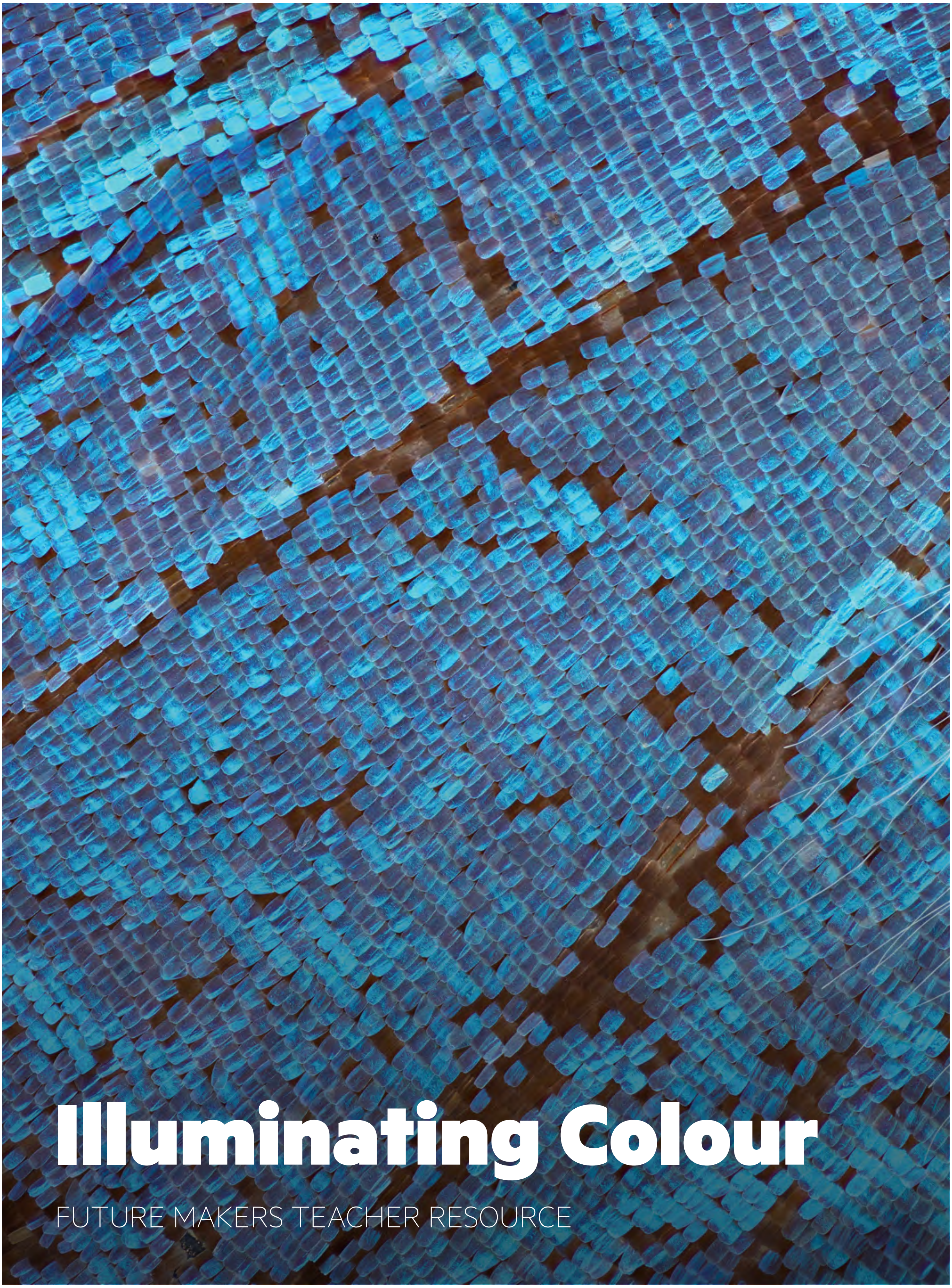

Illuminating Colour

FUTURE MAKERS TEACHER RESOURCE

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: Dorsal view of scales on the left hindwing of a butterfly, Ogyris iphis iphis. QM, Geoff Thompson.

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QUEENSLAND MUSEUM NETWORK Queensland Government THE UNIVERSITY OF QUEENSLAND AUSTRALIA

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Contents

Workshop Overview

Delve into the world of light and colour in this illuminating workshop. Within this workshop, students explore how light and colour can be used and changed. They investigate how both people and fish use refraction to catch food, and inquire into the origins and purpose of colour in the natural world.

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 **EXPLORE** **EXPLAIN**	**Are You on My Wavelength?** Use objects from Queensland Museum's Cultures and Histories collection to explore how electromagnetic radiation is used for different purposes. Then, investigate how cultural institutions, such as museums, use and avoid electromagnetic radiation to conserve their collections.
EXPLORE **EXPLAIN** **ELABORATE** **EVALUATE**	**Colour My World** Investigate how we can use light and colour to change the way things look. Explore how light can be split, mixed and blocked, and create a coloured shadows light show.
EXPLORE	**Science, Colour, Light: Community of Inquiry** Participate in a community of inquiry to discuss why it is useful to understand colour and light from a scientific perspective, and how colour and light can help us in our daily lives.
EXPLORE **EXPLAIN** **ELABORATE** **EVALUATE**	**The One That Didn't Get Away** Investigate the refraction of light. Explore what happens to a beam of light when it passes through transparent materials, and how refraction can affect the appearance of objects.
EXPLORE **EXPLAIN**	**The Colour of Life** Consider why living things come in such a huge array of different colours.
EXPLORE **EXPLAIN** **ELABORATE**	**Light and a Feather: Investigating Colour** Investigate feathers of different colours to recognise that not all colours are created equally.
EVALUATE	**Reflecting on Colour and Light: Community of Inquiry** Participate in a community of inquiry to review and reflect on learning and new understandings and skills.

ENGAGE – EXPLORE – EXPLAIN

Are You on My Wavelength?

Teacher Resource

Electromagnetic radiation is a type of energy that travels in waves. It exists along a spectrum, and can take many different forms depending on its wavelength, frequency and energy. These properties impart different characteristics, which influence their use by people in science and technology, as well as in our daily lives.

In this activity, students explore how electromagnetic radiation is used for different purposes. It is assumed that students have been introduced to the electromagnetic spectrum, electromagnetic radiation, and the properties of different types of electromagnetic radiation, prior to engaging with this activity. Objects from Queensland Museum's Cultures and Histories collection provide context for learning within this activity.

Queensland Museum's Cultures and Histories collection provides a tangible link to human innovation and experience. The collection is comprised of objects that are significant to the people of Queensland, including the material culture of Aboriginal Peoples and Torres Strait Islanders. You can view objects from this collection online and in person at exhibitions on display across the Queensland Museum Network.

Detailed step-by-step instructions can be seen below. It is recommended that you use these instructions to guide your students through the activity. Prior to implementing this activity, we recommend you print out the *Electromagnetic Spectrum Diagram* (see page 6). This diagram can be displayed on the floor or wall. Students should not see this diagram until Step 3.

Following this activity, students have the opportunity to investigate how cultural institutions, including museums, galleries and libraries, use and avoid different types of electromagnetic radiation to conserve their collections. Students will need to conduct online research to complete this activity.

1. Divide students into groups of two or three. Distribute one object image to each group. Ask students to analyse the object using the See-Scan-Analyse strategy:

   See: Describe what you see.

   Scan: Look closely at the object.
   What extra details do you notice now that you didn't before?
   When do you think this object was made?

   Analyse: How do you think this object was used?

   The objects selected for this activity will vary in terms of recognition by students. For differentiation, you may like to provide some students with more recognisable objects (i.e. the television, microscope or some cameras) and other students with less recognisable objects (i.e. the Graflex Series B camera, ophthalmoscope or X-ray tubes).

   Student groups then share their objects and response to the See-Scan-Analyse questions with the class.

2. Inform students that all of the objects have something in common. Provide student groups with time to discuss what this might be, before sharing suggestions with the class. If not already suggested, inform students that all of the objects use electromagnetic radiation to function, and that the frequency at which these objects operate can provide us with more information about how they are used.

   Provide student groups with the frequency at which their object operates (see page 20). Ensure students are aware that objects can operate across a frequency range. For example, although a specific frequency is provided for the mantle clock radio, it is actually able to operate across a range between 535 – 1065 kHz. This is also the case for the television and the X-ray tubes.

   Provide groups with time to convert their given frequency into Hertz (see answers below). You may like to provide students with a conversion table to assist this process (see page 21).

Answers: Frequencies Converted to Hertz

Object		**Frequency**		
Object A	Mantle clock radio	600 kHz	⟶	600,000 Hz 6 x 10^5 Hz
Object B	Television	64.25 MHz	⟶	64,250,000 Hz 64.25 x 10^6 Hz
Object C	Monocular microscope	430–750 THz	⟶	430,000,000,000,000 – 750,000,000,000,000 Hz 4.3 x 10^{14} – 7.5 x 10^{14} Hz
Object D	No. 3A Folding Pocket camera			
Object E	Box camera			
Object F	Graflex Series B camera			
Object G	View camera			
Object H	Kodak Brownie Six-20 camera			
Object I	Trench periscope			
Object J	Opthalmoscope			
Object K	X-ray tube	20 EHz	⟶	20,000,000,000,000,000,000 20 x 10^{18} Hz
Object L	X-ray tube	19.5 EHz	⟶	19,500,000,000,000,000,000 19.5 x 10^{18} Hz

3. Ask groups to move with their object images to the electromagnetic spectrum diagram (see page 6). Ask groups to identify where their object is situated on the electromagnetic spectrum and to place their object at this location. Ask students to consider what they already know about this form of electromagnetic radiation. Pose the following question for students to discuss in their groups: **How does this information change or further inform your thoughts about this object and how it was used?** Student groups then share their responses with the class.

4. Ask students if they are ready to learn more about their objects. Share information about each object (see page 22) with individual student groups. Ask students to comment on this information: **How did your predictions compare and were there any surprises?**

5. Return to the diagram and objects. Inform students that these objects are from Queensland Museum's Cultures and Histories collection. Ask students if they have noticed that some forms of electromagnetic radiation are missing an object (i.e. microwave, infrared, UV and gamma). Ask students to hypothesise why this might be the case. Students may consider both the purpose of a museum and the types of objects that use these forms of electromagnetic radiation in their response.

   Note: Queensland Museum collections are comprised of objects that are significant to the people of Queensland. Items accepted in to the collection must meet significance criteria and support the Museum's strategic themes. They are also assessed for required and/or ongoing conservation work and how much space is needed to store the object.

6. Ask student groups to identify two additional objects that can be added to the diagram. Inform students that each object must use a different form of electromagnetic radiation. Students may conduct research to complete this task, and then present their additions to the class.

7. Following this, students may like to investigate how cultural institutions, including museums, galleries and libraries, use and avoid different types of electromagnetic radiation to conserve their collections.

