, before asking students to draw a ray diagram of this occurrence and to explain how the periscope works.

Students also identify where the approaching threats are on the trench map and their approximate location. Students then write a short message that communicates this information to their supervisors. The message written by students will be used in future activities featured within this resource. The map can be used to further explore mathematical concepts with students, including identifying the:

- Coordinate location of specific landmarks;
- Distance between specific landmarks, including shortest and longest routes; and,
- Area of natural and manmade features.

7. Students refine the design and construction of their periscopes before re-testing. During this time, students should share their observations, challenges experienced and discuss what they should change to address or resolve these problems. Students could share this information with the class group before progressing with the design challenge. Following subsequent testing, students should describe how any changes made to the periscope influenced its performance.

   Extension opportunities exist for students who successfully complete the design challenge within the allocated time. These may include:

   - Modifying the periscope so that it is useful in students' everyday lives.
   - Modifying the periscope so that something behind the user can be observed.
   - Adding more mirrors to the periscope, and observing the effects of these changes.
   - Modifying the periscope so that the top can rotate 180 or 360 degrees, and observing the effects of these changes.

8. Students reflect on and evaluate their final design and experiences:

   - What new knowledge/understandings helped you make decisions about your periscope?
   - Are there any further changes you could make to improve your design?
   - What were the main challenges you experienced during the design process? How did you overcome these?
   - What have you learnt about science/design 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 periscopes?

After completing this activity, you may further investigate the law of reflection with your students. The following hands-on resource, ***Mirror Mirror***, developed by The University of Texas at Austin, McDonald Observatory, provides students with an opportunity to test the law of reflection and explore the relationship between the angle of incidence and the angle of reflection.

Curriculum Links

Science

YEAR 5

Science Understanding

Light from a source forms shadows and can be absorbed, reflected and refracted (ACSSU080)

Science as a Human Endeavour

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE083)

Science Inquiry Skills

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS093)

Design and Technologies

YEAR 5 AND 6

Design and Technologies: Knowledge and Understanding

Investigate characteristics and properties of a range of materials, systems, components, tools and equipment and evaluate the impact of their use (ACTDEK023)

Design and Technologies: Processes and Production Skills

Critique needs or opportunities for designing, and investigate materials, components, tools, equipment and processes to achieve intended designed solutions (ACTDEP024)

Generate, develop and communicate design ideas and processes for audiences using appropriate technical terms and graphical representation techniques (ACTDEP025)

Select appropriate materials, components, tools, equipment and techniques and apply safe procedures to make designed solutions (ACTDEP026)

Negotiate criteria for success that include sustainability to evaluate design ideas, processes and solutions (ACTDEP027)

Mathematics

YEAR 5

Measurement and Geometry

Use a grid reference system to describe locations. Describe routes using landmarks and directional language (ACMMG113)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

Numeracy

Using spatial reasoning

Using measurement

ICT Capability

Investigating with ICT

Creating with ICT

Critical and Creative Thinking

Inquiring: Identifying, exploring and organising information and ideas

Generating ideas, possibilities and actions

Reflecting on thinking and processes

Analysing, synthesising and evaluating reasoning and procedures

Personal and Social Capability

Self-management

Social management

Periscope Design Challenge

Student Activity

Imagine:

You are a soldier asleep in a dugout (a protective hole dug into the side of a trench). As you wake up you hear a mechanical sound in the distance. This sound is different to the whistling shells, incessant artillery and machine gun fire heard throughout the day; it is a rumbling and a crunching that you have never heard before and it sounds dangerous. You need to know what is coming towards you so that you can communicate this information to your supervisors... but how? The trench you are positioned in is between two to three metres high. You do have some equipment to stand on to see over the top of the trench, but do not wish to do so for fear of being shot. There are also many different materials and debris scattered at your feet. You have a thought – perhaps these might help you see over the trench without exposing yourself to the enemy.

Task:

Design, build and test a periscope that will let you see beyond the trench and identify approaching threats. The height and mirrors of the periscope must be adjustable.

You must:

- **Investigate:**
    - o The development of the periscope.
    - o How periscopes were used during the First World War.
- **Design** a periscope that can help you to see beyond the trench and identify approaching threats. The height and mirrors of the periscope must be adjustable.
- **Create** a prototype of your periscope from recyclable materials supplied by your teacher.

- **Test** the prototype's ability to see the approaching threats.
- **Refine** the periscope's design and construction to make it work more effectively.
- **Collaborate** in teams of two. Your teacher may allocate a role to each team member.
- **Evaluate** continuously to design a periscope that meets the brief. You may also be required to evaluate social interactions to effectively work in a team.

Investigate and Design

You must write a proposal to explain the design of the periscope and gain approval from your supervisor (in this case, your teacher) before creating your periscope.

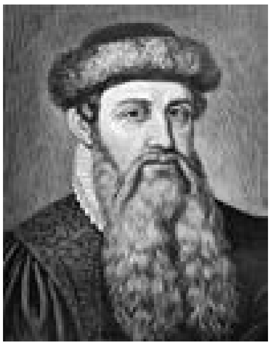
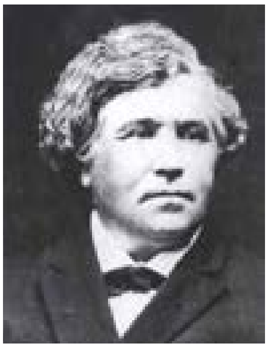
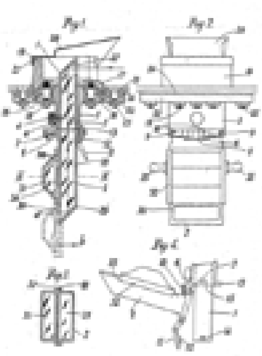
Your proposal should include:

- ☐ Information about the development of the periscope
- ☐ Labelled sketch or digital representation of the periscope
- ☐ Justification for design
- ☐ Materials required to build the periscope

You should also investigate how periscopes were used during the First World War. You can do this by visiting the ***Australian War Memorial*** website and typing 'periscope' into the search bar. Make sure you filter your results by viewing photographs from the First World War. You may choose to base your design on the periscopes viewed during this investigation.

Once your proposed design has been approved, you can create your periscope prototype.

Investigate how the following people contributed to development of the periscope.
Record your findings in the table below.

Name	**Nationality**	**Occupation**	**Contribution** (including year and significance)
Johannes Gutenberg 			
Hippolyte Marié-Davy 			
Rudolf Gundlach 			

Draw a labelled diagram of your periscope. Make sure you identify the materials you will use to make the periscope, and explain and justify its components.

Create

Create your periscope using the materials provided. Record any modifications required as you build the periscope.

Modification	Reason

Test

Make your way over to the trench wall. Move along the trench, using your periscope to see over the top. What do you notice? Record your observations and discuss your results on the following pages.

Refine

Based on your observations, modify the periscope's design to make it work more effectively. Continue to refine and test until the height and mirrors of the periscope can be easily adjusted to identify the approaching threats. You may like to take a photo of the threats seen through your periscope using an electronic device, such as a camera or iPad.

