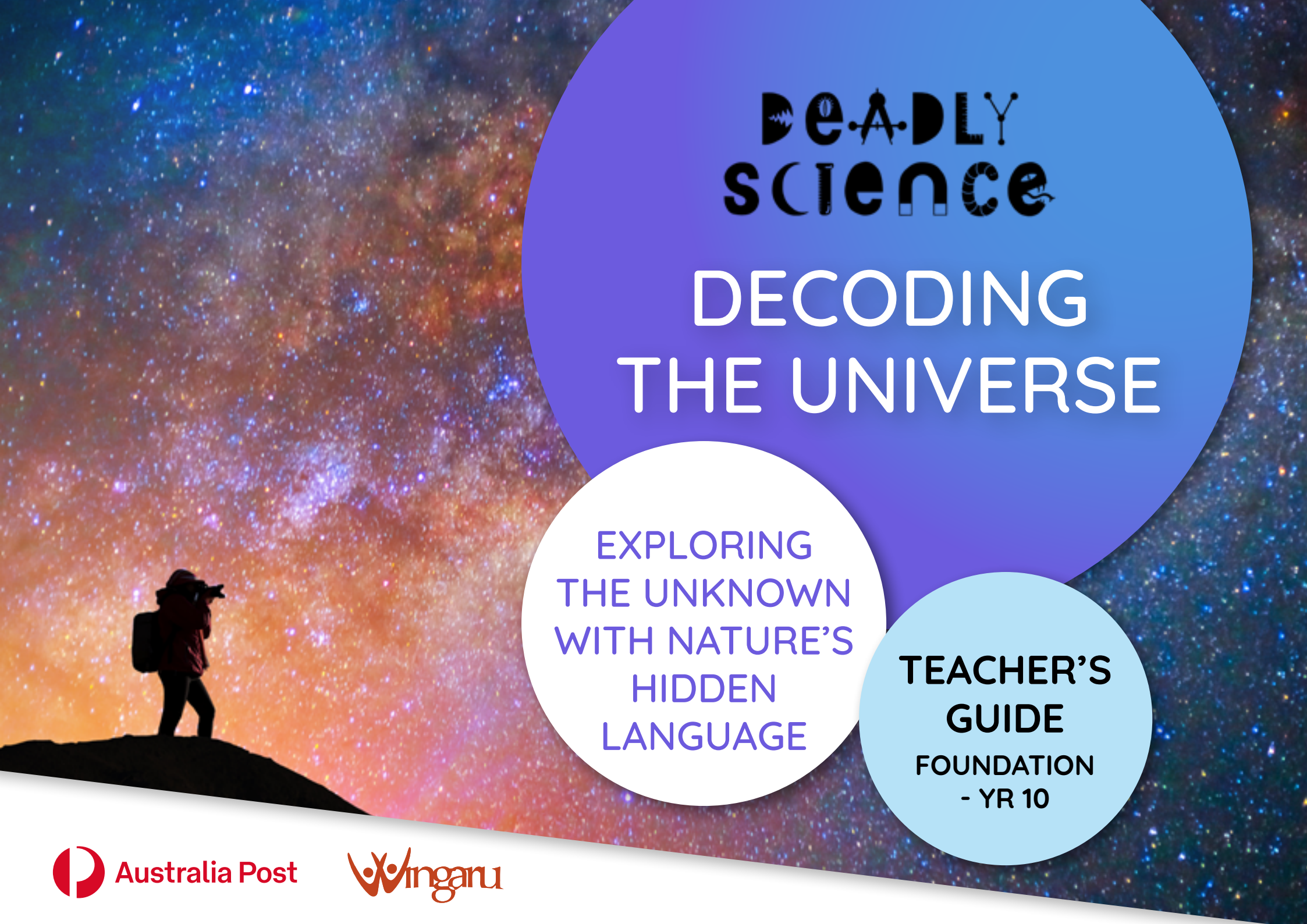

DEADLY SCIENCE

DECODING THE UNIVERSE

EXPLORING THE UNKNOWN WITH NATURE'S HIDDEN LANGUAGE

TEACHER'S GUIDE

FOUNDATION - YR 10

Australia Post

Wingaru

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BE-A-DLY science

Australia Post

Wingaru

ACKNOWLEDGMENT OF COUNTRY

DeadlyScience, Australia Post and Wingaru Education pay respect to the Traditional Custodians of the land, to all Elders past and present, and to First Nations people everywhere. First Nations people have used science for over 65,000 years, making their culture the oldest in the world. The first scientists passed on the lessons of the land, sea and sky to the future scientists of today, through stories, song and dance. We call this caring for Country; if you care for Country, Country will care for you.

INTRODUCTION

It is really deadly to hear that the 2025 National Science Week's school theme is **Decoding the Universe – Exploring the unknown with nature's hidden language**. As explained by the National Science Week team - "This theme encourages exploration of the fundamental languages of nature, including mathematics and quantum science, and how they relate to both the natural world and modern technologies.

Also, this theme is particularly relevant as it coincides with the 2025 United Nations International Year of Quantum Science and Technology and the 2025 International Mathematical Olympiad being hosted in Australia. It aims to inspire and engage students by exploring the science behind natural patterns, codes, signals, and systems, from DNA and animal communication to weather patterns and astronomical observation."

For over 65,000 years, Aboriginal and Torres Strait Islander peoples have drawn on deep knowledge systems grounded in quantum-like and complex mathematical understandings of the natural world. This practice is known as the First Scientifical of this continent, now known to Australia post-colonisation.

This rich tradition continues today, passed down from generation to generation through story, observation, and practice. Thanks to this 2025 Science Week Teaching Guide, you will learn and explore knowledge, perspectives and wisdom from Aboriginal and Torres Strait Islander people and how this knowledge has changed and adapted over time, what still remains today and will likely remain well into the future.

Corey

Corey Tutt OAM
CEO, Founder of DeadlyScience

"Mathematics is holistic, a set of interwoven concepts, seen through patterns and cycles within the natural environment."

Quandamooka man, Professor Chris Mathews
Associate Dean (Indigenous Leadership and Engagement) in the Science Faculty, University of Technology Sydney (UTS)

DEADLY SCIENCE Australia Post Wingaru

ABOUT THIS GUIDE

As the first scientists of Australia, First Nations people throughout this land have an enduring connection to Country. Theirs is an innate understanding of the seasons, weather, animals, plants and ecosystems of the continent, collected, remembered and passed down through the generations. It is a rich lore, an embedded understanding of how to help Country not just survive – but thrive.

The lessons in this guide are designed to inspire students to learn more about First Nations people and their connection to Country, as well as their millennia-rich history of decoding nature's hidden language into mathematical and scientific principles that underpin the natural world.

It is anticipated classes will build connections with local First Nations communities and connect with local Aboriginal and Torres Strait Islander people and organisations who can help the class develop a deeper understanding of the interconnectivity that exists in the natural world, the scientific and mathematic principles that are embedded within this, and an ability to decode meaning from everyday life.

TEACHER NOTES

Use a map, such as the Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) Map of Indigenous Australia, to teach students about the Traditional Custodians of the land on which they live, learn and play. Explain there are over 500 distinct First Nations cultural and language groups across Australia.

Introduce students to the concept of a 'yarning circle', which is something used in many First Nations communities as a way to share knowledge, ideas and points of view. It's an engaging, fun and safe place for students and teachers to be heard and to have opinions. You can read more about yarning circles on page 8 of this Teacher's Guide.

Begin each lesson with an Acknowledgement of Country to respectfully recognise the Traditional Custodians of the land, sea, waterways and sky of your area. Discuss the meaning an Acknowledgement of Country provides as an opportunity to introduce the themes of the lessons, including custodianship, respect and connection to Country.

LESSON OVERVIEW | INTRODUCTION

The **DeadlyScience Guide to Decoding the Universe: Exploring the unknown with nature's hidden language** is a practical and fun resource for teachers of Foundation to Year 10 learners. It champions the importance of science and mathematics in decoding the world around us, through the lens of Australia's First Nations people.

Developed in partnership with **Australia Post, DeadlyScience** and **Wingaru Education,** this guide is Australian Curriculum-aligned and strongly features the cross-curriculum priority of Aboriginal and Torres Strait Islander Histories and Cultures. Each lesson reflects the ongoing STEM practices of Aboriginal and Torres Strait Islander people as part of caring for Country, and how these ideas are intrinsically part of understanding the environment we exist within.

First Nations cultures maintain cultural practices that embed understanding, respect and connections between land, water and sky. This interconnectedness is the basis to a rich and enduring mathematical and quantum knowledge, passed down through generations. Seasonal calendars, navigation via astronomy, and ratio-based sustainable land management are just some examples of an ancient and ongoing capacity to 'decode' and work collaboratively with Country.

Decoding the Universe will empower educators to inspire and engage students by exploring the mathematics and quantum science that underpin both the natural world and the modern technologies we use every day – from photosynthesis to satellite navigation – from a First Nations perspective.

WHAT IS QUANTUM SCIENCE?

Quantum science studies the behaviour of matter and energy at the smallest scales: quantum mechanics, quantum particles, quantum physics – the list is long. In fact, quantum science is used in a wide array of everyday applications: the semiconductors in computer chips, fibre optics that transmit information via the internet, and MRI machines that scan your body are all examples.

Looking towards the future, quantum technology (commonly referred to as 'quantum tech') is all about creating new ways to model, compute, decode and sense the world. Quantum communications for example, applies quantum physics to securely encode and transmit information; nanofabrication is the fabrication of circuits and other devices on a nanometric scale; and quantum algorithms enable AI (Artificial Intelligence) to develop more powerful machine learning.

LESSON OVERVIEW

Year	Lesson Overview	Australian Curriculum V9 links	
		Learning area: Science	Cross-curriculum priority: Aboriginal and Torres Strait Islander Histories and Cultures
F	**IDENTIFYING PATTERNS IN NATURE**		
	Introduce students to patterns found in nature, including animal tracks, the structure of plants, and constellations in the skies. Understanding how First Nations Australians use these patterns, and understood changing patterns to hunt and harvest, to predict the weather and to navigate, as well as how patterns are used in storytelling.	AC9SFU01 AC9SFH01 AC9SFI02	A_TSICP1
1-2	**COUNTING + GROUPS**		
	Introduce students to Aboriginal and Torres Strait Islander cultural counting practices such as body tallying and explore grouping concepts for First Nations people across Australia, investigating the cultural practices behind different counting and grouping techniques.	AC9S1I03 AC9S2I03 AC9M1N01	A_TSIC2

Year	Lesson Overview	Australian Curriculum V9 links	
		Learning area: Science	Cross-curriculum priority: Aboriginal and Torres Strait Islander Histories and Cultures
3-4	**SYMMETRY IN TOOLS + PRACTICES**		
	Investigate the symmetrical shapes of First Nations tools such as boomerangs, woomera and shields, and encourage students to consider the practical and cultural reasons for these designs. Investigate how Aboriginal and Torres Strait Islander people refine the principles of engineering symmetry into everyday tools. Investigate distance and flight patterns of different shaped boomerangs and analyse the variables involved, including weight, density and material.	AC9S3H02 AC9S3I03 AC9S4H02 AC9S4I03	A_TSICP1 A_TSIC2
5-6	**SKY NAVIGATION**		
	Investigate how First Nations Australians use astronomical patterns and movements for navigation, seasonal change and migration patterns. Understand the many and varied cultural meanings attributed to night-sky constellations, and how these are incorporated into cultural practice. Identify southern hemisphere constellations and the shifting nature of these star patterns. Explore whether the dark emu can always be seen in the sky. Investigate how Aboriginal and Torres Strait Islander people use sunlight and shadows to estimate distance when travelling, hunting and navigating.	AC9S5H02 AC9S5I01 AC9S6H02 AC9S6I01 AC9S6U02 AC9S5U03	A_TSICP1 A_TSIC2

Year	Lesson Overview	Australian Curriculum V9 links	
		Learning area: Science	Cross-curriculum priority: Aboriginal and Torres Strait Islander Histories and Cultures
7-8	**EXPLORING RATIOS**		
	Explore the significance of ratios in First Nations practices and their significance in sustainable land management. Further investigate sustainable-land-management knowledge of First Nations Australians and analyse the sophisticated mathematical understanding required to carefully and effectively manage Country. Explore how totems play a role in sustainability including examples of how some individuals may be given a totem of plants or animals they would not be allowed to eat and this would be considered a way of protecting populations from overconsumption.	AC9S7U02 AC9S7H01 AC9S7H02 AC9S7H03 AC9S8H01 AC9S8H02 AC9S8H03	A_TSICP1 A_TSIC2
9-10	**SCALES OF THE UNIVERSE**		
	Understanding the mathematics of scale in the natural world, including atomic scale, molecular scale, unicellular scale, multicellular scale and continental scale. Use scientific instruments to investigate scale at a molecular level, including an investigation of the mineral compound of ochre. Analyse the longevity of mineral compounds in rock art and our ability to date art, introducing students to the science of optically stimulated luminescence (OSL) dating. Students consider examples of unicellular, multicellular and continental scale in the natural environment. Analyse how radiocarbon dating and other dating methods have been used to establish that Aboriginal and Torres Strait Islander people have been present on the Australian continent for more than 60,000 years.	AC9S9H02 AC9S9H04 AC9S9I01 AC9S10H02	A_TSICP1

HAVE A YARN!

A good yarn is the perfect way to share knowledge, ideas and points of view. It's engaging and fun, and gives us the chance to explore concepts, to challenge ideas and to consider how we think.

Yarning circles are an enriching way for students to engage with First Nations knowledge and practices. It is a practice that has been an effective teaching method for thousands of years, providing a safe place to be heard and to offer an opinion, as well as naturally building connectedness.

YARNING TOPICS

F | Patterns in Nature

- What patterns have you noticed in nature?
- What would happen if everything in nature was completely mixed up with no patterns at all?
- Can you see patterns in the stars?

1-2 | Counting + Groups

- Before pens and paper, can you think of strategies that might have been used to calculate mathematical problems?
- You can count to 10 on your fingers. What happens if you want to count to 25?
- What could we find in nature to help us count up to 25?

3-4 | Symmetry in Tools + Practice

- What is symmetry?
- How many Aboriginal and Torres Strait Islander tools do you know of and do you know what they are used for?
- How do you think the shape of the boomerang helps with how it works?