Curriculum Links

Science

YEAR 9

Science Understanding

Energy transfer through different mediums can be explained using wave and particle models (ACSSU182)

Science as a Human Endeavour

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

People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE160)

Values and needs of contemporary society can influence the focus of scientific research (ACSHE228)

Science Inquiry Skills

Formulate questions or hypotheses that can be investigated scientifically (ACSIS164)

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS170)

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS171)

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)

Mathematics

YEAR 9

Number and Algebra

Express numbers in scientific notation (ACMNA210)

General Capabilities

Literacy

Composing texts through speaking, writing and creating

Numeracy

Estimating and calculating with whole numbers

ICT Capability

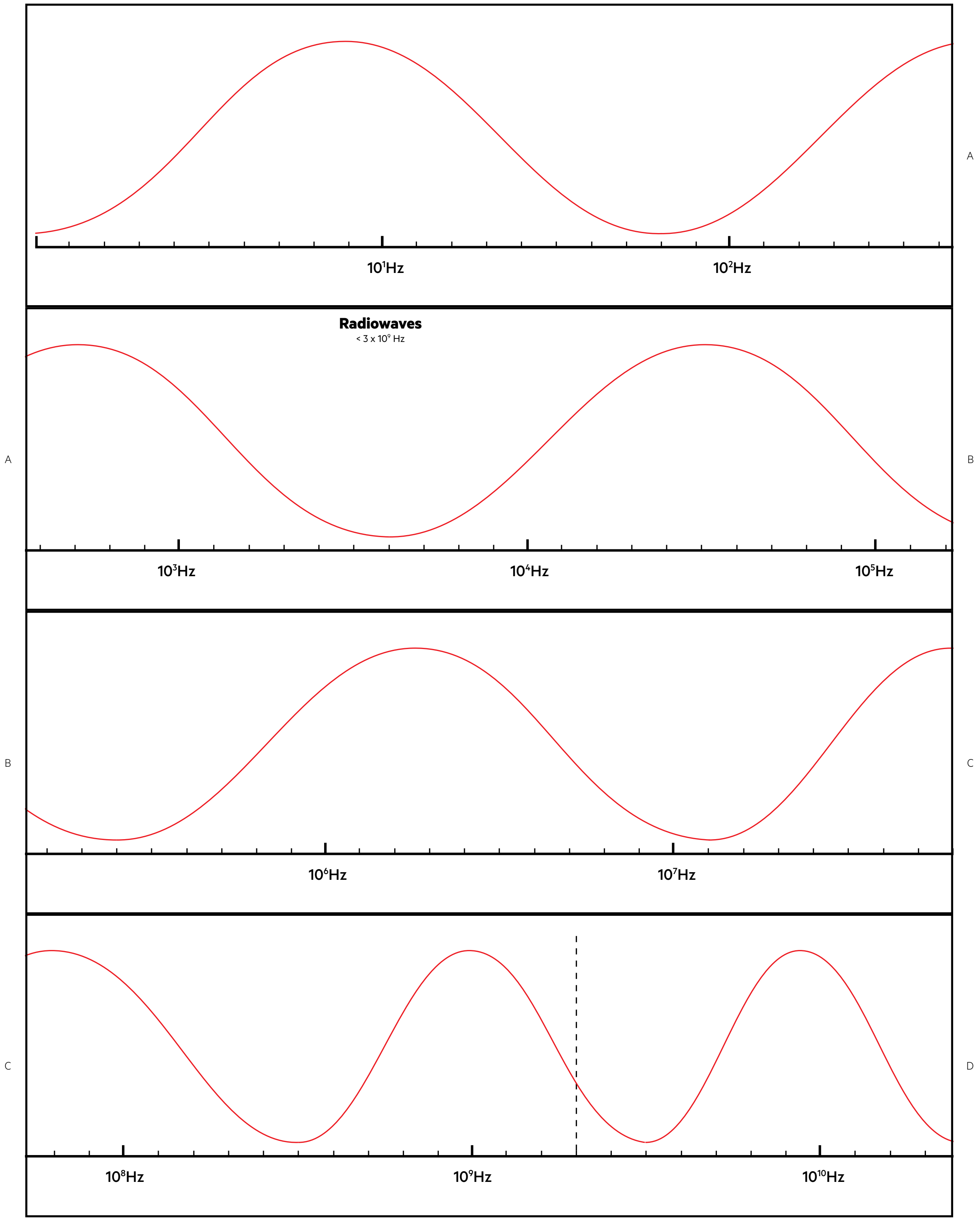
Investigating with ICT

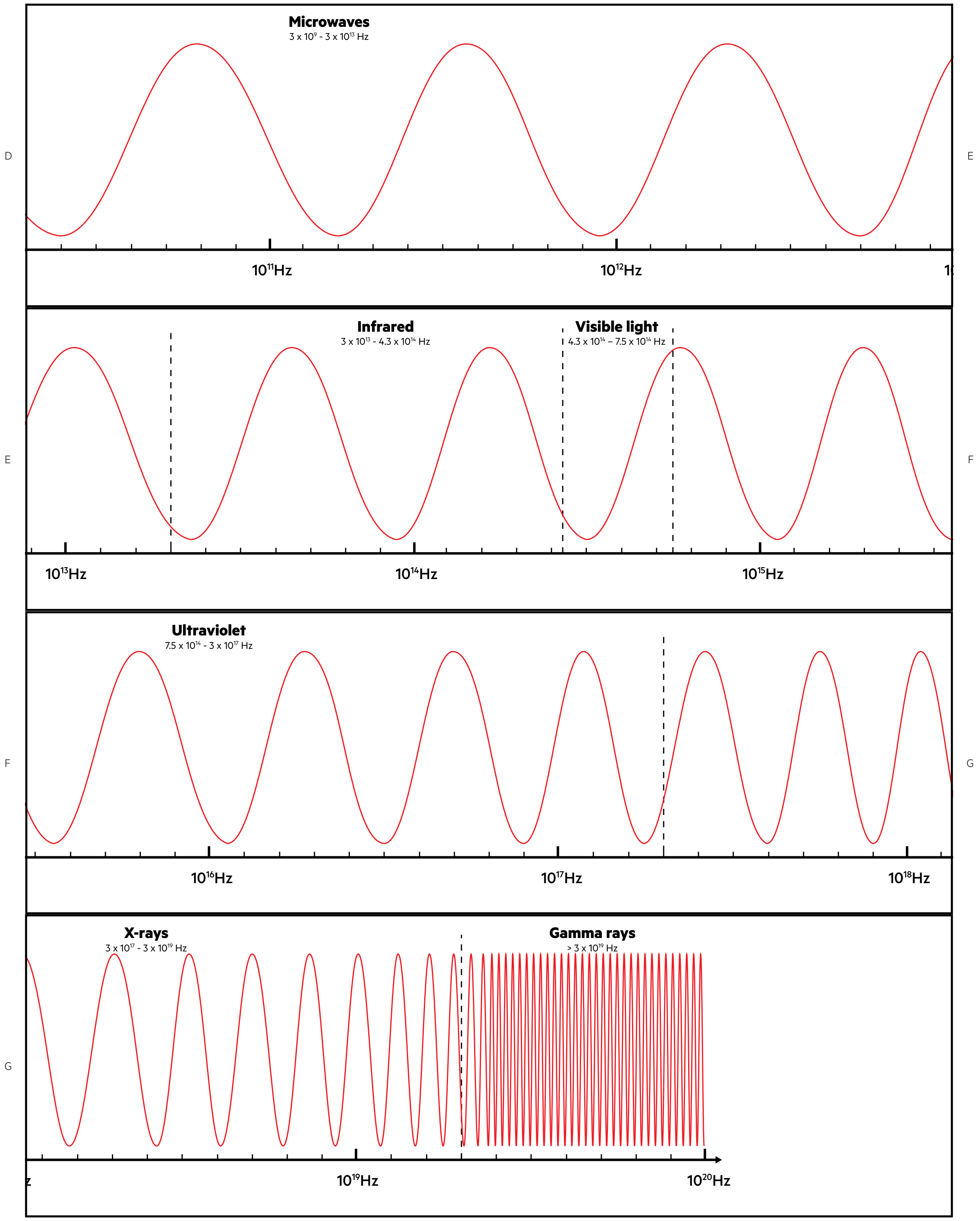
Critical and Creative Thinking

Reflecting on thinking and processes

Electromagnetic Spectrum: Diagram

You can access this resource online at Queensland Museum Network Learning Resources. Search for 'Electromagnetic Spectrum: Diagram'. After downloading the resource, print to A3. Use clear tape or glue to join the sections together.





D
E
Microwaves
3 x 10^{9} - 3 x 10^{13} Hz
10^{11}Hz
10^{12}Hz
E
F
Infrared
3 x 10^{13} - 4.3 x 10^{14} Hz
Visible light
4.3 x 10^{14} – 7.5 x 10^{14} Hz
10^{13}Hz
10^{14}Hz
10^{15}Hz
F
G
Ultraviolet
7.5 x 10^{14} - 3 x 10^{17} Hz
10^{16}Hz
10^{17}Hz
10^{18}Hz
G
X-rays
3 x 10^{17} - 3 x 10^{19} Hz
Gamma rays
> 3 x 10^{19} Hz
10^{19}Hz
10^{20}Hz

Mystery Objects: Images

Object A

© Peter Waddington, Queensland Museum

Object B

© Peter Waddington, Queensland Museum

Object C

© Peter Waddington, Queensland Museum

Object D

© Jeff Wright, Queensland Museum

Object E

© Peter Waddington, Queensland Museum

Object F

© Peter Waddington, Queensland Museum

Object G

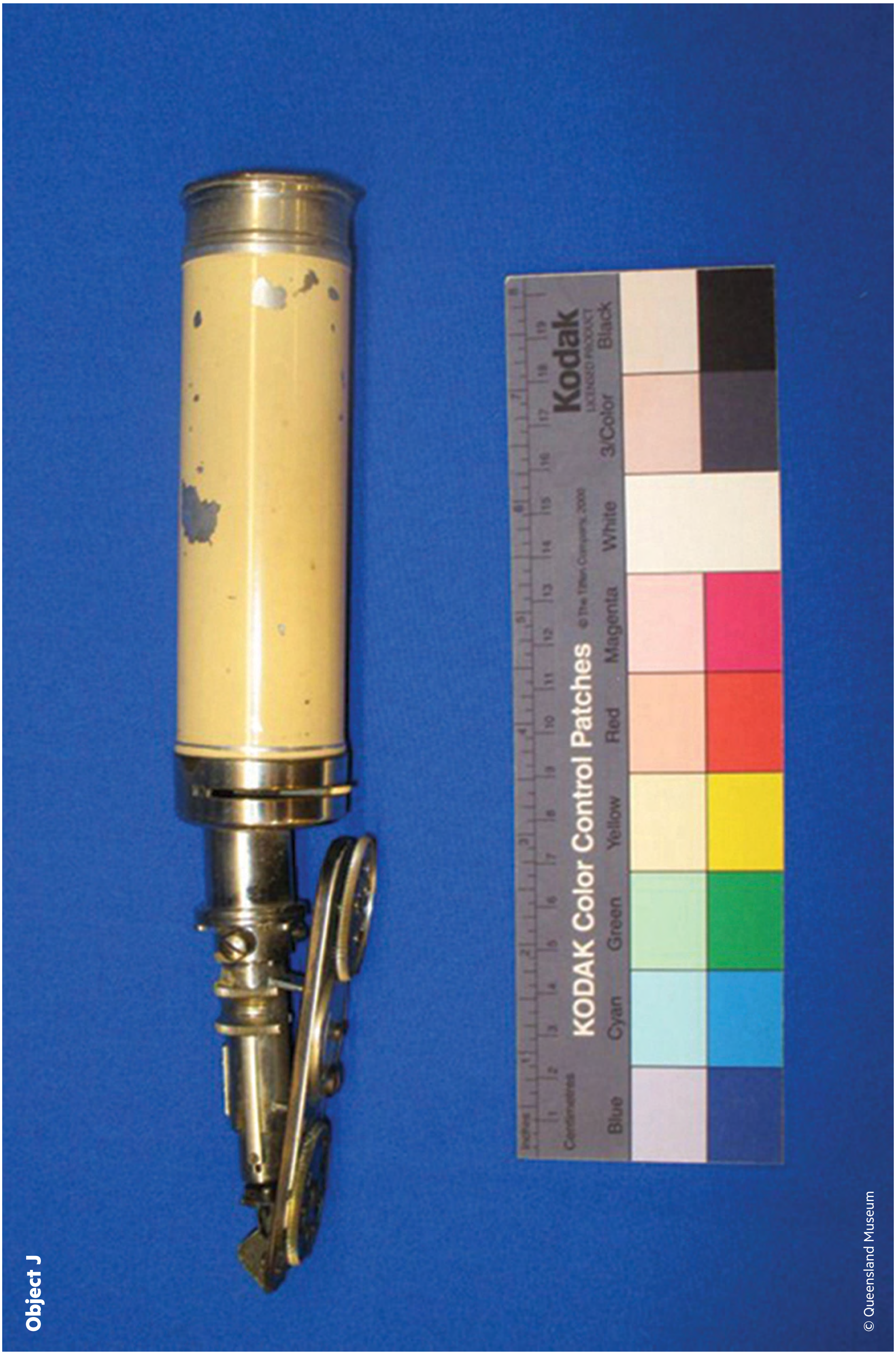
© Peter Waddington, Queensland Museum

Object H

© Peter Waddington, Queensland Museum

Object I

© Peter Waddington, Queensland Museum



Object J

© Queensland Museum

Object K

© Peter Waddington, Queensland Museum

Object L

© Peter Waddington, Queensland Museum

Mystery Objects and Frequencies

Object A 600 kHz	**Object B** 64.25 MHz
Object C 430 – 750 THz	**Object D** 430 – 750 THz
Object E 430 – 750 THz	**Object F** 430 – 750 THz
Object G 430 – 750 THz	**Object H** 430 – 750 THz
Object I 430 – 750 THz	**Object J** 430 – 750 THz
Object K 20 EHz	**Object L** 19.5 EHz