Recording Results

1. Are you able to adjust the height of your periscope? What happens when you do?

2. Describe any changes you will make to improve this aspect of the periscope.

3. Are you able to adjust the periscope's mirrors? What happens when you do?

4. Describe any changes you will make to improve this aspect of the periscope.

5. What can you see when you look through your periscope?

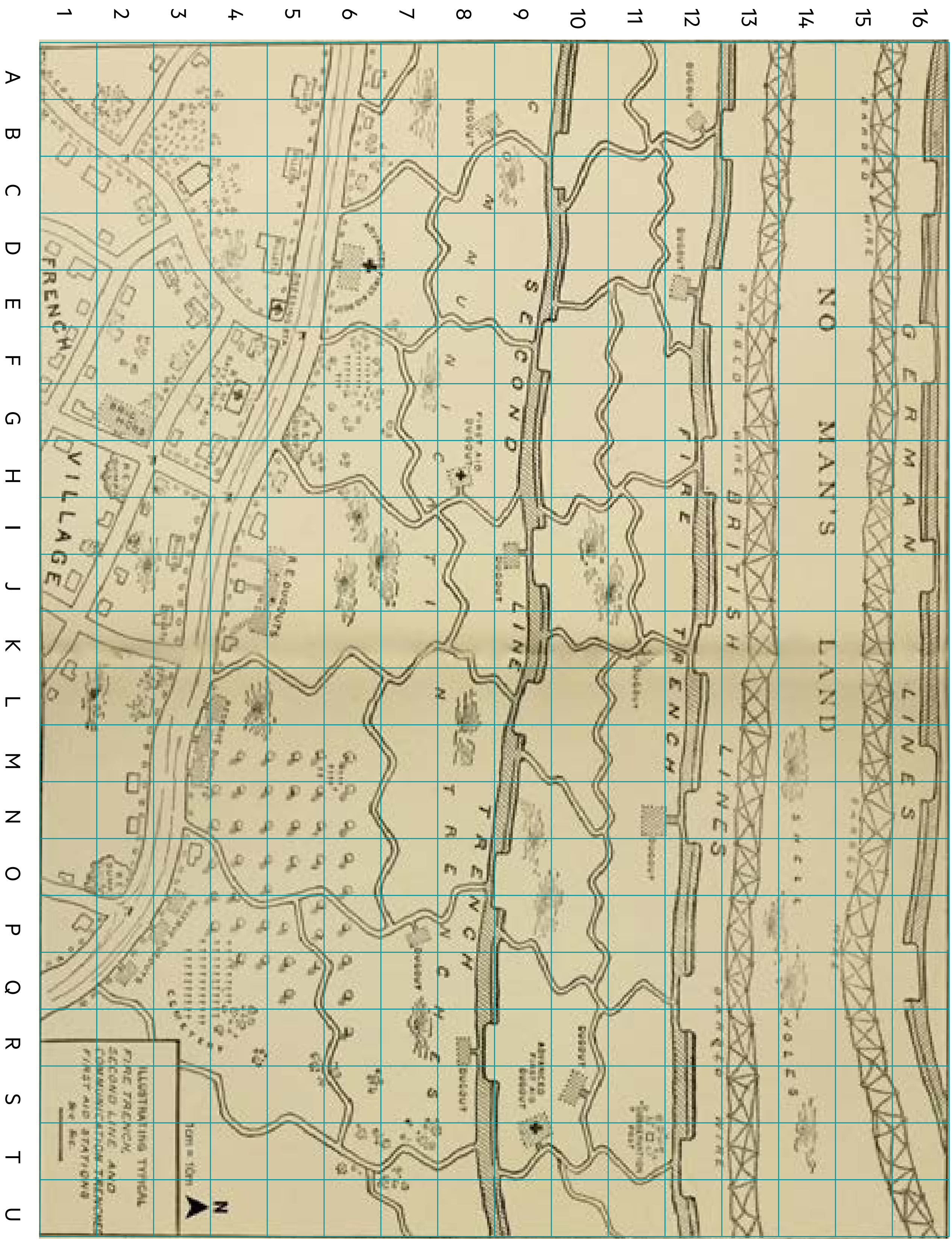
Based on your observations through the periscope and the environment around you, use the trench map on the following page to:

a) Determine where you are on the battlefield and mark this position on the trench map. Justify your reasoning below.

b) Determine the approximate coordinates of the approaching threats. Mark these positions on the trench map.

6. Write a message that communicates your location and information about the approaching threats to your supervisors.

Trench Map



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
A B C D E F G H I J K L M N O P Q R S T U
NO MAN'S LAND
GERMAN LINES
BRITISH LINES
FIRE TRENCH
SECOND LINE
COMMUNICATION TRENCHES
FRENCH VILLAGE
BARBED WIRE
SHELL HOLES
FIRST AID DUGOUT
ADVANCED FIRST AID DUGOUT
DUGOUT
A.E. DUGOUTS
ILLUSTRATING TYPICAL FIRE TRENCH, SECOND LINE AND COMMUNICATION TRENCHES FIRST AID STATIONS &c &c.
N

Discussing Results

1. Draw a ray diagram to show the path light takes as it travels through the periscope. Your teacher may work with your class to open up a periscope and investigate how light travels through the device.

2. Explain how your periscope works. Consider what you already know about light and make sure you include scientific language in your explanation.

3. Describe the outcome of any changes made to the design of the periscope. Were the changes effective? Why?

4. Modify the periscope so that it is useful in your everyday life. Draw a labelled diagram to show these modifications. Make sure to explain how these changes support the new purpose of the periscope.

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 new knowledge/understandings helped you make decisions about your periscope?
- Are there any further changes you could make to improve your design?
- What were the main challenges you experienced during the design process? How did you overcome these?
- What have you learnt about science/design 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 periscopes?

Explore More!

- Modify the periscope so that you can see something behind you.
- What happens if you add more mirrors to the periscope?
  How does this change affect the periscope?
- Modify the periscope so that it can rotate 180 or 360 degrees.
  How does this change affect the periscope?
- Investigate how we use maps for recreation, including geocaching and orienteering. You may like to locate or hide a geocache, or design an orienteering challenge for your class!

EXPLORE – EXPLAIN – ELABORATE

Tanked! Energy Transformations of Mephisto

Teacher Resource

In this activity students investigate the energy transformations found in the First World War tank, Mephisto. This activity requires students to have an understanding of energy types and energy transformations and may be used to assess and extend student knowledge.

Mephisto was one of 20 A7V Sturmpanzerwagen tanks produced by the German Army in late 1917 and is the last surviving tank of its kind in the world.

To deliver important tactical messages to Mephisto, a messenger was required to run up to the tank and tap messages on the door with a hammer. This was an extremely dangerous job due to its proximity to the centre of the battlefield and exposure to enemy fire. This is an important energy transformation that is not seen in the image on the following pages; however, it could be shared with students as an example response to the activity. Today you can still see marks left by these messengers on the door of Mephisto, which is on display at Queensland Museum, South Bank.

Curriculum Links

Science

YEAR 8

Science Understanding

Energy appears in different forms, including movement (kinetic energy), heat and potential energy, and energy transformations and transfers cause change within systems (ACSSU155)

Science Inquiry Skills

Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS148)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

Visual knowledge

Critical and Creative Thinking

Inquiring: Identifying, exploring and organising information and ideas

Tanked! Energy Transformations of Mephisto

Student Activity

Tank Warfare

The First World War represents one of the bloodiest conflicts in the history of humankind. The war witnessed the mechanisation of armed forces across the world. All sides raced to develop new weaponry that would bring some advantage over their opponents, especially in the landlocked stalemates in the trenches of the Western Front. In 1916 the British Army deployed the first tanks at the Battle of the Somme. The allied forces continued to use tanks in larger numbers in 1917. The potential of this new weapon was realised perhaps too late by the German Army.

In late 1917 the German Army produced 20 A7V Sturmpanzerwagens which were deployed in combat the following year. The German tanks fought in locations such as Villers-Bretonneux, a small French village that was recaptured by Australian soldiers at the cost of 1,200 lives. The A7Vs were also involved in the first tank versus tank action.

A7Vs, including Mephisto (pictured below), were crewed by 18 men who worked in uncomfortably hot, cramped and loud conditions amongst the tank's fuel-powered engine and internal artillery. Despite its strong armour and large size, the men inside were thrown around mercilessly during battle as the tank moved over uneven ground and was hit by artillery. Each hit sent particles of hot metal flying off the walls inside the tank into the crew. The crew also had very poor vision from the tank, looking through tiny slits on the front and side of the tank.

A7V Specifications

- Weight: 33.4 tonnes
- Length: 8 m
- Width: 3.2 m
- Height: 3.3 m
- Range: 40 km
- Speed: 16 km/h (with 'tail wind')
- Armour: 10-30 mm
- Crew: 18

Queensland Museum, Fred Port Collection
Mephisto – the German A7V recovered by the 26th Battalion. Mephisto was named after the smiling red demon painted on the front of the tank. After capture, the allied soldiers marked the tank with a crown-wearing British lion, its right paw resting on an A7V tank, as shown in the image above.

Mephisto

The A7V Sturmpanzerwagen known as Mephisto was immobilised in an area close to Villers-Bretonneux called Monument Wood. In July 1918 a detachment of soldiers from the 26th Battalion, mainly comprised of Queenslanders, helped recover the abandoned tank and drag it back to the allied lines. It was sent to Australia as a war trophy, arriving at Norman Wharf in June 1919 where it was towed by two Brisbane City Council steamrollers to Queensland Museum, then located in Fortitude Valley. One of Australia's most significant war trophies, Mephisto is now in its permanent home within the *Anzac Legacy Gallery* at Queensland Museum, South Bank. It remains the sole surviving A7V tank in the world.