5-6 | Sky Navigation

- What are star constellations?
- Have you heard about the emu in the sky? If yes, what have you heard about it or what do you already know about it?
- How do you think First Nations Australians navigate during the daytime?
- Why do you think shadows might be useful when hunting?

7-8 | Exploring Ratios

- What is a ratio?
- How can understanding ratios help protect Country?
- What does 'kinship' mean within Aboriginal and Torres Strait Islander communities?
- How might the concept of 'kinship' protect First Nations populations and sustainability of resources?

9-10 | Scales of the Universe

- What is ochre and what are some uses for ochre?
- Can you think of an example of scale – biggest to smallest – in the natural world?
- How do we know about migrations and movements of First Nations people across the continent and how long ago this stretches back?

FIVE TIPS FOR A YARNING CIRCLE

Sit in a circle

Sitting in a circle means everyone gets to be a part of the conversation, listening, talking and thinking.

Set some expectations

Yarning circles are a safe space where everyone should feel comfortable contributing. Setting some expectations around listening, using respectful language, and not judging what others say can help ensure your circle is a positive space.

Provide focus questions

Sometimes lots of voices can take you off track. Introducing focus questions so that everyone knows what they are discussing can really help, and follow-up questions will keep you on track.

Encourage sharing of ideas

Encouraging students to take turns to talk gives everyone the chance to share, but don't force them. The yarning experience is always better if students are given time and space to feel comfortable sharing.

Make time for reflection

Reflecting on what you have talked about will help instill any ideas or actions decided on by the group.

DECODING THE UNIVERSE | EXPLORING THE UNKNOWN WITH NATURE'S HIDDEN LANGUAGE

Our beautiful, diverse and complex world has an integrated 'language', a rich layer of connection that is often hidden from the human eye. The spiral pattern in flowers such as sunflowers, native daisies and Banskia cones, for example, follows the mathematical Fibonacci sequence, a series of numbers where each number is the sum of the two numbers before it. Fireflies can synchronise their flashing patterns with remarkable precision, a phenomenon governed by mathematical principles of coupled oscillators and phase synchronisation. And some migratory birds navigate using Earth's magnetic field using a quantum mechanical process called radical pair mechanism, in which their biological makeup responds to the magnetic field.

Exploring this hidden language is a fascinating adventure in the fields of maths and quantum science. Observing nature's patterns can help us decode meaning from everyday experiences and learning. Exploring First Nations body tallying practices, the design of Aboriginal and Torres Strait Islander tools, celestial maps and their role in ancient navigation practices, the use of ratios in sustainable land management, breaking down ochre into its molecular qualities – each element of this guide is designed to give students the opportunity to 'see' the universe in a different way, and understand its inherent interconnectivity.

WHY THIS THEME?

Each year the United Nations (UN) dedicates an entire calendar year to a particular topic or theme. The purpose is to raise awareness of how the topic is important to life, society and progression. This year's theme explores the interconnectedness of the universe, from a molecular level to a continental scale. It encompasses an understanding that our existence is part of a bigger picture, something Australia's First Nations people have always known. It welcomes a rich investigation into mathematical principles, and a deep dive into diverse elements of quantum science.

HOW IS IT RELEVANT TO STUDENTS?

This guide is designed to provide all Australian students with fun and engaging opportunities for scientific inquiry, and an important insight into the vital contributions of First Nations knowledge and innovation.

DOES IT LINK TO THE CURRICULUM?

Yes! All the lessons in this guide link directly to the Australian Curriculum V9 , with relevant codes noted. Each lesson provides learning intentions, guiding questions and vocabulary lists, as well as yarning suggestions.

DID YOU KNOW?

2025 is the United Nations International Year of Quantum Science and Technology and Australia is hosting the 2025 International Mathematical Olympiad, which is the World Championship Mathematics Competition for high-school students, held annually in a different country. It's a big deal and widely regarded as the most prestigious mathematical competition in the world.

A FIRST NATIONS PERSPECTIVE

Aboriginal and Torres Strait Islander people have 65,000+ years of ongoing cultural practice on Country, and a highly sophisticated understanding of the land, sea and sky that supports them, as well as the flora and fauna around them. Theirs is an innate understanding of a universal scale, from the molecular makeup of natural resources to continental ecosystems, weather patterns, plant and animal behaviour, celestial maps and the interconnectedness between them.

FIRST NATIONS STEM PROGRAMS

Enduring First Nations knowledge forms the basis for significant STEM integration in Australia.

Examples of this include:

- The Indigenous STEM Education Project
- Drone projects, which use drone technology to monitor and manage Country
- Ecological knowledge programs that incorporate Aboriginal and Torres Strait Islander knowledge into environmental management, conservation, and climate research
- Bush medicine research
- Major infrastructural projects that incorporate First Nations design principles and engineering knowledge into contemporary architecture – including seasonal responsiveness to an Indigenous calendar, as well as sustainable resource use – and ranger programs that apply both ecological knowledge and modern conservation techniques in land and sea management.

TWO-WAY LEARNING

'Two-way learning' and 'both way learning' relates to the complementary use of First Nations knowledge systems and Western scientific approaches, rather than considering them separate domains. The growth of this learning duality reflects increasing recognition of the value of Indigenous knowledge and the importance of improving STEM participation and career pathways for Aboriginal and Torres Strait Islander peoples.

"Aboriginal perspectives are about understanding how all things in the world are interconnected through patterning."

Prof Chris Matthews, Keynote ATSIMA 2023

A FIRST NATIONS PERSPECTIVE

‘LIVING MATHS’

To understand a First Nations perspective of maths, it is necessary to accept the premise that to Aboriginal and Torres Strait Islander people, maths is intrinsically connected to culture and therefore has many different cultural expressions. Western perceptions of maths see it as an objective science and not connected to culture. Perhaps we should see maths as a knowledge system bound by culture, in which subjectivity allows for a much richer, diverse knowledge system to engage with and understand.

Early anthropologists perpetuated the myth that Australia’s Indigenous communities had no concept of number, as well as a singular language, when in fact there were over 250 languages spoken and over 800 dialects at the time of colonisation. When confronted with ‘a language’ that only had two words for number, the equivalent word for one and two, used to construct numbers for three (one two) and four (two two), they believed they were witnessing a primitive, prehistoric number system that had no capacity beyond small numbers. The reality is the opposite!

First Nations mathematical understanding is part of a sophisticated system that defines interconnected relationships between all elements of the world – people, animals, plants, insects, wind, fire, water, land, etc. It forms a complex system of interconnected cycles. Aboriginal and Torres Strait Islander children are immersed in this system from birth, growing up to become system-thinkers.

First Nations people’s genealogical kinship systems form the basis of this understanding, an encoding of complex relational patterns that effectively solve social organisational challenges through elegant mathematical principles. Kinship systems vary across different clans and nations, but these intricate relationship rules often connect to other groups, showing the interconnectedness of the system and its principles.

This knowledge determines marriage rules, social responsibilities, and ceremonial roles as part of the generational cycle where relationship patterns repeat after a specific number of generations. It also incorporates sophisticated spatial reasoning, mapping on to geographical features and cardinal directions, creating a unified mathematical-geographical-social framework.

“Culture and connection to Country showed maths in the land, in the sky, in the ways of living, in kinship and family – and connected this back to understanding number systems, patterns, quantifying and space.”

Laura Barry, *Connectedness in mathematics*

SCIENTIFIC TEACHING STRATEGY | POE

The Predict-Observe-Explain (POE) teaching strategy, developed by White and Gunstone (1992) helps to ensure Indigenous perspectives are included in the STEM classroom. This strategy supports students through the basics of the investigation process in a way that is independent of cultural background and knowledge. It offers teachers information about how much and what type of knowledge students hold already, generates discussion, and inspires students to ask questions and think more deeply so they can further investigate the topic.

The POE strategy is a collaborative process: the teacher investigates students' understanding by asking them to carry out the predict, observe and explain steps. This encourages students to use their prior knowledge and understanding and supports developing an agreed meaning of specific words as used and understood by by the whole class.. It is especially important for Aboriginal and Torres Strait Islander students because the student may have access to culturally specific knowledge which they may be able to share with the class. This demonstrates acknowledgement and inclusion of Indigenous perspectives through engagement with the student and potentially the wider First Nations community.

PREDICT

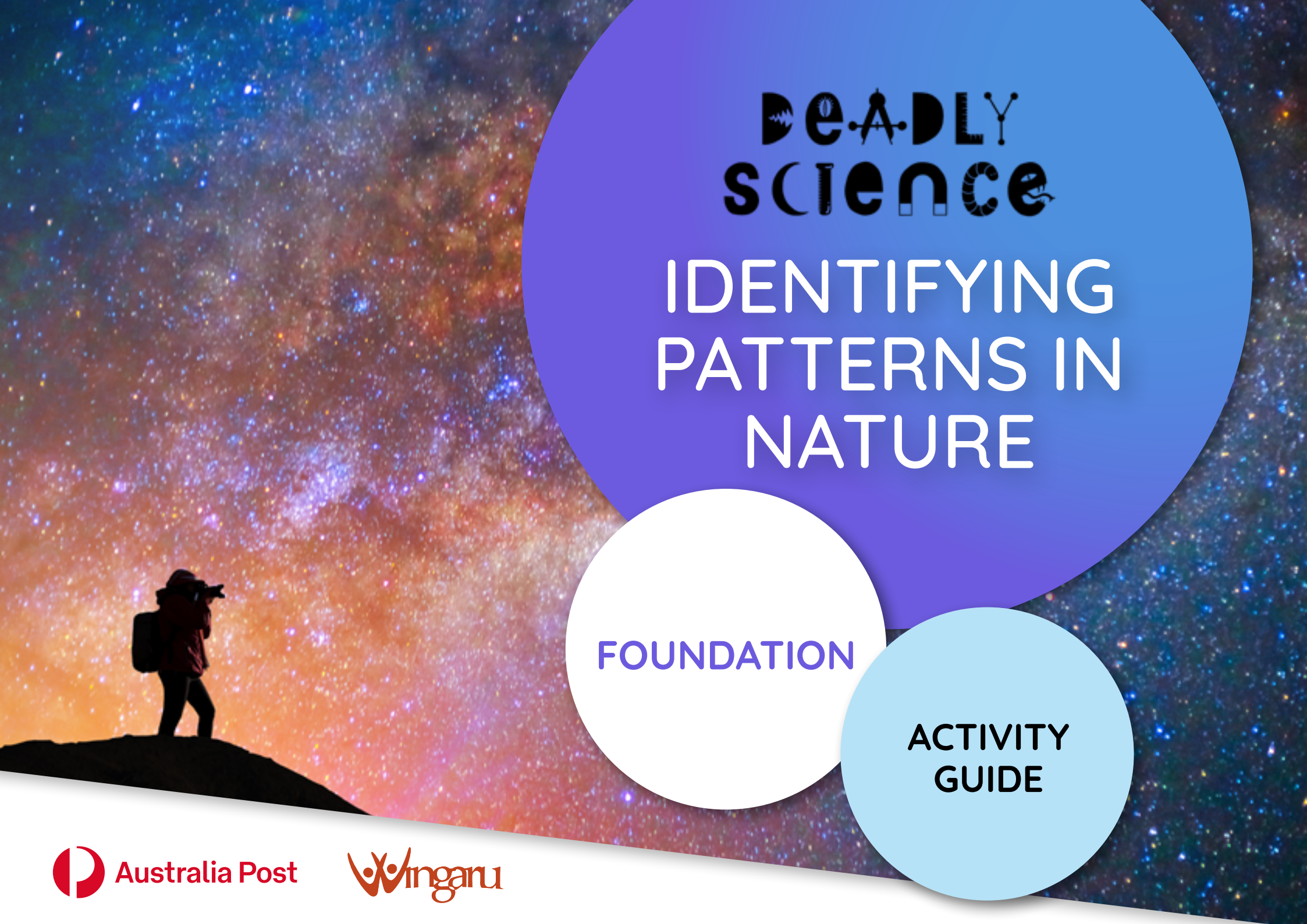
This is the process of using what we already know in order to ask questions that will help us learn something and create a strong foundation to build upon. This predication is often referred to as an hypothesis, or a testable question. We create hypotheses based on our accumulated knowledge, available tests and investigations.

OBSERVE

This is the process where students use experimentation to test their hypothesis. They can do this by watching someone else solve the problem or they can work to solve the problem themselves. During this process, students review their hypothesis through iterations as they progress through the problem-solving phase to discover new information.

EXPLAIN

This is the process of analysing, synthesising and communicating what the problem-solving phase has uncovered according to what we see. We try to answer our question in this step. Sometimes we see the results differently and sometimes the results move us to ask more questions.



DEADLY SCIENCE

IDENTIFYING PATTERNS IN NATURE

FOUNDATION

ACTIVITY GUIDE

Australia Post

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FOUNDATION | IDENTIFYING PATTERNS IN NATURE

LESSON OVERVIEW

This lesson introduces students to the patterns that can be seen in nature, such as animal and insect markings, tracks, repeating patterns in plants, constellation maps, movement patterns and environmental signs. It frames this information as part of 'nature's hidden language' and shows how recognising patterns can provide further information about the Country around us. The lesson encourages students to identify patterns in nature and consider their meaning, while the Aboriginal and Torres Strait Islander perspectives connects this new understanding to how First Nations communities used knowledge of these patterns for hunting, storytelling, dancing and predicting the weather, and incorporates Djanbun writer Bronwyn Bancroft's *Patterns of Australia* and *Shapes of Australia*.

Learning intention

- To identify and describe patterns that occur in nature
- To recognise repeating patterns, spiral patterns, and symmetry
- To use observational skills to explore the natural world
- To explore how patterns may help living things survive

Guiding questions

- How could animal tracks help someone find water?
- What does it tell you about the seasons if the same flower grows every time it gets cold?
- Why are there patterns in a gum leaf? What might their patterns mean?
- Why do you think Aboriginal and Torres Strait Islander people watched the stars or the sky to know what season it was?
- Are patterns in nature important?
- Why do you think patterns are important in nature?

