PrimaryConnections®
Linking science with literacy

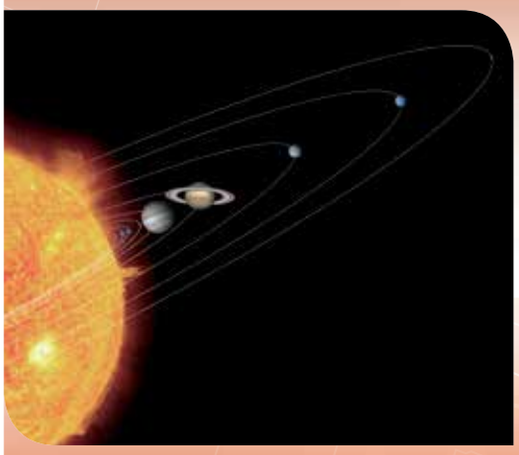
Fully aligned with the Australian Curriculum

The PrimaryConnections program is supported by astronomer, Professor Brian Schmidt, 2011 Nobel Laureate

Earth's place in Space

Year 5

Earth and space sciences



Primary**Connections project**

Australian Government

Australian Academy of Science

Professional learning program

The Primary**Connections** program includes a sophisticated professional learning component and exemplary curriculum resources. Research shows that this combination is more effective than using each in isolation.

Professional Learning Facilitators are available throughout Australia to conduct workshops on the underpinning principles of the program: the Primary**Connections** 5Es teaching and learning model, linking science with literacy, investigating, embedded assessment and collaborative learning.

The Primary**Connections** website has contact details for state and territory Professional Learning Coordinators, as well as additional resources for this unit. Visit the website at:
www.science.org.au/primaryconnections

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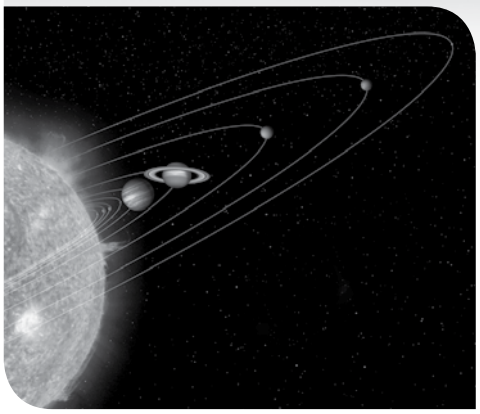

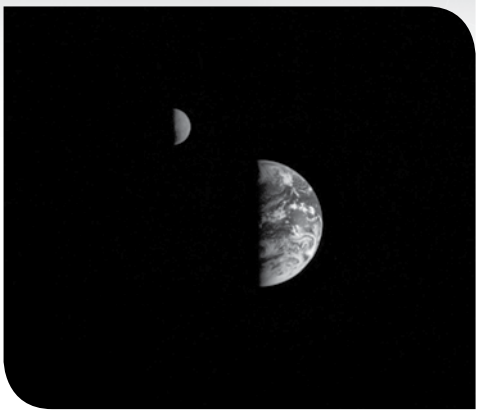

Humans have always looked with wonder at the movement of celestial bodies in the sky. We have used its rhythms to define our days, our months and our years. Not only have we defined time by these patterns, we learned to navigate using their predictable motions. Scientists have used observations of the day and night sky to understand our place in Space. With the advance of technology, astronomers seek answers to the big questions in life, such as the origins of the Universe and the existence of life on other planets.

The *Earth's place in Space* unit is an ideal way to link science with literacy in the classroom. It provides opportunities for students to explore how the patterns in the sky relate to days, months and years. Students' understanding of how observation and models can be used to shape ideas and understandings is developed through hands-on activities and student-planned investigations. Students also investigate the elements of our Solar System and Earth's position within it.

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GPO Box 783
Canberra ACT 2601
Telephone: (02) 9386 4544
Fax: (02) 9387 7755
Email: pc@science.org.au
www.primaryconnections.org.au

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Contents

Foreword

The Australian Academy of Science is proud of its long tradition of supporting and informing science education in Australia. 'PrimaryConnections: linking science with literacy' is its flagship primary school science program, and it is making a real difference to the teaching and learning of science in Australian schools.

The PrimaryConnections approach has been embraced by schools since its inception in 2004, and there is substantial evidence of its effectiveness in helping teachers transform their practice. It builds teacher confidence and competence in this important area, and helps teachers use their professional skills to incorporate elements of the approach into other areas of the curriculum. Beginning and pre-service teachers find the approach do-able and sustainable. PrimaryConnections students enjoy science more than in comparison classes and Indigenous students, in particular, show significant increases in learning using the approach.

The project has several components: professional learning, curriculum resources, research and evaluation, and Indigenous perspectives. With the development of an Australian curriculum in the sciences by ACARA in December 2010, it is an exciting time for schools to engage with science, and to raise the profile of primary science education.

Students are naturally curious. PrimaryConnections provides an inquiry-based approach that helps students develop deep learning, and guides them to find scientific ways to answer their questions. The lessons include key science background information, and further science information is included on the PrimaryConnections website.

Science education provides a foundation for a scientifically literate society, which is so important for engagement in key community debates, such as climate change, carbon emissions and immunisation, as well as for personal decisions about health and well-being. The inquiry approach in PrimaryConnections prepares students well to participate in evidence-based discussions of these and other issues.

PrimaryConnections has been developed with the financial support of the Australian Government and has been endorsed by education authorities across the country. The Steering Committee, comprising the Department of Education, Employment and Workplace Relations and Academy representatives, and the Reference Group, which includes representatives from all stakeholder bodies including states and territories, have provided invaluable guidance and support over the last seven years. Before publication, the teacher background information on science is reviewed by a Fellow of the Academy. All these inputs have ensured an award-winning, quality program.

The Fellows of the Academy are committed to ongoing support for teachers of science at all levels. I commend PrimaryConnections to you and wish you well in your teaching.

Professor Suzanne Cory, AC PresAA FRS
President
Australian Academy of Science
2010–2013

The PrimaryConnections program

PrimaryConnections is an innovative program that links the teaching of science and literacy in the primary years of schooling. It is an exciting and rewarding approach for teachers and students, with a professional learning program and supporting curriculum resources. Further information about professional learning and other curriculum support can be found on the PrimaryConnections website: www.science.org.au/primaryconnections

Developing students' scientific literacy

The learning outcomes in PrimaryConnections contribute to developing students' scientific literacy. Scientific literacy is considered the main purpose of school science education and has been described as an individual's:

- scientific knowledge and use of that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues
- understanding of the characteristic features of science as a form of human knowledge and enquiry
- awareness of how science and technology shape our material, intellectual and cultural environments
- willingness to engage in science-related issues, and with the ideas of science, as a reflective citizen (Programme for International Student Assessment & Organisation for Economic Co-operation and Development, 2009).

The PrimaryConnections teaching and learning model

This unit is one of a series designed to exemplify the PrimaryConnections teaching and learning approach, which embeds inquiry-based learning into a modified 5Es instructional model, with the five phases: *Engage, Explore, Explain, Elaborate* and *Evaluate* (Bybee, 1997). The relationship between the 5Es phases, investigations, literacy products and assessment is illustrated below:

PrimaryConnections 5Es teaching and learning model

Phase	Focus	Assessment focus
ENGAGE	Engage students and elicit prior knowledge	**Diagnostic assessment**
EXPLORE	Provide hands-on experience of the phenomenon	**Formative assessment**
EXPLAIN	Develop scientific explanations for observations and represent developing conceptual understanding Consider current scientific explanations	**Formative assessment**
ELABORATE	Extend understanding to a new context or make connections to additional concepts through a student-planned investigation	**Summative assessment** of the Science Inquiry Skills
EVALUATE	Students re-represent their understanding and reflect on their learning journey, and teachers collect evidence about the achievement of outcomes	**Summative assessment** of the Science Understanding

More information on PrimaryConnections 5Es teaching and learning model can be found at: www.science.org.au/primaryconnections/teaching-and-learning

Assessment

Assessment against the year level achievement standards of the Australian Curriculum: Science (ACARA, 2010) is ongoing and embedded in PrimaryConnections units. Assessment is linked to the development of literacy practices and products. Relevant understandings and skills are highlighted at the beginning of each lesson. Different types of assessment are emphasised in different phases:

Diagnostic assessment occurs in the *Engage* phase. This assessment is to elicit students' prior knowledge so that the teacher can take account of this when planning how the Explore and *Explain* lessons will be implemented.

Formative assessment occurs in the *Explore* and *Explain* phases. This enables the teacher to monitor students' developing understanding and provide feedback that can extend and deepen students' learning.

Summative assessment of the students' achievement developed throughout the unit occurs in the *Elaborate* phase for the Science Inquiry Skills, and in the Evaluate phase for the Science Understanding.

Linking science with literacy

PrimaryConnections has an explicit focus on developing students' knowledge, skills, understanding and capacities in science and literacy. Units employ a range of strategies to encourage students to think about, reason and represent science.

PrimaryConnections develops the literacies of science that students need to learn and to represent their understanding of science concepts, processes and skills. Representations in PrimaryConnections are multi-modal and include text, tables, graphs, models, drawings and embodied forms, such as gesture and role-play. Students use their everyday literacies to learn the new literacies of science. Science provides authentic contexts and meaningful purposes for literacy learning, and also provides opportunities to develop a wider range of literacies. Teaching science with literacy improves learning outcomes in both areas.

Alignment with the Australian Curriculum: Science

The Australian Curriculum: Science has three interrelated strands — Science Understanding, Science as a Human Endeavour and Science Inquiry Skills — that together 'provide students with understanding, knowledge and skills through which they can develop a scientific view of the world' (ACARA, 2010).

The content of these strands is described by the Australian Curriculum as:

Science Understanding	
Biological sciences	Understanding living things
Chemical sciences	Understanding the composition and behaviour of substances
Earth and space sciences	Understanding Earth's dynamic structure and its place in the cosmos
Physical sciences	Understanding the nature of forces and motion, and matter and energy
Science as a Human Endeavour	
Nature and development of science	An appreciation of the unique nature of science and scientific knowledge
Use and influence of science	How science knowledge and applications affect people's lives and how science is influenced by society and can be used to inform decisions and actions
Science Inquiry Skills	
Questioning and predicting	Identifying and constructing questions, proposing hypotheses and suggesting possible outcomes
Planning and conducting	Making decisions regarding how to investigate or solve a problem and carrying out an investigation, including the collection of data
Processing and analysing data and information	Representing data in meaningful and useful ways, identifying trends, patterns and relationships in data, and using evidence to justify conclusions
Evaluating	Considering the quality of available evidence and the merit or significance of a claim, proposition or conclusion with reference to that evidence
Communicating	Conveying information or ideas to others through appropriate representations, text types and modes

AC All the material in this table is sourced from the Australian Curriculum.

There will be a minimum of four Primary**Connections** units for each year of primary school from Foundation to Year 6 — at least one for each Science Understanding sub-strand of the Australian Curriculum. Each unit contains detailed information about its alignment with all aspects of the Australian Curriculum: Science and its links to the Australian Curriculum: English and Mathematics.

Safety

SAFETY

Learning to use materials and equipment safely is central to working scientifically. It is important, however, for teachers to review each lesson before teaching to identify and manage safety issues specific to a group of students. A safety icon SAFETY is included in lessons where there is a need to pay particular attention to potential safety hazards. The following guidelines will help minimise risks:

- Be aware of the school's policy on safety in the classroom and for excursions.
- Check students' health records for allergies or other health issues.
- Be aware of potential dangers by trying out activities before students do them.
- Caution students about potential dangers before they begin an activity.
- Clean up spills immediately as slippery floors are dangerous.
- Instruct students never to taste, smell or eat anything unless they are given permission.
- Discuss and display a list of safe practices for science activities.

References

Australian Curriculum Assessment and Reporting Authority (ACARA). (2010). *Australian Curriculum: Science*. www.australiancurriculum.edu.au

Bybee, R.W. (1997). *Achieving scientific literacy: from purposes to practical action*. Portsmouth, NH: Heinemann.

Programme for International Student Assessment & Organisation for Economic Co-operation and Development. (2009). *PISA 2009 assessment framework: key competencies in reading, mathematics and science*. Paris: OECD Publishing.

Unit at a glance *Earth's place in Space*

Phase	Lesson	At a glance
ENGAGE	**Lesson 1** Model arguments ***Session 1*** Eratosthenes' epiphany ***Session 2*** Centred on the Sun	To capture students' interest and find out what they think they know about the Earth as part of a system of planets orbiting a star (the Sun) To elicit students' questions about how humans have sought to explore and understand Earth's place in Space
EXPLORE	**Lesson 2** Rising and setting	To provide shared experiences of the observable movement of the Sun and Moon in our sky
	Lesson 3 Going in circles	To provide hands-on, shared experiences of testing theories to explain observable movement of the Sun and Moon in our sky
EXPLAIN	**Lesson 4** Galvanising Galileo	To support students to represent and explain their understanding of how the Earth orbits the Sun while rotating on its axis To introduce current scientific views about Earth's place in Space
	Lesson 5 Chasing constellations (*Optional*)	To introduce current scientific views about how the observation of constellations provides evidence about Earth's place in Space
ELABORATE	**Lesson 6** Solar System scientists ***Session 1*** Dealing with data ***Session 2*** Size matters	To support students to investigate characteristics of objects in the Solar System and create an accurate model of the Solar System
EVALUATE	**Lesson 7** Sunning it up	To provide opportunities for students to represent what they know about the Earth as part of a system of planets orbiting a star (the Sun) and to reflect on their learning during the unit

A unit overview can be found in Appendix 8, page 84.