© Queensland Museum, Peter Waddington
Mephisto in its permanent home in the Anzac Legacy Gallery *at Queensland Museum, South Bank.*

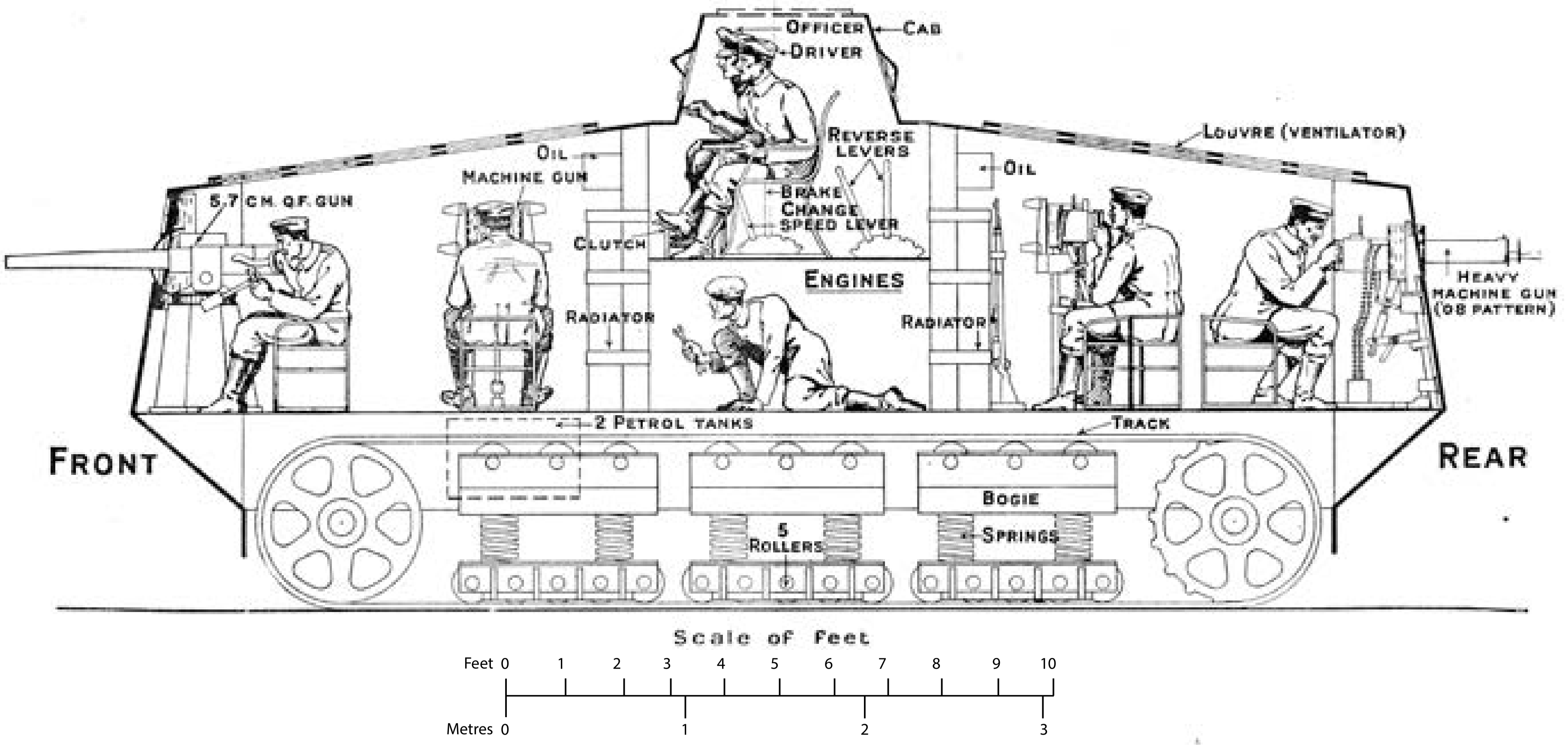
Energy to Work

Tanks were one of the major technological innovations of the First World War. Tanks, like all machines, rely on energy to do work; the transformation and transfer of energy allows the tank to move and cause damage. It is your task to identify the energy and energy transformations in the diagram below.

© Queensland Museum, Gary Cranitch
Damage in the armour of Mephisto. What may have caused this damage?

1. How many types of energy can you identify in the diagram below? Label these on the diagram of Mephisto.
2. Draw a flow diagram to represent each energy transformation that would occur as Mephisto travelled through the battlefield.

Fig. 1.



VIEW OF INTERIOR OF TANK.

Courtesy of The Gregory Czechura Collection

3. What waste energy is produced by Mephisto? Explain the advantages of a more energy efficient tank.

4. Focussing on energy transformation and transfer, how could you stop the tank from advancing and causing damage?

5. What energy transformations occur when projectiles hit the tank?

6. The tank is equipped with heavy artillery, however most soldiers were equipped with rifles or grenades. Use your knowledge of physics to explain why soldiers could not carry heavy artillery.

7. Imagine you are a member of the Mephisto crew. Write a persuasive letter home to either:
   a) Convince your brother or sister that they should NOT join the war effort.
   b) Convince your parents that you are fine and enjoying your time fighting for freedom on the front lines.

EXPLORE – EXPLAIN – ELABORATE – EVALUATE

Communication Technology

The battlefields were dangerous places where the flow of critical information was stalled by frontline conditions. In response, communication during the war evolved dramatically; new inventions were developed while existing technologies were adapted to better suit the context of war.

In the following activities, students identify and evaluate the communication technologies used during the war. They then apply their understanding of the physical sciences to construct a telegraph machine and develop and use a cipher to send a coded message.

Activity 1: First World War Communication Technologies

Teacher Resource

Students identify and evaluate the communication technologies used during the First World War. Detailed step-by-step instructions for this activity can be seen below. It is recommended that you use these instructions to guide your students through the activity as a class.

1. Share the following statement with students:
   Communication can make or break a war.
   Ask students to respond to this statement, and to discuss what they think it means. Students may engage in a Think-Pair-Share to complete this task.
2. Inform students that they will spend time investigating and evaluating the communication technologies used during the First World War. Divide students into groups of two or three and distribute communication technology images to student groups. Provide groups with time to view and read about each communication technology.
3. Students complete a PMI chart for each communication technology (see below). They discuss and/or write down the positive, negative and interesting implications associated with use of the communication technology in the context of war. Students may also consider the ethical implications associated with the use of each communication technology.

Plus	Minus	Interesting

4. Students then evaluate the communication technologies, rating them from most effective to least effective in the context of war. Students should also be able to provide reasons to justify their decisions.
5. Students share their responses with the class group. Compare the responses of all groups. What do students notice? Are their responses very similar or very different? Why might this be the case? How could students make more informed decisions about the effectiveness of each communication technology?

Following this, you may ask students to conduct further research into each communication technology. Students use researched information to reconsider and revise their response to the previous task. Students could also investigate the development and/or invention of these communication technologies, and consider which are still in use today and why this might be the case.

Curriculum Links

Science

YEAR 5

Science as a Human Endeavour

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE083)

YEAR 6

Science as a Human Endeavour

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

YEAR 7

Science as a Human Endeavour

Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures (ACSHE223)

Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE120)

People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE121)

YEAR 8

Science as a Human Endeavour

Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures (ACSHE226)

Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE135)

People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE136)

YEAR 9

Science as a Human Endeavour

Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (ACSHE158)

Design and Technology

YEAR 5 AND 6

Design and Technologies: Knowledge and Understanding

Investigate characteristics and properties of a range of materials, systems, components, tools and equipment and evaluate the impact of their use (ACTDEK023)

Investigate how electrical energy can control movement, sound or light in a designed product or system (ACTDEK020)

Design and Technologies: Processes and Production Skills

Critique needs or opportunities for designing, and investigate materials, components, tools, equipment and processes to achieve intended designed solutions (ACTDEP024)

YEAR 7 AND 8

Design and Technologies: Knowledge and Understanding

Analyse how motion, force and energy are used to manipulate and control electromechanical systems when designing simple, engineered solutions (ACTDEK031)

Analyse ways to produce designed solutions through selecting and combining characteristics and properties of materials, systems, components, tools and equipment (ACTDEK034)

Design and Technologies: Processes and Production Skills

Critique needs or opportunities for designing and investigate, analyse and select from a range of materials, components, tools, equipment and processes to develop design ideas (ACTDEP035)

YEAR 9

Design and Technologies: Knowledge and Understanding

Investigate and make judgments on how the characteristics and properties of materials are combined with force, motion and energy to create engineered solutions (ACTDEK043)

Investigate and make judgments on how the characteristics and properties of materials, systems, components, tools and equipment can be combined to create designed solutions (ACTDEK046)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