Vocabulary

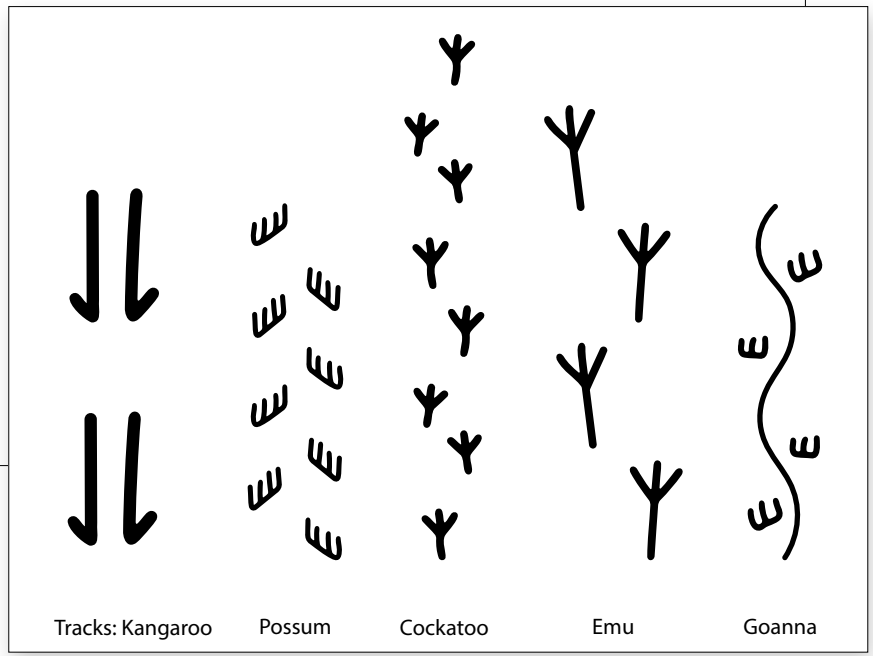
- Pattern
- Nature/natural world
- Hidden language
- Repeat
- Spiral
- Symmetry
- Aboriginal and Torres Strait Islander
- Knowledge

Resources

- Natural resources (leaves, shells, banksia seeds, flowers)
- Optional: Magnifying glasses
- Drawing paper and colouring materials
- Optional: digital camera/tablet for photography
- Australian Geographic DeadlyScience Book 9: Numbers in Nature, pp 11
- *Patterns of Australia* by Bronwyn Bancroft
- *Shapes of Australia* by Bronwyn Bancroft
- *The Art in Country: a Treasury for Children* by Bronwyn Bancroft
- *Sky Country* by Aunty Patsy Cameron
- Patterns of Australia | Deadly Kindies | You Tube
- The Kamilaroi and Euahlayi Emu in the Sky | Australian Indigenous Astronomy
- The epic migrations of our local eels – Sustainable Macleod
- CUSTOMS AND BELIEFS – Worimi Conservation Lands
- Understanding Indigenous knowledge of weather and seasons

PREDICT, OBSERVE, EXPLAIN

Step 1 **PREDICT**	Start by gathering students in a circle. Read *Patterns of Australia and Shapes of Australia* by Djanbun author Bronwyn Bancroft, or watch the You Tube link that relates to this. Then, start a yarn about patterns that exist in nature. What patterns do animals make and why? What patterns do animals have on them and why? What plants have patterns? What patterns are seen in landforms? Ask students to think about why patterns might exist in nature. Explore the concept of repeating patterns, spirals and symmetry in nature and why they may be important. Read *Tracking Through Time* (*Australian Geographic DeadlyScience Book 9: Numbers in Nature*, pp 11) and discover how First Nations people used patterns in nature to calculate volumes of water and predict the weather! Introduce stories about Aboriginal and Torres Strait Islander people's knowledge of patterns – and how they used this to find water, to track and hunt animals, and to map the Country around them. Revisit Bronwyn Bancroft's books to help illustrate this.
Step 2 **OBSERVE** **PART 1 – PATTERNS IN NATURAL OBJECTS**	Become a nature observer! Head outside and look at the Country around you. Are there any snails around? Can you see where they have been? Can you see any feathers? Look for animal tracks of birds, lizards and other animals you usually see in the school grounds. Collect leaves, sticks, bark, rocks, flowers and seed pods, too, and investigate repeating patterns, spirals and symmetry on these items. You may like to use a magnifying glass. Then create patterns with the collections. **Guiding questions** • How could animal tracks help someone find water? • What might it mean if the same flower grows every time it gets cold? • Why are there patterns in a gum leaf? What do they mean?



Step 2 **OBSERVE** **PART 2 – PATTERNS IN NATURE**	Patterns exist throughout nature, from clouds to ocean waves and animal behaviour. Head outside and have a look at the sky: What is happening with the weather? Where is it sunny/shady? Is there any wind? What direction is it coming from? Are there any clouds? Can you see any patterns or shapes in the clouds? Then, imagine you are bird: Where will you sit? Where will you fly? Where will your house be? Where will you get water? What will you eat? Now, ask similar questions imagining you are a lizard, but maybe don't ask where it will fly! Draw a picture of these places and animals. Label and mark animal tracks to the closest supply of water. Does the place of water supply change at all when the seasons change? Go through same questions above for each animal thinking about a different season. **Guiding questions** • Why do you think Aboriginal and Torres Strait Islander people watched the stars or the sky to know what season it was? • Why do you think patterns are important in nature?
Step 3 **EXPLAIN**	Discuss how patterns are interpreted by First Nations Australians to find water, food and shelter, and act as a warning when bad weather is coming, or as an indication it's time to go somewhere. Ask learners to come up with reasons for why knowing where an animal drinks everyday could be useful information, or what patterns can tell us about migration and seasonal change. What patterns can you see outside in the area you live in?

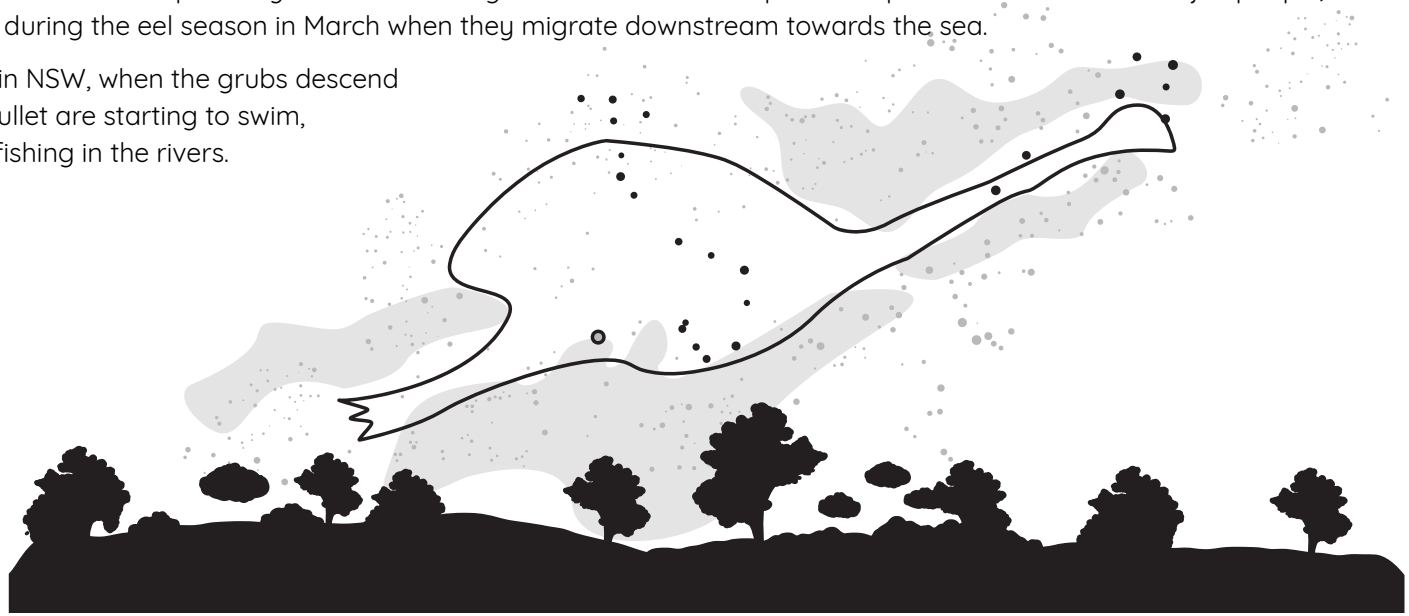
DEADLY PATTERNS IN NATURE

The ‘emu in the sky’ exists for many First Nations clans across Australia, and the story has many different meanings, depending on where these mobs live: it can be an indication of the time to collect resources, or representation of a spiritual hero. The Kamilaroi and Euahlayi peoples, who live in the north and northwest of New South Wales, share their knowledge of an emu in the sky that differs from many other beliefs held from other First Nations clans around Australia. For them, the celestial emu represents different things at different times of the year. The emu first becomes visible in March. When it is fully visible in the Milky Way during April and May, it assumes the form of a running emu (below). This represents a female emu chasing the males during the mating season. Because emus begin laying their eggs at this time, this appearance of the celestial emu is a reminder that the emu eggs are available for collection. That’s deadly!

As summer ends in Victoria, it is time to go hunting for eels, because this is the time that these intrepid migrating creatures begin their lives in the Coral Sea (between northern Queensland, PNG, New Caledonia and Vanuatu), where they hatch from eggs as larvae. The larvae drift on ocean currents for several months before reaching the estuaries and rivers of southeastern Australia, including the Yarra River where the Wurundjeri people live. Once in freshwater, the larvae mature into adult eels. This process can take up to 20 years. Eels hold significant cultural and spiritual importance for the Wurundjeri people, and are also a vital food source, especially during the eel season in March when they migrate downstream towards the sea.

On Worimi Country, around Port Stephens in NSW, when the grubs descend from the trees in April, people know that mullet are starting to swim, so they move from fishing on the coast to fishing in the rivers.

That’s deadly!



LOCAL PATTERNS IN NATURE

Ask your local Land Council about the patterns in nature in your local area.

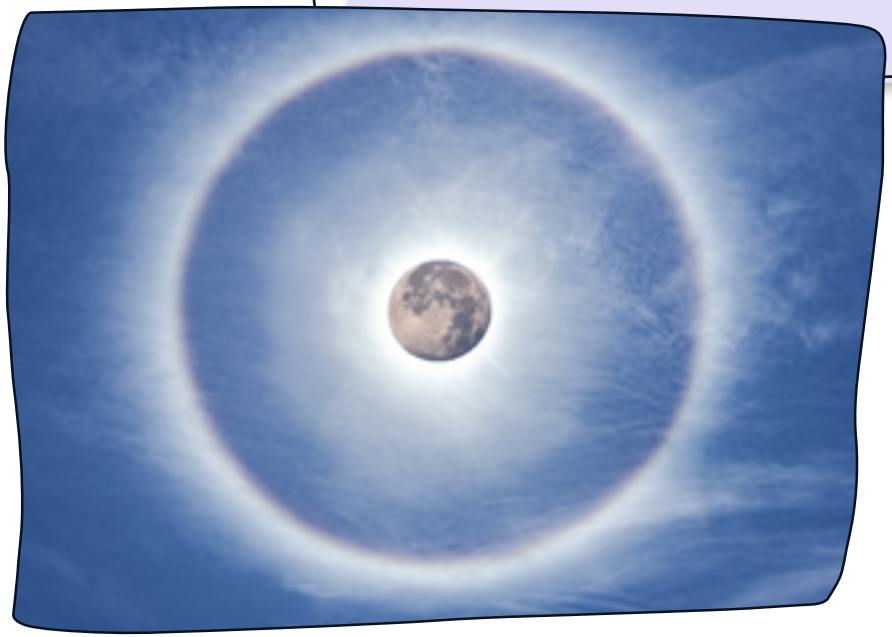
DID YOU KNOW?

Many Central Desert mobs, including the Pitjantjatjara, the Arrente and the Walpiri people, know that the appearance of the constellation Pleiades (also known as the Seven Sisters) in the dawn sky indicates the beginning of the cold season.

Aunty Joanne Selfe is a Gadigal woman from the eastern edge of Australia. She explains that "In First Nation's knowledge systems, moon halos depict the onset of rain; sometimes the moon isn't in the centre of that halo, it might be to one side a little bit, and that would indicate that there's some wind coming as well..."

TEACHER'S NOTE

This reading of the environment corresponds directly with contemporary science which recognises that moon halos occur when ice crystals of cirrus clouds are suspended in the upper atmosphere; moonlight is refracted and reflected by the ice crystals creating the halo: this often precedes a low-pressure system, frequently followed by rain and cooler temperatures within the next day.