Alignment with the Australian Curriculum: Science

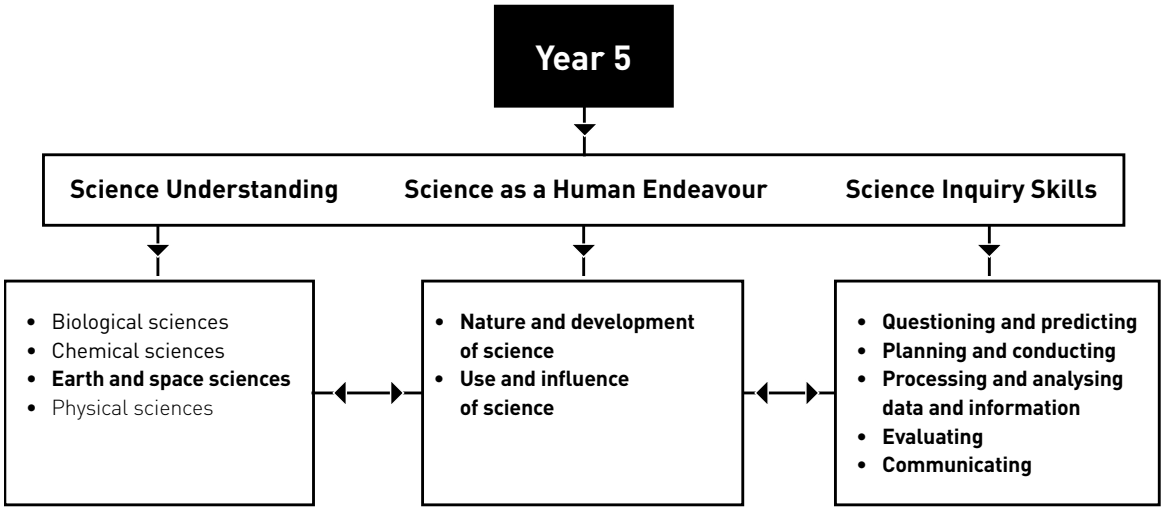
Earth's place in Space embeds the three strands of the Australian Curriculum: Science. The particular sub-strands and their content for Year 5 that are relevant to this unit are shown below.

Strand	Sub-strand	Code	Year 5 content descriptions	Lessons
Science Understanding	**Earth and Space sciences**	ACSSU078	The Earth is part of a system of planets orbiting a star (the Sun)	2–7
Science as a Human Endeavour	**Nature and development of science**	ACSHE081	Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena	1, 4, 5, 6, 7
		ACSHE082	Important contributions to the advancement of science have been made by people from a range of cultures	4, 5
	Use and influence of science	ACSHE083	Scientific understandings, discoveries and inventions are used to solve problems that directly affect people's lives	1, 4, 7
		ACSHE217	Scientific knowledge is used to inform personal and community decisions	2–7
Science Inquiry Skills	**Questioning and predicting**	ACSIS231	With guidance, pose questions to clarify practical problems or inform a scientific investigation, and predict what the findings of an investigation might be	1–5
	Planning and conducting	ACSIS086	With guidance, plan appropriate investigation methods to answer questions or solve problems	3, 6
		ACSIS087	Decide which variable should be changed and measured in fair tests and accurately observe, measure and record data, using digital technologies as appropriate	3
		ACSIS088	Use equipment and materials safely, identifying potential risks	1, 3, 4, 5
	Processing and analysing data and information	ACSIS090	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	2, 3, 6
		ACSIS218	Compare data with predictions and use evidence in developing explanations	2, 3, 5 ,6
	Evaluating	ACSIS091	Suggest improvements to the methods used to investigate a question or solve a problem	3, 6, 7
	Communicating	ACSIS093	Communicate ideas, explanations and processes in a variety of ways, including multi-modal texts	3, 7

AC All the material in the first four columns of this table is sourced from the Australian Curriculum.

Interrelationship of the Science strands

The interrelationship between the three strands — Science Understanding, Science as a Human Endeavour and Science Inquiry Skills — and their sub-strands is shown below. Sub-strands covered in this unit are in bold.



All the terms in this diagram are sourced from the Australian Curriculum.

Relationship to Overarching ideas

In the Australian Curriculum: Science, six overarching ideas support the coherence and developmental sequence of science knowledge within and across year levels. In *Earth's place in Space*, these overarching ideas are represented as follows:

Overarching idea	Incorporation in *Earth's place in Space*
Patterns, order and organisation	Students investigate different models in order to explain patterns of observation at different timescales, including over the course of a day, ie the Sun and Moon rising and setting, and over the course of a year, ie different constellations visible at different times of the year.
Form and function	Students explore how the characteristics of the Earth, Moon, Sun and stars influence our observations on Earth. They identify the Sun as a source of light and model how it affects the spherical Earth and Moon to bring about day and night and annual patterns in the stars.
Stability and change	Students explore patterns of change, for example, the rising and setting of the Sun and Moon. They identify that these patterns can be seen as stable or changing depending on the timescale, ie the Moon rises every day but not necessarily in the same place or at the same time.
Scale and measurement	Students consider the relative sizes and positions of planets within the Solar System and construct accurate scaled models. Students discuss the merits of different scales in models depending on the purpose of the model.
Matter and energy	Students recognise the Sun and stars as sources of light energy and the planets and moons as receivers of their light. Students investigate the size and movements of different space objects in the Solar System. Through modelling the orbits of the planets they investigate the relative speeds of planets and therefore how much movement energy the planets have.
Systems	Students identify observable components within the Solar System and their movements in relation to one another. Through investigations and models, students relate the interaction of elements in the Solar System to the systems that they experience on Earth, for example the availability of sunlight.

Curriculum focus

The Australian Curriculum: Science is described by year level, but provides advice across four year groupings on the nature of learners. Each year grouping has a relevant curriculum focus.

Curriculum focus Years 3–6	Incorporation in *Earth's place in Space*
Recognising questions that can be investigated scientifically and investigating them	Students are presented with theories about Earth's place in Space. They choose questions that could help evaluate the theories. Students also investigate secondary knowledge on elements of the Solar System, such as the Sun.

Achievement standards

The achievement standards of the Australian Curriculum: Science indicate the quality of learning that students typically demonstrate by a particular point in their schooling, for example, at the end of a year level. These standards will be reviewed regularly by ACARA and are available from the ACARA website.

By the end of this unit, teachers will be able to make evidence-based judgements on whether the students are achieving below, at or above the Australian Curriculum: Science Year 5 Achievement standard. Rubrics to help teachers make these judgements are available on the website: www.science.org.au/primaryconnections/curriculum-resources

General capabilities

The skills, behaviours and attributes that students need to succeed in life and work in the 21st century have been identified in the Australian Curriculum as General capabilities. There are seven general capabilities, which are embedded throughout the units. For unit-specific information see the next page. For further information see: www.australiancurriculum.edu.au/generalcapabilities

Earth's place in Space — Australian Curriculum General capabilities

General capabilities	Australian Curriculum description	*Earth's place in space* examples
Literacy	Literacy knowledge specific to the study of science develops along with scientific understanding and skills. Primary**Connections** learning activities explicitly introduce literacy focuses and provide students with the opportunity to use them as they think about, reason and represent their understanding of science.	In *Earth's place in Space* the literacy focuses are: • science journals • TWLH charts • word walls • glossaries • flow charts • role-plays • procedural texts • tables • factual recounts.
Numeracy	Elements of numeracy are particularly evident in Science Inquiry Skills. These include practical measurement and the collection, representation and interpretation of data.	Students: • collect, interpret and represent data about planets in the Solar System • create models with different scales.
Information and communication technology (ICT) competence	ICT competence is particularly evident in Science Inquiry Skills. Students use digital technologies to investigate, create, communicate, and share ideas and results.	Students are given optional opportunities to: • use interactive resource technology to view, record and discuss information • use programs, such as Stellarium and Celestia, to visualise *Earth's place in Space* • use ICT to prepare and publish a text.
Critical and creative thinking	Students develop critical and creative thinking as they speculate and solve problems through investigations, make evidence-based decisions, and analyse and evaluate information sources to draw conclusions. They develop creative questions and suggest novel solutions.	Students: • use reasoning to develop questions for inquiry • formulate, pose and respond to questions • develop evidence-based claims.
Ethical behaviour	Students develop ethical behaviour as they explore principles and guidelines in gathering evidence and consider the implications of their investigations on others and the environment.	Students: • ask questions of others, respecting each other's point of view.
Personal and social competence	Students develop personal and social competence as they learn to work effectively in teams, develop collaborative methods of inquiry, work safely, and use their scientific knowledge to make informed choices.	Students: • work collaboratively in teams • listen to and abide by rules of a new game • follow a procedural text for working safely • participate in discussions.
Intercultural understanding	Intercultural understanding is particularly evident in Science as a Human Endeavour. Students learn about the influence of people from a variety of cultures on the development of scientific understanding.	• 'Cultural perspectives' opportunities are highlighted where relevant. • Important contributions made to science by people from a range of cultures are highlighted where relevant.

All the material in the first two columns of this table is sourced from the Australian Curriculum.

Cross curriculum priorities

There are three cross curriculum priorities identified by the Australian Curriculum:

- Aboriginal and Torres Strait Islander histories and cultures
- Asia and Australia's engagement with Asia
- Sustainability.

One of these is embedded within this unit as described below. For further information see: www.australiancurriculum.edu.au/CrossCurriculumPriorities

Aboriginal and Torres Strait Islander histories and cultures

Primary**Connections** has developed an Indigenous perspective framework that has informed practical reflections on intercultural understanding. It can be accessed at: www.science.org.au/primaryconnections/indigenous

Earth's place in Space focuses on the Western science method of gaining knowledge, including using models to test different theories to explain observations. Students are introduced to some of the evidence and reasoning that led scientists to conclude that Earth is a planet orbiting the Sun while rotating on its own axis, and is just one of several planets in the Solar System. For example, students explore how the rising of the Sun and Moon in the sky can be explained by the rotation of the Earth. Indigenous cultures might have different explanations for observations of the movement of space objects, such as the Sun, Moon and stars in the sky, often referring to Dreamtime. For example, many groups tell stories of a female Sun who walks across the sky during the day. Indigenous people have long studied the night sky, and the position of the stars can be used for navigation, a calendar for food collection, or even serve as a reminder of social rules and norms.

Primary**Connections** recommends working with Indigenous community members to access contextualised, relevant Indigenous perspectives. Protocols on seeking out and engaging Indigenous community members are discussed in state and territory Indigenous education policy documents, and can be found on the Primary**Connections** website.

Alignment with the Australian Curriculum: English and Mathematics

Strand	Sub-strand	Code	Year 5 content descriptions	Lessons
English – Language	**Language variation and change**	ACELA1500	Understand that the pronunciation, spelling and meanings of words have histories and change over time	1
	Language for interaction	ACELA1502	Understand how to move beyond making bare assertions and take account of differing perspectives and points of view	1, 4, 5, 6
	Text structure and organisation	ACELA1504	Understand how texts vary in purpose, structure and topic as well as the degree of formality	1–6
	Expressing and developing ideas	ACELA1512	Understand the use of vocabulary to express greater precision of meaning, and know that words can have different meanings in different contexts	1, 6, 7
English – Literature	**Responding to literature**	ACELT1609	Present a point of view about particular literary texts using appropriate metalanguage and reflecting on the viewpoints of others	1, 4, 5
English — Literacy	**Interaction with others**	ACELY1699	Clarify understanding as it unfolds in formal and informal situations, connecting ideas to students' own experiences, and present and justify a point of view	1–7
		ACELY1796	Use interaction skills, for example, paraphrasing, questioning and interpreting non-verbal cues, and choose vocabulary and vocal effects appropriate for different audiences and purposes	1, 2, 3, 5, 6, 7
		ACELY1700	Plan, rehearse and deliver presentations for defined audiences and purposes, incorporating accurate and sequences content and multimodal elements.	2, 7
	Interpreting, analysing, evaluating	ACELY1703	Use comprehension strategies to analyse information, integrating and linking ideas from a variety of print and digital sources	6
	Creating texts	ACELY1704	Plan, draft and publish imaginative, informative and persuasive print and multi-modal texts, choosing text structures, language features, images and sound appropriate to purpose and audience	7
Mathematics	**Measurement and geometry**	ACMMG108	Choose appropriate units of measurement for length, area, volume, capacity and mass	6
	Statistics and probability	ACMSP118	Pose questions and collect categorical or numerical data by observation or survey	3, 6
		ACMSP120	Describe and interpret different data sets in context	6

All the material in the first four columns of this table is sourced from the Australian Curriculum.

Other links are highlighted at the end of lessons where possible. These links will be revised and updated on the website: www.science.org.au/primaryconnections/curriculum-resources

Introduction to our place in Space

Teacher background information

The Sun, Moon and Earth

The Earth is a planet in orbit around the Sun. This orbit takes slightly more than one year — 365¼ days — so we add an extra day to our calendar, 29 February, in every fourth year, which we call a leap year.

As the Earth slowly orbits the Sun, it rotates on its axis once every 24 hours (a day). The rotation of the Earth causes the apparent rising and setting of the Sun and is the reason we experience alternating night and day. The tilt of the Earth's axis does not change as it goes around the Sun. This causes the seasons.

The Moon is a satellite of the Earth. It orbits the Earth once a lunar month. The method of reckoning a lunar month varies from culture to culture and depends on the frame of reference, but the most common way of measuring (from New Moon to New Moon) is about 29½ days. Since calendars count full days only, most calendar months are around 30 days in length.

We always see the same face of the Moon from the Earth because the Moon spins on its axis once each time it goes around the Earth. We see the Moon from the Earth because the Moon reflects light from the Sun. The Moon itself does not emit light. The Sun is the only body in our Solar System that emits light.

The Solar System and beyond

The Sun, Earth and Moon belong to the Solar System, which includes all the space objects that are in orbit around the Sun. A 'space object' (or celestial body/heavenly body/space body) refers to naturally occurring objects in Space, such as planets, asteroids and comets. Space objects in the Solar System are visible because light from the Sun reflects off them to reach our eyes.

The Sun is the largest object in the Solar System, containing 99 per cent of its total mass. The Sun is so massive that the planets and asteroids of the Solar System are attracted to it and revolve in orbit around it. The whole Solar System is moving at great speed through the Galaxy. Our Solar System is part of the Milky Way Galaxy, which contains tens of billions of stars. Our Universe comprises billions of galaxies.

Nature of Science

As the Australian Curriculum: Science states, 'Science investigations are activities in which ideas, predictions or hypotheses are tested and conclusions are drawn in response to a question or problem'. Theories can be tested through direct investigations, but also through comparing their explanatory power. The theory of space objects spinning around the Earth explained the apparent movements of the Sun, Earth and Moon, but as our observations improved, increasingly complicated addendums had to be invented to explain them.
The theory that the Earth is part of a system of planets rotating around the Sun provided simple explanations for all the observations and could accurately predict observations not yet technically possible.