Visual knowledge

Critical and Creative Thinking

Inquiring: Identifying, exploring and organising information and ideas

Reflecting on thinking and processes

Personal and Social Capability

Social management

Semaphore Flags

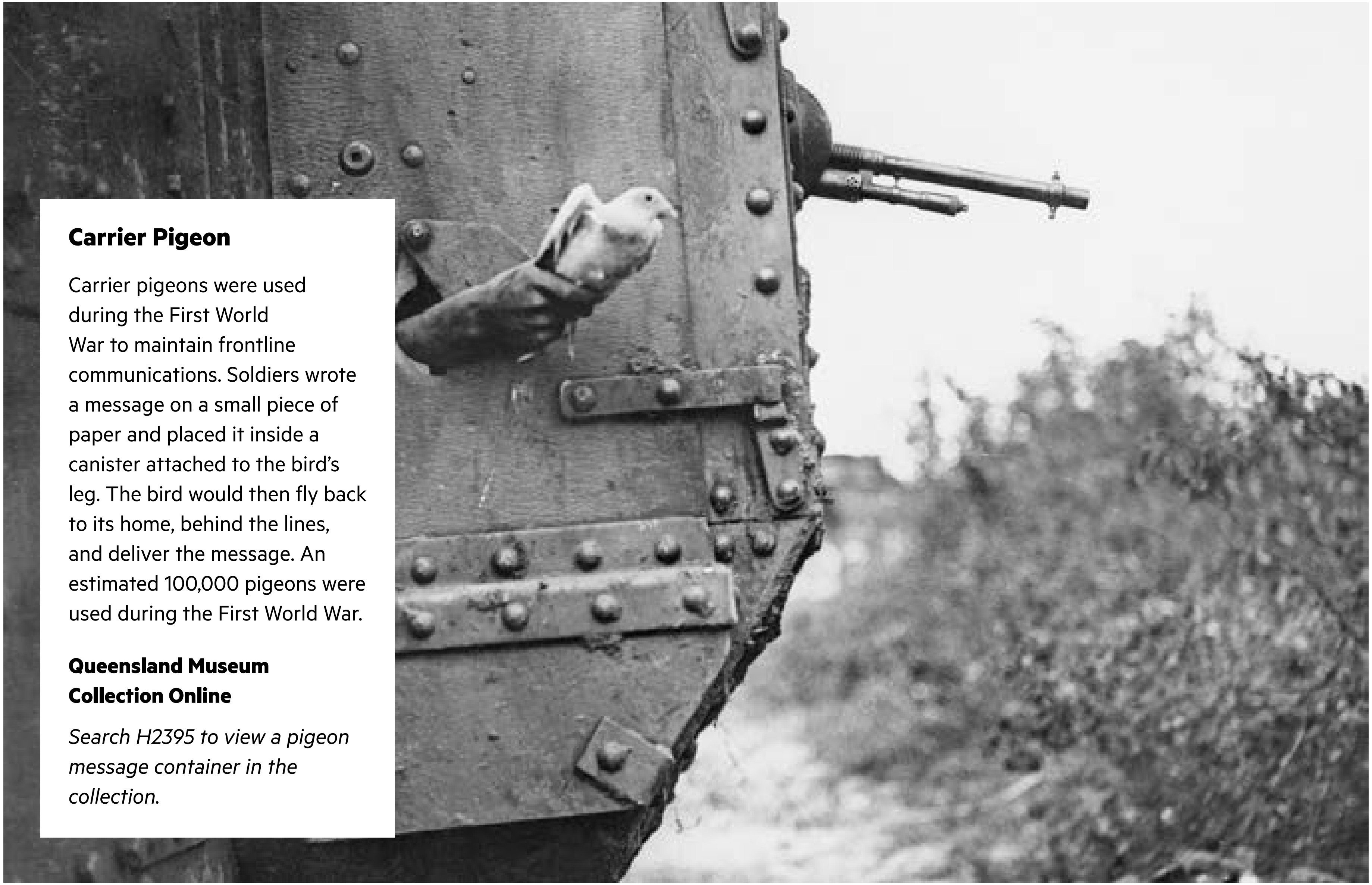
Semaphore flags were used as a daytime signalling system during the First World War.

The signaller held one brightly coloured semaphore flag in each hand and extended their arms to form specific positions or angles. Each position corresponded to a different letter or numeral, allowing the signaller to spell out and receive messages. Experienced signallers could relay twelve words per minute.

Queensland Museum Collection Online

Search H43438 to view a set of cards used to teach semaphore in the collection.

Courtesy of Australian War Memorial



Carrier Pigeon

Carrier pigeons were used during the First World War to maintain frontline communications. Soldiers wrote a message on a small piece of paper and placed it inside a canister attached to the bird's leg. The bird would then fly back to its home, behind the lines, and deliver the message. An estimated 100,000 pigeons were used during the First World War.

Queensland Museum Collection Online

Search H2395 to view a pigeon message container in the collection.

Courtesy of Australian War Memorial

Heliograph

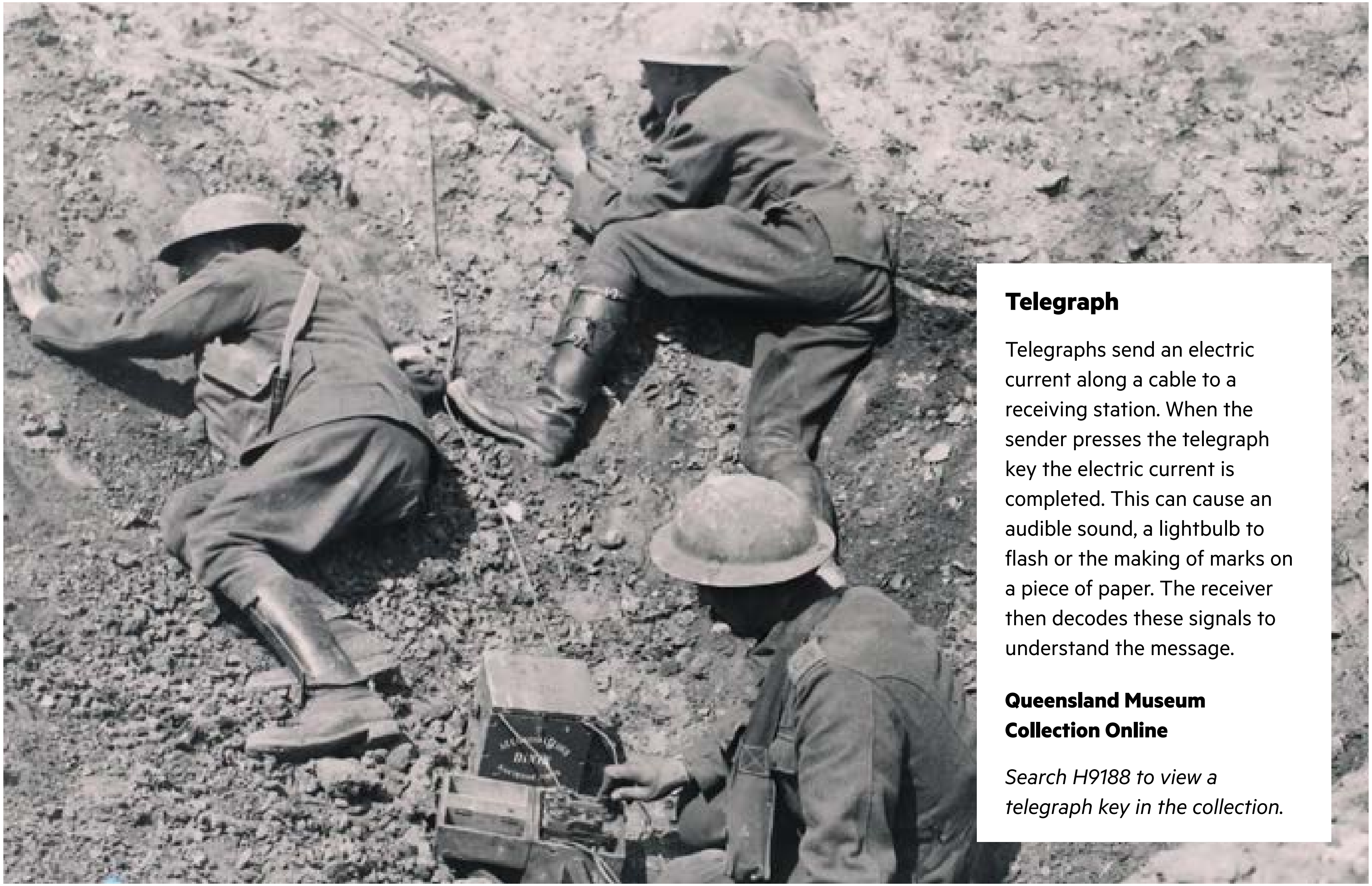
The heliograph used a mirror to reflect sunlight to a distant observer. Flashes of light could be used to send Morse code by covering or moving the mirror away from the sun.

Courtesy of Australian War Memorial

Messenger Dog

Dogs were used to send and receive messages across the front line and between bases throughout the First World War. Messages were carried in a metal tube attached to the dog's collar.

Courtesy of Australian War Memorial



Courtesy of BT Heritage

Telegraph

Telegraphs send an electric current along a cable to a receiving station. When the sender presses the telegraph key the electric current is completed. This can cause an audible sound, a lightbulb to flash or the making of marks on a piece of paper. The receiver then decodes these signals to understand the message.

Queensland Museum Collection Online

Search H9188 to view a telegraph key in the collection.

Courtesy of Australian War Memorial

Telephone

Telephones allowed soldiers to communicate with each other across the battlefield. Telephones convert sound into electrical signals suitable for transmission via cables. These signals are received and the electric signals converted back into sound. Telephones could operate point to point or via a switchboard at a command post.