EXTEND THE LEARNING

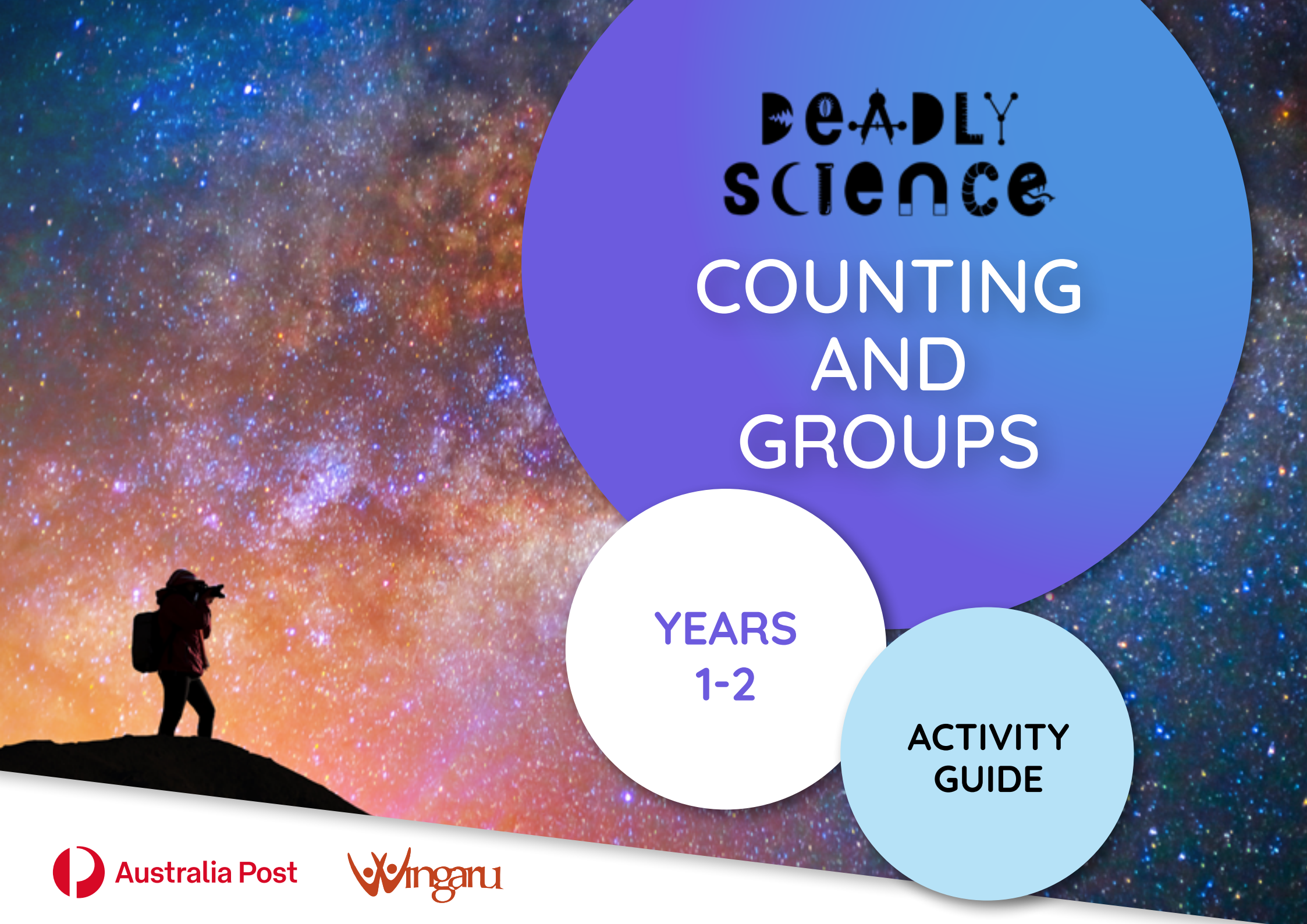
Look at pictures and books about Aboriginal art and consider how First Nations people use patterns to tell stories and express their culture. Then, ask students to get creative, arranging the natural treasures they found to make their very own pattern, and create a drawing that shows a pattern they found in nature.

A great example is *Sky Country* by Aunty Patsy Cameron who traces her Aboriginal heritage to four ancestral grandmothers: Pleenpereener, Wyerlooberer, Teekoolterme and Pollerelbrener, The book uses some traditional language to tell a creation story from the stars, and features beautiful artwork with striking patterns.

DID YOU KNOW?

Aboriginal and Torres Strait Islander people can 'read' animal tracks like a book! They can understand subtle marks made by hundreds of different species, from which they can tell the animal's age, size and even gender. Plus, they can use track patterns to predict the animal's behaviour, or pathways that show which way they are moving. They can even tell how long ago the animal was there, which is deadly information if you are hunting something to eat!

Check out *Bush Tracks* by Ros Moriaty.



DEADLY SCIENCE

COUNTING AND GROUPS

YEARS 1-2

ACTIVITY GUIDE

Australia Post

Wingaru

1-2 | COUNTING + GROUPS

LESSON OVERVIEW

Mathematics is a way of discovering and explaining the patterns we see around us, and this lesson teaches students about the diverse cultural expressions of this, showing the different ways numbers and groups can be counted according to different cultures. It encourages an understanding of Aboriginal and Torres Strait Islander counting practices such as body tallying, as well as exploration of grouping concepts across Australia, and an investigation into the cultural practices behind different counting and grouping techniques.

In First Nations cultures, storytelling is used to solve maths problems, whereby numbers and operations in equations become symbols or characters. These characters then take part in a story. For example, the actions might bring characters together in a story (addition and multiplication) or take them apart (subtraction and division). Animals and birds can be used to symbolise individual numbers, and physical movement or dancing is also important.

Dr Chris Matthews of the Aboriginal Torres Strait Islander Maths Alliance describes how Aboriginal children turned the equation 4 x 2 = 8 (4 twos is equivalent in value to 8 in total) into a dance about flying brolgas. A group of two children, acting as brolgas, flew together, and then linked up with another group of two, and then two more groups of two to become a collection of eight in total.

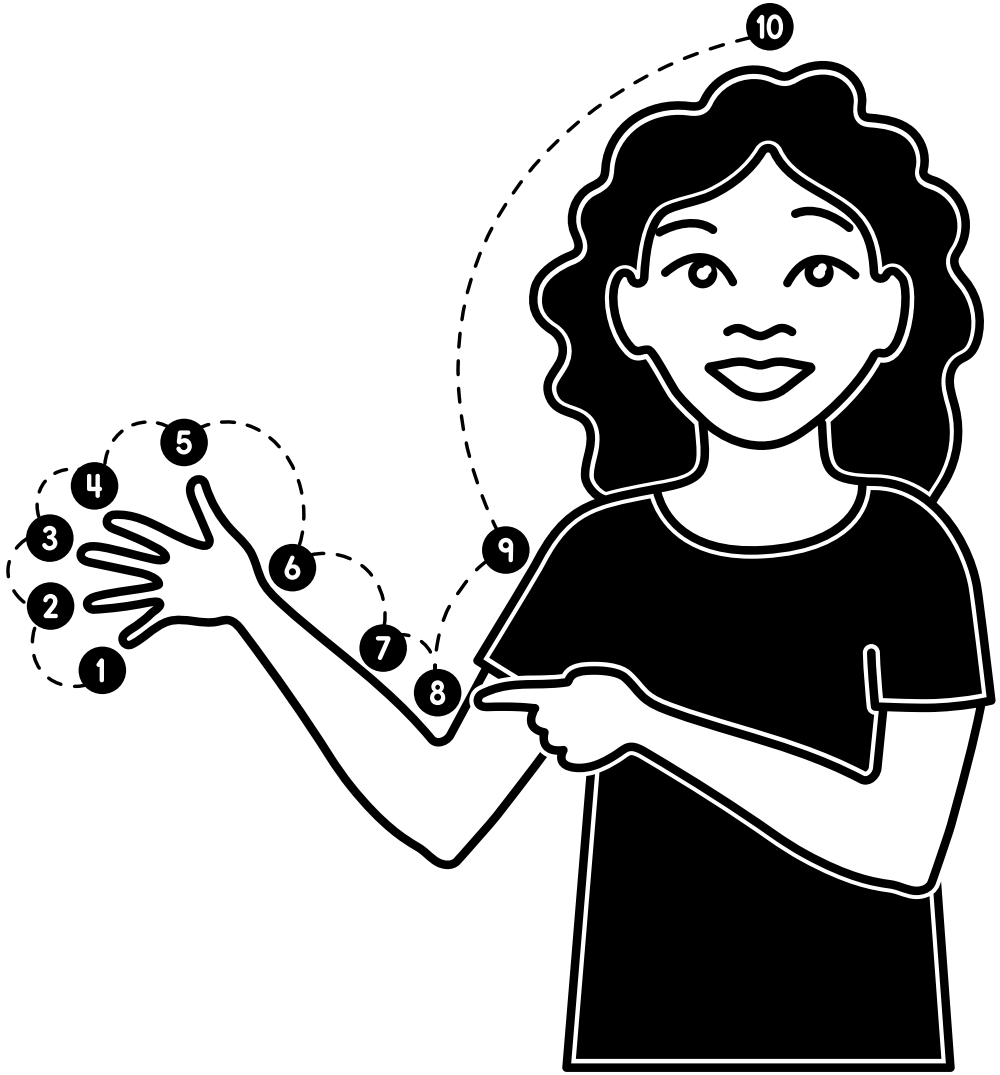
WHAT IS BODY TALLYING?

Body tallying is one of the oldest calculation systems, a clever and effective way of counting and communicating numbers using the human body, which demonstrates a complex understanding of maths that predates written notation. Many First Nations groups use a 'counting in fives' system: 5, 10, 15, 20...

Tallying can include counting on the fingers, as well as the hands, arms, eyes and more, depending on which mob, clan or nation people belong to. For some mobs, counting starts on the little finger of the left hand (number 1), which is held or touched by the right hand of the person counting. Moving past the ring finger (number 2), the middle finger (number 3) and index finger (number 4), to reach the thumb (number 5). Counting then climbs the left arm, from the wrist (number 6) to the lower arm (7), elbow (8), upper arm (9) and head (10). In some mobs, the counting then moves to the neck, ear, nose and eyes before counting down the right arm from the shoulder.

Unlike simple finger counting, body tallying can track much larger quantities by assigning numerical values to different parts of the body. In fact, some tallying systems could count well into the hundreds.

Which means you can do a sum using your body!
That's deadly...



Learning intention

- To explore and practice Aboriginal and Torres Strait Islander body tallying systems
- To understand how different First Nations groups used grouping strategies
- To appreciate the cultural significance of Indigenous counting systems
- To make the connection between Aboriginal and Torres Strait Islander counting methods and the maths we learn in the classroom today

Guiding questions

- How do we count things? What tools do we use? [fingers, brain, abacus, calculator, computer]
- Before pens and paper, can you think of strategies that might have been used to calculate mathematical problems?
- What happens when you count to 10 on your fingers but want to count further?
- Why would counting be important for First Nations people? What would they need to count? [animals, days, people, resources, distance, navigation points]
- If you needed to count to 30, how could grouping help you? (5 groups of 6, 3 groups of 10 etc)
- What other things do you think Aboriginal and Torres Strait Islander people used to count and group? [message sticks, knots, stones, shells]

Resources

- *Australian Geographic DeadlyScience Book 9: Numbers in Nature*
- Counting materials [sticks, stones, shells, rope to be knotted]
- Counting in Nyungar
- Counting in Gomeroi
- Learn to count in Dharug
- Karuna for Kids: Counting

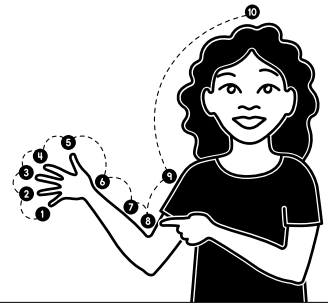
Teacher's Resources

- Explainer: how does the Aboriginal numeric system work? | Sydney University
- Mathematics | Narragunnawali

Vocabulary

- Aboriginal and Torres Strait Islander
- First Nations
- Body tallying
- Addition
- Subtraction
- Grouping

PREDICT, OBSERVE, EXPLAIN

Step 1 **PREDICT**	Start by asking students how we count things, and discuss all the different ways, including memorising, writing numbers down, using a calculator etc. Discuss why writing numbers down when it gets too hard to count in your head is important. Introduce counting in languages using counting videos listed in the resources. Then, using body tallying visual resource, introduce Aboriginal and Torres Strait Islander body tallying practices, and ask students to predict which parts of the body relate to which numbers or think about how they would count to 30.
Step 2 **OBSERVE**	OK, it's your turn! We've devised a simple body tallying system for you to count with: • 1-5: touch five fingers of the left hand, starting with the little finger • 6: touch the wrist • 7: touch the forearm • 8: touch the elbow • 9: upper arm • 10: head 
	Teacher's Note: Choose an example (touch your elbow) and ask students to tell you what number you are communicating. The response should be the number 8. Then, call out a number from the list and ask students to show you as a group what is that number using the system. Then, call out individual students for specific numbers. **Yarning question:** Is it possible to add and subtract numbers? Yes! Addition can be done by combining counts from different body positions; and subtraction by moving backward through the body sequence.

Step 2 **OBSERVE**	Now demonstrate how to count to twenty using this system, and how addition and subtraction can be shown. Divide students into groups and ask them to work on what comes next as they count to 20, explaining that they can start with 10 + 1, 10 + 2... Give students an example of what 11 would look like [10 + 1: head + little finger left hand], and remind them that tallying varied between different communities, clans and language groups. In Aboriginal and Torres Strait Islander society, number 'grouping' was used to understand bigger numbers and count into the hundreds, generally using natural objects like sticks, shells, seeds etc. Ask students to think about how they can count to 30 using these materials and creating groups of 5. It makes sense, then, that these two counting methods can be used together. Show students how 5 [one hand] + 10 [two hands] = 20 [all fingers and toes] • 5: one hand • 10: two hands • 20: fingers and toes Show learners how a grouping system applied to body tallying can be used in lots of different ways to count to 30: • one hand x five times • two hands x 3 times • fingers and toes + two hands • one hand x six times Ask them to develop a way to count to 40.
Step 3 **EXPLAIN**	Encourage students to talk about what they have learned, and how they think body tallying would have been used in everyday life. [resource distribution; navigation points; measuring space and volume; counting the days to a ceremony; trading with neighbours]. Explain that the sequence of body parts created a physical memory system, a way of remembering, and ask students to think about situations when this might be more useful than having to write numbers down. Then ask students to consider why making groups of 5 or 10 make sense for humans, and why these tallying systems make such sense for life on Country. Ask learners if anyone has a story to share about counting on Country.

EXTEND THE LEARNING

Find out how items are counted on the Country you are on, and make a poster to reflect this. Ask an Elder to come in and share knowledge about counting, or go outside and do a scavenger hunt to find 20 rocks and practice grouping and counting techniques.

DID YOU KNOW?

For the Warlpiri people of the Western Desert region, the number 7 is called ‘wirlki’, which is a boomerang with arms of uneven length. Number 8 is ‘milpa’, which means ‘eyes’, and the number 9 is called kartaku, which means ‘cup’ or ‘billycan’ and refers to the fact the shape of the number mirrors the shape of the cup plus its handle when viewed from above.