When comparing theories about things that are too large to observe like the Solar System, or too small to observe like atoms, scientists use models to test their theories. The models might be:

- verbal descriptions, such as 'The Earth travels around the Sun'
- 2D descriptions, for example, the drawing Eratosthenes makes for his companion
- 3D models, for example, the orreries that students create during the unit
- computer simulations, for example, the Stellarium and Celestia programs that can provide simulations of the sky for your particular region at different times.

All models are simplifications of reality, and their advantages and limitations need to be carefully judged before they are used to test theories. The use of models to test theories is different from creating communication devices to simply provide information.

Asking students to generate their own representations and then test them against observations is a very powerful teaching approach, particularly when students are introduced to other theories and the way those theories explain our observations. This is because students tend to centre on evidence that confirms their current beliefs, a common human fallacy called 'confirmation bias'. Students do not consider that the evidence might also confirm other models, and do not seek to compare the models to identify the one that provides the greatest explanatory power.

Students' conceptions

Taking account of students' existing ideas is important in planning effective teaching approaches that help students learn science. Students develop their own ideas during their experiences in everyday life and might hold more than one idea about an event or phenomenon.

Students might think that the Earth is the centre of the Universe. They might believe this because the Earth feels like it is staying still while the Sun appears to move across the sky. However the Earth is spinning on its axis as it orbits the Sun. We do not feel these movements because gravity pulls everything towards the centre of the Earth.

Students might think that the Solar System is only made up of the Sun, the Moon and the planets. There are many other 'space objects' in the form of naturally occurring objects, such as asteroids and comets, and human-made objects, such as space stations, satellites and rockets.

Some students might think that the stars they see at night are a part of the Solar System. The Solar System consists of objects that orbit the Sun ('solar' comes from the Latin term for Sun). Many other stars have their own systems of planets and/or asteroids that orbit them. Space objects from our Solar System, such as planets and moons, are visible because they reflect light from the Sun. Stars are visible because they, like the Sun, produce their own light powered by nuclear fusion.

Many students hold non-scientific ideas about the size of objects in Space and the distance between them. For example, some students might believe that the Sun and the Moon are about the same size because they appear to be the same size in the sky. The Moon is actually much smaller than the Sun, but it is also much closer to Earth. These non-scientific ideas about size and distance in Space are often reinforced by representations, for example, in books and 3D models that are not made to scale.

It is recommended that the *Spinning in Space* unit be taught before the *Earth's place in Space* unit. *Spinning in Space* introduces and explains concepts about day and night, and the shapes and movements of the Sun and Earth. These concepts are used in the *Earth's place in Space* unit.

Reference

Skamp, K. (Ed.). (2012). *Teaching primary science constructively* (4th Edn). South Melbourne: Cengage Learning Australia.

To access more in-depth science information in the form of text, diagrams and animations, refer to the Primary**Connections** Science Background CD, which has now been loaded on the Primary**Connections** website: www.science.org.au/primaryconnections. Note that this background information is intended for the teacher only.

Lesson 1 Model arguments

AT A GLANCE

To capture students' interest and find out what they think they know about the Earth as part of a system of planets orbiting a star (the Sun).

To elicit students' questions about how humans have sought to explore and understand Earth's place in Space.

Session 1 Eratosthenes' epiphany

Students:

- discuss a historical debate about whether the Earth is flat
- identify the way scientists use claims and evidence to test their theories.

Session 2 Centred on the Sun

Students:

- create a 3D, moving model of the Earth, Sun and Moon
- start a glossary of scientific terms to do with Space.

Lesson focus

The focus of the *Engage* phase is to spark students' interest, stimulate their curiosity, raise questions for inquiry and elicit their existing beliefs about the topic. These existing ideas can then be taken into account in future lessons.

Assessment focus

Diagnostic assessment is an important aspect of the *Engage* phase. In this lesson you will elicit what students already know and understand about:

- how the Earth is part of a system of planets orbiting a star (the Sun).

ENGAGE

Key lesson outcomes

Students will be able to represent their current understanding as they:
• identify features of scientific dialogues and debates
• discuss different theories about the movements of the Earth, Sun and Moon
• contribute to discussions about Earth's place in Space
• identify the purpose and features of a science journal and word wall
• contribute to the beginning of a TWLH chart
• work in teams to create orreries to represent their understanding of the movements of the Earth, Sun and Moon.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page 5).

Session 1 Eratosthenes' epiphany

Teacher background information

How scientists think and work

Scientific knowledge is a set of explanations made by scientists based on observations and evidence. These explanations have been built up over time in an attempt to explain how the world works, and continue to be revised as new evidence emerges.

Scientists conduct investigations in order to test ideas and find evidence; however, the conclusions and explanations drawn from the evidence can be influenced by the life experiences and beliefs of the scientists. Scientists are a part of the world they study and their ideas can be influenced by it.

When scientists disagree, they first check the available information. In scientific publications the authors highlight their procedure so that the investigations can be replicated. Scientific debate is, however, generally about what conclusions can be drawn from the available evidence. The example given in this unit is a debate between Eratosthenes (Erra–tos–the–neez) — a Greek mathematician and astronomer who lived around 200BC — and a member of the general public who is of the belief that the Earth is flat based on their everyday experience. The theory that the Earth was flat was not a scientific theory, however it was disproved using a scientific method. It provides a good example for students of how scientists have to examine carefully the ideas and evidence of their everyday lives.

The dialogue presented here is imagined, since various philosophers in previous centuries had argued that the Earth was spherical, including Pythagoras (who noted the shapes of lunar eclipses) and Aristotle. Eratosthenes was chosen as a subject for the play as he used the described investigation not only to show that the Earth was spherical but also to calculate its size.

The described investigation

The Greek scholar Eratosthenes' investigation of the size of the Earth occurred during the 'summer solstice' of the Northern Hemisphere in the 2nd century BC. The summer solstice is the day when the North Pole is tipped the closest to the Sun. The Sun therefore rises the highest in the sky on this day, however it will only be exactly overhead for cities that are on the Tropic of Cancer. The ancient Egyptian city of Swenet (Syene to the Ancient Greeks and Aswan today) is on the Tropic of Cancer. The city of Alexandria is north of Swenet.

By measuring the shadows produced at high noon on the summer solstice in Alexandria (the point at which the Sun reaches its maximal point), Eratosthenes could calculate the angle of elevation of the Sun. It was one-fiftieth of a circle, therefore he estimated that the distance between the two cities was one-fiftieth of the circumference of the Earth. He checked the distance between the two cities by calculating travel times between them, and came up with a solution that was accurate with an error less than 2 per cent. This is surprising given the possible sources of error, including using a model that assumed the Sun appeared as a point of light in the sky not a disc, and distances calculated by overland travel were not the most reliable as deviations were sometimes made to ensure water supply.

Students' conceptions

Students have a range of conceptions or non-scientific ideas about the Sun and Earth, as it is not obvious that we are on a spherical planet that is orbiting the Sun. Students might say that they think the Earth is round or spherical, but when they respond to questions their answers will often indicate that they believe it is flat like a plate. If most students in the class still have this conception, it might be necessary to review activities in *Spinning in Space*.

Equipment

FOR THE CLASS

- class science journal
- word wall
- TWLH chart
- 1 enlarged copy of 'But it looks flat' (Resource sheet 1)
- 1 enlarged copy of 'Debating our place' (Resource sheet 2)
- 3 pieces of A4 paper
- *Optional:* cards or paper strips for words for the word wall
- *Optional:* multimedia resources on Eratosthenes (see 'Preparation')

FOR EACH STUDENT

- science journal
- 1 copy of 'But it looks flat' (Resource sheet 1)
- *Optional:* 1 copy of 'Debating our place' (Resource sheet 2)

ENGAGE

Preparation

- Read 'How to use a science journal' (Appendix 2).
- Read 'How to use a word wall' (Appendix 3).
- Read 'How to use a TWLH chart' (Appendix 4), and prepare a large four-column chart as follows:

What we **think** we know	What we **want** to learn	What we **learned**	**How** we know

- Read 'How to facilitate evidence-based discussions' (Appendix 5).
- Read 'But it looks flat' (Resource sheet 1), and decide how it will be presented to your class, for example, students could read it as an independent reading task, in teams or in guided reading groups. Alternatively, two drama students/teachers enter in togas to surprise the students and enact the dialogue live. Provide students with copies of the dialogue as a reference.
- *Optional:* Provide students with multimedia resources to help them understand the dialogue, for example, a map showing the locations of the cities.
- Prepare three A4 signs with the headings 'Claim 1', 'Claim 2' and 'Claim 3'.
- *Optional:* This unit identifies opportunities to use interactive digital software in the form of the planetarium programs Stellarium and Celestia. They allow students to observe the night sky and movements of different objects in real time or in fast forward, and find many other details. If your school has ICT capacity, begin familiarising yourself with the free programs by downloading them at www.stellarium.org and www.shatters.net/celestia
- Enlarge a copy of 'But it looks flat' (Resource sheet 1) and 'Debating our place' (Resource sheet 2).
- *Optional:* Display the class science journal, the word wall, the TWLH chart, 'But it looks flat' (Resource sheet 1), 'Debating our place' (Resource sheet 2) and the planetarium programs on an interactive whiteboard or a computer connected to a projector. Check the Primary**Connections** website to see if an accompanying interactive resource has been developed: www.science.org.au/primaryconnections

Lesson steps

1 Organise for students to be introduced to 'But it looks flat' (Resource sheet 1) (see 'Preparation'). Discuss the summer solstice. Discuss the dialogue, asking questions such as:

- How did the characters use information in their world to form their ideas?
- Why did the characters disagree?
- What did Eratosthenes (Erra–tos–the–neez) suggest when they disagreed? Why?
- Why do you think the companion listened to Eratosthenes' ideas?

- What evidence do we have now that would further support Eratosthenes' ideas that the Earth is a sphere? (For example, photos of Earth taken from Space, travelling around the Earth and finding no edges, Earth's curved shadow on the Moon during an eclipse, viewing other planets as spheres using telescopes.) If students are unfamiliar with the word 'evidence', explain that it is the facts or information that help us decide whether a claim or idea is valid.

2 Introduce the class science journal and discuss its purpose and features.

Literacy focus

Why do we use a science journal?

We use a **science journal** to record what we see, hear, feel and think so that we can look at it later to help us with our claims and evidence.

What does a science journal include?

A **science journal** might include dates and times, written text, drawings, labelled diagrams, photographs, tables and graphs.

Record students' ideas about the science presented in the dialogue and their ideas about the nature of science as seen in the dialogue (see 'Teacher background information').

3 Discuss how scientific knowledge is a set of claims made by scientists based on observations and evidence. If students are unfamiliar with the term 'claims', discuss its meaning (see Appendix 5). Explain that throughout history different scientists have had different claims about the world and have argued about the evidence and reasoning (thinking) behind their claims.

4 Discuss that hundreds of years ago there was a major debate about whether the Sun orbited the Earth or whether the Earth orbited the Sun. Explain that in this unit students will be creating their own dramatic dialogue about this debate.

5 Introduce the enlarged copy of 'Debating our place' (Resource sheet 2). Ask students to think about each claim. Place the signs 'Claim 1', 'Claim 2' and 'Claim 3' (see 'Preparation') at separate parts of the room and ask students to stand in front of the claim they think is accurate. Ask students to discuss with other students in front of the sign why they chose that answer.

6 Introduce the TWLH chart (see 'Preparation'), and discuss its purpose and features.

Literacy focus

Why do we use a TWLH chart?

We use a **TWLH chart** to show our thoughts and ideas about a topic before, during and after an investigation or activity.

What does a TWLH chart include?

A **TWLH chart** includes four sections with the headings: 'What we think we know', 'What we want to learn', 'What we learned' and 'How we know'.

ENGAGE

7 Record how many students agreed with each claim in the 'What we **think** we know' column of the TWLH chart. Ask each group to share their reasons and evidence for choosing that claim and record next to the tally.

Note: The purpose of this activity is to elicit students' existing conceptions so you can take account of their ideas in the following lessons. Do not correct alternative conceptions at this stage.

8 Invite students to contribute further thoughts about Earth's place in space to the first column of the TWLH chart by asking questions such as:

- What do we know about…?
- Are there…?
- How do we know…?

Record students' answers in the first column of the TWLH chart.

Optional: Organise students' thoughts within the chart into categories, for example, 'What we think we know about the Moon' within the first column of the TWLH chart. Organising the information into rows allows students to record relevant questions, new claims and evidence opposing their original thoughts on the subject, and therefore easily follow the progression of their thoughts.

	What we THINK we know	**What we WANT to learn**	**What we LEARNED**	**HOW we know**
Claim 1 The Moon and Sun both circle the Earth	The Sun travels across the sky during the day. The Moon travels across the sky at night.	Is the Moon in the sky during the day?		
Claim 2 The Moon circles the Earth while the Sun circles them both	The Moon and Sun both move across the sky. The Sun is a lot further away from the Moon and Earth and therefore circles them both.	How far away are the Moon and the Sun? How can we find out if the Sun moves?		
Claim 3 The Moon circles the Earth while the Earth circles the Sun	We have read that the Earth goes around the Sun. The Moon and the Sun are sometimes in the sky together.	Why don't we feel the Earth moving?		
Sun	It is massive. It gives light. It rises and sets.	How big is the Sun? What is it made from?		
Moon	It is a sphere. It comes out at night and looks like it 'glows'. It can come out in the day also. It moves around the Earth.	How big is the Moon? Why is it sometimes a crescent shape?		
Earth	It is a sphere.			

Example of TWLH chart for *Earth's place in Space*

9 Introduce the second column of the TWLH chart ('What we **want** to learn'), and ask students to suggest questions that would help them gather evidence to clarify their existing claims or make new ones. Record their questions on the chart.

10 Discuss words or phrases that students know about the Solar System and Space. Record students' responses on cards or paper strips. Discuss which words could be grouped, for example, words about planets. Group the words according to students' suggestions for display on the word wall. Add headings and words to the word wall and discuss its purpose and features.

Literacy focus

Why do we use a word wall?

We use a **word wall** to record words we know or learn about a topic. We display the word wall in the classroom so that we can look up words we are learning about and see how they are spelt.