Electromagnetic Wave Frequency Conversion Table

Electromagnetic Wave Frequency	Abbreviation	Equivalent Hertz			
Hertz	Hz				
Kilohertz	kHz	1 kHz	=	1,000 Hz	(thousand)
			=	1 x 10^3 Hz	
Megahertz	MHz	1 MHz	=	1,000,000 Hz	(million)
			=	1 x 10^6 Hz	
Gigahertz	GHz	1 GHz	=	1,000,000,000 Hz	(billion)
			=	1 x 10^9 Hz	
Terahertz	THz	1 THz	=	1,000,000,000,000 Hz	(trillion)
			=	1 x 10^{12} Hz	
Exahertz	EHz	1 EHz	=	1,000,000,000,000,000,000 Hz	(quintillion)
			=	1 x 10^{18} Hz	

Electromagnetic Wave Frequency	Abbreviation	Equivalent Hertz			
Hertz	Hz				
Kilohertz	kHz	1 kHz	=	1,000 Hz	(thousand)
			=	1 x 10^3 Hz	
Megahertz	MHz	1 MHz	=	1,000,000 Hz	(million)
			=	1 x 10^6 Hz	
Gigahertz	GHz	1 GHz	=	1,000,000,000 Hz	(billion)
			=	1 x 10^9 Hz	
Terahertz	THz	1 THz	=	1,000,000,000,000 Hz	(trillion)
			=	1 x 10^{12} Hz	
Exahertz	EHz	1 EHz	=	1,000,000,000,000,000,000 Hz	(quintillion)
			=	1 x 10^{18} Hz	

Electromagnetic Wave Frequency	Abbreviation	Equivalent Hertz			
Hertz	Hz				
Kilohertz	kHz	1 kHz	=	1,000 Hz	(thousand)
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			=	1 x 10^6 Hz	
Gigahertz	GHz	1 GHz	=	1,000,000,000 Hz	(billion)
			=	1 x 10^9 Hz	
Terahertz	THz	1 THz	=	1,000,000,000,000 Hz	(trillion)
			=	1 x 10^{12} Hz	
Exahertz	EHz	1 EHz	=	1,000,000,000,000,000,000 Hz	(quintillion)
			=	1 x 10^{18} Hz	

Mystery Object Information

OBJECT A	
Object	Mantle clock radio
Production Date	Unknown
Materials	Bakelite (plastic), metal
Description	This Mantle radio was manufactured by A.W.A. Radiola. This particular model (Model 469 MA) is a stylish mantle radio with a maroon and cream Bakelite (plastic) housing. The insert features an analogue clock plus radio volume and tuning knobs with a list of AM radio stations. The working clock included in the radio, in addition to the frequency display, made it truly a "clock" radio.

OBJECT B	
Object	Television
Production Date	1958
Materials	Plastic, metal, glass
Description	This visually interesting black and white Pye-Technico Television was purchased in Sydney in 1958. Manufactured by James N. Kirby Holdings Pty Ltd in Sydney, the use of coloured plastics such as this pink casing for this television was the height of fashion in the 1950s. A speaker grate is cut into the right side of the television, with speaker mesh behind it. Two metal dials are positioned on the front face of the television, with the model name and crest embossed on a metal plate in the centre of the set. An aerial plate is fixed the top right hand side of the television. James N. Kirby Holdings Pty Ltd was established by James Kirby in 1946. Kirby was a well-regarded industrialist and worked on a number of precision engineering projects and recognised the potential market for household consumer goods in post-war Australia.

OBJECT C	
Object	Monocular microscope
Production Date	1940 - 1959
Materials	Glass, metal (including ferrous and non-ferrous)
Description	This black enamelled metal microscope was made in the Munitions Supply Laboratories (M.S.L) in Maribyrnong, Melbourne. M.S.L worked with the Australian Optical Company to manufacture Australian-made optical instruments during and after the Second World War. There was a shortage of optical instruments during and immediately after the war in Australia because most of the major optical manufacturers were German, or international branches of German companies. This created trade complications and it was decided that Australia would increase their research and supply their own instruments for both military and later civilian use. This would also keep Australia in adequate supply in case war was to break out again. The MSL facility in Maribyrnong, also called the Ordnance Factory, remained open and operational after the War and was used to make microscopes such as this monocular model, which was used in the University of Queensland's Zoology department.

OBJECT D	
Object	No. 3A Folding Pocket camera
Production Date	1903 - 1915
Materials	Non-ferrous metal, glass, leather, wood, paper
Description	The camera has a wood and aluminium body and red leather bellows (the pleated expandable part of the camera). The camera opens out onto a metal support system with a metal track. Wood panelling on either side of the metal track slides out to allow for the extension of the bellows. The camera is protected by a brown leather case. This No. 3A Kodak Folding Pocket camera was owned by Captain Leslie Russell Blake, Queensland Geological Survey Geologist. The camera was possibly used by Blake on the 1913-1914 Mawson Expedition to Macquarie Island. Blake, taking leave from the Queensland Geological Survey, worked on the Steam Yacht Aurora as a cartographer and geologist. He mapped the island and conducted a geological survey, collecting samples and descriptions and taking photographs in an unofficial capacity. This model of folding pocket camera was Kodak's first postcard format camera. The roll film allowed for easy negative development and the camera, while it certainly wouldn't fit in a coat pocket, folded down for ease of transport and storage.

OBJECT E	
Object	Box camera
Production Date	1888
Materials	Metal, leather
Description	This is an example of the first Kodak camera. The camera is made from metal and is covered in leather. It has a single lens, with lens cap, at the front and a small circular button on the left hand side. Released in 1888, this simple box camera was easy to operate and sold for $25 which, while still relatively costly at the time, allowed more people than ever to take photographs outside of formal studios. The camera was sold ready loaded with film sufficient for 100 shots. When the film was used, the entire camera was sent to the Kodak factory for processing. New film was then loaded into the camera, which was returned to the customer along with their photographs. The innovation involved in this camera was chiefly in the film. In 1884 George Eastman, founder of Eastman Kodak, developed paper-backed film which was more flexible than glass backing. He then invented roll-holders for film, allowing for easy and ample portable storage. Eastman's aim was "to make the camera as convenient as the pencil".

OBJECT F	
Object	Graflex Series B camera
Production Date	1907 - 1927
Materials	Wood, glass, paper, leather, metal
Description	Staff of the Commonwealth Prickly Pear Board used this Graflex single-lens reflex camera in their research to document prickly pear insects potentially useful for the eradication of the plant in Australia. Members of the Prickly Pear Board travelled all over North, South and Central America - wherever the prickly pear grew - and sent back the most effective insect specimens to the central receiving and quarantining station in Sherwood, Brisbane. The Graflex Series B model marks read ‘Eastman Kodak Co’ indicating that the camera was made between 1907 and 1927, so it was most likely in use in the height of the Prickly Pear Board’s research activities.

OBJECT G	
Object	View camera
Production Date	1870 - 1910
Materials	Wood, brass, metals (non-ferrous), indeterminate textiles
Description	This Thornton Pickard 'Imperial Perfecta' field camera has black leather bellows (the pleated expandable part of the camera) and a dove tailed wood case, with brass fittings. The shutter release cable has a metal handle, with rope cover. A small section of the cable has been repaired with leather, hand-sewn together. The camera runs on a monorail with an adjustable winding mechanism to allow for different focal lengths. The whole device folds up and has a leather carry handle. Thornton and Pickard were a Manchester based company that initially focussed on shutter production and then moved into making quality cameras. This camera belonged to Mr Owen Cook, who purchased it from Mr E. E. Farmer from Rockhampton in the 1930s. At the turn of the century, Mr Farmer was an avid photographer in the Rockhampton region and recorded many community moments in the region with his photographs.

OBJECT H	
Object	Kodak Brownie Six-20 camera
Production Date	1937 - 1940
Materials	Leather, nickel (metal plating), steel
Description	This Brownie camera has a black leather covering over a black painted steel body. It has a leather hand strap on one side, a shutter mechanism and a meniscus lens. The front door is hinged with one side attached to the lens and bellows (the pleated expandable part of the camera). As the cover opens, the lens is automatically advanced and the bellows unfolds. To refold the bellows and stow the lens, the mechanism is released with the lock open button. This Kodak Brownie Six-20 belongs to a collection of objects used by Maude Rose "Lores" Bonney (1897–1994), one of the great early Australian airwomen. Bonney was the first Australian woman to gain a commercial pilot licence, the first woman to fly around Australia, the first woman to fly from Australia to England, and the first person – of either gender – to fly solo from Australia to South Africa. This Six-20 Folding Brownie camera was released by Kodak Limited of the United Kingdom in 1937, the year of Bonney's flight to South Africa. It would have been useful for Bonney's travels because it could fold away, occupying less space when not in use.

OBJECT I	
Object	Trench periscope
Production Date	Pre 1916
Materials	Steel, glass
Description	This portable trench periscope consists of two steel backed and framed glass mirrors linked by two steel rods. When disassembled, the rods are stored between the mirrors, the mirrors nest together and the whole object fits into a cloth pouch. This periscope is an example of the simplest type of periscope, comprising of mirrors that allow the observer to see objects at a distance. Periscopes are instruments that are used to view something that is not in a direct line of sight. While the earliest periscopes were used to see over the heads of others at religious festivals, they were later used mainly in warfare. During the First World War they were commonly used by the troops to see around them while remaining behind shelter, thus reducing the risk of being shot. As the name suggests, trench periscopes allowed the troops to see over the walls of their trench while remaining safe from snipers. This trench periscope was owned by First World War veteran John McGuirk.

OBJECT J	
Object	Ophthalmoscope
Production Date	1940s
Materials	Metal, glass
Description	This ophthalmoscope has an ivory painted handle, an on/off switch at the top of the handle and an optical attachment clamped to the lamp which has two rotating discs. The posterior disc is connected to a third disc which has numbers on the dial. This ophthalmoscope represents the early designs of electric ophthalmoscopes, which came with their own light source rather than relying on separate light and magnifying devices. The instrument was used by medical practitioners to examine the eye. It was made in the 1940s by Keeler Optical Products, Ltd, a British company who at that time operated out of London and Philadelphia. The object was used in a medical practice on Wickham Terrace in Brisbane.

OBJECT K	
Object	X-ray tube
Production Date	Unknown
Materials	Wood, glass, steel, copper
Description	This X-ray tube consists of a large hand-blown vacuum glass tube, with four protruding glass stems. There are four electrical contacts at various points of the X-ray tube. The tube is firmly mounted on a wooden stand. In 1864, Carl Heinrich Florenz Müller, who was then 19 years old, began a small glass blowing facility in Hamburg, Germany, where he produced mainly artistic glass products, including wine glasses and "Venetian" goblets. Later, he decided to use his experience in glass making to produce other glass products, including Geissler, Hittorf and Crookes gas discharge tubes, and incandescent light bulbs. Shortly after Röntgen's announcement of the discovery of the new X-rays in January 1896, Müller began to play a prominent role in this area; he constructed the first X-ray tube in 1896 and in 1901 was awarded a gold medal for his X-ray tubes by the British Röntgen Society.