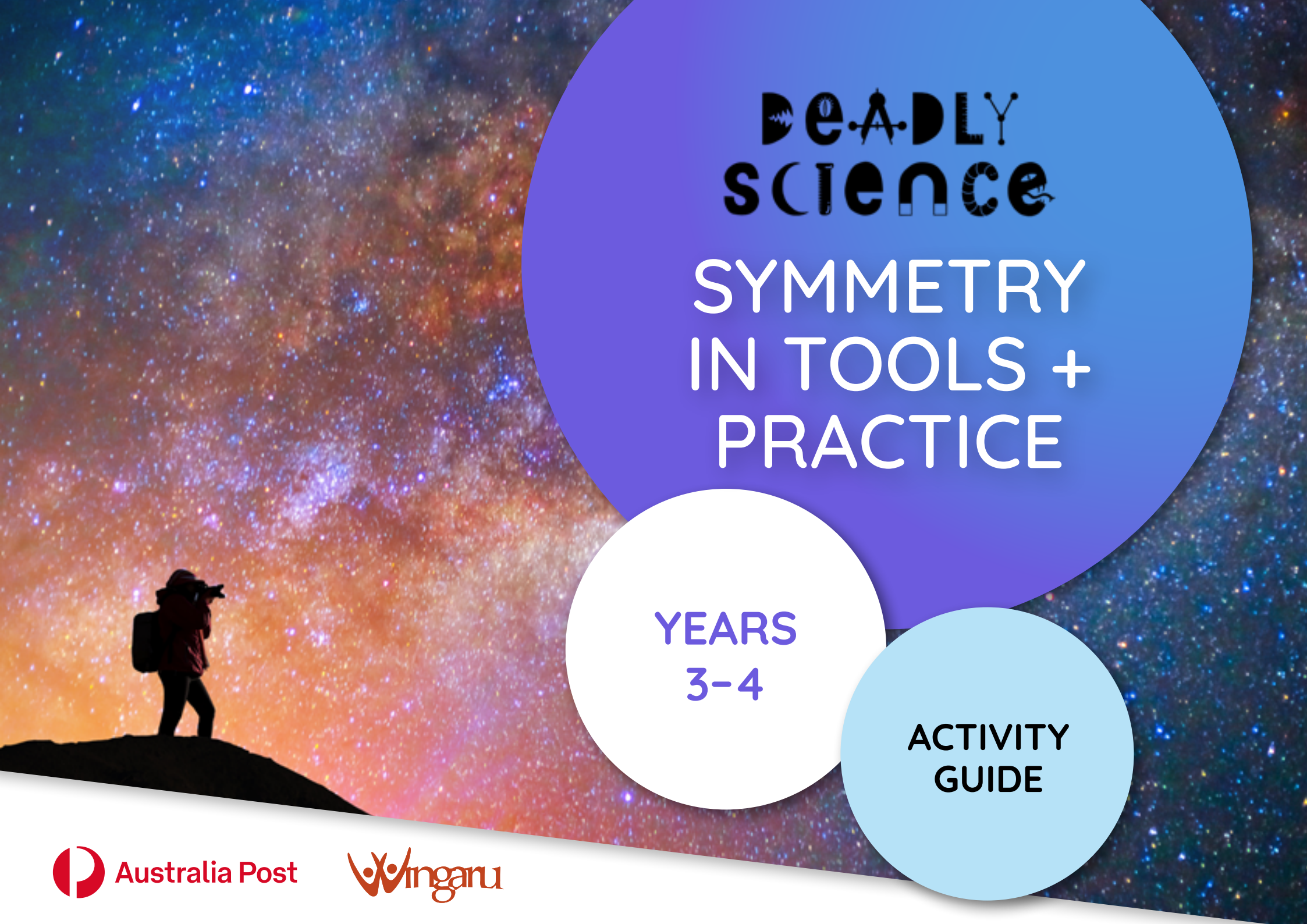
That’s deadly!

LINKS

Australian Aboriginal and Islander Mathematics

Yolŋu culture | Dhimurru Aboriginal Corporation

Countering the claims about Australia’s Aboriginal number systems | The Conversation



DEADLY SCIENCE

SYMMETRY IN TOOLS + PRACTICE

YEARS 3–4

ACTIVITY GUIDE

Australia Post

Wingaru

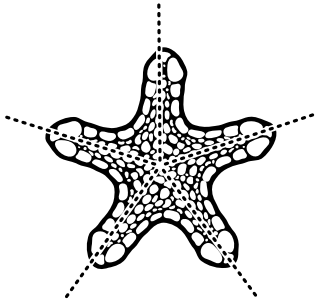
3-4 | SYMMETRY IN TOOLS + PRACTICE

LESSON OVERVIEW

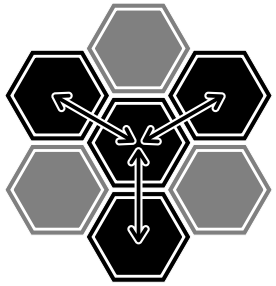
An introduction into the understanding and use of symmetry in First Nations life, this lesson investigates Aboriginal and Torres Strait Islander tools, such as boomerangs, woomera and shields, and encourages students to consider the practical and cultural reasons for these designs. More broadly, it provides insight into how Australia's First Nations people refined the principles of engineering symmetry to use in multiple aspects of their lives.

Students will also be encouraged to investigate distance and flight patterns of different shaped boomerangs to understand and analyse the scientific and mathematic variables involved, including weight, density, material and force.

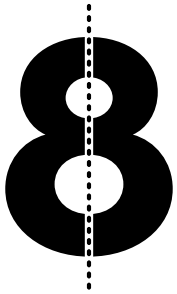
Symmetry relates to the correspondence of size, form and arrangement of parts on opposite sides of a plane, line or point, and the regularity of form or arrangement when referring to corresponding parts. A starfish has radial symmetry; a beehive hexagon has translational symmetry, as in it can be moved sideways without changing its shape; the number 8 has mirror symmetry; a circle has scale symmetry [it doesn't change its shape when expanded or contracted]; and an equilateral triangle has rotational symmetry – it can be rotated around a fixed point and still look the same.



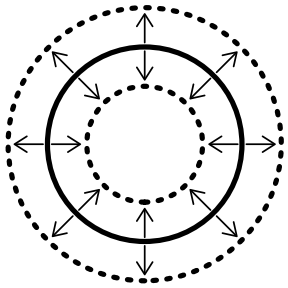
Radial Symmetry



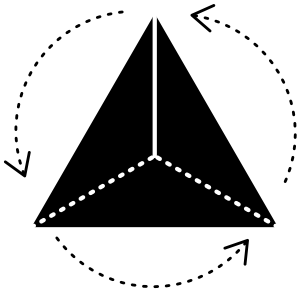
Translational Symmetry



Mirror Symmetry



Scale Symmetry



Rotational Symmetry

Learning intention

- To identify and describe symmetry in First Nations tools
- To explain how symmetry impacts the function of different tools
- To investigate variables affecting the flight patterns of boomerangs
- To recognise Aboriginal and Torres Strait Islander peoples sophisticated understanding of engineering principles

Guiding questions

- How many Aboriginal and Torres Strait Islander tools do you know of and do you know what they are used for?
- How is their shape and the way they move useful for what they do?
- What is 'symmetry'? How might symmetry be useful when making tools?
- Can you think of an example of symmetry in nature? [Starfish; circle; sunflower]
- How do you think the shape of a boomerang will change the way it works?

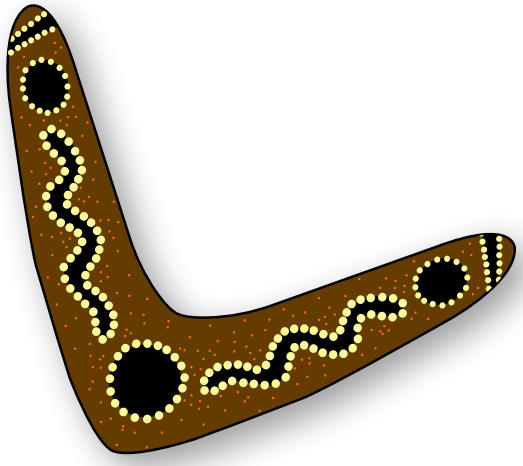
Resources

- Cardboard or wooden boomerang templates of different shapes:
  - How to make a paper indoor boomerang
  - Think like an engineer: a Teacher's Guide | Boomerangs
  - Make a DIY boomerang from cardboard
- Measuring tapes or trundle wheels for longer distances, stopwatches
- Recording sheets for experiments
- Drawing materials
- *National Geographic DeadlyScience Book 9: Numbers in Nature, pp 29*
- ABC: First Weapons | The Boomerang
- ABC: How a boomerang works | Great Australian Stuff
- Wingaru Didge Ya Know? Tools cards
- Wingaru First Nations Tools Matching Game
- First Weapons | The Wartilykirri

Vocabulary

- Symmetry
- Boomerang
- Woomera
- Flight pattern
- Aerodynamic
- Density
- Asymmetry

BOOMERANGS



Boomerangs have been used for thousands of years by First Nations people. They are specifically designed to do a number of things, which means there are lots of different designs. Some boomerangs are used to hunt, others to fight. Some are clapper sticks used for ceremonial purposes; some are toys, and some are used as decoys when hunting waterbirds. Some are even used as friction poles to start fires!

BOOMERANGS UTILISE MULTIPLE TYPES OF SYMMETRY:

Mirror symmetry
where one half mirrors the other along a central axis, common in returning boomerangs with symmetrical arms

Rotational symmetry
in which the boomerang still looks the same while rotating. This is common in cross-shaped boomerangs.

Functional symmetry
Boomerangs need to have balanced weight distribution while maintaining asymmetrical shapes, and often have twisted planes that work together to create gyroscopic stability.

Asymmetry
Many functioning boomerangs intentionally incorporate asymmetry, with different arm lengths, varying thicknesses, and differences in the airfoil shape between the arms, used for specific flight patterns.

Cultural symmetry
Ceremonial boomerangs often feature cultural markings and artwork, the symmetry of which is always significant, including repeated motifs, symmetrical carved and painted designs that represent cultural stories, totems or Country.

PREDICT, OBSERVE, EXPLAIN

Step 1 **PREDICT**	After showing students images (or replicas) of boomerangs, woomera and shields used by First Nations people, and identifying the different types of symmetry [bilateral; rotational; functional; asymmetry, cultural markings], start a yarn with students about the incredible timescale of First Nations engineering and mathematical knowledge. Then introduce the idea of making and testing different types of boomerangs: can students make predictions about what will happen to boomerangs made of different materials? What other variables might come into play?
Step 2 **OBSERVE**	Making boomerangs from templates After demonstrating a simple flight test with different boomerang shapes, explaining variables such as shape, weight and throwing force, and modelling how to measure the distance of each throw, and observe flight patterns, ask students to work in small groups to test fly two to three cardboard boomerang templates. Ensure they can measure and record the distance travelled, the flight path (straight? Curved? Returning?) and the flight time using a stopwatch and measuring tape or trundle wheel. Ask students to make observations about which designs work best, and why.
Step 3 **EXPLAIN**	Students are encouraged to present their findings to the rest of the group, detailing which design travelled furthest, and why this was. Discuss how symmetry affected the flight patterns of the test boomerangs, and which variables seemed most important. Return to previous inquiry about materials: if a cardboard boomerang can fly this far, how will a hardwood timber boomerang perform? What affects this? Finally, ask the class to discuss how First Nations people would have refined boomerang designs over time, and why different shapes were developed for different purposes. Did the boomerangs fly straight or curved? Did they return to the thrower?

EXTEND THE LEARNING

Ask students to research the woomera and how it works by extending the throwing arm and creating a long lever, which significantly increases the force and distance a spear can be thrown. Cardboard models of spear-throwers can be used to test variables like length, weight distribution, and handle design affects how accurate the woomera is, and how far the spear travels. This learning connects directly to physics concepts like levers, force multiplication, and projectile motion while showcasing the sophisticated understanding First Nations peoples had of these principles thousands of years before Western physics formalised them.

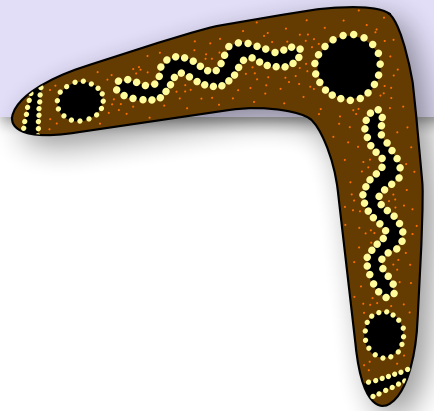
"Boomerangs are now seen as great examples of traditional flight principles. The flat bottom of the boomerang, in combination with its curved upper surface, create lift. This is because of Bernoulli's Principle which tells us that the air going over the curved surface of the boomerang travels further than the air going along the underside. This creates a difference in pressure which gives us lift. The wings on an aeroplane also create lift in this way. The only difference being they are straight, helping the plane to move forward, as opposed to boomerangs which are a unique 'U' shape helping them to return to whoever threw them."