First World War Communication Technologies

Student Activity

Communication Technology	Positive	Minus	Interesting

Activity 2: Construct a Telegraph Machine

Teacher Resource

"This mode of instantaneous communication must inevitably become an instrument of immense power, to be wielded for good or for evil, as it shall be properly or improperly directed."
Samuel Morse in an 1838 letter to Francis O.J. Smith

The telegraph machine was developed by Samuel Morse and other inventors in the 1830s and 1840s. The telegraph transformed how people communicated for both business and private purposes, providing a reliable and relatively fast method of transmitting information across long distances.

Telegraphs consist of a transmitter and receiver, a power source and wire cable. When the transmitter key is pressed down, the electric circuit between the transmitter, power source and receiver is completed. This produces a pulse of electricity that is sent through the wire cable to the receiver. When it reaches the receiver, the electric current passes through an electromagnet. This creates a magnetic field that causes a piece of metal to be attracted to an underlying metal plate, producing an audible sound. Alternatively, a light or buzzer may be used to create the visual needed to convey the message. Depending on the type of machine in use, the receiver may then send a return message along the same wire to the original sender.

The code used to send messages via a telegraph was developed by Samuel Morse. Morse devised combinations of dots, dashes and spaces to represent letters, numbers and punctuation. The length of the signal determined whether a dot or dash was received. The length of space heard between dots and dashes determined if the following code was part of the same or a different word.

During the war, telegraphs were used to communicate across the trenches and between towns, cities and nations. While telegraphs allowed those involved in the war to receive crucial information about the movement of soldiers and battle outcomes, the wires used to operate the machines were frequently damaged or destroyed as a result of intense artillery fire.

In this activity, students apply their understanding of the physical sciences to construct a telegraph machine. Detailed step-by-step instructions can be seen below. It is recommended that use these instructions to guide your students through the scientific investigation.

1. Focus students' attention on the telegraph image featured within the previous activity. Explore what students already know about telegraph machines, including how these machines work. A KWL Chart could be completed with the class group to record ideas and thoughts shared during this time.

2. Inform students of their next challenge, which is to construct a simple telegraph machine from a circuit diagram. Students should work in groups of two to complete this challenge. Provide students with time to view and interpret the circuit diagram before they begin constructing their telegraph machine. Students may be provided with a variety of materials to construct the telegraph machine. These could include:
   - 9V batteries
   - Thumb tacks
   - Paper clips, various sizes
   - Aluminium foil
   - Bendable non-magnetic metal, such as cut up roasting trays or soft drink cans

     Teacher preparation: The metal that is chosen should be pre-cut to varied lengths and widths. Corners should be rounded to reduce likelihood of injury. You may decide that students can trim metal pieces themselves, in which case students should be supervised by an adult. They should also exercise care and control while completing this task.

   - Balsa wood, 1cm thick

     Teacher preparation: Balsa wood should be pre-cut to varied lengths. Pieces of balsa wood should be at least 10cm long.

   - Box cardboard
   - Insulated wire cables

     Teacher preparation: Wire cable should be pre-cut to varied lengths, with some lengths much longer than others to allow for the development of a telegraph machine that can transmit messages around corners to multiple people. Approximately 1.5 cm of insulation should also be removed from both ends of wire cable. A wire stripper, utility knife or sand paper could be used to assist in the completion of this task.

   - Electric buzzers or LED lights
   - Electrical tape
   - Scissors

   Students complete an investigation sheet (see below) to document the development of their telegraph machine and their engagement with the scientific inquiry process.

3. Following the completion of the telegraph machines, ask students to consider how they might go about sending a message to another person using this device, considering written words cannot be seen and spoken words cannot be heard. If not already identified by students, introduce the idea of a code, a system of rules used to convert information, such as a letters, numbers or punctuation, into another form or representation.

   Inform students that the code used to send messages via a telegraph was developed by Samuel Morse. Morse devised combinations of dots, dashes and spaces to represent letters, numbers and punctuation. Students could view the International Morse Code infographic included within this resource as this information is explained.

The length of the signal determines whether a dot or dash is received, with the duration of a dash being three times longer than a dot. The length of space heard between dots and dashes determines if the following code is part of the same or a different word; dots and dashes within the same word are separated by a space equal to three dots; while words are separated by a space equal to seven dots.

Before continuing, ask the class to determine the approximate signal length of one dot (i.e. half a second, one second, two seconds etc.), which will then be used to determine the signal length of dashes and the spaces between individual letters from the same word and different words. You may wish to use timer to help demonstrate signal lengths for dots and dashes. The chosen signal length should be used by all students for the remainder of this activity and the following activity.

4. Students encode the message they devised at the end of the periscope activity using Morse code. Provide students with time to practice sending and receiving this message using their telegraph machines.

5. Introduce students to the next challenge, which is to investigate how they could send messages to more than one person using their telegraph machine. Provide students with time to respond to this challenge. If desired, student groups could present how they completed the challenge to the class.

Curriculum Links

Science

YEAR 6

Science Understanding

Electrical energy can be transferred and transformed in electrical circuits and can be generated from a range of sources (ACSSU097)

Science as a Human Endeavour

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE098)

Science Inquiry Skills

With guidance, pose clarifying questions and make predictions about scientific investigations (ACSIS232)

Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using equipment and materials safely and identifying potential risks (ACSIS103)

Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate (ACSIS107)

Compare data with predictions and use as evidence in developing explanations (ACSIS221)

Reflect on and suggest improvements to scientific investigations (ACSIS108)

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS110)

YEAR 8

Science Understanding

Energy appears in different forms, including movement (kinetic energy), heat and potential energy, and energy transformations and transfers cause change within systems (ACSSU155)

Science as a Human Endeavour

Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures (ACSHE226)

People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE136)

Science Inquiry Skills

Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS139)

Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS140)

Measure and control variables, select equipment appropriate to the task and collect data with accuracy (ACSIS141)

Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSIS144)

Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence (ACSIS145)

Reflect on scientific investigations including evaluating the quality of the data collected, and identifying improvements (ACSIS146)

Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS148)

Design and Technology

YEAR 6

Design and Technologies: Knowledge and Understanding

Investigate how electrical energy can control movement, sound or light in a designed product or system (ACTDEK020)

Design and Technologies: Processes and Production Skills

Critique needs or opportunities for designing, and investigate materials, components, tools, equipment and processes to achieve intended designed solutions (ACTDEP024)

Generate, develop and communicate design ideas and processes for audiences using appropriate technical terms and graphical representation techniques (ACTDEP025)

Select appropriate materials, components, tools, equipment and techniques and apply safe procedures to make designed solutions (ACTDEP026)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

Visual knowledge

ICT Capability

Investigating with ICT

Critical and Creative Thinking

Inquiring: Identifying, exploring and organising information and ideas

Generating ideas, possibilities and actions

Reflecting on thinking and processes

Analysing, synthesising and evaluating reasoning and procedures

Personal and Social Capability

Self-management

Social management

Construct a Telegraph Machine

Student Activity

Objective

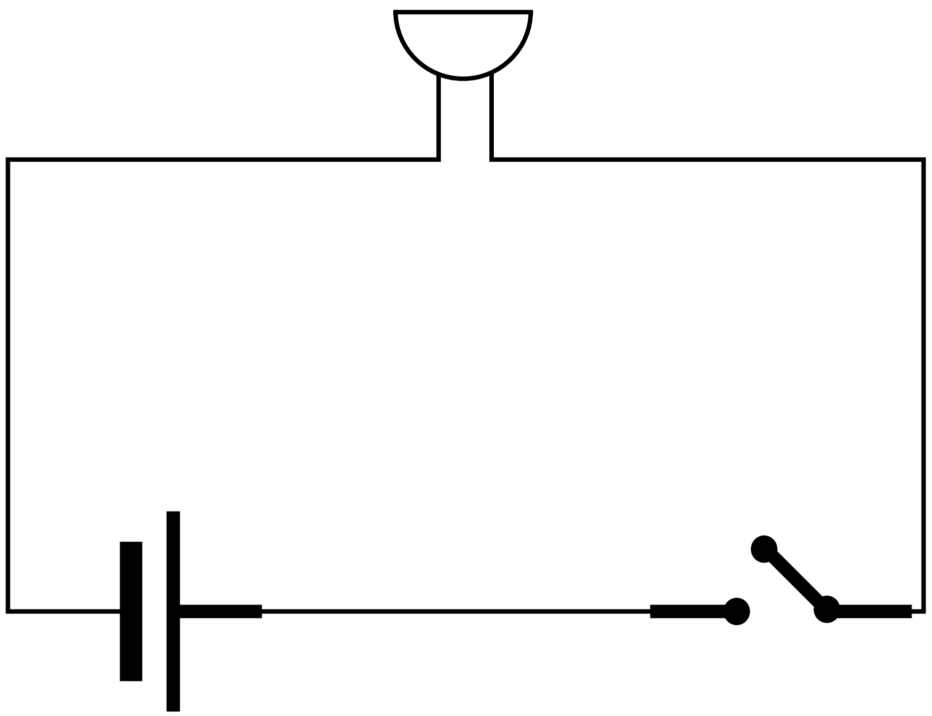
To construct a simple telegraph machine from a circuit diagram.