OBJECT L	
Object	X-ray tube
Production Date	1898
Materials	Glass, metal, wood
Description	This X-ray tube consists of blown glass tube with anode, anticathode and focus cathode. Electrodes are connected to soldered terminals by wires. This is an extremely rare and fine example of early X-ray technology. The cathode X-ray tube was amongst the first radiological equipment developed. The cathode, being concave, focuses an electron beam to a small spot on the anticathode, where they are absorbed. This excites atoms in the anticathode, which relax by emitting X-ray photons. X-rays emerge from the side of the tube and since they emanate from a small spot on the anticathode, X-ray images are sharp. The glass becomes discoloured due to radiation damage or metal deposits. Tubes of this kind were used in medicine and for further X-ray experimentation.

Are You on My Wavelength?

Student Activity

Electromagnetic Radiation in Museums, Galleries and Libraries

Museums, galleries and libraries use and avoid different types of electromagnetic radiation to conserve their collections. In this activity, you will identify which types of electromagnetic radiation assist with conservation and/or have damaging properties, and explain how these are used or avoided in a cultural heritage setting. Remember to record any sources of information you have referenced on the following page.

Electromagnetic radiation	**Assists with conservation (Y/N)**	**Has damaging properties (Y/N)**	**Explain how it is used and/or avoided**
Radio waves			
Microwaves			
Infrared radiation			

Electromagnetic radiation	Assists with conservation (Y/N)	Has damaging properties (Y/N)	Explain how it is used and/or avoided
Visible light			
Ultraviolet radiation			
X-rays			
Gamma rays			

Sources:

Colour My World

Teacher Resource

In this activity, students investigate how they can use light and colour to change the way things look. Students firstly explore how they can split, mix and block light in a teacher-led demonstration. They then use their knowledge and understanding of light and colour to create a coloured shadows light show inspired by a Queensland Museum Network exhibition.

Light and Colour Demonstration

Materials required to complete the demonstration include:

- White wall or white board
- Dolphin torch
- 5 x CDs
- 1 x Red LED coloured light

  1 x Green LED coloured light

  1 x Blue LED coloured light

  Please note, we only recommend using coloured cellophane to cover LED torches; the heat produced by other torches will melt the cellophane, which can result in a health and safety hazard.
- Sheets of coloured perspex or cellophane

  Various colours should be provided to allow for experimentation.
- Circles of white and black cardboard, various sizes, adhered to a stick
- Objects, such as a stand or blu-tak, to hold up the board and/or perspex/cellophane sheets in front of the wall or board

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. Gather students around a white wall, ensuring all can see the demonstration. Alternatively, set up the white board in a location where all students can see the demonstration. Turn off the lights in the classroom.

2. Shine the torch onto the wall/board. Ask students: What colour does the wall/board look?

3. Inform students that you have some objects that can change the colour of the wall/board.

Pass the objects (CDs) around to students. As the objects are passed around, ask students to discuss in pairs or threes: What do you notice about the object? How might this object change the colour of the wall/board? Why do you think this? These questions could be written on the whiteboard or pieces of butchers paper for students to refer to during this time. Ask students to return the objects. Students share their thoughts with the class. Responses and predictions could also be recorded on the white board or pieces of butchers paper.

4. Position a CD in front of the wall/board, holding the CD so that its reflective surface faces the wall/board. Shine the torch onto the reflective surface of the CD. Ask students: What do you see? Student responses may include a rainbow and the colours they see. Students may even like to count the number of different colours they see. You may need to adjust the angle of the CD and/or torch to see this effect.

5. Move the CD away from the torch. Inform students that white light is made up of each of these colours. Move the CD back in front of the torch. Inform students this object, a CD, separates white light into its component colours: red, orange, yellow, green, blue and violet.

6. Inform students that they are going to be mixing colours to see what types of different colours they can make on the wall/board. Ask students: Has anyone enjoyed mixing different colours before? What are your favourite colour combinations/mixes?

   Inform students that they can also mix colours together using light from torches and that this will give completely different results to mixing colours with paint. Show students available objects, including coloured lights, sheets of coloured perspex/cellophane and circles of black and white cardboard. Ask the students to suggest which objects they would like to investigate and how they would like to investigate the objects (i.e. the object's position in relation to the torch, wall/board and any other objects already in use).

   The following questions can be used to guide this investigation process. It is recommended that you repeat this process three to four times, investigating the effects of a new object each time. Ensure students make predictions about how each object will change the colour of the wall/board before use, share observations when the object is in use and discuss results using scientific knowledge and understanding.

   - What could we do first?
   - Let's make a prediction. What colour will the wall/board be when we shine this light/place this coloured sheet in front of the wall/board?
   - What colour is the wall/board now?
   - What else could we do? Could we add something or take something away?
   - What do you notice now? Why do you think this has happened?

7. Remove all previously used objects away from the wall/board. Show students the red, green and blue coloured lights. Ask students: What do you think will happen if we shine these three lights on to the wall/board? Shine the lights on to the wall/board and compare predictions with results.

8. Facilitate a think-pair-share discussion with students. What surprised students the most? What did students learn during the demonstration? What might students like to explore further?

Coloured Shadows

Materials required to complete the design challenge will vary. At the very least, each student group will require access to one red, one green and one blue coloured light. Such lights can be sourced from educational suppliers or can be made by covering individual torches with red, green and blue lighting gels.

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

Before introducing the design challenge, you and your students may like to explore how different cultures and professions use light and colour. For instance, students could view puppet theatre plays produced by Asian cultures, such as Wayang from Java, Indonesia or Chinese shadow puppetry, and discuss how light and colour have been used to engage and entertain audiences. Students could also investigate the use of lighting in the theatre, and how colour and light in this setting can help to create atmosphere or tell a story.

1. Introduce students to the design challenge:

   Create a light show inspired by a Queensland Museum Network exhibition. Your light show must use only red, green and blue lights, and feature six different coloured shadows!

   To better suit your classroom context, you may like to change the source of students' inspiration to support a cross-curriculum priority or other subject area learning.

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

   - Size of student groups (three to four students per group)
   - Student roles
   - Materials to complete the challenge
   - Time limit to complete the challenge

3. Divide students into groups, ensuring each student knows their individual role if assigned. Provide students with time to complete *Part 1: Coloured Shadows Design Challenge.* Additional information regarding specific aspects of the design challenge can be found below.

   Investigate

   Students identify the different coloured shadows they can make using a red, green and blue light. Ensure students use correct terminology when describing the secondary colours of light: *magenta* rather than *pink* and *cyan* rather than *light blue*. During this time, you may also like to inform students that the primary colours of light are red, green and blue. Our eyes can only detect red, green and blue light. All other colours we see, including cyan, magenta and yellow, are a mixture of these three primary colours.

Create and Test

Students explain why they observe different coloured shadows when they hold various objects in front of a red, green and blue light. While student wording may be different, an accurate explanation should include the following information:

- The three primary colours of light are red, green and blue. When red, green and blue lights are combined, we see white light.
- Light travels in straight lines. Light can be blocked to create shadows.
- In this investigation, there are three lights. Each light is in a different position. When an object blocks one or more of these lights, multiple shadows are created.
- A shadow against a white wall shows as a different colour depending on which colour of light has been blocked. If the red light source is blocked, the green and blue light will still reach the wall. When mixed, these two colours make cyan and so we see a cyan shadow. This is the same for the other light sources. When the green light source is blocked, the blue and red light will still reach the wall. When mixed, these two colours make magenta and so we see a magenta shadow. When the blue light source is blocked, the green and red light will still reach the wall. When mixed, these two colours make yellow and so we see a yellow shadow.

After completing the design challenge, students reflect on and evaluate their final design and experiences:

- What knowledge/understandings helped you make decisions about your light show?
- Are there any further changes you could make to improve the light show?
- What were the main challenges you experienced during the design process? How did you overcome these?
- What have you learnt about colour and light/the design process from this activity?
- How could you apply this knowledge and understanding to your learning in other contexts?
- What more would you like to know about colour and light?

4. Students complete *Part 2: Coloured Shadows Show*. You may wish to negotiate the duration of the coloured shadow show with students before they start this activity. Students present their coloured shadow shows to the class.

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

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE081)

Science Inquiry Skills

With guidance, pose clarifying questions and make predictions about scientific investigations (ACSIS231)

Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using equipment and materials safely and identifying potential risks (ACSIS086)

Decide variables to be changed and measured in fair tests, and observe measure and record data with accuracy using digital technologies as appropriate (ACSIS087)

Compare data with predictions and use as evidence in developing explanations (ACSIS218)

Reflect on and suggest improvements to scientific investigations (ACSIS091)

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

Design and Technologies

YEAR 5 & 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)

English

YEAR 5

Language

Understand how texts vary in purpose, structure and topic as well as the degree of formality (ACELA1504)

Literacy

Plan, draft and publish imaginative, informative and persuasive print and multimodal texts, choosing text structures, language features, images and sound appropriate to purpose and audience (ACELY1704)

Re-read and edit student's own and others' work using agreed criteria for text structures and language features (ACELY1705)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

Information and Communication Technology

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

Social management

Colour My World

Student Activity

Part 1: Coloured Shadows Design Challenge

Lighting, colour and shadow effects are commonly used in theatre and film. These effects are carefully considered by lighting designers, and are deliberately selected to engage and entertain audiences, create atmosphere or help tell a story.

Task:

Create a light show inspired by a Queensland Museum Network exhibition. Your light show must use only red, green and blue lights, and feature six different coloured shadows!

You must:

- **Investigate** how you can use red, green and blue lights to create different colours and coloured shadows.
- **Design** a light show stage that uses red, green and blue lights to create different colours and coloured shadows.
- **Create** your light show stage.
- **Test** your light show stage. Move different opaque, translucent and transparent objects in front of the lights and observe the effects.
- **Refine** your light show stage so that you can see at least six different coloured shadows when you move an object in front of the lights.
- **Collaborate** in teams of three or four.
- **Evaluate** your light show stage. Does it allow you to present a light show where we can see different colours and coloured shadows? You may also be required to evaluate social interactions and your ability to work effectively in a team.

Investigate

Describe how you created different colours and coloured shadows using the red, green and blue lights.

Design

Design a stage for your light show. How will you arrange the lights so that you can see different colours and coloured shadows? What materials will you need to construct the stage? Draw a labelled diagram of your light show stage below.

Describe how the light show stage works. Explain how you decided on the position of your lights.

Create and Test

Create your light show stage.

Test your light show stage. Describe what happens when you place an object in between the screen and lights, and then move the object towards and away from the light source. Record the object/s used and your observations below.

Describe what happens when you move an opaque, translucent and transparent object in front of the lights. Record the object used and your observations below.

a) Opaque

b) Translucent

c) Transparent

Explain your observations using your scientific understanding of light.

Refine

Refine your light show stage so that you can see at least six different coloured shadows when you move an object in front of the lights. Describe how you achieved this effect.

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 light show?
- What aspects of your light show are you very satisfied with and why?
- Describe any further changes you could make to improve the light show.
- What were the main challenges you experienced during the design process? How did you overcome these challenges?
- What have you learnt about colour and light/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 colour and light?

Part 2: Coloured Shadows Show

Create a coloured shadows show inspired by a Queensland Museum Network exhibition.

You may visit the closest Museum or research the exhibitions at Queensland Museum, The Workshops Rail Museum, Cobb+Co Museum or Museum of Tropical Queensland.

The exhibition that will provide inspiration for our coloured shadows show is:

Brainstorm any initial ideas you may have for a story. Select your best idea, and then complete the narrative story map to describe how your coloured shadows show will unfold.

Orientation	
	Materials Required
	Lighting Effects

Complication	
	Materials Required
	Lighting Effects

Series of Events	
	Materials Required
	Lighting Effects

Resolution	
	Materials Required
	Lighting Effects

Explain how you used different visual and lighting effects to tell your story, including moving objects closer and further from the light source, and the use of opaque, transparent and translucent objects.

Present your coloured shadows light show to the class. You may even like to film your coloured shadows light show to share with your school or family.

Coloured Shadows at *SparkLab, Sciencentre*

Children creating coloured shadows at the Coloured Shadows exhibit at *SparkLab, Sciencentre*.

Visit *SparkLab, Sciencentre* to create a number of coloured shadows on the white light wall.

What colours are your shadows?

How do your shadows change when you move side to side, or towards or away from the lights?

How can you make your shadows the same size as a friend or caregiver?

Find out the answers to these questions and pose your own in this interactive space!