What does a word wall include?

A **word wall** might include a topic title or pictures and words that we have seen or heard about the topic.

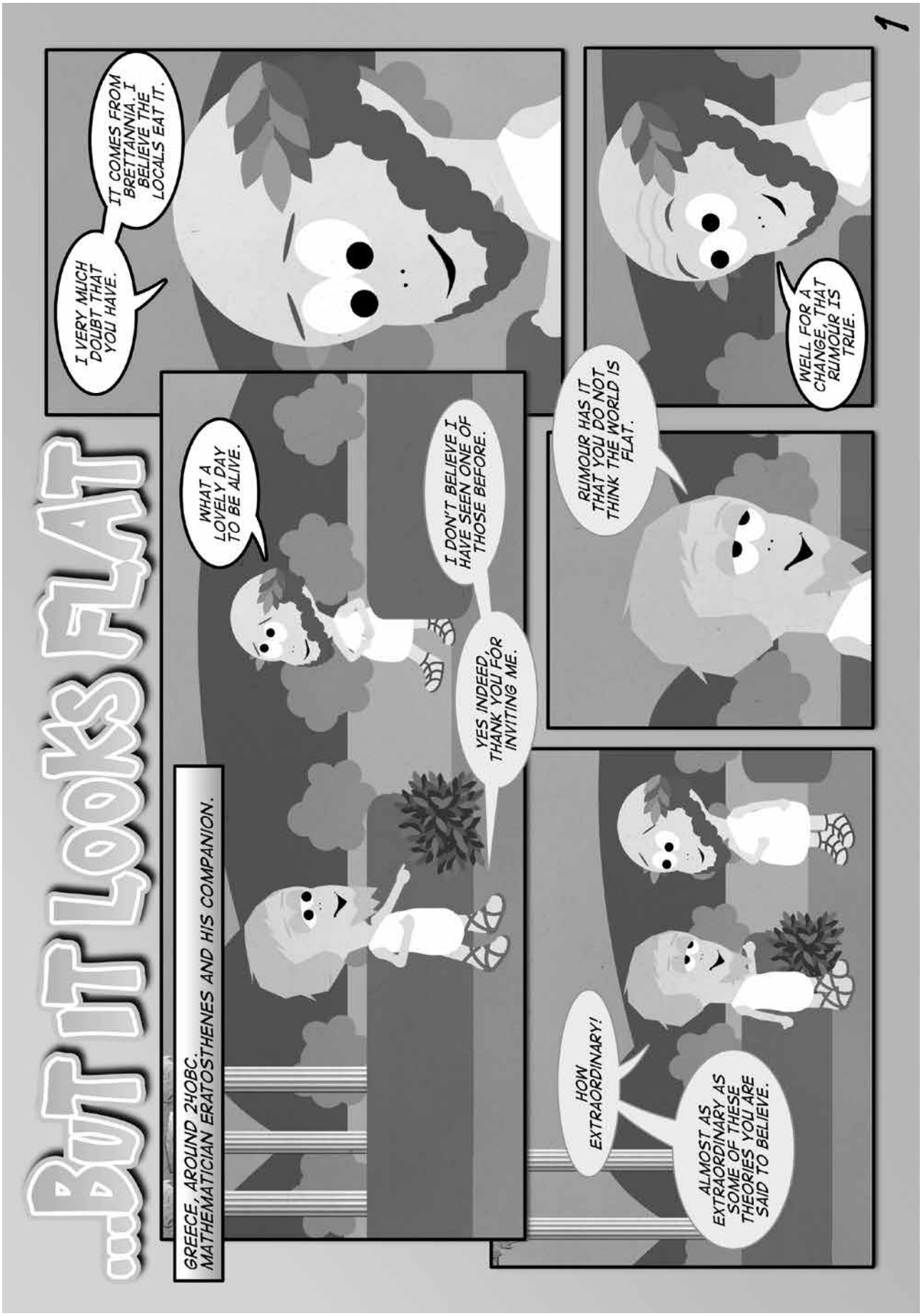
Invite students to contribute words from different languages to the word wall, reminding them that Standard Australian English is one of many social dialects used in Australia.

Australian Curriculum links

English

- Explore the rules and conventions of debating.

But it looks flat (1)



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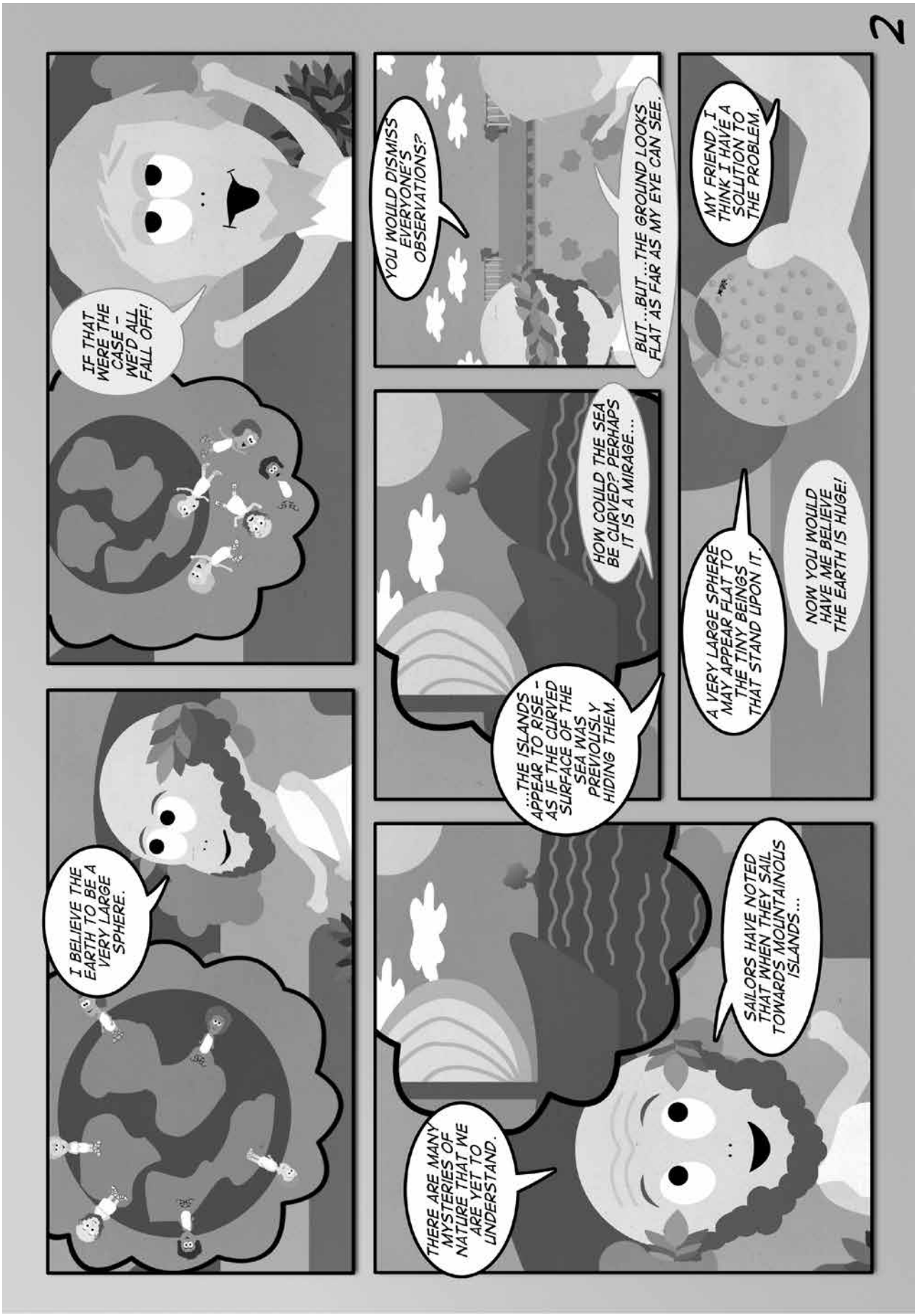

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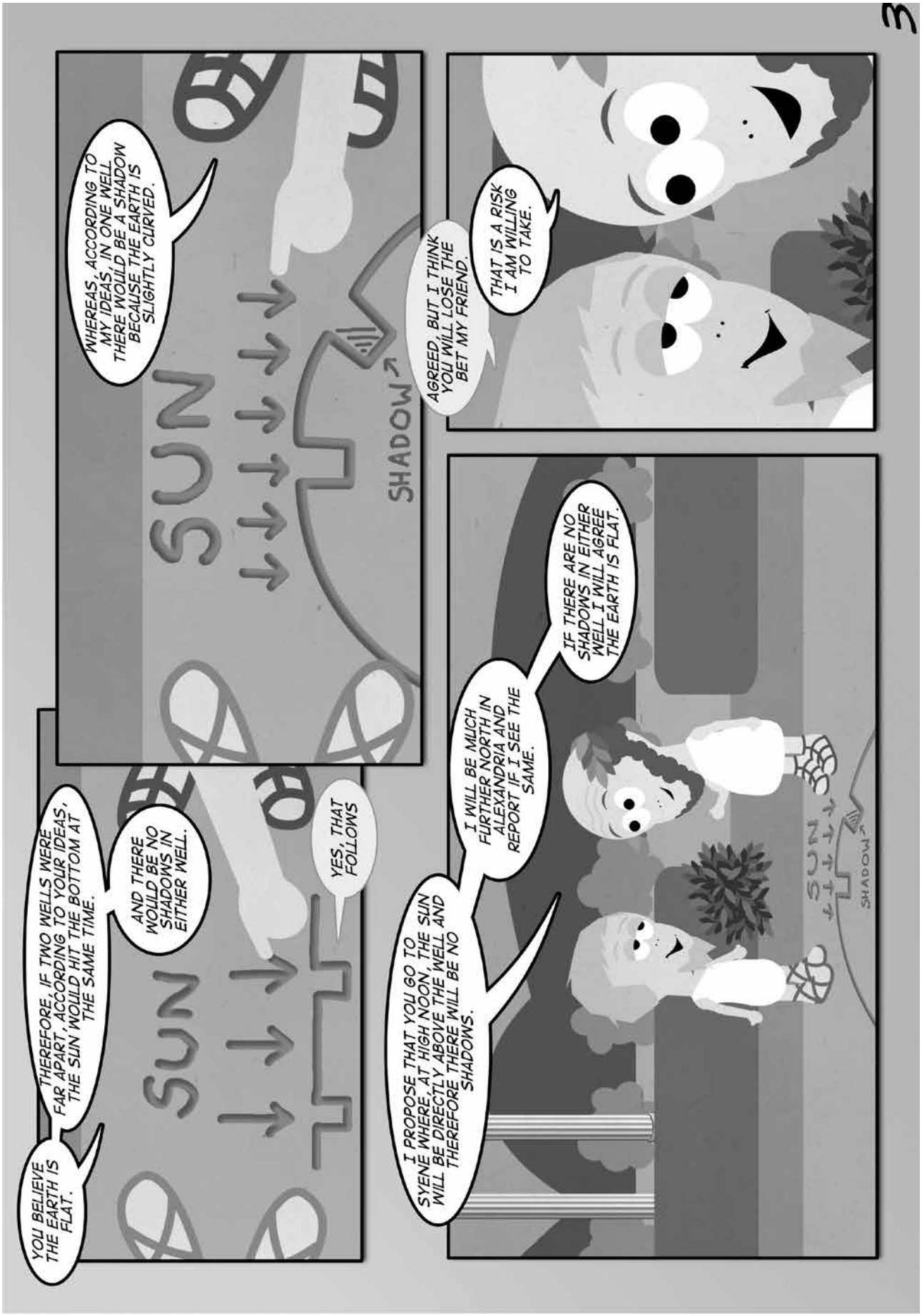

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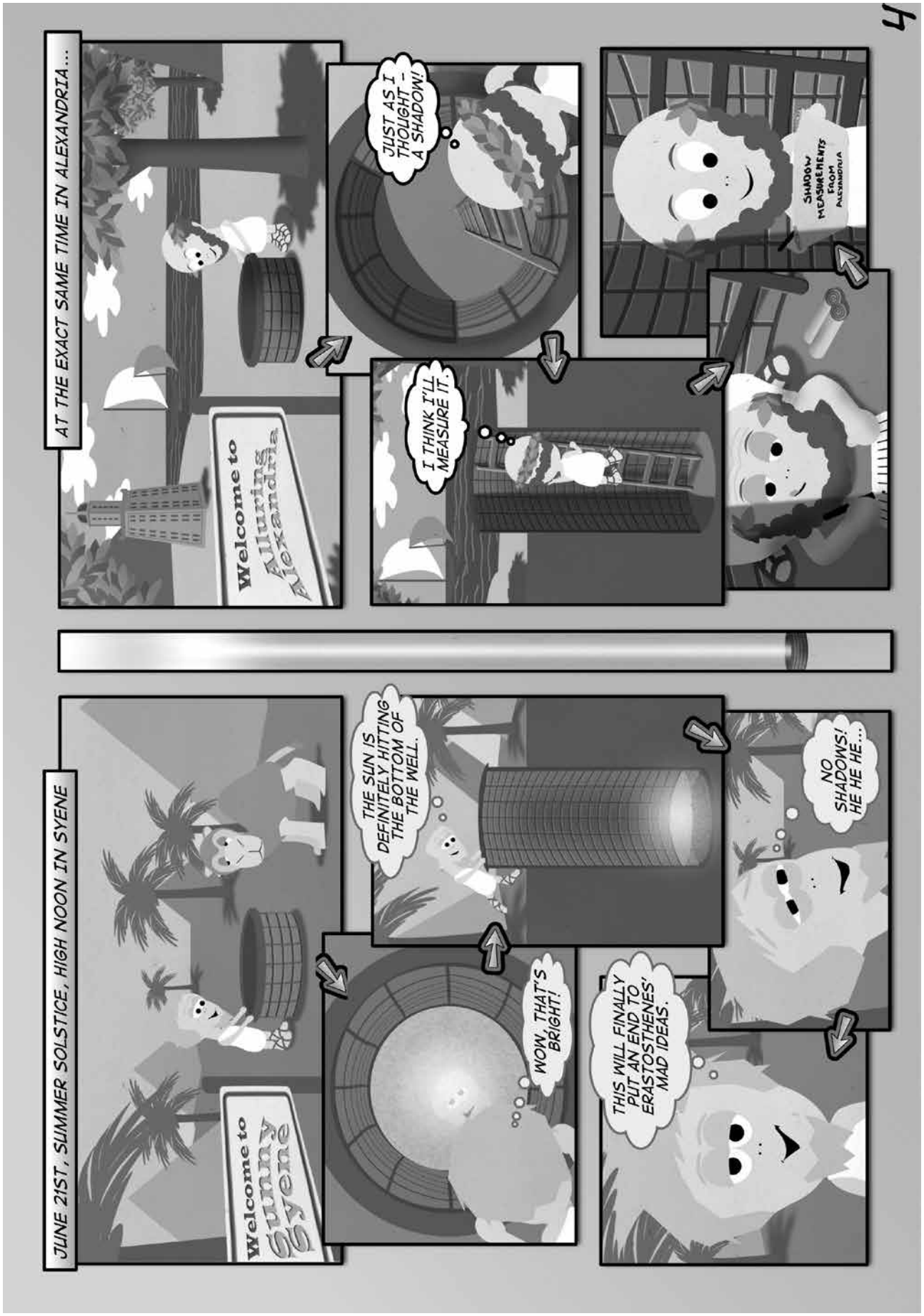