Materials

As provided by your teacher.

Activity

1. View the following circuit diagram of a simple telegraph machine. You will use this circuit diagram to construct your own telegraph machine. Label the symbols used to represent the components of the telegraph machine in the below circuit diagram



2. View the materials that are available to construct the telegraph machine. Determine which materials you will use to make the telegraph based on the circuit diagram. Write down which materials you will use and draw a labelled diagram to show how you will construct the telegraph using these materials. Explain why you think this will work.

Materials What will you use to make the telegraph?	
Predict Draw a labelled diagram to show how you could construct the telegraph using these materials.	
Reason Why do you think this will work? Discuss type and use of materials in your response.	

3. Before constructing your telegraph machine, discuss any potential safety hazards with your group. Record these hazards and the actions your group will take to ensure this is a safe investigation.

4. Construct and test your telegraph machine. Record and explain your observations.

Observe What happened? What did you see?	
Explain Why did this happen? Did your results support your prediction? Why?	

5. Draw an energy flow diagram of the energy transformations that occur in the device.

6. Use Morse code to send a message about a threat such as an approaching tank to your supervisors. You can record this message and/or encode it in the space below.

Practice sending and receiving this message with your group. How quickly can you send a message? How quickly can your team members decode your message?

7. How could you send a message to more than one person using your telegraph machine? Discuss this question with your team members. Draw a circuit diagram to show how you will construct the telegraph using these materials and explain why you think this will work.

Materials What will you use to make the telegraph?	

Predict Draw a circuit diagram to show how you could construct the telegraph using these materials.	
Reason Why do you think this will work? Discuss type and use of materials in your response.	

8. Construct and test your telegraph machine. Record and explain your observations.

Observe What happened? What did you see?	

Explain Why did this happen? Did your results support your prediction? Why?	

9. What could you do to improve the telegraph? Why will you make these changes?

Draw a labelled diagram to show these improvements.

10. Test your revised design. Describe how these changes did or did not improve the telegraph machine.

Activity 3: Coded Messages

Teacher Resource

In this activity, students investigate how they can use ciphers to keep confidential information from prying eyes. In cryptography (from the Greek *kryptos* for hidden and *graphia* for writing), ciphers are used to encrypt and decrypt messages. Ciphers use algorithms, set processes or series of rules that must be followed in order to solve a problem, to mix up or substitute individual letters within a message with other letters or symbols. For a cipher to be useful, the sender and receiver must know the:

- Algorithm used to encipher the original message, also known as 'plaintext'.
- Key used with the algorithm to encipher and decipher the plaintext.
- Period of time for which the key is valid.

Ciphers were used extensively during the First World War and varied in complexity, depending on the nature of the message to be sent. Students will explore two types of ciphers within this activity, a substitution and a transcription cipher, and associated methods of decryption. Detailed step-by-step instructions can be seen below. It is recommended that you use these instructions to guide your students through the activity.

1. Review the positive, negative and interesting implications students recorded for the telegraph machine in Activity 1. Provide students with time to add to their initial responses before sharing as a class group. Ask students to discuss the positive, negative and interesting implications of using Morse code to send and receive messages, especially those of a sensitive nature. Students brainstorm how they could reduce or eliminate the discussed negative implications. If students have not already raised the idea by this time, suggest the possible interception of messages by the enemy, and how the enemy may use these messages to their advantage.
2. Focus on the interception of messages by the enemy. If students have not already raised the idea by this time, discuss the use of encrypted messages to keep the information contained in messages secret. Note that there are many different ways to encrypt a message; these can include the use of ciphers. Discuss what a cipher is with students, and how a cipher is different to a code (a cipher mixes up or substitutes individual letters within a message with other letters or symbols, while a code replaces whole words in a message with different words). Students will investigate how they can encrypt (write) and decrypt (decode/read) a substitution and a transcription cipher.
3. Devise a message for students to encrypt, or ask students to think of a short message that could be encrypted as a class group. This message could be:

   CODING IS AWESOME

   Introduce the first cipher, a Caesar cipher, which is an example of a substitution cipher. The Caesar cipher is one of the earliest known and simplest ciphers to use; this also makes the cipher relatively easy to break. The Caesar cipher was named after the Roman emperor, Julius Caesar, who used this encryption method to communicate with his generals. In order to use this cipher, each letter of the alphabet is replaced by a letter some fixed number of positions further down the alphabet. To start, a fixed number between 1 and 26 is chosen. This, for example, could be the number four. Each letter of the message is then replaced with the letter four places down the alphabet. Students could also use a cipher wheel to assist in the completion of this task.

The previous message would then read as:

GSHMRK MW EAIWSQI

Ask students: What else could be done to make this message more difficult to decode? Methods could include changing where the spaces are in the message. Provide students with an opportunity to encrypt their own short messages using the Caesar cipher.

Display a new Caesar cipher for the class to analyse. The message should be one developed by the teacher, to allow for students to explore decryption methods and 'break' the cipher. Ask students how they could go about decrypting the cipher when they do not know the key. This discussion could occur as a class or in small groups. While various methods may be explored, one of the most common decryption methods for this cipher is trial and error, whereby students test each shift in turn, moving letters back by fixed numbers until the message appears.

Students could also explore the process of 'frequency analysis' to decrypt messages. Frequency analysis is the study of the distribution of letters in a text. Every language uses some letters more often than others. Frequency analysis exploits these patterns by comparing letter frequencies in a plain text message with letter frequencies in an encrypted message. The average letter frequencies in the English language are as follows:

E	12.7%	**T**	9.1%	**A**	8.2%	**O**	7.5%
I	7.0%	**N**	6.7%	**S**	6.3%	**H**	6.1%
R	6.0%	**D**	4.3%	**L**	4.0%	**C**	2.8%
U	2.8%	**M**	2.4%	**W**	2.4%	**F**	2.2%
G	2.0%	**Y**	2.0%	**P**	1.9%	**B**	1.5%
V	1.0%	**K**	0.8%	**J**	0.2%	**X**	0.2%
Q	0.1%	**Z**	0.1%				

Using this information, it could then be assumed the letter that appears the most frequently in an encrypted message will translate to 'e'. The next letter that appears most frequently is then likely to translate to 't' or 'a' and so on. Frequency analysis generally only applies to longer encrypted messages for the frequencies to be statistically significant. Consequently, this method should be used to decrypt messages that are at least one paragraph in length.

Students could practise applying this method when working to decrypt longer messages encrypted with a Caesar cipher, such as the diary entry of Alan Dodd (see Student Activity). Firstly, students could work together to calculate letter frequencies, working with a page of text from a book or a webpage from the internet to complete this task. Students could then display collected data in a table and graph, and compare their results with other groups. Alternatively, students could use the data presented in the previous letter frequency table to assist with the decryption of messages. They then use the frequency analysis to decrypt the message by:

- Identifying the total number of characters in the message.
- Tallying how many times each encrypted letter appears in the message.
- Converting encrypted letter totals to a percentage.
- Comparing this data to the frequency analysis percentages to decrypt letters.

After exploring one or both of the above methods, students can practise sending, receiving and decrypting previously devised messages using Morse code and their telegraph machines.

4. Devise a second message for students to encrypt, or ask students to think of a short message that could be encrypted as a class group. This message could be:

SCIENCE IS AWESOME

Introduce the next cipher, a transposition cipher, which is an example of a transcription cipher. A transposition cipher rearranges the order of the letters in the plaintext according to some predetermined method without making any letter substitutions. In order to use this cipher, each letter of the alphabet is organised into a grid, moving from left to right. The grid may be any dimension. The above message then might look something like this:

S	C	I	E
N	C	E	I
S	A	W	E
S	O	M	E

A ‘padding character’ such as the letter ‘X’ would be added to any boxes that are not filled by the original message.

The message is then encrypted by reading the letters in order down the columns, starting from the left hand side. If using the above example, the encrypted message would read as:

SNSS CCAO IEWM EIEE

Ask students: What else could be done to make this message more difficult to decode? Methods could include changing where the spaces are in the message. Provide students with an opportunity to encrypt their own messages using the transposition cipher.

Display a new transposition cipher for the class to analyse. The message should be one developed by the teacher, to allow for students to explore decryption methods and 'break' the cipher. Ask students how they could go about decrypting the cipher when they do not know the key. This discussion could occur as a class or in small groups. While various methods may be explored, the following process may be explored with students:

- Identify the total number of characters in the encrypted message.

  E.g. In the previous example there are 16 characters.

- Identify the combination of grid dimensions that this number of characters could completely fill.

  E.g. With 16 characters, the combination of grid dimensions used to encrypt the message could be 1 x 16, 2 x 8, 4 x 4, 8 x 2, 16 x 1

- Test placing the encrypted message into each of these combinations, working down and across the columns, starting from the right hand side. Students may find it useful to work from grid paper during this time. The encrypted message is broken when, reading from left to right from the first row, all letters combine to form understandable words.