EXPLORE

Science, Colour, Light: Community of Inquiry

Teacher Resource

In this activity, students participate in a community of inquiry to discuss why it is useful to understand colour and light from a scientific perspective, and how colour and light can help us in our daily lives. This process provides students with an opportunity to reach a deep, shared understanding of the concepts and issues underpinning the inquiry topic.

The community of inquiry is a structured, dialogic process that requires participants to ask open inquiry questions, listen and think, share ideas and consider alternative viewpoints. Problematic issues and concepts are discussed collaboratively within a supportive learning environment where all views are considered and respected. Reflecting on thinking is integral to the process.

The following engagement protocols are used during the community of inquiry process, and these should be included on the walls for all students to see.

- Listen attentively
- Build on and connect ideas
- Respect self, others and place
- Disagree reasonably and respectfully
- There may be many responses considered to be correct

Detailed step-by-step instructions for this activity can be seen below.

1. In small groups, students discuss the overarching question: **Why is it useful to understand colour and light from a scientific perspective?** The following stimulus suggestions may be shared with students if they require prompting:
    - Think about our eyes and how we see.
    - Think about our emotions.
    - Think about different technologies (such as cameras).
    - Think about reflection.
    - Think about how things appear underwater.
    - Think about how we create colours and shadows.

2. Ask students to share their responses to these questions. Record students' answers on the whiteboard or butchers paper. Record any questions posed by students on a separate page. These can be addressed at a later point in the unit.
3. Pose the next question: **How can a scientific understanding of colour and light help us in our daily lives?** Students again discuss in small groups. You may like to ask students to think about any colour and light activities they have already completed, and how learnings from these activities may apply to their daily lives.
4. Ask students to share their responses to these questions. Record students' answers on the whiteboard or butchers paper. Record any questions posed by students on a separate page. These can be addressed at a later point in the unit.
5. Keep a record of the responses to display around the room. These can be added or referred to throughout the unit.

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)

YEAR 9

Science Understanding

Energy transfer through different mediums can be explained using wave and particle models (ACSSU182)

Science as a Human Endeavour

People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE160)

Science Inquiry Skills

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)

General Capabilities

Literacy

Composing texts through speaking, writing and creating

Critical and Creative Thinking

Inquiring – Identifying, exploring and organising information and ideas

Reflecting on thinking and processes

The One That Didn’t Get Away

Teacher Resource

In this activity, students investigate the refraction of light. They explore what happens to a beam of light when it passes through transparent materials, and how refraction can affect the appearance of objects. The ways in which Indigenous cultures, including Aboriginal and Torres Strait Islander people, use scientific knowledge to accurately spear fish in fresh and salt water provides context for the latter inquiry. Explore the spears Queensland Museum has in its collection by searching 'spear' at Queensland Museum Collection Online.

Detailed step-by-step instructions, including variations for Year 5 and Year 9, can be seen below. It is recommended that you use these instructions to guide your students through the activity.

1. Begin with the ‘Bent Pencil’ experiment. View the pencil from different angles. Ask students to describe their observations, posing questions such as:
    - Where does the pencil appear to be?
    - Where is it actually?

    Ask students to take photos of the pencil from different angles, and to record their observations as a labelled diagram.

2. Using their knowledge of the properties of light, ask students to explain why this might be happening. Provide students with a scientifically accurate explanation of this phenomenon:

    Year 5

    Light is reflecting off the pencil. As light reflects off the lower (submerged) part of the pencil, it is transmitted (or passes) through water and then air.

    Light travels at slightly different speeds through different transparent materials. When light travels from one transparent material to another, the change in speed can cause light to change direction. This is called refraction.

    Let’s take another look at the pencil; as the light from the pencil passes from the water to the air, it speeds up a little and changes direction. This change in the direction of light makes the pencil appear as if it is in a different position to where it actually is when placed in water.

    Year 9

    Different materials have different optical densities. The optical density of a material affects the speed at which light is transmitted through the material. Light will travel at slower speeds though more optically dense materials, compared to less dense materials.

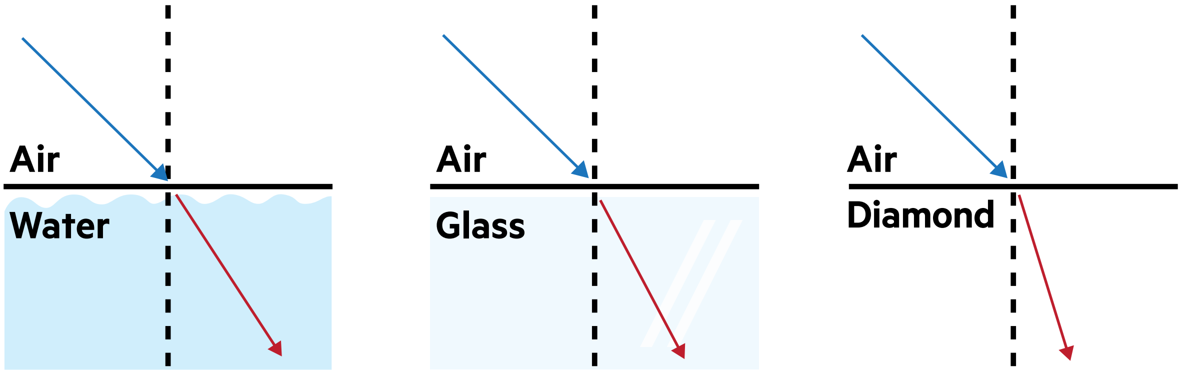
    When light passes through two transparent materials of different optical densities, it either slows down or speeds up. This change in speed may cause the light waves to change direction as it crosses the boundary between the two materials. This phenomenon is known as refraction.

    Let’s take another look at the pencil. Light waves reflecting off the submerged part of the pencil must be transmitted through water and then air before reaching our eyes. Water is denser than air; when light waves pass from water to air they speed up and change direction. This change in the direction of light makes the pencil appear as if it is in a different position to where it actually is when placed in water.

3. Students can further explore refraction by shining a thin beam of light or laser through various transparent materials, including a glass of water, ice, an acrylic or glass rectangular prism and even jelly or gelatine. Students may even change the amount of jelly or gelatine in the mixture, and observe how this affects angle of refraction. Students may also identify additional transparent materials for testing.

   NB: If using a liquid, such as ice, jelly or gelatine, we recommended the use of silicon moulds. A silicon mould will make it much easier for students to remove the liquid from its container. Alternatively, containers lined with cling wrap would also fulfil the same purpose.

   Students observe how light travels through each of the materials and, based on their observations, determine which material appears to refract, and therefore slow light the most (i.e. which material has the greatest optical density). To assist with comparison, students should ensure the light enters each material at the same angle (i.e. 40°). Denser materials will refract light towards the normal (i.e. a line perpendicular to the boundary between the two materials) compared to less dense materials.



Refraction of light waves through water, glass and diamond. Diamond has the greatest optical density of the three materials as the light ray refracts more towards the normal (dotted line) when it crosses through the air-diamond boundary.

NB: Students may find it easier to observe how light travels through each material when the classroom lights are dimmed or turned off. Ensure appropriate safety precautions are taken if lights are dimmed or turned off during this time.

Year 5

In order to assist comparisons, students could draw ray diagrams of each tested material or take a series of bird's eye photographs of how each material refracts light. Students could then view these diagrams or images side-by-side to determine which material refracts light the most, and which material refracts light the least.

Year 9

In order to assist comparisons, students can draw a ray diagram for each tested material, and then calculate the angle of refraction. As discussed previously, optically dense materials will bend light towards the normal; this will result in a smaller angle of refraction. Less dense materials will bend light away from the normal; this will result in a larger angle of refraction.

4. Ask students: **Could refraction affect how we see objects that are underwater?**
   Record students' predictions. Ensure students provide reasons for their responses.
5. Set the context of future learning by sharing the following information from the Australian Institute of Aboriginal and Torres Strait Islander Studies[1] (AIATSIS):
   "[Fishing] forms part of the deep cultural and spiritual connection many communities have with their waters and marine resources, whether saltwater or freshwater. Fishing is a matter of practice, and is informed by traditional knowledge."
   "Many Aboriginal and Torres Strait Islander peoples have a strong relationship with the oceans or inland waterways that form part of their country."
   "For thousands of years, Aboriginal and Torres Strait Islander people have used fishing to build a livelihood for themselves, their families and their communities. A catch of fresh fish provides a community with immediate subsistence and future trade and sale options, as well as employment."
   Inform students that many different peoples from around the world, including Aboriginal and Torres Strait Islander peoples, have used their knowledge of refraction to spear fish for tens of thousands of years. Students will explore how in this investigation.
6. Students work in small groups to complete *The One That Didn't Get Away: Refraction Investigation*.
   After completing the investigation, facilitate a whole-class discussion to explore students' findings. Students then complete *The One That Didn't Get Away: Design Challenge*.
   Alternatively, Year 9 teachers could ask their students to modify the experiment in order to investigate a related hypothesis or question. For example, students may investigate how increasing quantities of salt affect refraction or how other solutes (i.e. sugar) affect refraction.
7. Students apply their understanding of refraction to complete the activity, *Fishy Physics*.

1 Australian Institute of Aboriginal and Torres Strait Islander Studies. (2007). A brief history of Indigenous fishing. Retrieved from https://aiatsis.gov.au/exhibitions/brief-history-indigenous-fishing

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

Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena and reflects historical and cultural contributions (ACSHE081)

Science Inquiry Skills

With guidance, pose clarifying questions and make predictions about scientific investigations (ACSIS231)

Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using equipment and materials safely and identifying potential risks (ACSIS086)

Decide variables to be changed and measured in fair tests, and observe measure and record data with accuracy using digital technologies as appropriate (ACSIS087)

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 (ACSIS090)

Compare data with predictions and use as evidence in developing explanations (ACSIS218)

Reflect on and suggest improvements to scientific investigations (ACSIS091)

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

YEAR 9

Science Understanding

Energy transfer through different mediums can be explained using wave and particle models (ACSSU182)

Science Inquiry Skills

Formulate questions or hypotheses that can be investigated scientifically (ACSIS164)

Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS165)

Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately (ACSIS166)

Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies (ACSIS169)

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS170)

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS171)

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)

Mathematics

YEAR 9

Measurement and Geometry

Apply trigonometry to solve right-angled triangle problems (ACMMG224)

Design and Technology

YEAR 5 & 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)

YEAR 7 & 8

Design and Technologies: Knowledge and Understanding

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)

Generate, develop, test and communicate design ideas, plans and processes for various audiences using appropriate technical terms and technologies including graphical representation techniques (ACTDEP036)

Select and justify choices of materials, components, tools, equipment and techniques to effectively and safely make designed solutions (ACTDEP037)

Curriculum Links

YEAR 9 & 10

Design and Technologies: Knowledge and Understanding

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

Design and Technologies: Processes and Production Skills

Critique needs or opportunities to develop design briefs and investigate and select an increasingly sophisticated range of materials, systems, components, tools and equipment to develop design ideas (ACTDEP048)

Develop, modify and communicate design ideas by applying design thinking, creativity, innovation and enterprise skills of increasing sophistication (ACTDEP049)

Work flexibly to effectively and safely test, select, justify and use appropriate technologies and processes to make designed solutions (ACTDEP050)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

Information and Communication Technology

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 management

Cross-Curriculum Priorities

Aboriginal and Torres Strait Islander Histories and Cultures

Aboriginal and Torres Strait Islander Peoples have holistic belief systems and are spiritually and intellectually connected to the land, sea, sky and waterways. (OI.3)

Aboriginal and Torres Strait Islander Peoples' ways of life are uniquely expressed through ways of being, knowing, thinking and doing. (OI.5)