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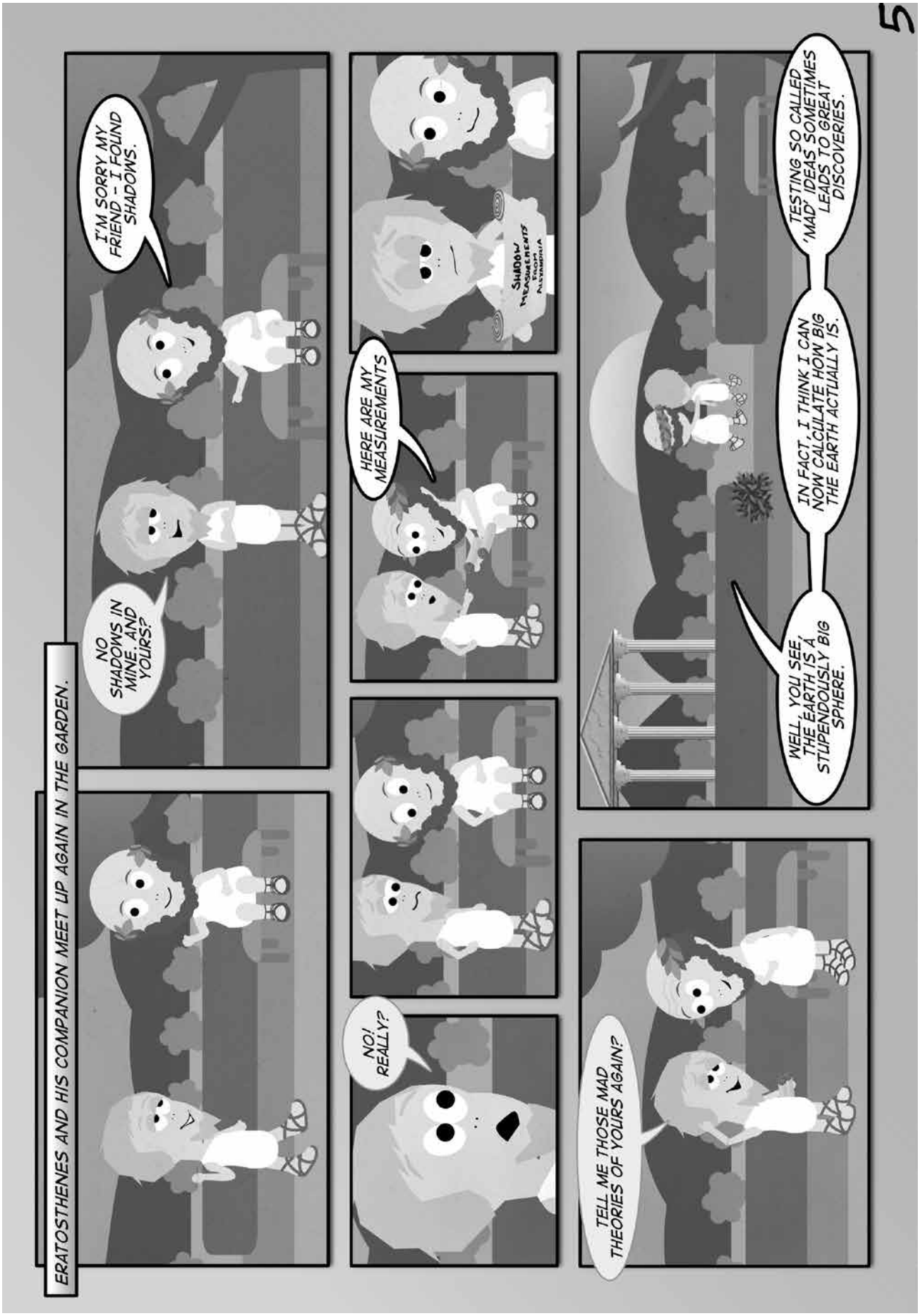
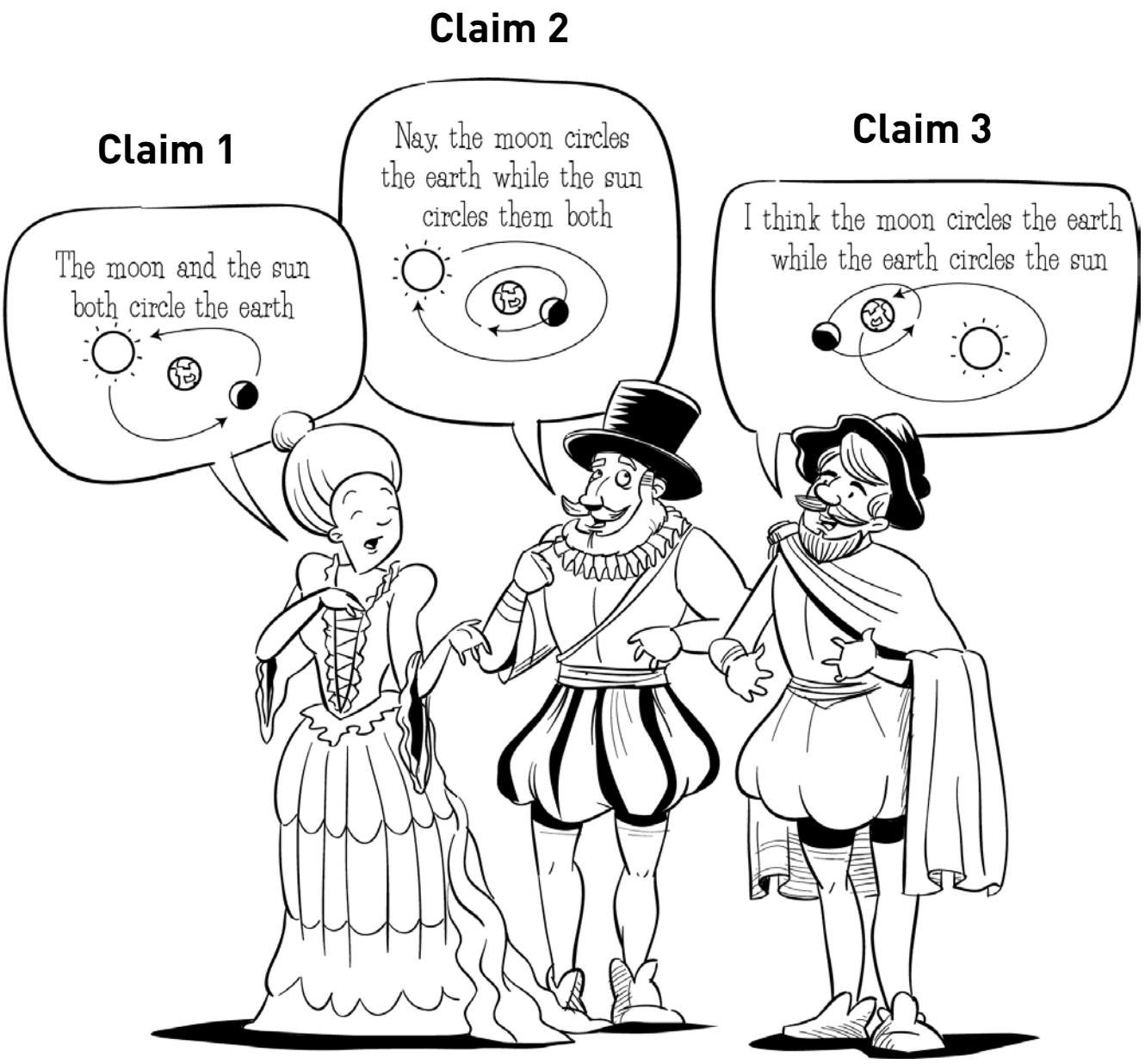


Debating our place



Session 2 Centred on the Sun

ENGAGE

Teacher background information

Using models to illustrate theories

In this lesson, students are encouraged to develop 3D models in order to represent what they think they know. 3D models were chosen because they focus students' attention on the relative movement of the space objects rather than simply drawing an illustration that they have seen before. The purpose of the models is to use them to test theories and ideas, and identify issues.

Equipment

FOR THE CLASS

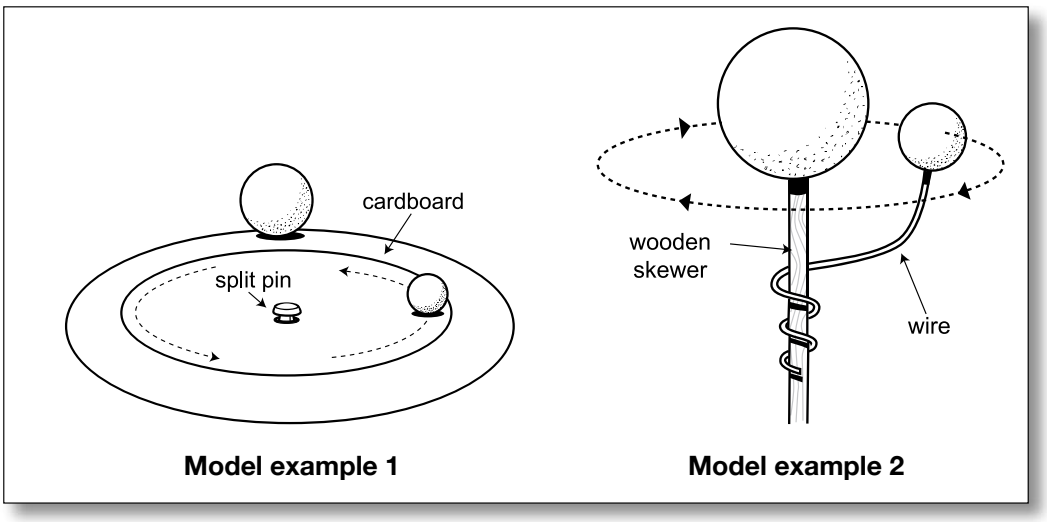
- class science journal
- word wall
- TWLH chart
- team skills chart
- team roles chart
- 1 enlarged copy of 'Information note for families' (Resource sheet 3)
- *Optional:* camera

FOR EACH TEAM

- role wristbands or badges for Director, Manager and Speaker
- each team member's science journal
- material for making models (see 'Preparation')
- 1 copy of 'Information note for families' (Resource sheet 3)

Preparation

- Read 'How to organise collaborative learning teams' (Appendix 1). Display an enlarged copy of the team skills chart and team roles chart in the classroom. Prepare role wristbands or badges and the equipment table.
- Read 'Information note for families' (Resource sheet 3) and organise a date for students to report back on their observations, preferably for Lesson 2. Write this information on the 'Information note for families' (Resource sheet 3). Check what time the Moon will rise and set from your location at: www.ga.gov.au/geodesy/astro/moonrise.jsp
- Work out if it will be possible for students to observe the movement of the Moon at an appropriate hour of the night or day, and either discuss it in Lesson step 11 or organise for Lesson 3 to take place at an appropriate time for viewing the Moon.
- Enlarge a copy of 'Information note for families' (Resource sheet 3).
- Collect a variety of materials for students to use in their models, such as plasticine, polystyrene balls, table tennis balls, wooden skewers, toothpicks, string, cardboard, foam, wire and split pins.
- Familiarise yourself with a couple of techniques for making moving parts for the 3D models (Lesson step 4). Here are two possible techniques:



Two techniques for making 3D models

- *Optional:* Display the enlarged copy of 'Information note for families' (Resource sheet 3) on an interactive whiteboard or a computer connected to a projector. Check the Primary**Connections** website to see if an accompanying interactive resource has been developed: www.science.org.au/primaryconnections

Lesson steps

1. Review students' exploration of the three different claims about the relative movement of the Earth, Sun and Moon.
2. Remind students how in 'But it looks flat' (Resource sheet 1), Eratosthenes used diagrams and models to explain his claim. Discuss how it is easier to understand models when they are shown physically rather than just described.
3. Explain that students are going to work in collaborative learning teams to create an orrery (a 3D model with moving parts) to show how they think the Sun, Earth and Moon all move in relation to each other, for example, according to one of the claims from 'Debating our place' (Resource sheet 2).

   If students are using collaborative learning teams for the first time, introduce and explain the team skills chart and team roles chart. Explain that students will wear role wristbands or badges to help them (and you) know which role each team member has.
4. Explain that students will be asked to use scientific terminology in their orrery. Discuss the purpose and features of a glossary.

Literacy focus

Why do we use a glossary?

We use a **glossary** to record descriptions of technical terms that relate to a particular subject matter or topic. We might read a glossary in a book to find out what technical words about the topic mean.

What does a glossary include?

A **glossary** includes words, sentences or names, with a description or explanation for each.

ENGAGE

5 Model how to develop a glossary using the terms ‘orbit’ (move around something else) and ‘rotate’ (spin on an axis). Ask students to describe what each term means and how they are different. Add an agreed description of each term to start a glossary in the class science journal. These descriptions can be modified and adapted during the unit.