  E.g. A 1 x 16 grid does not rearrange the message at all.

  A 2 x 8 grid gives:

S	S	C	A	I	W	E	E
N	S	C	O	E	M	I	E

  SSCAIWEENSCOEMIE

  The letters do not combine to form understandable words.

  A 4 x 4 grid gives:

S	C	I	E
N	C	E	I
S	A	W	E
S	O	M	E

  SCIENCEISAWESOME

  With the addition of spaces, the letters combine to form understandable words.

  The cipher is broken.

  Following this, students can swap their previously encrypted messages with a peer to practise decryption. Students can practise sending, receiving and decrypting these messages using Morse code and their telegraph machines.

  Following this activity, you may also like to encourage students to reflect on how they and others keep important messages or information safe today.

Curriculum Links

Mathematics

YEAR 5

Number and Algebra

Identify and describe factors and multiples of whole numbers and use them to solve problems (ACMNA098)

Use efficient mental and written strategies and apply appropriate digital technologies to solve problems (ACMNA291)

Statistics and Probability

Pose questions and collect categorical or numerical data by observation or survey (ACMSP118)

Construct displays, including column graphs, dot plots and tables, appropriate for data type, with and without the use of digital technologies (ACMSP119)

Describe and interpret different data sets in context (ACMSP120)

YEAR 6

Number and Algebra

Select and apply efficient mental and written strategies and appropriate digital technologies to solve problems involving all four operations with whole numbers (ACMNA123)

Find a simple fraction of a quantity where the result is a whole number, with and without digital technologies (ACMNA127)

Make connections between equivalent fractions, decimals and percentages (ACMNA131)

Statistics and Probability

Interpret and compare a range of data displays, including side-by-side column graphs for two categorical variables (ACMSP147)

YEAR 7

Number and Algebra

Round decimals to a specified number of decimal places (ACMNA156)

Connect fractions, decimals and percentages and carry out simple conversions (ACMNA157)

Statistics and Probability

Calculate mean, median, mode and range for sets of data. Interpret these statistics in the context of data (ACMSP171)

Describe and interpret data displays using median, mean and range (ACMSP172)

YEAR 8

Number and Algebra

Investigate terminating and recurring decimals (ACMNA184)

General Capabilities

Numeracy

Estimating and calculating with whole numbers

Recognise and using patterns and relationships

Using fractions, decimals, percentages, ratios and rates

Interpreting statistical information

Critical and Creative Thinking

Inquiring: Identifying, exploring and organising information and ideas

Generating ideas, possibilities and actions

Reflecting on thinking and processes

Analysing, synthesising and evaluating reasoning and procedures

Activity 3: Coded Messages

Teacher Answers

Diary Entry of Alan Dodd

This is American Independence Day; a fair number of Yanks are round here, they ought to make splendid fighters, fresh and eager unlike the war weary troops [illegible words]. Their choice of language is not so [illegible word] as the [illegible word]. “God damn” repeated at very frequent intervals being the chief expression.

Friday, July 5

Fritz had his night out last night. Heard more bombs dropt [sic] than have since [illegible word] days. It is strange how bombs “put the wind up” the boys. As someone said, “When you hear the first of Fritzs engine directly overhead you sort of feel that yours is the only hut or tent in the world and you the only inhabitant.” Yes as tho [sic] the fates had taken control of the law of gravitation and then invisible hands were drawing the missiles to one’s destruction.

Saturday and Sunday, July 6 and 7

Up at Windy Ridge again tonight. Quiet enough at first trip at 12.30am, after leaving the ridge and nearly at the foot of the hill, we could notice gas shells bursting in numbers just ahead of us; caught one whiff, then ran into a thick cloud if it. Put our gas masks on at the [illegible word], and drove on thru [sic] the village with [illegible word] gas shells and HE [high explosives] coming thick and fast. At the [illegible word] stuff was flying in all directions and we unloaded our patients hurriedly and waited in the 20 foot deep dugout. Several hits on the dugout but after an hour things quietened down. Made two more trips with masks on; on the last with a full load on nearly upset the car, the wheels went over the edge of a shell hole but held at precarious angle; unloaded our patient onto the Sunbeam car and willing helpers soon righted the bus. Quiet enough through the day. Relieved at 6.30pm and back home. A bit of excitement is stimulating – after it’s over, one feels the zest of the thing.

Monday July 8

Warm today, a storm gathered in the evening but [illegible word] to [illegible word] and only a few drops falling.

Activity 3: Coded Messages

Student Activity

Caesar Cipher

A Caesar cipher is an example of a substitution cipher. The Caesar cipher was named after the Roman emperor, Julius Caesar, who used this encryption method to communicate with his generals. To use this cipher, each letter is replaced by a different letter some fixed positions, or shifts, further down the alphabet. While the Caesar cipher is one of the earliest known and simplest ciphers to use, it is also one of the easiest to break.

A Caesar cipher has been used to encrypt the following message. Apply the frequency analysis method to 'break' the cipher and read the message.

Activity

1. Count the total number of letters in the message. Record this number in the table on the following page.
2. Tally how many times each encrypted letter appears in the message. You may need to attach additional paper if you run out of space in the table.
3. Calculate the letter frequency for each encrypted letter. Record this as a percentage of the total letters.
4. Compare this percentage with the percentages included in the frequency analysis table below to decrypt the letters. Use this information to decrypt the message.
5. Finally, identify the letter shift used to encrypt the message.

Frequency Analysis Table

E	12.7%
O	7.5%
S	6.3%
D	4.3%
U	2.8%
F	2.2%
P	1.9%
K	0.8%
Q	0.1%

T	9.1%
I	7.0%
H	6.1%
L	4.0%
M	2.4%
G	2.0%
B	1.5%
J	0.2%
Z	0.1%

A	8.2%
N	6.7%
R	6.0%
C	2.8%
W	2.4%
Y	2.0%
V	1.0%
X	0.2%

Encrypted Message

ftue ue myqduomz uzpqbqzpqzoq pmk; m rmud zgynqd ar kmzwe mdq dagzp tqdq, ftqk agstf fa ymwq ebxqzpup rustfqde, rdqet mzp qmsqd gzxuwq ftq imd iqmdk fdaabe [uxxqsunxq iadpe]. ftqud otauoq ar xmzsgmsq ue zaf ea [uxxqsunxq iadp] me ftq [uxxqsunxq iadp]. “sap pmyz” dqbqmfqp mf hqdk rdqcgqzf uzfqdhmxe nquzs ftq otuqr qjbdqeeuaz.

rdupmk, vgxk 5
rdufl tmp tue zustf agf xmef zustf. tqmdp yadq nayne pdabf ftmz tmhq euzoq [uxxqsunxq iadp] pmke. uf ue efdmzsq tai nayne “bgf ftq iuzp gb” ftq nake. me eayqazq emup, “itqz kag tqmd ftq rudef ar rdufle qzsuzq pudqofxk ahqdtqmp kag eadf ar rqqx ftmf kagde ue ftq azxk tgf ad fqzf uz ftq iadxp mzp kag ftq azxk uztmnufmzf.” kqe me fta ftq rmfqe tmp fmwqz oazfdax ar ftq xmi ar sdmhufmfuaz mzp ftqz uzhueunxq tmzpe iqdq pdmiuzs ftq yueeuxqe fa azq’e pqefdgofuaz.

emfgdpmk mzp egzpmk, vgxk 6 mzp 7
gb mf iuzpk dupsq msmuz fazustf. cguqf qzagst mf rudef fdub mf 12.30my, mrfqd xqmhuzs ftq dupsq mzp zqmdxk mf ftq raaf ar ftq tuxx, iq oagxp zafuoq sme etqxxe ngdefuzs uz zgynqde vgef mtqmp ar ge; omgstf azq iturr, ftqz dmz uzfa m ftuow oxagp ur uf. bgf agd sme ymewe az mf ftq [uxxqsunxq iadp], mzp pdahq az ftdg ftq huxxmsq iuft [uxxqsunxq iadp] sme etqxxe mzp tq [tust qjbxaeuhqe] oayuzs ftuow mzp rmef. mf ftq [uxxqsunxq iadp] efgrr ime rxkuzs uz mxx pudqofuaze mzp iq gzxampqp agd bmfuqzfe tgdduqpxk mzp imufqp uz ftq 20 raaf pqqb pgsagf. eqhqdmx tufe az ftq pgsagf ngf mrfqd mz tagd ftuzse cguqfqzqp paiz. ympq fia yadq fdube iuft ymewe az; az ftq xmef iuft m rgxx xamp az zqmdxk gbeqf ftq omd, ftq itqqxe iqzf ahqd ftq qpsq ar m etqxx taxq ngf tqxp mf bdqomduage mzsxq; gzxampqp agd bmfuqzf azfa ftq egznqmy omd mzp iuxxuzs tqxbqde eaaz dustfqp ftq nge. cguqf qzagst ftdagst ftq pmk. dqxuqhqp mf 6.30by mzp nmow tayq. m nuf ar qjoufqyqzf ue efuygxmfuzs – mrfqd uf’e ahqd, azq rqqxe ftq lqef ar ftq ftuzs.

yazpmk vgxk 8
imdy fapmk, m efady smftqdqp uz ftq qhqzuzs ngf [uxxqsunxq iadp] fa [uxxqsunxq iadp] mzp azxk m rqi pdabe rmxxuzs.