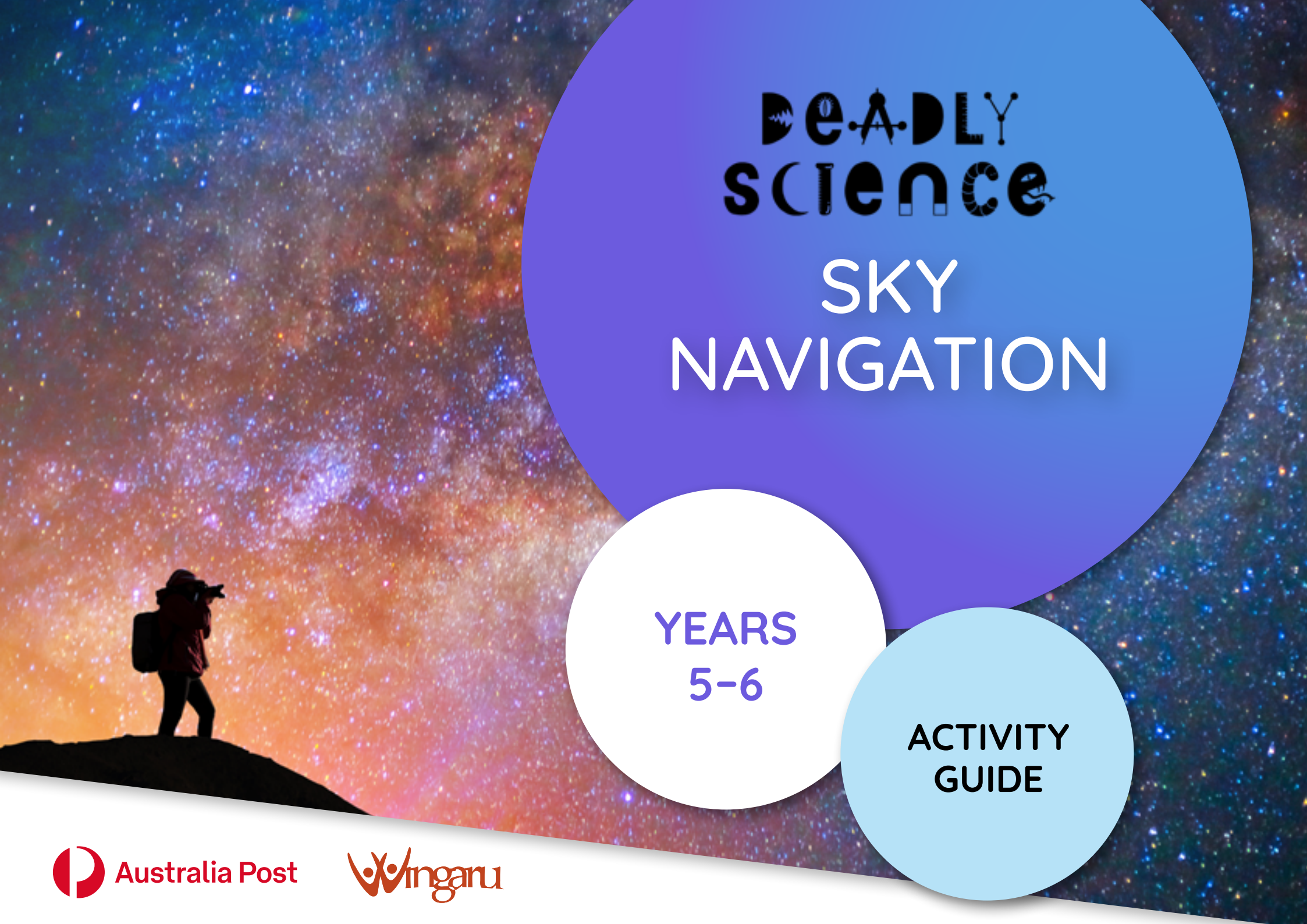
Taylah Griffin, Aerospace Engineer
DeadlyScience Ambassador

DID YOU KNOW?

Boomerangs use some of the same aerodynamic principles that were later used in the design of aircraft, but the mathematical formula for how they work was only 'devised' in 1970. That's 19,945 years later than the date First Nations Australians first used boomerangs! Described as 'genius mathematics', the design of boomerangs was a vitally important part of establishing the principles of flight.

That's Deadly!





DEADLY SCIENCE

SKY NAVIGATION

YEARS 5–6

ACTIVITY GUIDE

Australia Post

Wingaru

5-6 | SKY NAVIGATION

LESSON OVERVIEW

This lesson is an investigation into how First Nations Australians used movement patterns in the sky to navigate their way through Country, to understand time, to track the seasons, and for cultural storytelling – including the importance of cultural storytelling. It will provide an insight into how Aboriginal and Torres Strait Islander people use daylight and shadows to estimate distance when travelling, hunting and navigating, encourage students to understand the cultural meanings given to the constellations of the night sky, identify Southern Hemisphere star maps, and understand how these change overnight and during different seasons.

Learning intention

- Understand how Aboriginal and Torres Strait Islander people used the sky to help them navigate
- Identify important star patterns in the Southern Hemisphere sky, and recognise their cultural significance
- Be able to demonstrate how to use shadows for directions and to estimate distance
- Recognise the importance of First Nations navigational techniques in current wayfinding

Guiding questions

- How do people navigate today? How has this changed over time?
- How do you think people found their way before compasses and GPS?
- How and why does a shadow change during the day? What patterns can you see?
- How could the length and direction of a shadow help you determine the time of day?
- What mathematical relationships exist between the length of a shadow, the time of day, and different seasons?
- How can shadows help estimate distance?
- Why are shadows useful when you are hunting?
- How could you use shadows to navigate through Country?
- Why do stories about the Seven Sisters appear in stories across many different Aboriginal and Torres Strait Islander areas of Country?
- How do you navigate if it is a dark night, and you can't see the stars?
- Is the dark emu always in the sky?
- What star patterns signal the changing of seasons in the Southern Hemisphere?

Resources

- Sticks for shadow experiments
- Chalk for marking shadow positions
- Compass for reference
- Measuring tools (rulers, measuring tape, string etc)
- Camera(s) or devices(s) to take photos of the shadow movement (optional)
- Digital planetarium application (like Stellarium)
- *Australian Geographic DeadlyScience Book 5: The Solar System*
- *Australian Geographic DeadlyScience Book 9: Numbers in Nature, pp 11; 18-19; 22-23*
- *Australian Geographic DeadlyScience Book 10: Light and Colour, pp 26-27*
- Find North with the Stars – The Southern Cross (Southern Hemisphere)
- Ancient astrology and modern technology combine to tell stories of the night sky | ABC Australia
- Make a survival compass | shadow stick method

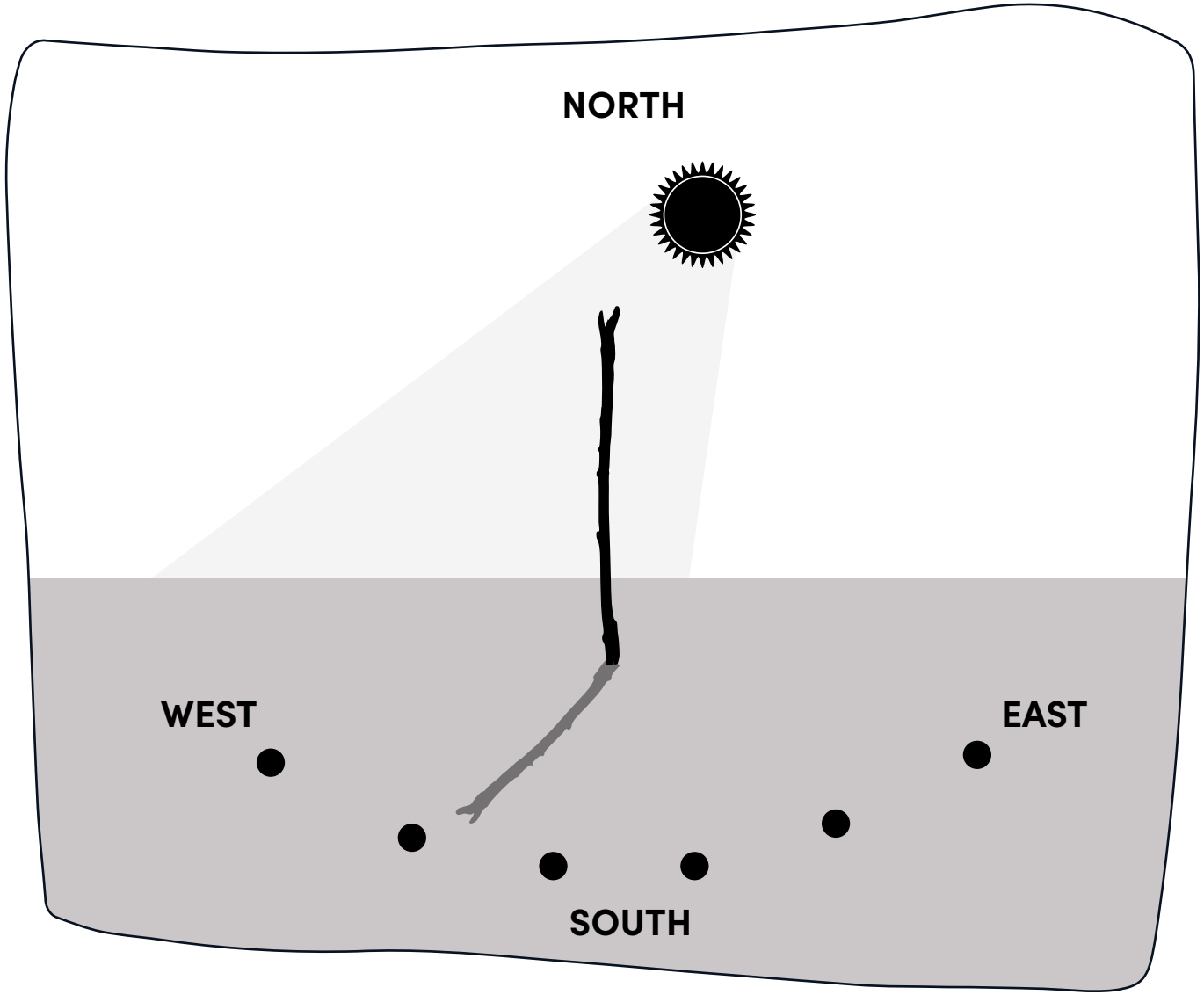
Vocabulary

- Navigation
- Celestial
- Astrology
- Southern Hemisphere
- Constellation
- Seven Sisters [The Pleiades]
- Dark Emu
- Southern Cross
- The Canoe [Orion]
- Country
- Bunjil
- Kulin Nation

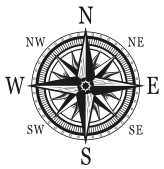
Aboriginal and Torres Strait Islander people have always observed and asked questions about the way things look in the sky, and how they change during the year. They pass this information on to their children and grandchildren through stories, songs, dances, ceremonies and artwork.
The sky is a vital part of looking after Country, it helps First Nations people navigate, understand when the seasons change, and even read the time. In eastern Australia, a certain movement of the star cluster known as the Seven Sisters tells people when whales are moving up the coast. In Central Australia, the same stars tell when the dingos are breeding, while other mobs tell of the constellation connecting to honey ants, bush tomatoes, and the thorny devil.

SHADOW NAVIGATION

The sun rises in the east and sets in the west, so in the middle of the day in the Southern Hemisphere, it will be to the north. This means that when using a shadow stick, when the sun is at its highest, it will always point south. When an object (like the stick) blocks some of the sun's light, it casts a shadow. The shadow always points away from the sun. How long the shadow is, depends on how low or high the sun is in the sky. If the sun is low, we see a longer shadow. If the sun is high, we see a shorter shadow.



PREDICT, OBSERVE, EXPLAIN

Step 1 **PREDICT**	Take the lesson outside. Place a stick upright in a sunny area of the school yard, and ask students to sketch what they think will happen to the shadow over several hours, use prompts such as "I think the shadow will..", "The shadow will be longest/shortest at.. because..." or "If I wanted to find north using this stick, I would..." – you may put these or similar prompts on some cards for your students help with how they are thinking about the shadow movement. Ask students to predict how the shadow will change throughout the day, and how you could use this to find direction.
Step 2 **OBSERVE**	Mark the position of the shadow tip every 30 minutes and ask students to record the shadow's length with a string or ruler; and direction, using chalk or stones. The students could even take photos of the shadows at the different times of the day. Then record the time of day for each measurement. [If a full-day observation isn't possible, pre-record data for the students to discuss.] Ask students to observe the shortest shadow points, how much the length changes, and the pattern of the movement.
Step 3 **EXPLAIN** 	Students analyse the collected data and compare observations with the predictions made earlier. Explain how Aboriginal and Torres Strait Islander people used shadows to navigate; how the shortest shadow typically points south; and how the length of the shadow indicates the time of day. Using the Make a survival compass | shadow stick method resource, create a shadow compass with students, and encourage them to use the compass to find North, East, South and West – the cardinal points. This is best done around solar noon when the sun is shining brightly. It is worth noting that the time of solar noon is not always 12pm. Discuss how a compass works, and then ask students to plan a short journey across the schoolyard using shadow directions and compare this with standard compass readings.

EXTEND THE LEARNING

STAR NAVIGATION

Many Aboriginal and Torres Strait Islander people know that when the Seven Sisters rise before dawn in early June, this is the beginning of the cold season for many groups across Australia. When they appear in the evening in the east, it indicates the start of warmer weather and the time to harvest.

The emu in the sky is formed of the dark patches – or dust lanes – of the Milky Way, and as it moves through the sky, it tells of what emus on Country are doing. For many clans, when the emu is 'sitting' on the horizon in autumn, it's time for the emus to lay their eggs... which heralds the time to harvest this protein-rich food source.

Orion's belt and sword is known as the 'saucepan' to many Australians, but to First Nations Australians, it is known as the 'canoe', and for people in the Torres Strait, it has particular significance for fishing seasons.

Most of us know about the Southern Cross, and how it points south. For many Aboriginal people, it also serves as a 'celestial clock' – you can read the star to tell the time, relative to the horizon! And different orientations of the cluster during different times of the year helps to track the seasons. In fact, the five stars appear in a number of creation stories, representing the eagle sky-god Bunjil's footprint for the people of the Kulin Nation, and Waluwarra for the Arrente people of Central Australia, for whom the four bright stars make up his talons, and the dark Coalsack Nebula, his nest.

Draw a star map that details these constellations, as well as the cardinal points.

Check out our at-home resource for more on star maps

DID YOU KNOW?

First Nations knowledge of star stories is increasingly being linked to modern astronomy. In fact, Aboriginal people of central Australia including the Kokatha people, appear to have known about the variable star Betelgeuse long before European astronomers, according to a new study. One story details the way Betelgeuse fades and brightens over a period of 400 days, capturing its variability long before this was discovered by European astronomers.

It is possible that many of the highways we dive on across Australia also may have been laid out according to the stars...

When researchers laid out known songlines over a modern map of Australia, they found that many highways appeared to line up with the star patterns. These roads were set along cattle trails established by early immigrant ranchers who were probably following songlines shown to them by Aboriginal and Torres Strait Islander guides.

That's deadly!