The One That Didn't Get Away

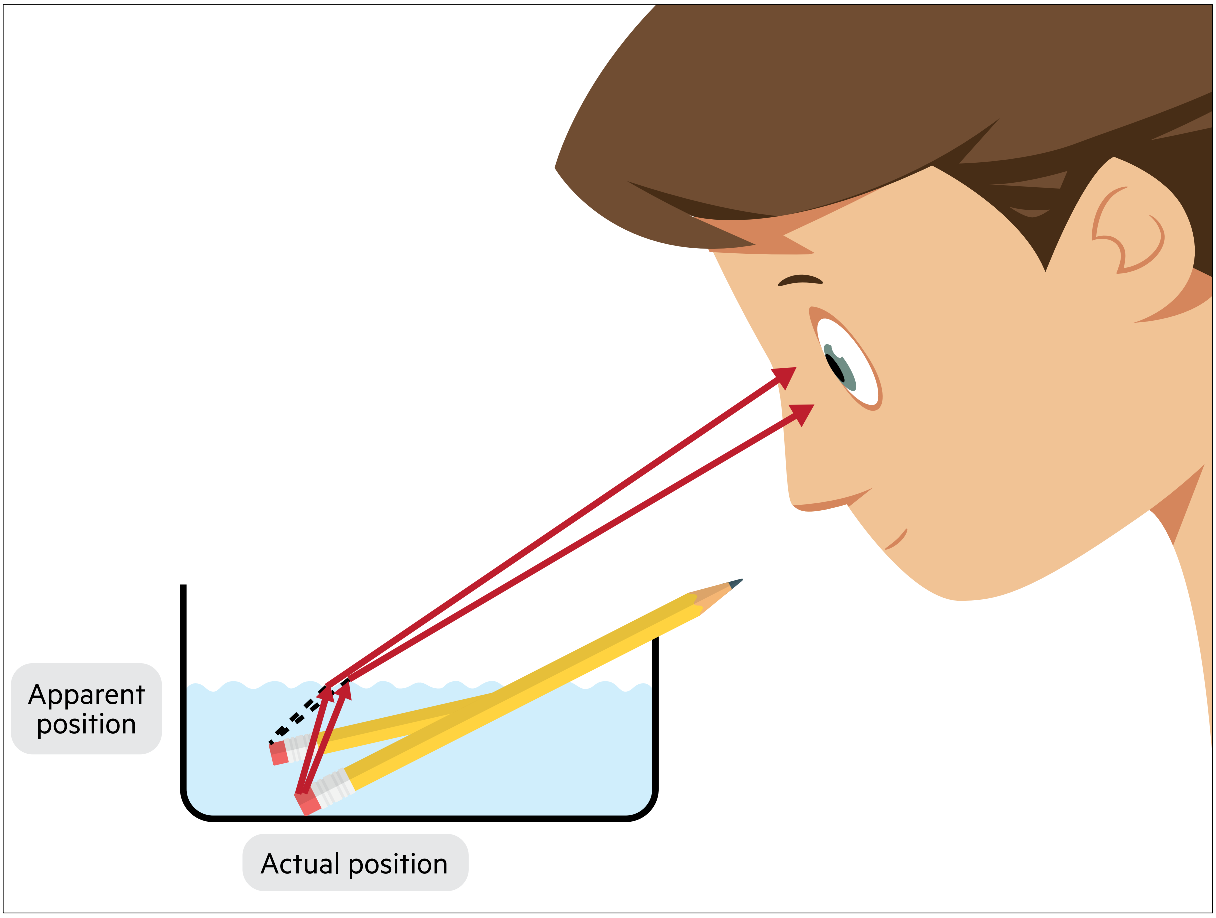
Student Activity

Refraction: Year 5

Light is reflecting off the pencil. As light reflects off the lower (submerged) part of the pencil, it is transmitted (or passes) through water and then air.

Light travels at slightly different speeds through different transparent materials. When light travels from one transparent material to another, the change in speed can cause light to change direction. This is called refraction.

Let's take another look at the pencil; as the light from the pencil passes from the water to the air, it speeds up a little and changes direction. This change in the direction of light makes the pencil appear as if it is in a different position to where it actually is when placed in water.



Refraction of light waves from water to air.

The One That Didn't Get Away

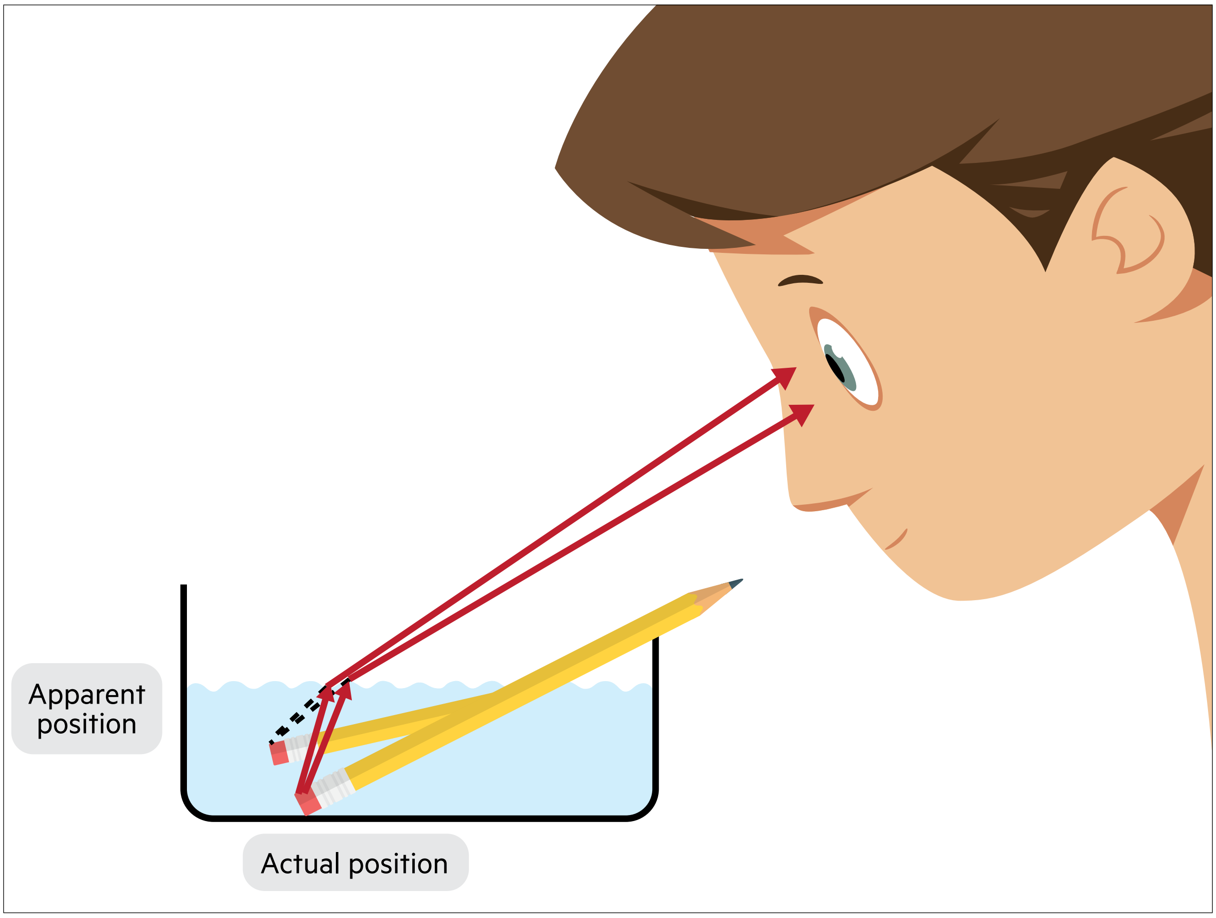
Student Activity

Refraction: Year 9

Different materials have different optical densities. The optical density of a material affects the speed at which light is transmitted through the material. Light will travel at slower speeds though more optically dense materials, compared to less dense materials.

When light passes through two transparent materials of different optical densities, it either slows down or speeds up. This change in speed may cause the light waves to change direction as they cross the boundary between the two materials. This phenomenon is known as refraction.

Let's take another look at the pencil. Light waves reflecting off the submerged part of the pencil must be transmitted through water and then air before reaching our eyes. Water is denser than air; when light waves pass from water to air they speed up and change direction. This change in the direction of light makes the pencil appear as if it is in a different position to where it actually is when placed in water.



Refraction of light waves from water to air.

The One That Didn't Get Away

Student Activity

Refraction Investigation

People from around the world, including Aboriginal and Torres Strait Islander people, have used their knowledge of refraction to spear fish for tens of thousands of years. In this investigation, you will explore how refraction affects the way we view objects that are underwater.

Materials

- 3 x transparent rectangular 2.5L containers
- 600 g coloured modelling clay
- 15 g black modelling clay
- Toothpick, cut into thirds
- 4 L water
- 70 g table salt
- Rolling pin
- Teaspoon
- Scale
- Bamboo skewer
- Extension activity materials:
    - o Laser pointer, <1 mW
    - o Ruler
    - o Fine tip marker

Method

1. Divide the coloured modelling clay into thirds. Use the rolling pin to roll out each portion of clay until it is a similar size to the base of the containers. Place one piece of clay into each container.

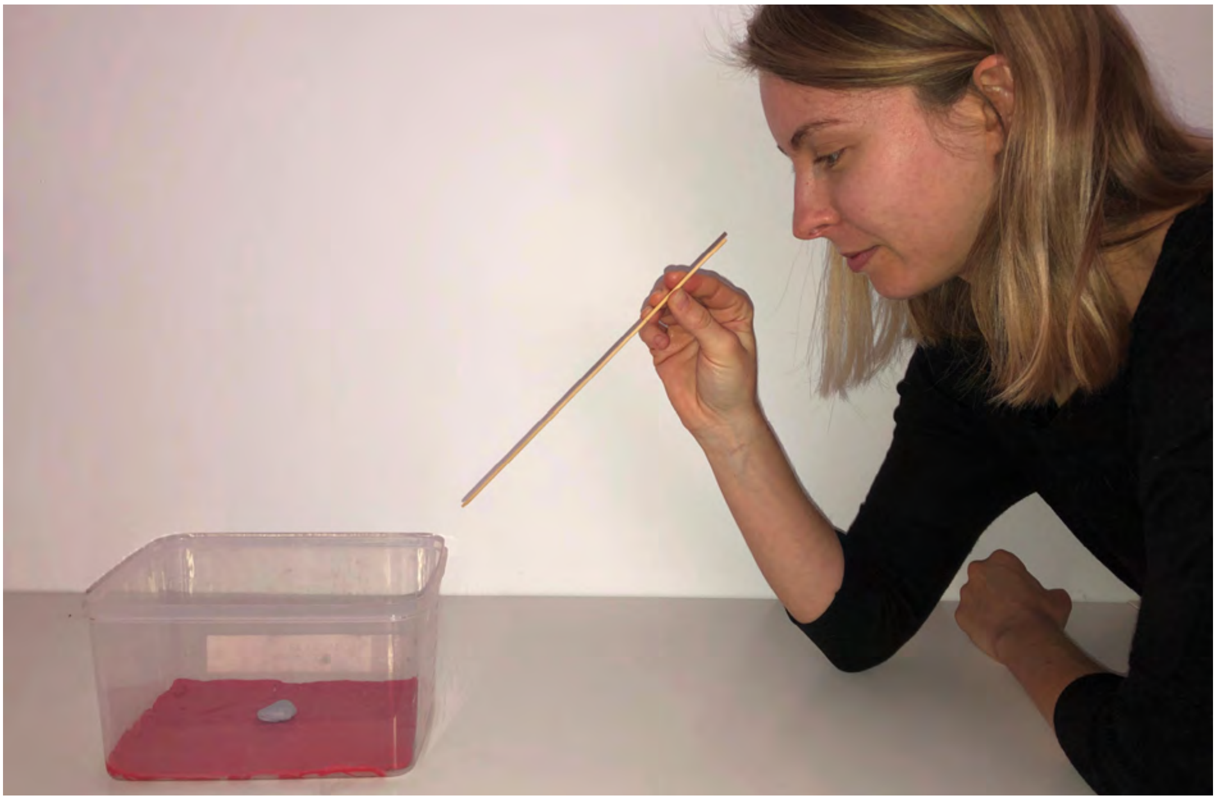
2. Divide the black modelling clay into thirds. Roll each portion of clay into the shape of a fish. Use one third of a toothpick to attach one model fish to the bottom of each container.