Note: It is important to use the word ‘describe’ rather than ‘define’. ‘Definitions’ are often viewed as fixed and unchangeable, whereas ‘descriptions’ support students to see that ideas can change as their understanding develops. Similarly, scientists’ ideas develop as they find more evidence or think creatively about existing information.

6 Draw students’ attention to the equipment table and discuss its use. Discuss how and why balls will be used to represent the Earth, Moon and Sun. Demonstrate two possible techniques for making moving parts in their orrery (see ‘Preparation’). Explain that this table is where Managers will collect and return equipment.

7 Ask students to explain the time each space object in their orrery takes to complete one orbit (one circle around another space object) or rotation (one turn or spin around its own axis). Ask students to use common timescales, such as minutes, hours, days, months or years. Discuss how to represent this on an orrery, for example, by attaching written tags to paths of orbits.

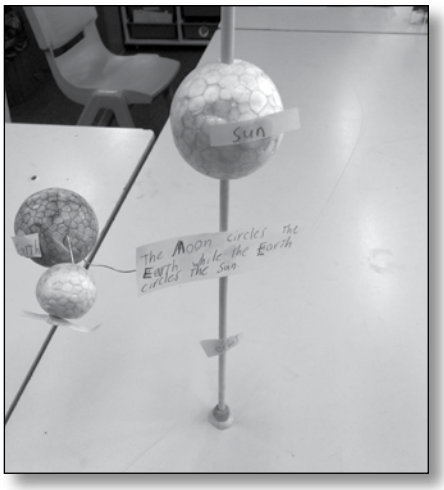
8 Form teams and allocate roles. Ask Managers to collect team equipment.

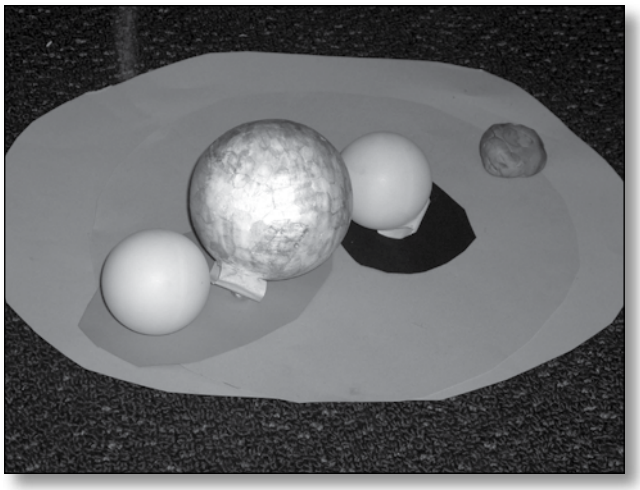
Note: Consider forming teams that have similar ideas on how the Sun, Earth and Moon rotate, for example, based on their claims made in the previous session.

9 Allow time for teams to complete their orreries. Ask questions such as:

- How do you think you could represent that?
- Can you tell me more about…?

Optional: Take photos of students’ orreries or allow time for students to draw their orreries in their science journals.





Work samples of orreries representing the movement of the Sun, Earth and Moon

10 Ask Speakers to discuss the challenges they had making the orrery. Ask questions such as:

- How did you decide how to represent the Sun, Earth and Moon?
- How did you represent their movements?
- Do you think your orrery is to scale? Why do you think that is important?
- What else would need to be included for it to be an orrery of the Solar System?

Explain that teams will have a chance to review and modify their orreries throughout the unit.

11 Introduce the enlarged copy of 'Information note for families' (Resource sheet 3). Read through and discuss with students. If students will have the opportunity to see the Moon, explain what time it will be rising (see 'Preparation').

12 Demonstrate how to make observations and draw a diagram.

Work sample of the 'Sky viewing' project

13 Review and update the TWLH with any new ideas or questions.

14 Update the word wall with words and images.

Australian Curriculum links

Mathematics

- Study how 3D shapes are represented in 2D representations, for example, spheres as circles.

Information note for families

Name: _____ **Date:** _____

Introducing the 'Sky viewing' project

This term our class will explore views of the sky and how scientists use this to understand Space. This is part of a science unit called *Earth's place in Space*. To help further their understanding, students are invited to make extra observations of the sky at home.

Students are invited to investigate whether objects in the sky move by:

- observing the position of the Sun relative to an easily recognisable landscape object, such as a tree

SAFETY

Students are asked not to look directly at the Sun as this can hurt their eyes.

- recording the time of observation and its location using a drawing including the tree, returning to the exact position one hour later and repeating the exercise until the Sun is set.

If the Moon is visible while students are awake, they are asked to also complete a similar set of observations for the Moon. If stars are visible before students' bedtimes, they might also complete a set of observations for an easily recognisable constellation.

Since looking at them does not hurt the eyes, students are invited to record actual distances from the Moon or constellation to the landscape object on their drawings. They can calculate them by holding one arm out straight and using hand and finger widths as measuring units, for example, the Southern Cross is three hand widths to the right of the tree.

Students are asked to bring their observations to class by _____

Class teacher

Lesson 2 Rising and setting

AT A GLANCE

To provide shared experiences of the observable movement of the Sun and Moon in our sky.

Students:

- present their observation from the home 'sky viewing' task
- use observations to describe how space objects move across the sky
- relate the apparent movement of the Sun to the notion of a 24 hour day.

Lesson focus

The *Explore* phase is designed to provide students with hands-on experiences of the science phenomenon. Students explore ideas, collect evidence, discuss their observations and keep records, such as science journal entries. The *Explore* phase ensures all students have a shared experience that can be discussed and explained in the *Explain* phase.

Assessment focus

Formative assessment is an ongoing aspect of the *Explore* phase. It involves monitoring students' developing understanding and giving feedback that extends their learning. In this lesson you will monitor students' developing understanding of:

- how planets in the Solar System orbit the Sun, and moons orbit the planets.

Key lesson outcomes

Students will be able to:
• identify the paths of space objects in the sky as seen on Earth
• predict what position space objects will be in after an hour and compare observations to predictions
• work in collaborative learning teams to represent their observations as flow charts
• contribute to discussions about their results and how they relate to their everyday lives.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page 5).

Teacher background information

Movement of the Sun

The Sun appears to move across the sky from East to West during the day because of the rotation of the Earth. But there is no feeling of movement when standing on the surface of the Earth. Therefore many cultures have described the Sun as moving around the Earth, for example, in Norse mythology the Sun is a goddess in a large chariot racing around the Earth.

This movement is actually an illusion, since it is the rotation of the Earth that changes what is seen in the sky. The Earth spins in an anti-clockwise direction when viewed from the North Pole so that the East coast of Australia moves into the sunlight first in the morning and sunrise is experienced about two hours later on the West coast of Australia. The differences in times of sunrise result in the different time zones in the world.

It does not feel as though the Earth is spinning. We are cushioned by the Earth's atmosphere, and gravity pulls everything towards the centre of the Earth. A day is defined as the amount of time it takes for the Sun to reappear in the same position relative to the Earth, for example, to cross the local North–South meridian.

Movement of the Moon

We have 'moonrise' as well as 'sunrise'. The Moon appears to rise and set each day, at different times throughout the month. This apparent movement of the Moon is due to the rotation of the Earth on its axis every 24 hours. The Moon also orbits the Earth over the period of a lunar month while the Earth is orbiting the Sun. The Moon orbits the Earth in 27.3 days, but because of the Earth's movement around the Sun the period between two similar Moon phases is 29.5 days. The movement of the Moon around the Earth results in its changing appearance as viewed from Earth over the course of the lunar month.

The Moon itself does not emit light. We see the Moon because it reflects light from the Sun. The Moon appears to change shape as it orbits the Earth because, as it moves, light from the Sun shines on different parts of its surface. We can often see only part of the side with sunlight on it.

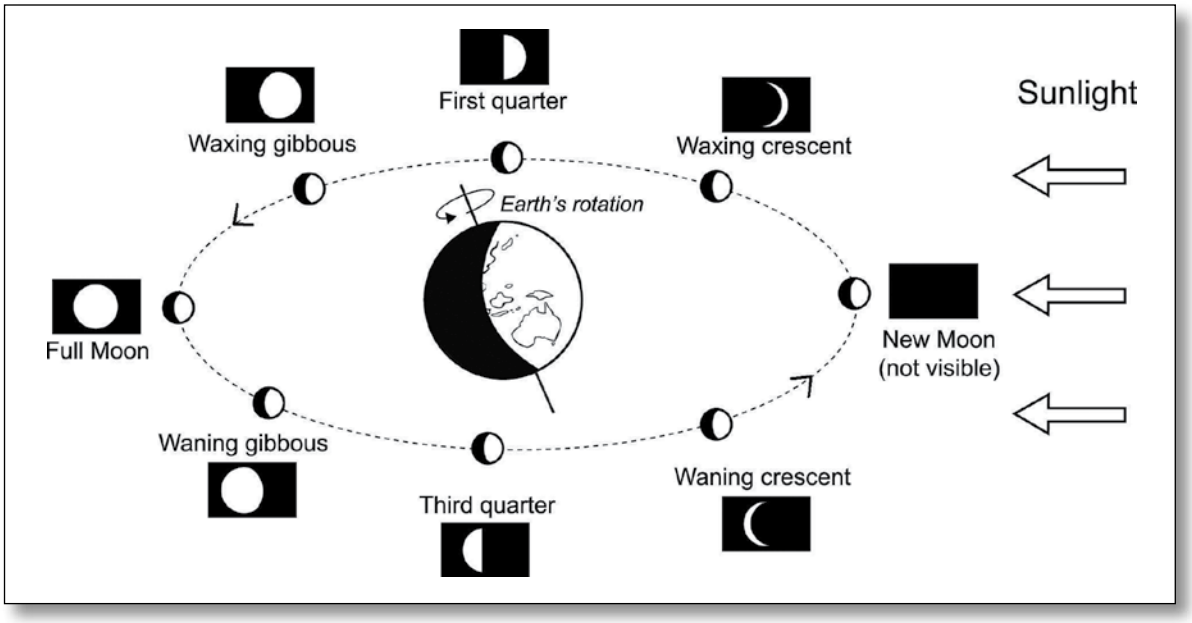


Diagram of the different positions of the Moon and how they are perceived from Australia

The Moon does not orbit the Earth in the same plane as the Earth rotates around the Sun. If that were the case, there would be both lunar and solar eclipses every lunar month.

Students' conceptions

Some students will affirm that the Earth goes around the Sun, yet they will affirm the opposite when asked about the movement of the Sun in the sky. This inconsistency is due to students repeating a scientific fact without having understood it or because they hold fragments of scientific conceptions and alternative conceptions simultaneously, using them in different contexts.

Students might not think the Moon is a sphere. They might think that it physically changes shape over the month. The Moon always retains its spherical shape. The only change is in how much of its sunlit hemisphere we can see from Earth as it orbits the Earth.

Some students might think that the Moon itself emits light. The Moon merely reflects the light of the Sun.

Students might think the Earth's shadow on the Moon is what causes the phases of the Moon. The phases are due to the Moon orbiting the Earth while the Sun remains stationery. When we see a full moon, we see the sunlight shining on the side of the Moon facing us. When we see the new Moon, the sunlight is falling on the side facing away from us. The Moon appears to be in darkness because the Sun is shining on the back side, not because the Earth is in the way.

Equipment

FOR THE CLASS

- class science journal
- word wall
- TWLH chart
- team skills chart
- team roles chart
- *Optional:* multimedia resources on the movement of the Moon and Sun (see 'Preparation')
- *Optional:* digital camera with tripod and projector/interactive whiteboard

FOR EACH TEAM

- role wristbands or badges for Director, Manager and Speaker
- each team member's science journal
- each team member's completed home observation task (see Lesson 1, Session 2)

Preparation

If the Moon is visible during the school day (see www.ga.gov.au/geodesy/astro/moonrise.jsp), organise for the lesson to take place at a time when students can see the Sun and the Moon at the same time.

Optional: Take photos of the Sun, Moon and skies at different times, for example, by setting up a camera with a tripod and taking a time-lapse series of photos, or by taking screen shots of the program Stellarium.

Optional: Download Stellarium (www.stellarium.org) onto your interactive whiteboard or a computer connected to a projector. You can fast forward the view of the sky over a day to demonstrate the apparent movement of the Sun and Moon. This is best viewed if you zoom out so that East and West are visible.

Lesson steps

1 Review the previous lessons, focusing students' attention on how different people have had different ideas (theories) over time about how the Sun, Earth and Moon move.

2 Remind students of the dialogue between Eratosthenes and his companion, and how they used evidence to support their claims. Discuss what evidence would have been available hundreds of years ago.

3 Ask students to look outside at the position of the Moon (see 'Preparation'), or indirectly at the position of the Sun. Ask students questions such as:

- Will it be in the same position in an hour?
- Will it be in the same position in a day?
- Will it be in the same position at this time tomorrow?

Record students' ideas in the class science journal.

SAFETY

Remind students not to look directly at the Sun.

Optional: Set up a camera with a tripod to take photos of the position of the space objects. Leave the camera in place so that in an hour, afternoon or day, photos can be taken from the same place and then compared.

4 Explain that students are going to work in collaborative learning teams to create flow charts of the evidence they have collected on how the Sun, Moon and stars appear over a period of several hours. Discuss the purpose and features of a flow chart and model how to draw one.

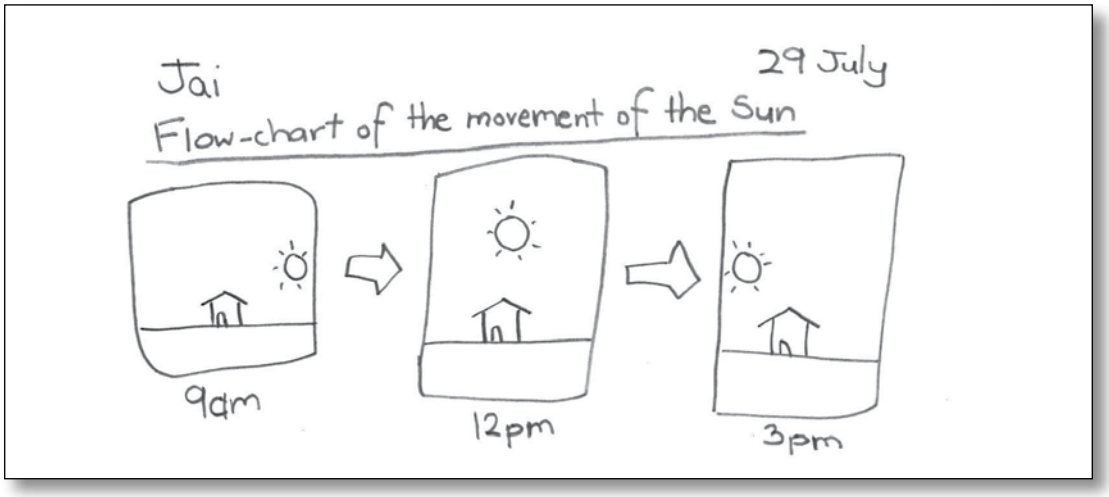
Literacy focus

Why do we use a flow chart?