EXTEND THE LEARNING

LINKS

Natural navigation in the Southern Hemisphere

Why do shadows change over time? | Schools Observatory

Observing and living with the seasons | Australians Together

The cultural history of the Southern Cross to the Wathaurung/Wadawurrung people of the Kulin Nation

Endeavour Voyage: Sky Stories | National Museum Australia

Ancient astronomy and modern technology combine to tell stories of the night | ABC

Ancient story tells of a star's variable nature

Aboriginal Star Maps | Earthdate

Dark Skies are a 'library' for Indigenous knowledge systems

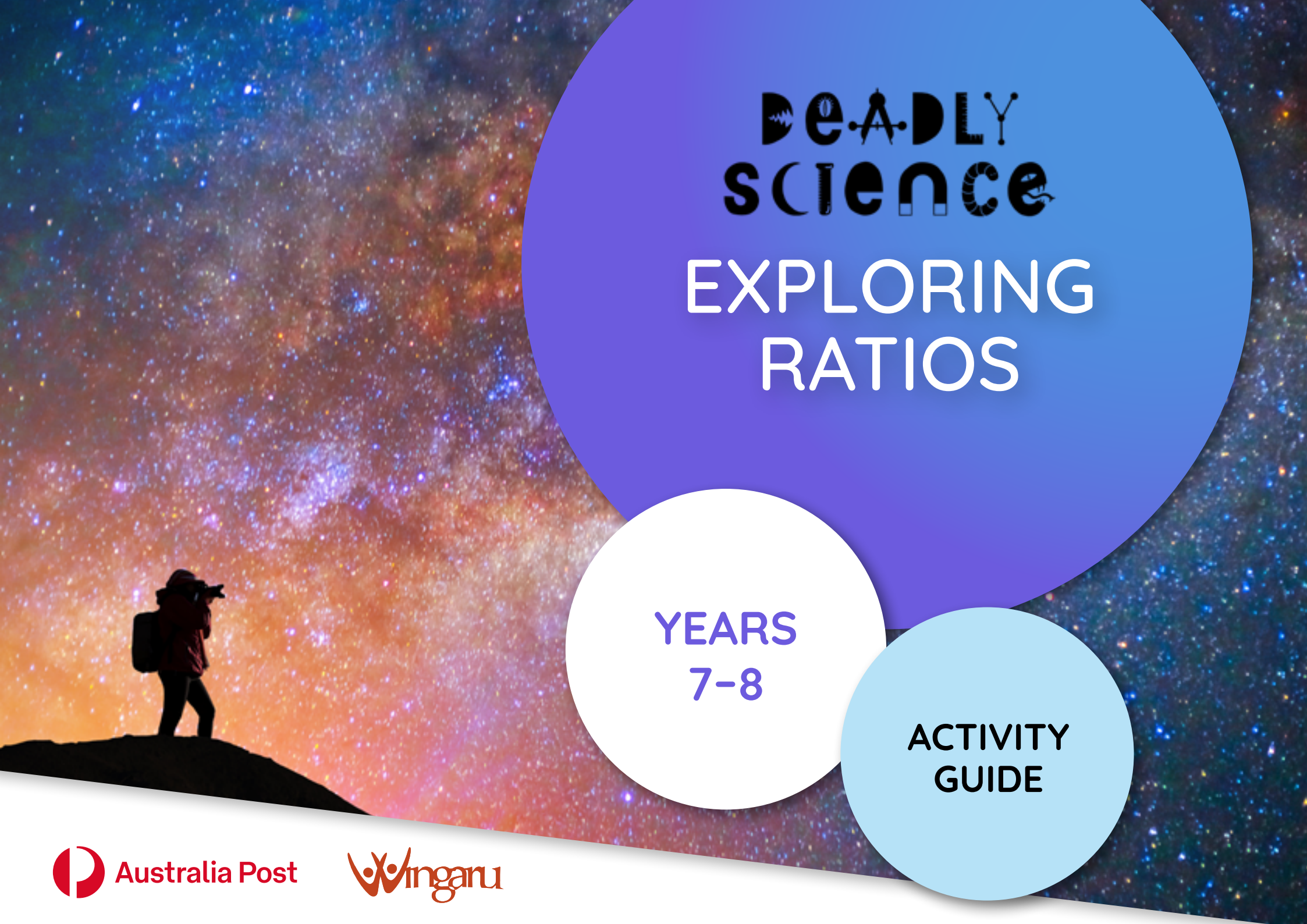
Navigation and Star Maps | Aboriginal Astronomy

Aboriginal astronomy can tell us about the link between sky and land | The Guardian

DID YOU KNOW?

Aboriginal and Torres Strait Islander people have an elaborate oral history passed down through generations to help them navigate and find food and water in their desert environment, which uses visual memory aids from the land... and the sky. When First Nations navigators found a successful path through the desert, they looked for a path in the stars that mimicked it, using stars to represent water holes and hilltops and gave them the same names. At night, they could point out the star patterns to others who had never made the trip, describing the path from one waypoint to the next. To help travellers remember the maps, clans preserved them in song, which they could sing along their journey to recall place names, orientations, and distances. In the process, they taught these songs – and the star maps they reflected – to younger generations. Used for millennia, many of these songlines are still used in Aboriginal treks today.

That's deadly!



DEADLY SCIENCE

EXPLORING RATIOS

YEARS 7–8

ACTIVITY GUIDE

Australia Post

Wingaru

7-8 | EXPLORING RATIOS

LESSON OVERVIEW

This lesson explores the significance of ratios and proportional reasoning in First Nations culture and practices, with particular relevance to sustainable land management and kinship systems. It includes investigation into Aboriginal and Torres Strait Islander sustainable land-management knowledge, and analysis of the sophisticated mathematical understanding required to carefully and effectively manage Country, including resource management, spatial understanding, and landscape burn regimes that maximise biodiversity.

Aboriginal kinship systems incorporate sophisticated proportional relationships that govern appropriate marriage arrangement and protect genetic diversity within communities, clans and nations. Moiety – or binary – kinship systems divide a community into two complementary halves: every individual belongs to exactly one moiety, often named after totems (animals, celestial bodies, and the natural elements), which establishes a strong foundation for more complex relationships.

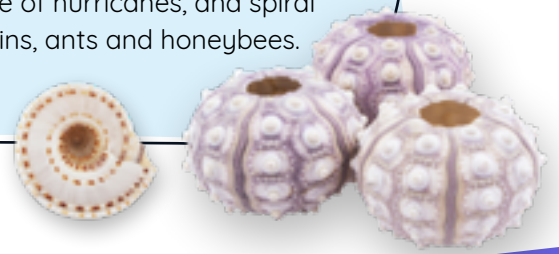
The sophisticated understanding of ratios in First Nations cultures reflects a holistic worldview where mathematical thinking is not separated from cultural, spiritual, and practical parts of life, but is integrated into a comprehensive knowledge system – a 'living maths' – developed by observation, experimentation and the transfer of knowledge over millennia.

DID YOU KNOW?

First Nations people have a longstanding practice of taking only what is needed. For example, during a pippi harvest, delicious tucker dug up from the sand in coastal areas, mob only take a third of what is available. They leave two thirds in the sand, one-third for other predators to ensure they are not left without food; and the other third left to make sure the pippi population is not destroyed and the population can sustain itself. This is sometimes referred to as the Rule of Three. It's a clever way of ensuring every element of Country is sustained.

THE GOLDEN RATIO

The Golden Ratio applies, if you draw a line and break it into two smaller, unequal parts ('a' and 'b'), the line's total length when divided by the larger part (a) will be the same as when you divide the length of (a) by the by the smaller part (b) because these two lengths follow the golden ratio (approximately 1:1618). This ratio is associated with our understanding of beauty and aesthetics, and it can be seen in artwork, shells, the human body, the shape of hurricanes, and spiral galaxies, elephant tusks, starfish, sea urchins, ants and honeybees.



FIRE MANAGEMENT

Fire management is the use of small, controlled ‘cool’ fires in a specific pattern (land ratio) to ensure trees and shrubs don’t grow too dense. This reduces the risk of major bushfires. Controlled burning is also a way of encouraging new growth in an area that provided food for animals and, in turn, food for local First Nations communities. The heat from fires causes seeds to germinate (sprout). The growth of plants attracts animals to feed in the area and also renews natural resources. Fire management techniques require a great deal of skill and knowledge, information that has been shared between generations of Aboriginal and Torres Strait Islander communities, and is still practiced today as an effective land-management method.

Learning intention

- To identify ways Aboriginal and Torres Strait Islander peoples use ratios in both cultural practice and land management
- To explain how mathematical understanding contributes to ongoing sustainable environmental practices
- Understand the application of ratio concepts to harvesting and resource sharing in Aboriginal and Torres Strait Islander society
- Appreciate the complexity and sophistication of kinship systems

Guiding questions

- What are some examples of the use of maths in caring for Country?
- What is the 'Rule of Three'? How can hunters and harvesters make sure they are sustaining Country while feeding the community?
- What impact do ratios have in protecting the environment?
- Can you think of any reasons that ratios might be used in First Nations land management?

Resources

- Maps that show sustainable cool burn ratios
- Case studies of cool burn practices
- Images showing aerial views of landscapes with clear mosaic burn patterns
- Before/after images of areas managed with cultural burning
- Comparative images of unmanaged areas after bushfire events
- Grid paper (1cm)
- Coloured pencils/markers (3 colours per student)
- Calculator (optional)
- Created handout with example burn pattern ratio
- *Australian Geographic DeadlyScience Book 9: Numbers in Nature*
- Indigenous fire methods protect land before and after the Tathra bushfire | ABC
- Three things I know about fire management | The Drum
- Historical burning: cool burning
- Right Way Fire | Indigenous Desert Alliance
- Burning the Desert the Right Way | Indigenous Desert Alliance
- Example of mosaic burn patterns | Bushfire Conference
- Cool Burns: Key to Aboriginal Fire Management
- Explore the vital role of clean air in human health and the environment | Fresh AIR Innovators

Vocabulary

- Ratios
- Golden ratio
- Proportions/ proportional reasoning
- Sustainable land management
- Resource management
- Spatial understanding
- Landscape burn regimes
- Biodiversity
- Kinship
- Moiety
- Mosaic burn

PREDICT, OBSERVE, EXPLAIN

Step 1 **PREDICT**	Review basic ratio concepts [making damper bread requires a ratio of flour to water of 2:1; on a map, the scale of 1:100,000 means 1cm on the map represents 100,000cm (1km) in real life; comparing price-to-price quantity ratios when buying a packet of chips: 170g of chips for $5, or $7.50 for a 20-pack of chips where each packet is 19g]. Then, ask students to consider how ratio principles are sustainable land management. Explain that mosaic burning (cultural burning) is the deliberate burning of small, carefully selected patches of land and different times and intensities, which creates a 'mosaic' pattern of vegetation at different stages of regrowth in the landscape, and that it, too, uses ratios. Ask students why ratios are used for fire management; ask them to consider what would happen if too much/too little was burned.
Step 2 **OBSERVE**	Show students mosaic burn pattern example, and before/after shots of areas managed by cultural burning. Then show aerial images of land that is unmanaged after a bushfire has gone through, and ask students to compare them. Ask students to observe and respond to the patterns they can see, and whether there is regularity or a visible system. Ask students to estimate the ratio of burned to unburned areas, and notice how the size of the burned patches relates to the surrounding vegetation. Explain that a 1:3:6 burn pattern ratio of fresh recent vegetation would refer to the proportional relationship between three different stages of vegetation recovery after burning: • 1 part fresh burns: Areas that have been recently burned (within the past season). These areas have minimal vegetation, exposed soil, and new shoots beginning to emerge. • 3 parts regrowth: Areas that were burned 1-3 years ago that now have moderate regrowth. These areas have young plants, increased ground cover, and are starting to provide new food sources for wildlife. • 6 parts mature vegetation: Areas that haven't been burned for several years (generally 4+ years). These have full vegetation coverage, established plant communities, and provide habitat for species that require dense vegetation.

Step 2 **OBSERVE**	Explain that this would look like the following: • 10% of the area would be freshly burned • 30% would be recent regrowth • 60% would be mature vegetation Direct students to design their own mosaic burning pattern using ratio principles for a hypothetical landscape. Provide students with grid paper representing a landscape, and ask them to create a burn pattern with a 1:3:6 ratio of freshly burned, recent regrowth and mature vegetation.
Step 3 **EXPLAIN**	Discuss observations with the class, and encourage students to see that mosaic burning isn't random – it follows sophisticated patterns based on an innate knowledge of the landscape and is designed to protect the ecological balance of Country. Ask students how these patterns might change in different seasons; what mathematical thinking is required to plan these burns; and how mosaic burning affects plant and animal life differently to a more uniform approach. Ask students to identify key geographical features on a map, such as waterways, slopes, and types of vegetation. Discuss how fire behaves in different areas – it moves faster uphill, slows near water, and burns differently in grasslands and forests. Ask students to label their mosaic burn patterns with notes about which areas they burned, how the geography influenced their choices, and the approximate ratios of fresh, recent, and mature vegetation. Encourage them to describe the size, shape, and location of each patch in relation to the landscape. Ask students to consider how burn patterns relate to geographical features, like waterways, slopes and different vegetation, and record the mosaic patterns they observe, labelling approximate ratios, and notes about patch size, shape and arrangement.

EXTEND THE LEARNING

Binary kinship systems (moieties) also use proportional relationships to ensure balance in the community. Provide students with circular templates divided into two equal halves and ask students to label one half Moiety A, the other Moiety B. Introduce the concept of the 1:1 division of a community and explain how each person belongs to a moiety. Using Moiety A and Moiety B, ask students to calculate the following:

- A hypothetical ceremonial role requires 2 people from one moiety and 3 from the other. What is the ratio of participants?
- If this pattern continues for multiple ceremonies, calculate the total representation ratio.

Explain that people must marry someone from the opposite moiety, and children belong to either their mother's or father's moiety (depending on whether it is a matrilineal or patrilineal system) and are bound by this. More complex ratio-based social structures (such as four- and eight-section systems) establish precise relationships between different family groups.

Of 20 people, 10 are from the Crocodile moiety, 10 are in the Brolga moiety:

- Ask students to calculate the ratio of possible marriage partners to non-eligible partners in a community.

DID YOU KNOW?

In Aboriginal and Torres Strait Islander culture, spatial proportions are used in memory devices like message sticks – this encoded information is understood through ratio-based systems and number systems that emphasise proportional relationships rather than absolute quantities. The motifs imprinted on each stick could signify news of war, death, peace, marriage and more. To decode the meaning, it is necessary to enlist the help of Elders, who understand depictions that may be particular to a certain group, location or idea.