3. Fill one container with 2 L of water.

4. Fill another container with 2 L of water. Add 70 g salt to the water. Stir to dissolve the salt.

5. Place the containers in a row, with the empty container on the left, the container filled with water in the middle, and the container filled with salt water on the right. Leave the containers overnight.

6. Start with the empty container. Carefully aim the skewer at the middle of the fish from the edge of the container. Make sure you hold the skewer at an angle, at least 5 cm above the container. Look directly above the skewer before you spear the fish.



An example of how to aim the skewer at the fish.

7. Try to spear the fish in the middle. Repeat five times. Record your observations and results.

8. Repeat Steps 6 and 7 with the remaining two containers. Record your observations and results.

9. Return to the fresh and salt water containers. Adjust your aim so that you successfully spear the fish in each container. Take note of where you need to aim the skewer in order to successfully spear the fish, and then move on to discussing your results.

Variables

Record the variables in the table below.

Independent variable	Dependent variable	Control variable

Results

1. Record your observations. Describe where your spear landed in relation to the fish.

No Water	Fresh Water	Salt Water

2. Remove the modelling clay from the containers. Record the strike distance from the fish for each test, and then represent this data on a Cartesian plane.

Strike Distance from Fish: No Water

Attempt	Hit	Miss	Distance (cm)	
			X axis	Y axis

Strike Distance from Fish: Fresh Water

Attempt	Hit	Miss	Distance (cm)	
			X axis	Y axis

Strike Distance from Fish: Salt Water

Attempt	Hit	Miss	Distance (cm)	
			X axis	Y axis

3. Use the above data to calculate the percent accuracy for each test.

Percent Accuracy

No Water	
Fresh Water	
Salt Water	

Discussion

1. Draw a ray diagram to show how light travels from the fish to our eyes. Use your understanding of light to explain what is happening in each test.

No Water

Ray Diagram	Explanation

Fresh Water

Ray Diagram	Explanation

Salt Water

Ray Diagram	Explanation

2. Which test yielded the most accurate results? Explain why this is the case, and how these results may differ in a real world context.

The refraction of light can change where an object appears visually. You can investigate how different materials affect the refraction of light in the online simulations: Bending Light by PhET Interactive Simulations or Refraction Interaction by The Physics Classroom.

Evaluation

1. Describe any challenges you experienced during the investigation.

2. Explain how you could improve the investigation.

Extension

Calculate the angle of refraction for fresh and salt water using a laser pointer and the appropriate trigonometric ratio (i.e. sine, cosine or tangent). Draw a diagram, and then record your working out and results below. *Hint: Your teacher may turn the lights off in the classroom to make it easier to see the laser beam.*

The One That Didn't Get Away

Student Activity

Design Challenge

Task:

Design a device that helps people account for refraction when fishing in salt water. People using the device should not need to adjust their aim in order to spear the fish.

You must:

- **Investigate** how light travels through water and where a person should aim if they are to spear a fish in salt water.
- **Design** a device that will help a person account for refraction when fishing in salt water. The person using the device should not need to adjust their aim in order to hit the fish.
- **Create** a model of your device.
- **Test** the model by simulating spear fishing in salt water. How could you test the effectiveness of your device?
- **Refine** your device to improve on the original design.
- **Collaborate** in teams of two.
- **Evaluate** your design. You may also be required to evaluate social interactions and your ability to work effectively in a team.

Investigate and Design

Draw a labelled diagram of your device, including reasons for your design and selection of materials.

Create and Test

Test the device and record the results in the PMI Chart below.

Plus	**Minus**	**Interesting**

Refine

Recommend future changes that could improve the effectiveness of the device.

The One That Didn't Get Away

Student Activity

Fishy Physics

Archerfish are a family of freshwater and estuarine fishes. Four species of archerfish are found in Australia; two of these species, the Banded Archerfish (*Toxotes jaculatrix*) and Seven-spot Archerfish (*Toxotes chatareus*) are found in the mangrove swamps, freshwater rivers and streams of North and Far North Queensland.

Banded Archerfish, *Toxotes jaculatrix*. © Queensland Museum, Bruce Cowell

Archerfish feed mainly on terrestrial and aquatic insects, but also on other small fish, crustaceans and floating plant matter. Archerfish have developed a unique ability to feed on terrestrial insects. When an archerfish spots an insect, it carefully aims and spits a jet of water. This jet of water has enough force to knock the insect into the water, where it is quickly consumed by the archerfish. You can check out a video of the archerfish in action here or by searching for 'archerfish spitting' videos on the internet. While most archerfish are able to spit distances of up to 150 cm, some larger specimens can spit water that spans a distance of 2 – 3 metres!

In order to successfully catch prey, archerfish must accommodate for the refraction of light at the surface of the water. Use your scientific understanding of refraction and light to answer the following questions.

1. Hypothesise how archerfish experience refraction. You may like to draw a ray diagram to help communicate your ideas.

2. Explain the adaptations that have enabled this animal to accommodate for refraction. These adaptations may be structural, functional or behavioural. You may also like to conduct further research to answer this question.

3. Describe any other challenges the archerfish may experience when catching its prey. Explain how the animal might overcome these challenges.

4. These animals also experience refraction:

    - Giant Trevally, *Caranx ignobilis*
    - Caspian Tern, *Hydroprogne caspia*
    - Eastern Osprey, *Pandion cristatus*

    Select an animal to research further. Describe how this animal experiences refraction, and explain how they have accommodated for this phenomenon. You can view these animals and learn more about their habitats in *Wild State* at Queensland Museum.

EXPLORE – EXPLAIN

The Colour of Life

Teacher Resource

There are millions of species of animal on Earth, and they display incredible diversity in size, shape and colour. In this activity, students will look at images of animals to facilitate a discussion about why animals display different colours, and make predictions about the purpose of colour.

Generally, animals display colours that help them survive in certain environments. Some animals are brightly coloured, while others blend into their environment. There are many reasons animals have evolved colours including camouflage, physical protection, temperature regulation, sexual selection and signalling, and warning, startling or dazzling predators.

While most colouration serves a specific purpose, scientists still do not know why some species are the colours they are.

For this activity, hand out the *Colour of Life Images* to pairs or groups of three students. You can then follow the See-Scan-Analyse scaffold for image analysis.

See:	View the image. What is shown in the picture?
Scan:	Look closely at the image. What colour is the animal?
	What habitat might your animal live in?
Analyse:	What does your animal use colour for?
	How might the colour of your animal help it survive?

Following this activity, you may wish to allow time for students to research the purpose of colour in animals. Scientists still do not know the purpose of some colours in animals, and students could research an animal species and write a persuasive essay to justify the reasons for the animal's colour. Some examples of colourful animals your students could research include:

- Christmas Beetle
- Blue Morpho Butterfly
- Chameleon
- Coral
- Parrot Fish
- Gouldian Finch

Curriculum Links

Science

YEAR 5

Science Understanding

Living things have structural features and adaptations that help them to survive in their environment (ACSSU043)

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

Science Inquiry Skills

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

YEAR 9

Science Understanding

Energy transfer through different mediums can be explained using wave and particle models (ACSSU182)

Science Inquiry Skills

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)

General Capabilities

Literacy

Composing texts through speaking, writing and creating

The Colour of Life

Student Activity

Animals have feathers, fur, exoskeletons, scales and skin that reflect different visible light waves, to appear different colours. Some animals blend in with their habitats, while others display incredibly bright colours in contrast to their environment.

When a particular colour helps an animals survive, the colour is passed onto their offspring. There are many reasons why animals have evolved different colours.

In this activity you will observe images of different animals and discuss:

- What is the colour used for?
- How does the colour help the animal survive?

Koala, *Phascolarctos cinereus*. © Queensland Museum, Gary Cranitch

Stag beetle, *Lamprima species*. © Queensland Museum, Gary Cranitch

Common Crow, *Euploea corinna*, larva. © Queensland Museum, Jeff Wright

Tawny Frogmouth, *Podargus strigoides*. © Queensland Museum, Gary Cranitch

Rose-crowned Fruit-dove, *Ptilinopus regina*. © Queensland Museum, Gary Cranitch

Butter Bream, *Monodactylus argenteus*.

Redback Spider, *Latrodectus hasseltii*, female. © Queensland Museum, Bruce Cowell

Clown Triggerfish, *Balistoides conspicillum*. © Queensland Museum, Gary Cranitch

Variegated Fairy-wren, *Malurus lamberti*, female. © Queensland Museum, Gary Cranitch

Variegated Fairy-wren, *Malurus lamberti*, male. © Queensland Museum, Bruce Cowell

Graceful Treefrog, *Litoria gracilenta*. © Queensland Museum, Gary Cranitch

Australian Pelican, *Pelecanus conspicillatus*. © Queensland Museum, Ray Viljoen

Mandrill, *Mandrillus sphinx*.

Blue-lined Octopus, *Hapalochlaena fasciata*. © Queensland Museum, Gary Cranitch

Fiddler Beetle, *Eupoecila australasiae*. © Queensland Museum, Jeff Wright

Mauve Stinger, *Pelagia noctiluca*. © Queensland Museum, Merrick Ekins

Ornate Bat-winged Sea Slug, *Sagaminopteron ornatum*. © Queensland Museum, Gary Cranitch

Tortoise Beetle, *Aspidimorpha (Aspidimorpha) westwoodi*, adult. © Queensland Museum, Jeff Wright

Robust Velvet Gecko, *Nebulifera robusta*. © Queensland Museum, Jeff Wright

Orchard swallowtail, *Papilio (Princeps) aegeus aegeus*, adult. © Queensland Museum, Jeff Wright

Common Death Adder, *Acanthophis antarcticus*, tail spur. © Queensland Museum, Jeff Wright

Common Grass Pyrgomorph, *Atractomorpha similis*, adult. © Queensland Museum, Jeff Wright

EXPLORE – EXPLAIN – ELABORATE

Light and a Feather: Investigating Colour

Teacher Resource

In this inquiry activity students will investigate feathers of different colours to recognise that not all colours are created equal.

Colour in animals can come from pigments, bioluminescence and structural colour. Students will investigate examples of pigments and structural colour to make observations, identify the different properties, and sort feathers into two groups – colours from pigments and structural colour.

It is important to include specimens that use structural colour. Peacock feathers and other natural blue feathers use structural colour, however many feathers from craft stores may be synthetically dyed. Peacock feathers are recommended because the green tail feathers around the eye use green structural colour and brown pigments, so show a dramatic colour change when underwater and covered in oil. You can also show students how feathers that have already been in oil do not show further colour change underwater because their structures are already disrupted. Peacock feathers can be purchased from craft stores. Students may also be happy to bring in feathers that have been naturally dropped from pets (blue and green Budgerigar feathers use structural colour) or found in the environment. Goose, duck, chicken and turkey feathers can also be purchased from most craft stores. Dyed feathers are effective in showing the properties of pigments.

Peacock feathers also have a strong historical connection – Robert Hooke, Isaac Newton and Thomas Young all investigated the iridescence of peacock feathers when studying light.

Students should work on this investigation in pairs or groups of three. You may ask your students to take photos of their results and label these photos to describe their observations. These can also be shared with the class to compare results.

Curriculum Links

Science

YEAR 5

Science Understanding

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

Science Inquiry Skills

Identify, plan and apply the elements of scientific investigations to answer questions and solve problems using equipment and materials safely and identifying potential risks (ACSIS086)

Decide variables to be changed and measured in fair tests, and observe measure and record data with accuracy using digital technologies as appropriate (ACSIS087)

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 (ACSIS090)

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

YEAR 9

Science Understanding

Energy transfer through different mediums can be explained using wave and particle models (ACSSU182)

Science Inquiry Skills

Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS165)

Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately (ACSIS166)

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Composing texts through speaking, writing and creating

Personal and Social Capability

Social management

Light and a Feather: Investigating Colour

Student Activity

Colour in nature serves many purposes – including camouflage, attracting a mate, warning predators, mimicry, physical protection and temperature regulation.

The Queensland Museum has many incredible animal species that display some spectacular colours. Look at the coloured living things in *Wild State* and the *Discovery Centre*. Observe the animals in the collection. Can you identify why these animals are the colours they are? Look for the brightest colours; what do you notice about these colours and organisms?