We use a **flow chart** to show a sequence of events or the stages in a process.

What does a flow chart include?

A linear **flow chart** organises events or stages in a line. Arrows are used to indicate the sequence in which they occur.



Work sample of a flow chart

5 Form teams and allocate roles. Allow time for teams to complete the task.

Optional: Provide photos for teams, or access to Stellarium (see 'Preparation'), to help them visualise the apparent movement of the space objects.

6 As a class discuss the task, asking questions such as:

- What is similar about the flow charts?
- What do we know about the movement of the Sun across the sky?
- Is the movement of the Moon similar or different? Why?
- Is the movement of the stars similar or different? Why?

Record students' thoughts in the class science journal.

7 Discuss the language used to describe the apparent movement of the Sun, for example, 'rising' and 'setting'. Ask students where the Sun appears to rise (in the East) and set (the West). Discuss whether the same language could be applied to the Moon and stars.

8 Ask students whether moonrise only happens at night. Discuss how the Moon cannot always be seen during the night and that it is less visible during the day. Ask students what they think happens to stars, other than the Sun, during the day (they cannot be seen because the Sun appears brighter and bigger because it is so much closer to Earth).

9 Discuss how humans decided what a ‘day’ is, for example, the amount of time from noon (when the Sun is at its ‘apex’ of movement) until it reaches noon again. Discuss the confusion between the term ‘day’ (24 hours) and the concept of ‘during the day’ (while there is light). Add an agreed description of each term to the glossary in the class science journal.

10 Look at the new position of the space objects and compare their positions with the positions at the beginning of the lesson and students’ predictions.

11 Review the TWLH chart. Record what students have learned and any questions that can be answered.

12 Update the word wall with words and images.

Australian Curriculum links

Mathematics

- Study time zones and daylight saving around the world, and their relationship with the movement of the Sun.

Lesson 3 Going in circles

AT A GLANCE

To provide hands-on, shared experiences of testing theories to explain observable movement of the Sun and Moon in our sky.

Students:

- work in teams to explore different models to explain why the Sun and Moon appear to move across the sky
- record, discuss and interpret their findings.

Lesson focus

The *Explore* phase is designed to provide students with hands-on experiences of the science phenomenon. Students explore ideas, collect evidence, discuss their observations and keep records, such as science journal entries. The *Explore* phase ensures all students have a shared experience that can be discussed and explained in the *Explain* phase.

Assessment focus

Formative assessment is an ongoing aspect of the *Explore* phase. It involves monitoring students' developing understanding and giving feedback that extends their learning. In this lesson you will monitor students' developing understanding of:

- how planets in the Solar System orbit the Sun but moons orbit the planets.

Key lesson outcomes

Students will be able to:
• work in collaborative learning teams to follow a procedural text to generate observations to test different claims
• record their observations in a table and compare them to 'real life' observations from Lesson 2
• contribute to discussion about their results and whether the evidence can support different claims
• identify the features and purpose of a role-play, as well as its advantages and disadvantages as a model to explain the movement of the Sun, Earth and Moon.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page 5).

Teacher background information

Using models to test theories

In this lesson, students are using role-play as a physical model. It is not being used as a device to explain an idea; it is being used to explore the implications of different models. This is a technique used by scientists, for example, when they are studying systems they cannot directly manipulate. By modelling what observations different models might generate, students can gather evidence as to whether certain models can explain observations. Students might not be familiar with this use of models, and the importance of this method of generating scientific knowledge might need to be highlighted.

Equipment

FOR THE CLASS

- class science journal
- word wall
- TWLH chart
- team roles chart
- team skills chart
- 1 enlarged copy of 'Revolving role-plays' (Resource sheet 4)
- 1 enlarged copy of 'Role-play observations' (Resource sheet 5)

FOR EACH TEAM

- role wristbands or badges for Director, Manager and Speaker
- each team member's science journal
- 1 copy of 'Revolving role-plays' (Resource sheet 4)
- 1 copy of 'Role-play observations' (Resource sheet 5)
- 1 clipboard with pen
- 1 torch or lamp
- 1 softball or baseball
- 1 world globe or soccer ball with a map of Australia attached (see 'Preparation')

Preparation

- If possible, organise a large room that is dark or can be darkened.
- Source some world globes or attach cut-out maps of Australia to soccer balls.
- Enlarge a copy of 'Revolving role-plays' (Resource sheet 4) and 'Role-play observations' (Resource sheet 5).
- *Optional:* Display the enlarged copy of 'Revolving role-plays' (Resource sheet 4) and 'Role-play observations' (Resource sheet 5) on an interactive whiteboard or a computer connected to a projector. Check the Primary**Connections** website to see if an accompanying interactive resource has been developed: www.science.org.au/primaryconnections

Lesson steps

1 Review the previous lesson and students' descriptions of the visible movements of the Sun and Moon in the sky. Remind students of the three theories from 'Debating our place' (Resource sheet 2), and discuss whether their observations could be considered evidence to support the theories.

2 Discuss how scientists use models to test their theories when they can't actually observe the event happening, for example, when it is too large, such as planetary movement, or too small, such as atomic movement.

3 Explain that students will be working in collaborative learning teams to explore models of the Earth, Moon and Sun's movements that could explain the apparent movement of the Sun and Moon in the sky.

4 Explain that teams will be using role-play to make observations. Discuss the purpose and features of a role-play.

Literacy focus

Why do we use a role-play?

We use a **role-play** as a physical representation of a system, process or situation.

What does a role-play include?

A **role-play** might include speech, gestures, actions and props.

5 Introduce the enlarged copy of 'Revolving role-plays' (Resource sheet 4) and 'Role-play observations' (Resource sheet 5), and discuss the features and purpose of a procedural text.

Literacy focus

Why do we use a procedural text?

We use a **procedural text** to describe how something is done. We can read a **procedural text** to find out how to do things.

What does a procedural text include?

A **procedural text** includes a list of materials needed to do the task and a description of the sequence of steps used. It might include annotated diagrams to describe how something is done.

Model how to follow the procedural text using three volunteers. Remind students that the Moon and Sun are not always on opposite sides of the Earth, which is why the Moon can be seen during the day. Explain that students always start with the Moon opposite the Sun so they can compare their observations more easily.

6 Explain that the person holding the Earth will observe which direction the Sun or the Moon will rise and set in Australia. Discuss what 'rising in the East' means (appearing on the eastern side of Australia), and what 'setting in the West' means (disappearing on the western side of Australia). Demonstrate to students using the Sun (torch) and Earth (globe or soccer ball).

7 Model how to fill out the table on 'Role-play observations' (Resource sheet 5). Discuss the purpose and features of a table.

EXPLORE

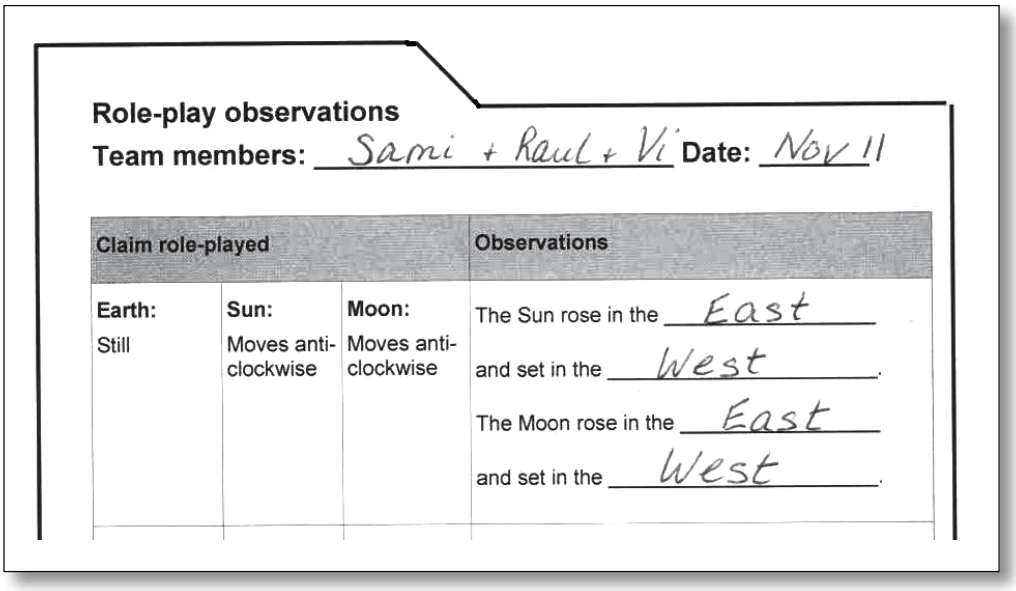
Literacy focus

Why do we use a table?

We use a **table** to organise information so that we can understand it more easily.

What does a table include?

A **table** includes a title, columns with headings and information organised under the appropriate headings.



Role-play observations

Team members: Sami + Raul + Vi **Date:** Nov 11

Claim role-played			Observations
Earth: Still	**Sun:** Moves anti-clockwise	**Moon:** Moves anti-clockwise	The Sun rose in the East and set in the West. The Moon rose in the East and set in the West.

Work sample of a record of observations in the 'Role-play observations' table

8 Form teams and allocate roles. Ask Managers to collect team equipment.

9 Allow time for teams to complete the task. Ask questions such as:

- Could you tell me more about…?
- What about if we change…?
- Can you describe what is happening?

If some teams finish the activity quickly, challenge them to explore other claims.

10 As a class, discuss students' observations for each model in turn. Ask a Speaker to share their team's observation for that claim, then ask the other Speakers if their teams' observations support or contradict that team's observations. Encourage students to use 'Science question starters' (see Appendix 5) to discuss each other's observations.

11 Remind students that they were conducting the observations to distinguish which claims were supported by the apparent movement of the Sun and Moon in the sky. Discuss how the role-plays of the claims 'The Earth rotates while the Sun and Moon remain in the same position' and 'The Sun and Moon orbit the Earth, which stays still' produce the same observations, and therefore this observation does not allow us to distinguish between the two claims.

12 Discuss with students what to do with the Earth globe for claims where the Earth rotates (spin the globe).

13 Discuss the advantages of using a role-play, for example, students can actually see things rather than imagine what they might see, and the disadvantages, for example, the torch does not accurately model the Sun which is a sphere that emits light from all angles. Record students' ideas in the class science journal.

14 Review the TWLH chart. Record what students have learned and any questions that can be answered.

15 Update the word wall with words and images.

Australian Curriculum links

Indigenous perspectives

- Invite local community members and/or Indigenous Education Officers to speak with students about their local explanations for the origin and movement of the Sun and Moon. Protocols are available on the website: www.science.org.au/primaryconnections/indigenous

Revolving role-plays

Description

In this activity you are role-playing what an observer on the Earth might see based on how the Sun, Moon and Earth move.

Equipment

- 1 torch
- 1 world globe or soccer ball with map of Australia attached
- 'Role-play observations' (Resource sheet 5)
- 1 softball or tennis ball
- 1 clipboard with pen

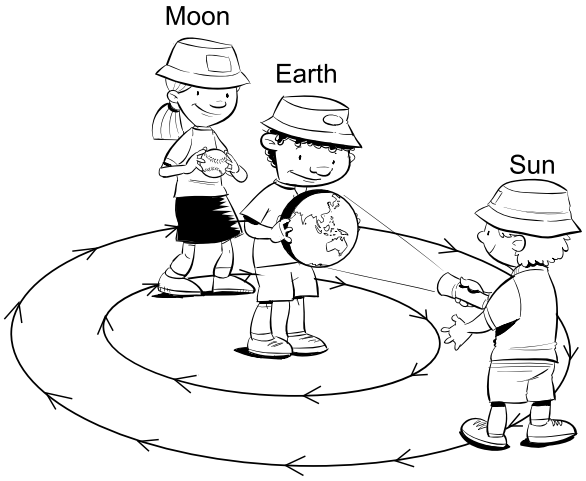
Preparation

- **Manager:** Collect a torch for the Director, a world globe/soccer ball, a clipboard, a pen and 'Role-play observations' (Resource sheet 5) for the Speaker, and a softball or tennis ball for yourself. You will role-play the Moon.
- **Director:** Find an area for the group with enough room for the 'Moon' and 'Sun' to walk around the 'Earth'. You will role-play the Sun.
- **Speaker:** You will role-play the Earth and observe which direction the Sun and Moon appear from in Australia.

Steps

1. Role-play the claim 'The Earth stays still while the Sun and the Moon move around clockwise remaining on opposite sides of the Earth' (see diagram).
2. Continue the role-play until the Speaker ('Earth') has observed which direction the 'Sun' and 'Moon' rose and set in Australia.
3. Swap roles and repeat the role-play until everyone has had a turn.
4. Discuss the observations and record them in 'Role-play observations' (Resource sheet 5).
5. Repeat steps 1–4 for the next claim.

If there is time, make up your own claims to role-play, for example, 'The Earth stays still, the Sun moves anticlockwise and the Moon moves clockwise'.



Starting the role-play for the claim — 'The Earth stays still while the Sun and Moon move clockwise around it'

Role-play observations

Team members: _____ **Date:**_____

Claim role-played			Observations
Earth: Still	**Sun:** Moves clockwise	**Moon:** Moves clockwise	The Sun rose in the _____ and set in the _____. The Moon rose in the _____ and set in the _____.
Earth: Rotates anti-clockwise	**Sun:** Still	**Moon:** Moves anti-clockwise	
Earth:	**Sun:**	**Moon:**	
Earth:	**Sun:**	**Moon:**	

Lesson 4 Galvanising Galileo

AT A GLANCE

To support students to represent and explain their understanding of how the Earth orbits the Sun while rotating on its axis.