Coded Messages: Break The Cipher!

Total Number of Letters

Encrypted Letter	Tally	Total Number of Letters	Percentage	Actual Letter
A				
B				
C				
D				
E				
F				
G				
H				
I				
J				
K				
L				
M				
N				
O				
P				
Q				
R				
S				
T				
U				
V				
W				
X				
Y				
Z				

Alan Dodd

The message you decrypted is actually a diary entry written by Alan Dodd. Dodd was a budding 20-year-old entomologist when he enlisted in the Australian Army in February 1916. His father was Frederick Dodd, a well-known naturalist nicknamed 'the Butterfly man of Kuranda'. You can view the insects collected by Frederick and Alan Dodd at ***Queensland Museum's Google Arts and Culture*** webpage, including the:

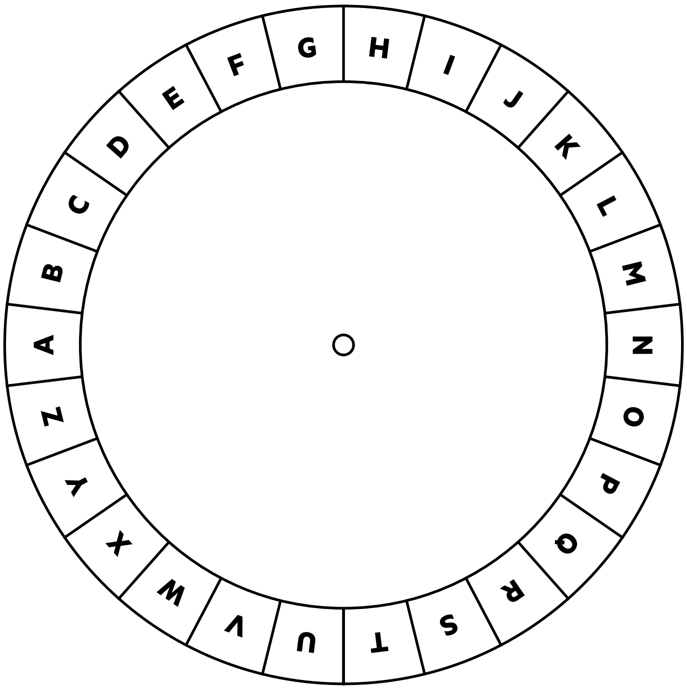
- ***King stag beetle case***
- ***Ulysses butterfly case***
- ***New Guinea jezebel butterfly case***

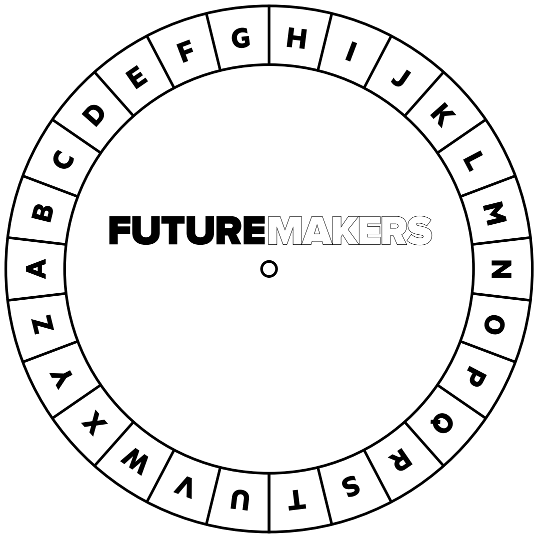
As a boy, Alan had been involved in the family business of collecting and preserving insects for sale worldwide. He had published 12 papers in Australian and European scientific journals by the age of 19, and was working in research with the Queensland Bureau of Sugar Experimental Station at Gordonvale when he enlisted.

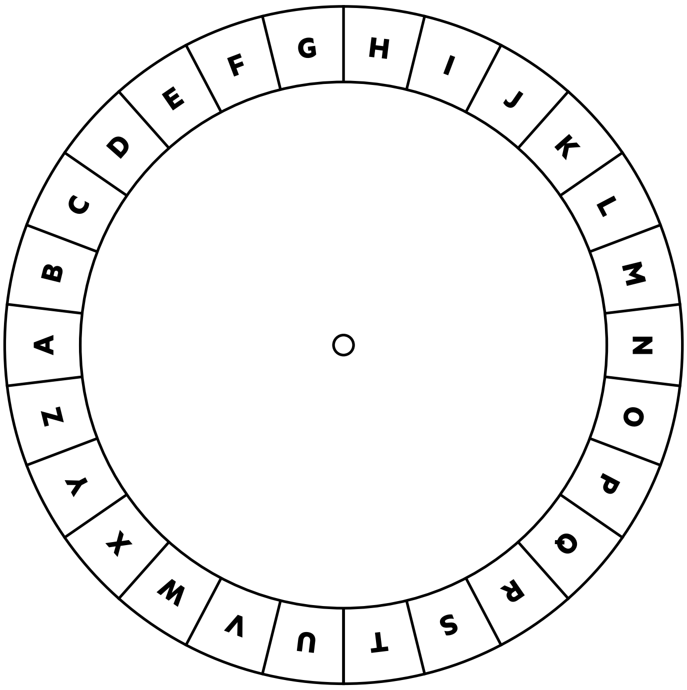
Alan left Australia in July 1917 and served as a medical orderly with the 15th Field Ambulance in France. He kept a meticulous record of his war service in three small, covered notebooks, documenting the weather, the landscape, and his, sometimes harrowing, experiences with his unit.

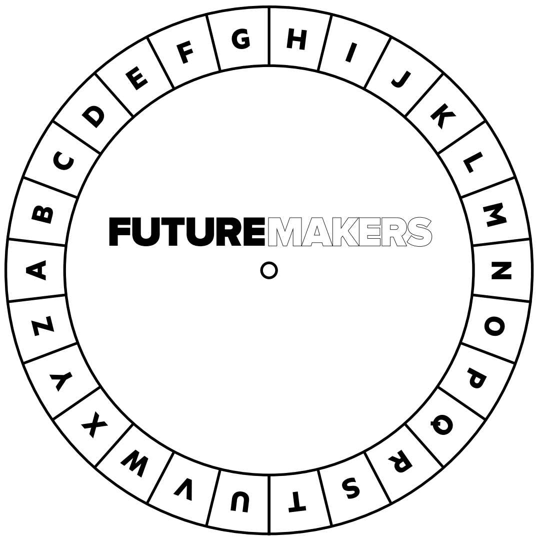
© Queensland Museum

Cipher Wheel









EVALUATE

Ethical Science Use

Teacher Resource

In this activity, students reflect on why it is important to use scientific knowledge responsibly and ethically. They discuss what it means to be an ethical science user in today's world and how they would recognise ethical science use. Detailed step-by-step instructions can be seen below. It is recommended that you use these instructions to guide your students through the activity.

1. Revise prior learning from any activities completed with students from this resource book. Ask students to recall/discuss:
    - The main scientific/technological advances of the First World War.
    - How else science/technology was used during the war.
    - The advantages and disadvantages associated with the use of this knowledge.
2. State that our collective understanding of science and technology, and the application of these understandings, rapidly expands at key points of human history particularly during periods of war. Ask students to discuss why they think this might be the case. Following student discussion, state that this expansion of knowledge is often a matter of survival. Countries need to know how to protect their people. Countries also desire to be victors of war; this desire can result in significant harm to a large number of humans, or cause great damage to the man-made and natural environment. This tension does not only exist in the past in relation to the First World War; it exists today and is highly likely to exist in the future for a whole range of scientific and technological discoveries and applications. It is important then for us to consciously recognise that science and technology are powerful, that the products of science and technology have power, and there is a need to use science and technology responsibly and ethically.
3. Ask students to consider and discuss the following questions in small groups, then to share with the class. Students could conduct research to inform their responses.
    - What does it mean to be 'an ethical science user'?
    - How would you recognise ethical science use?
    - Why does this matter to me? How can I be an 'ethical science user'?

Curriculum Links

Science

YEAR 7

Science as a Human Endeavour

Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE120)

YEAR 8

Science as a Human Endeavour

Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE135)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Critical and Creative Thinking

Inquiring: Identifying, exploring and organising information and ideas

Reflecting on thinking and processes

Personal and Social Capability

Social awareness

Ethical Understanding

Understanding ethical concepts and issues

Reasoning in decision making and actions

Exploring values, right and responsibilities