Aim

In this activity you will investigate the reflection, refraction and absorption of light on different feathers to explore the properties of colour.

You will have pairs of feathers so one feather of each pair can act as the control and is not changed.

Materials

- 4 pairs of feathers (e.g. 2 x peacock feathers, 2 x rooster feathers etc.)
- Torch
- Pipette
- Water
- 500 mL beaker or other transparent container
- Vegetable oil (or any clear oil)

Method

Make observations of each feather.

- What colour is the feather?
- Move it around in your hand.
- Shine light on the feather.
- Shine light through the feather.
- Place the feather underwater. Compare with the dry 'control' feather.
- Pour some oil on one feather. Compare with the dry 'control' feather.

Record your observations in the table below.

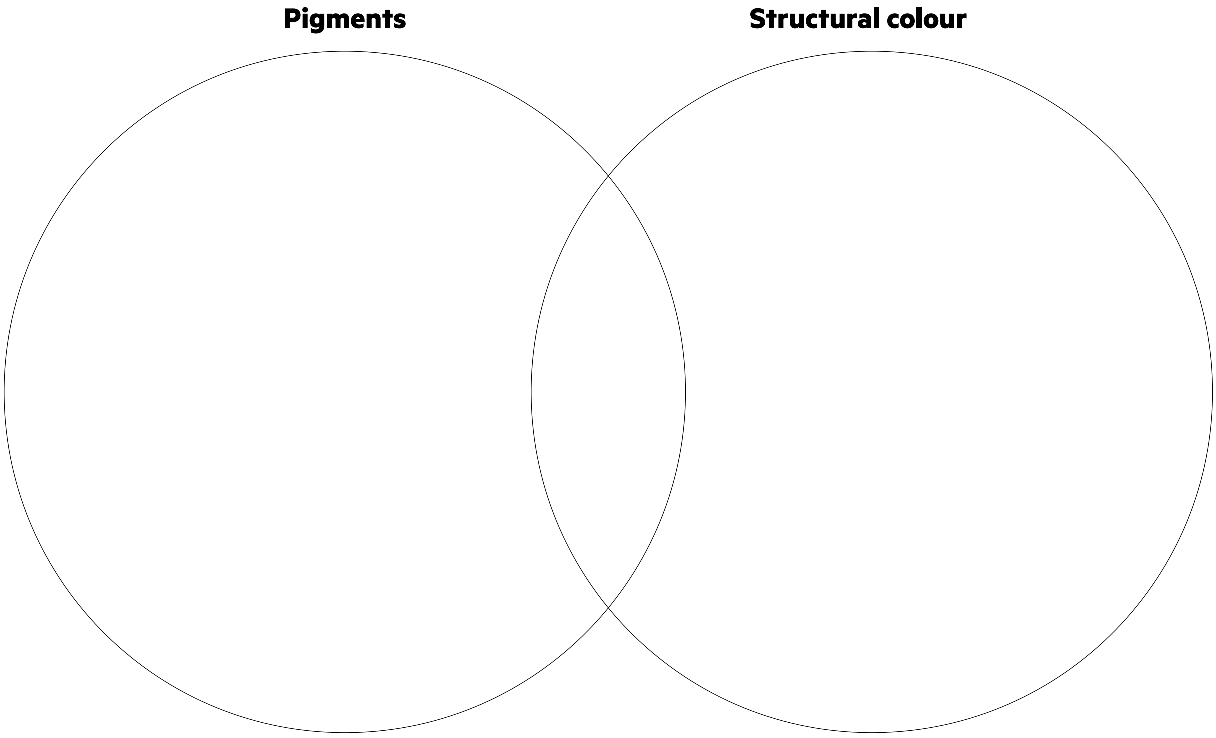
Feather name.				
Colour of the feather.				
Move the feather around in your hand. **Describe your observations.**				
Shine a light on the feather. What colour does it appear?				
Shine a light through the back of the feather. What colour does it appear?				
Place the feather underwater. What colour does it appear?				
Pour some oil on the feather. What colour does it appear? What do you notice?				
Record any additional observations.				

Questions

Describe how light interacts with each feather.

Group the feathers according to the interactions with light.

Read *Where does colour come from?* Group the feathers into pigments, structural colour or both.



Explain how you chose these groups.

Where does colour come from?

In nature, colours come from three main sources: pigments, bioluminescence and structural colour.

Pigments

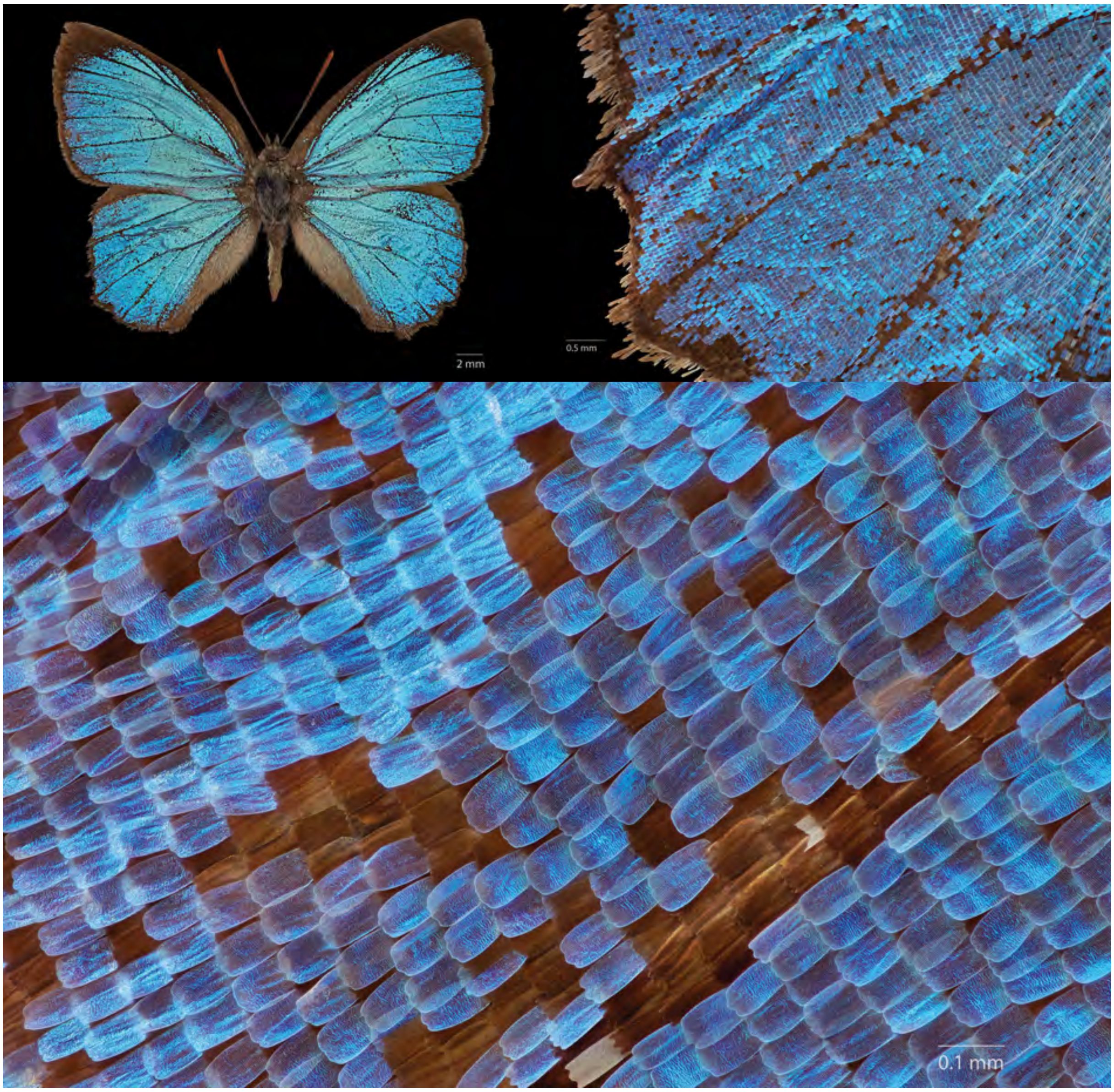
Pigment molecules selectively absorb every wavelength of light, except for the colour that we see. Pigments are the most common source of natural colour; some living things create pigments, while others take pigments from food and so it is the animal's diet which causes them to change colour. Pigments can slowly fade over time, causing specimens coloured by pigments to fade.

(a) The human body produces many pigments including melanin. Different skin, hair and eye colours are produced by different amounts of melanin. (b) Chlorophyll, used for photosynthesises, is a pigment in plants that reflects green light and absorbs all other colours, causing plants to appear green. ©Queensland Museum, Gary Cranitch. (c) Pink flamingos are born light grey. They eventually turn pink from pigments called carotenoids which are found in their food. Carotenoid pigments (specifically beta-carotene) are also found in carrots and pumpkin. These can turn human skin orange if consumed in large quantities.

Structural Colour

Structural colour is produced by structures such as scales or ridges which refract and reflect certain wavelengths of light – similar to a prism. When light hits the ridges interference occurs, reinforcing certain wavelengths while cancelling out others. This is how our eyes perceive the brilliant colours of many beetles, birds and butterflies.

Almost all of the blue in nature is due to structural colour. The vibrant blue wings of the Ulysses Butterfly are an excellent example of this. Instead of being coated with a pigment, the butterfly wings are coated with tiny scales which reflect blue light, and interfere with all other visible light.

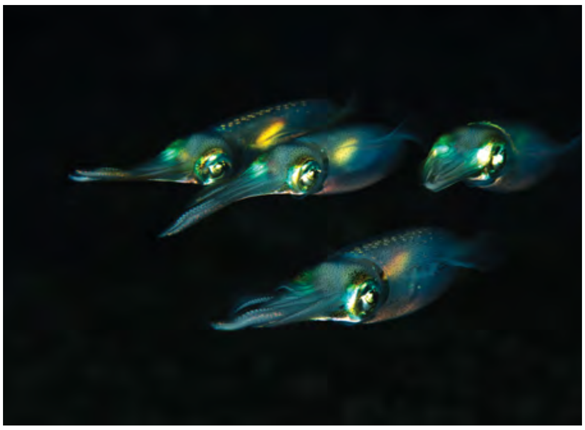


The wings of the Ulysses Butterfly appear blue due to the ridges on the wings reflecting blue wavelengths of light. © Queensland Museum, Geoff Thompson.

Bioluminescence

Bioluminescence occurs when living things produce and emit light through chemical reactions. Fireflies and glowing mushrooms use bioluminescence, as do many deep sea creatures that live where sunlight does not penetrate.

Bioluminescent squid in Indonesia (right).



EVALUATE

Reflecting on Colour and Light: Community of Inquiry

Teacher Resource

In this activity, students participate in a community of inquiry to review and reflect on learning and new understandings and skills. This process provides students with an opportunity to reach a deep, shared understanding of the concepts and issues underpinning the inquiry topic.

The community of inquiry is a structured, dialogic process that requires participants to ask open inquiry questions, listen and think, share ideas and consider alternative viewpoints. Problematic issues and concepts are discussed collaboratively within a supportive learning environment where all views are considered and respected. Reflecting on thinking is integral to the process.

The following engagement protocols are used during the community of inquiry process, and these should be included on the walls for all students to see.

- Listen attentively
- Build on and connect ideas
- Respect self, others and place
- Disagree reasonably and respectfully
- There may be many responses considered to be correct

In small groups, students discuss the following questions. Students then share their responses with the larger group; students should be encouraged to give reasons for their answers. You may like to record students' answers on a whiteboard or butchers paper.

- What more do we understand about colour and light?
- In what ways did our community assist us to gain new understandings?
- How can we apply these new understandings to the ways in which we interact with our world?
- What more would we like to know as individuals/as a community?

Curriculum Links

Science

YEAR 5

Science Understanding

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

Science Inquiry Skills

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YEAR 9

Science Understanding

Energy transfer through different mediums can be explained using wave and particle models (ACSSU182)

Science Inquiry Skills

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)

General Capabilities

Literacy

Composing texts through speaking, writing and creating

Critical and Creative Thinking

Reflecting on thinking and processes

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