LINKS

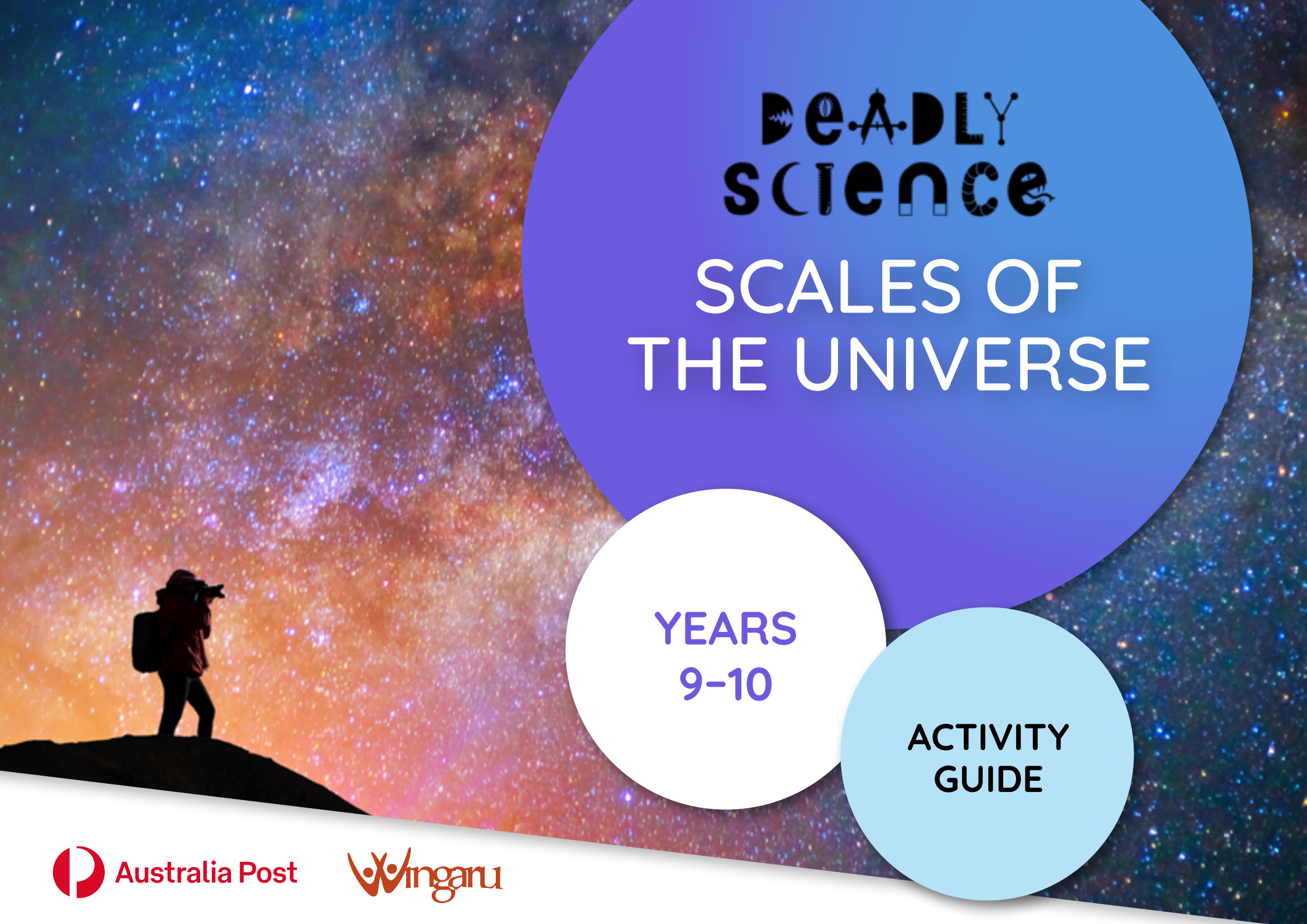
Indigenous Australians and the environment | Kids Britannica

Indigenous fire methods protect land before and after the Tathra bushfire | ABC

The 'fire-stick farming' hypothesis | PNAS

Australian Aboriginal Kinship: Social Category Systems

Message sticks: Australia's unwritten language | BBC



DEADLY SCIENCE

SCALES OF THE UNIVERSE

YEARS 9–10

ACTIVITY GUIDE

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9-10 | SCALES OF THE UNIVERSE

LESSON OVERVIEW

This lesson explores the mathematics of scale in the natural world, from atomic scale to unicellular scale, multicellular scale and continental scale. It uses scientific instruments to investigate scale at a molecular level, such as an investigation of the mineral compound of ochre.

This feeds into an analysis of the longevity of mineral compounds in rock art and our ability to date art, introducing students to the science of Optically Stimulated Luminescence (OSL) dating, and an understanding of how radiocarbon dating and other dating methods have been used to establish that Aboriginal peoples have been present on the Australian continent for more than 60,000 years.

At the other end of the scale, students are asked to consider examples of unicellular, multicellular and continental scale in the natural environment, and form an appreciation of how these elements work together.

Aboriginal and Torres Strait Islander people have incredible knowledge of the chemical properties of ochre as an important resource in pictorial messaging and artworks, as well as an understanding of the properties of binding agents, which are an essential part of developing a water-based suspension that can evenly carry ochre pigment, and allow application of the 'paint'. Animal fat, egg yolks, even blood was used so that the ochre 'stuck' to the rock, as well as fixatives such as orchid sap, which were applied at each layer, and played an important role in protecting the work.

Mathematical scaling exists throughout the natural world, and examples of it can be seen in every aspect of First Nations culture and in Country.

- **Atomic scale** defines sizes of minute objects as approximately 10^{-10}m, which is 10 to the power of -10 metres – 0.0000000001m, or 100,000th of a millimetre. An atom, for example, and invisible to the human eye: you would need to line up 10 million atoms side by side to make a line which is 1 millimetre long
- **Unicellular Scale** is the scale of single-celled organisms such as bacteria and amoeba. These cells can range from 10 to the power of -6 to -4 metres (10^{-6} to 10^{-4}m) which is shown as 0.000001 to 0.0001m: bacteria, amoeba etc
- **Multicellular Scale** is the scale of multicellular organisms – including all plants and animals – which can range in size from 0.1mm to 100m: (10^{-4} to 10^{2} metres)
- **Continental scale** relates to the size of a continent: it could range up to 10 to the power of 6 or 7 metres, (10^{6}m), or 10,000,000m. The Great Barrier Reef, for example, spans 2,300 km along the rim of Australia's continental shelf.

Learning intention

- To describe different scales of measurement in the natural world
- To explain how mineral compounds in ochre create stable rock art pigments
- To begin to understand the scientific principles behind Optically Stimulated Luminescence (OSL), radiocarbon dating, and other dating methods
- To analyse how dating techniques have transformed our understanding of Australia's human history
- To understand the significance of multiple levels of scale, in science and more broadly

Guiding questions

- How do scientists measure things that are too small to see with the naked eye or time frames too long to imagine?
- Who knows what a scale is in relation to the natural world? Can you think of something minute at one end of the scale, and something gigantic at the other end?
- Why is understanding different scales important for studying both ancient art and the materials it's made from?
- How might your perception of time differ from that of someone who lived 60,000 years ago?
- How does studying rock art enhance our understanding of Aboriginal cultures?
- Our understanding of human history in Australia has changed as dating methods have improved. Does anyone know about this?

Resources

- Ochre samples – Protocols around collecting and using ochre vary across communities and it is important to check with your local community before collecting. We recommend using First Nations-led Braveant as a culturally safe source of ochre.
- Microscope
- Stationery
- Optically Stimulated Luminescece: Archeological Dating Methods
- Optically stimulated luminescence diagram
- *National Geographic DeadlyScience Book 9: Numbers in Nature*, *pp21*
- *National Geographic DeadlyScience Book 10: Light and Colour*, *pp24*
- 'Rings of Mystery' excavation reveals rich Aboriginal history: Australian Geographic
- Madjedbebe (Malakunanja II): unveiling Australia's ancient secrets | You Tube
- Aboriginal inhabitants of Madjedbebe used different ways to adapt to environmental change
- Digging deeper into a 65,000-year story
- Wasp nests help to unlock secrets of WA's Aboriginal rock art
- Aboriginal timeline: Arts
- Radiocarbon dating at ANSTO informs date of oldest known Aboriginal rock art

Vocabulary

- Atomic
- Unicellular
- Multicellular
- Continental
- Atom
- Organism
- Electrons
- Pigments
- Rock art
- Optically Stimulated Luminescence (OSL)
- Radiocarbon dating
- Carbon-14
- Isotope
- Goethite
- Hematite
- Limonite
- Quartz
- Logarithmic timeline

PREDICT, OBSERVE, EXPLAIN

	One of the most notable characteristics of ochre is its high permanence and resistance to fading and degradation due to light, heat, or other environmental pollutants over time, largely thanks to its iron content. Introduce students to the atomic structure of ochre, comprised of iron oxide minerals bonded to oxygen in a specific crystalline arrangement, which allows it remarkable stability over tens of thousands of years: • Goethite (yellow ochre): FeO(OH) – iron(III) oxide-hydroxide • Hematite (red ochre): Fe_2O_3 – iron(III) oxide • Limonite (brown ochre): $FeO(OH)\cdot nH_2O$ – hydrated iron oxide
Step 1 **PREDICT**	Explain that understanding the structure of ochre at an atomic level can provide complex additional information about how it interacts with and can affect other compounds. The distinctive properties we associate with ochre as a material that has withstood millennia – as seen in First Nations art – is thanks to the hardness of the iron [goethite, hematite, limonite], with its covalent bonds and iron oxide sheets, which make it highly resistant to weathering. It's impossible to date ochre, however, the pigment it is painted on can be dated. Introduce the concept of OSL (Optically Stimulated Luminescence) dating. Ask students to consider how OSL dating could be used to date ancient Aboriginal and Torres Strait Islander culturally significant sites.

OSL (Optically Stimulated Luminescence) dating is a method of measuring time since mineral grains in a sample were last exposed to sunlight or heat. Electrons are trapped in crystal defects in the mineral structure when mineral grain, usually quartz or feldspar are buried under sediment, which means when they are exposed to sunlight or heat again, the electrons are released, producing measurable light. The amount of light that is released indicates the amount of time that has elapsed since the crystal was buried.

Step 2 **OBSERVE**	Watch the Optically Stimulated Luminescece: Archeological Dating Methods resource, and ask students to discuss how understanding the atomic makeup of the rock layers ochre is painted on is important when using this dating technique, and how they would go about dating the age of a newly discovered First Nations rock-art site. [Dating quartz sand near rock art, sediments in caves; dating mud-wasp nests: see video resources]. Using a microscope, encourage students to view ochre samples at a series of magnifications and note down what they see. Ask students to consider what additional information the different microscopic scales provide, and what this greater understanding of molecular scale could mean in terms of the makeup of the rocks art is painted on, and the way ochre behaves. Ask students to study the arts timeline listed in the Aboriginal timeline: Arts then compile a logarithmic timeline of their own showing the following points: • Half-life of carbon-14 (5,730 years) • Age of oldest dated Australian rock art (~65,000 years) • Length of recorded (written) human history (~5,000 years) • Time since dinosaur extinction (66 million years) • Age of Earth (4.54 billion years)
Step 3 **EXPLAIN**	Discuss the effectiveness of OSL dating and radiocarbon dating, and how understanding the molecular structure of something can give us an insight into its age. Next, analyse this information when considering why First Nations rock art endures [chemical stability of iron oxide minerals; reactions with rock surfaces to form stable compounds; protection from environmental factors (arid desert environment, cave overhangs); and cultural practices that maintain these important sites]. Apply different concepts of scale to this example: while atomic scale provides vital information, continental scale offers a different perspective. Encourage students to explain that a scaled overview of this information provides evidence for the migration and movement of Aboriginal and Torres Strait Islander peoples across the continent, as well as a rich insight into First Nations culture.

EXTEND THE LEARNING

Introduce students to additional methods of dating, including U-Th (Uranium-Thorium) dating – used for determining the age of calcium; TL (Thermoluminescence) dating, similar to OSL dating, and used for heated materials; and stratigraphic analysis, commonly used to study layers of archaeological deposits.

Watch the YouTube footage of the Madjedbebe (Malakunanja II) case study in Arnhem Land in the resources section, which shows evidence of human occupation dating to 65,000+ years ago.

Investigate the different methods used to verify findings, the types of artefacts discovered, and the significance of this site for understanding Aboriginal history.

DID YOU KNOW?

Radiocarbon dating is another method used to identify the age of something. It works as a measure of decay of carbon-14 isotopes [carbon-14, C-14, 14C or radiocarbon, is a radioactive isotope of carbon]; living organisms all absorb carbon-14 from the atmosphere, and, after death, carbon-14 decays at a known rate. Therefore, the remaining carbon-14 in an organic element will indicate the time since death. Radiocarbon dating offers contemporary science an effective and fascinating insight into the past.

LINKS

The evolution of the atom | BBC

Unicellular vs multicellular | National Geographic

Cell size and scale | Genetic Science Learning Centre

Great Barrier Reef | UNESCO

Research At Multiple Scales: A Vision for Continental Scale Biology

Natural Pigments

Mineralogical and chemical characterisation of ochres | Science Direct

Australia: the land where time began

Optically Stimulated Luminescence: Archaeological Dating Methods

'Rings of Mystery' excavation reveals rich Aboriginal history: Australian Geographic

Madjedbebe (Malakunanja II): unveiling Australia's ancient secrets | You Tube

Aboriginal inhabitants of Madjedbebe used different ways to adapt to environmental change

Digging deeper into a 65,000-year story

Languages Alive | AIATSIS

LINKS AND SOURCES

Connectedness in mathematics: teaching in a way that shows the maths in culture, rather than putting the culture into maths; Laura Barry, Middle Harbour Public School| 2020 Premier's Mathematical Association of NSW Mathematics Scholarship

Astronomical knowledge of celestial objects influences and informs the life and law of First Nations people | SBS

Sky Country, Aunty Patsy Cameron

Bush Tracks, Ros Moriaty

Explainer: How does the Aboriginal numeric system work? | University of Sydney

The returning boomerang: how it flies | Australian Museum

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