To introduce current scientific views about Earth's place in Space.

Students:

- review and update their orreries, identifying how they relate to everyday timescales
- read and discuss Galileo's story and evidence to support the theory that the Earth orbits the Sun
- brainstorm objects that can be found in the Solar System.

EXPLAIN

Lesson focus

In the *Explain* phase students develop a literacy product to represent their developing understanding. They discuss and identify patterns and relationships within their observations. Students consider the current views of scientists and deepen their own understanding.

Assessment focus

Formative assessment is an important aspect of the *Explain* phase. It involves monitoring students' developing understanding and giving feedback that extends their learning. In this lesson you are looking for evidence that students are developing an understanding about:

- how we know that the Earth is part of a system of planets orbiting a star (the Sun).

Key lesson outcomes

Students will be able to:
• review and update their orreries, identifying observations and evidence that support their point of view
• read and discuss a text about Galileo
• identify that the Earth orbits the Sun in a year, the Moon orbits the Earth in a month and the Earth rotates on its axis in a day
• brainstorm space objects present in the Solar System.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page 5).

Teacher background information

The first mathematical model of a Solar System of planets rotating around the Sun ('heliocentric') was developed in the 16th century by Nicolaus Copernicus, who was a mathematician, astronomer and Catholic monk born in the Kingdom of Poland. There is still some discussion as to whether Copernicus was aware that a 14th century mathematician, Ibn al-Shantir, had used similar mathematical equations in his model of a solar system rotating around the Earth ('geocentric'). Nor is it certain if Copernicus knew of arguments in medieval Islam that used similar evidence to those that he proposed. However, as Copernicus was the first to document the mathematical idea of a Sun-centred Solar System, the gradual acceptance of the model was called the Copernican Revolution.

Tycho Brahe, a Danish nobleman, appreciated Copernicus' ideas, but the pre-Newton physics of the time could not explain how such a massive thing as the Earth could be moving so quickly, nor why its movement could not be felt. Since no data was available on the other space objects of the Solar System, it was easy to imagine that they were made of a different substance from Earth, which was lighter and quick to move ('ether'). Tycho proposed that the Sun and Moon orbited the Earth, and that the other planets orbited the Sun.

Galileo Galilei, an Italian scientist, used improved telescopes and described additional observations, such as the phases of Venus, which could not be explained by the Earth-centric model. Johannes Kepler, a German mathematician, proposed that the planets followed elliptical orbits rather than circular ones. This made the Copernican model much more accurate at explaining observations, but he was ignored at the time by people such as Galileo. When the English scientist Isaac Newton was able to provide an explanation for Kepler's ideas in terms of 'gravitation', heliocentrism (Sun centred) was finally on a firm theoretical base.

Equipment

FOR THE CLASS

- class science journal
- word wall
- TWLH chart
- team skills chart
- team roles chart

FOR EACH TEAM

- role wristbands or badges for Director, Manager and Speaker
- each student's science journal
- team orreries created in Lesson 1, Session 2
- 1 copy of 'Perplexing planets' (Resource sheet 6) per student

Preparation

- Read 'Perplexing planets' (Resource sheet 6), and decide how you will use it in your class. It might be used as an independent reading task, in teams or in guided reading groups.
- *Optional:* Collect photos or videos showing the different aspects of the Moon and the paths of the planets (the 'dance of the planets').
- *Optional:* Download Celestia (www.shatters.net/celestia) onto your interactive whiteboard. Familiarise yourself with its functioning so that you can show students the solar systems elsewhere in the Galaxy.

EXPLAIN

Lesson steps

1. Review the previous lessons using the class science journal and TWLH chart. Remind students that they will be creating a dialogue similar to the one witnessed in Lesson 1, Session 1 and discuss evidence collected to date.
2. Ask students to review the orreries they created in Lesson 1, Session 2. Ask questions such as:
   - Does this still reflect what you think? Why or why not?
   - What would you like to change?
   - What observations and evidence support your model?
   - What are you not sure about?

   Record students' thoughts in the class science journal.
3. Ask students to write a summary of how their orrery represents a day, month and year. Ask teams if their model is an Earth-centred model or a Sun-centred model and explain why.
4. Explain that students are going to read a factual recount about the person who is famous for popularising the claim that 'The Earth is part of a system of planets orbiting the Sun'. Discuss the purpose and features of factual recounts.

Literacy focus

Why do we use a factual recount?

We use a **factual recount** to describe things that have happened to us. We can read a factual recount to find out about things that have happened to someone else.

What does a factual recount include?

A **factual recount** might include descriptions of how the writer felt and of other people who were part of the events. It is often written in the past tense.

5 Arrange for students to read 'Perplexing planets' (Resource sheet 6) individually, in teams or in guided reading groups (see 'Preparation').

6 After students have read the text, ask them to brainstorm the key points and record them in their science journal, to serve as a reminder when they create their own texts.

7 As a class, discuss why Galileo's model was ultimately accepted as the preferred explanation (see 'Teacher background information').

Optional: Introduce images and videos of other observations that the model explained, for example, the movement of the planets (see 'Teacher background information').

8 Ask students what they think the term 'Solar System' means. Explain that scientists define the Solar System as being all space objects in orbit around the Sun, or in orbit around space objects that are orbiting the Sun. Add an agreed description of the term 'Solar System' to the glossary in the class science journal.

9 Discuss how astronomers now have access to more powerful instruments and have been able to detect the presence of solar systems around other stars, which also supports the 'Solar System' theory.

Optional: Show students other constellations using Celestia (see 'Preparation').

10 Ask students what space objects other than planets are in our Solar System. Record students' answers on the TWLH chart.

11 Allow time for teams to revise and update their orreries if required.

12 Ask students to record what they have learned in their science journals. Provide them with sentence starters such as:

- I learned that…
- I enjoyed/did not enjoy…
- I want to know more about…

13 Review the TWLH chart. Record what students have learned and any questions that can be answered.

14 Update the word wall with words and images.

EXPLAIN

Australian Curriculum links

Science

- Explore the contributions made to the understanding of the Solar System by people from a range of cultures, for example, Copernicus and Khayyám.

Indigenous perspectives

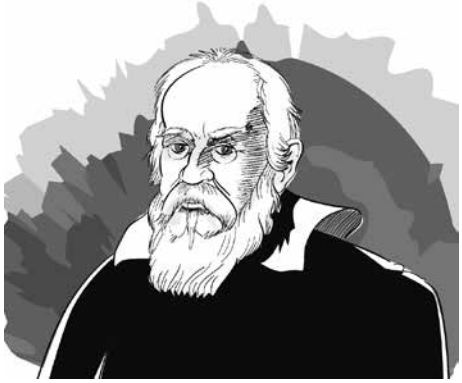
- Western science's explanation of Earth's place in Space, as part of a Solar System around a star (the Sun), is explored in this lesson. Indigenous people might have their own way of explaining observations and conceptualising Earth's place (see page 6). Contact Indigenous community members and/or Indigenous Education Officers to access relevant, local, Indigenous knowledge. Protocols are available on the website: www.science.org.au/primaryconnections/indigenous

EXPLAIN

Perplexing planets

In the early 1600s when Galileo Galilei lived, almost everyone believed that the Earth was the centre of the Universe, with the Sun, the Moon and all the planets and stars orbiting the Earth.

Galileo thought differently. He claimed that the Sun was the centre of the Universe and that the Earth was one of several planets that orbited the Sun. Galileo was not the first to have this idea, but he was one of the first people to provide evidence to support it.

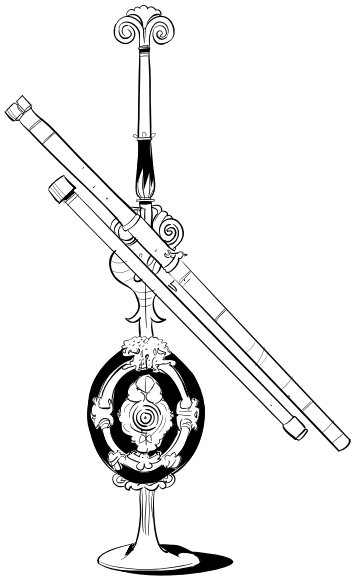


Galileo Galilei

The evidence

In 1609, Galileo built a telescope powerful enough to see the four largest moons of Jupiter. He observed these four moons for many months and found that they appeared to orbit Jupiter. He wondered how the moons could orbit Jupiter when everything in Space was thought to orbit the Earth.

Galileo made more and more powerful telescopes that helped him observe space objects in greater detail. Every observation he made supported his claim that the planets orbited the Sun rather than the Earth.



Galileo Galilei's first telescope

A gradual change in beliefs

Galileo published his ideas and these were noticed by people who strongly believed that the Earth was the centre of the Universe. They complained to the authorities. Galileo was put under house arrest, which meant that he could not leave his home or receive visitors for the remainder of his life.

Over time, scientists created better telescopes to observe the movement of planets and their moons. The Earth-centred models became increasingly complicated when they were modified to accept new evidence. However, the Sun-centred model already explained this new evidence and people slowly began to accept that model. If only Galileo was still alive today to see his ideas widely accepted!

Lesson 5 Chasing constellations (*Optional*)

AT A GLANCE

To introduce current scientific views about how the observation of constellations provides evidence about Earth's place in Space.

Students:

- discuss constellations in the sky
- read a text about how different constellations are not always visible in the sky
- use models to explore how to explain this observation.

Lesson focus

In the *Explain* phase students develop a literacy product to represent their developing understanding. They discuss and identify patterns and relationships within their observations. Students consider the current views of scientists and deepen their own understanding.

EXPLAIN

Assessment focus

Formative assessment is an important aspect of the *Explain* phase. It involves monitoring students' developing understanding and giving feedback that extends their learning. In this lesson you are looking for evidence that students are developing an understanding about:

- how we know that the Earth (and other planets) orbit the Sun.

Key lesson outcomes

Students will be able to:
• identify different constellations and the nature of stars
• read and discuss a factual text about Scorpius and Orion
• work in teams to create models to explain the observations of the story
• discuss the results of their investigations and how the appearance of constellations at different times of the year supports the model of the Earth orbiting the Sun
• discuss how Indigenous Australians recognised constellations and used them for various purposes, including navigation and calendars.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page 5).

Teacher background information

Stars are space objects and some are similar to our Sun. They are much further away — the light from the nearest star takes more than four years just to reach us, whereas the light from the Sun takes eight minutes. The light from distant stars therefore appears to be not as bright in the sky as the Sun, which is why stars cannot be seen during the day even though they are present in the sky. Sometimes the first 'star' to be seen at dawn or dusk is in fact the planet Venus, reflecting light back from the Sun to our eyes.

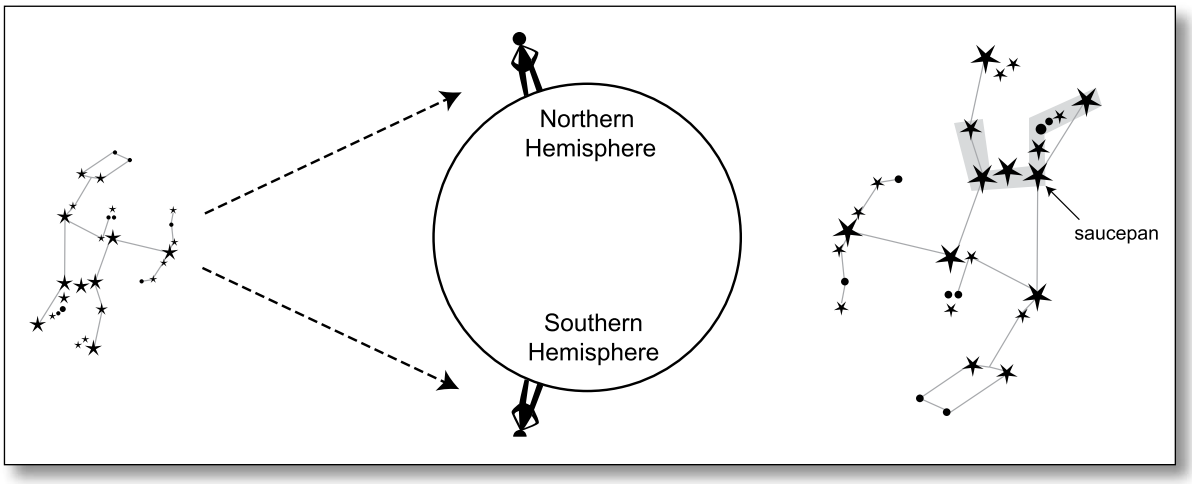
The stars appear to be in groups, which we call constellations. Different cultures have named some star groups as constellations based on their mythology. People observed that during the night different constellations passed overhead, and some constellations were more visible at different times of the year. Different cultures have used this observation to track time and/or have explained the patterns in the sky through myths and legends. Some of these myths and legends link the events in the sky to seasonal events at the Earth's surface.

The appearance of different constellations has been explained differently by scientists and others across the ages. When observing that two constellations never appeared at the same time, Greco–Roman mythology explains that one constellation is a hunter (Orion) and the other is the scorpion that killed him (Scorpius). Scientists explain this observation by the fact that certain constellations are on the same plane as our path around the Sun (the ecliptic). The Sun 'passes through' them once each year, hiding them from view. The constellations of Orion and Scorpius are diametrically opposed on the plane, hence they are not seen in the sky at the same time.

The constellations of the Zodiac lie on the ecliptic and the dates of the different star signs were determined by calculations of when the related constellation was overhead at midday.

Today they are about a month out. For example, Sagittarius is overhead at midday in Europe from mid-December to mid-January, whereas according to astrology, Sagittarius is dated as 23 November to 22 December. This occurs because the direction and tilt of the Earth's axis have changed gradually since the constellations were named 2000 years ago.

Orion is near the ecliptic so it also is not always seen in the sky. The constellation is located near Aries and Taurus. It appears upside down in the Southern Hemisphere, as do all constellations named by Europeans.



'Orion, the Hunter' appears upside down in Australia.
In Australia we find it easier to see the 'Saucepan'.

EXPLAIN

Students' conceptions

Students might think that stars go to the other side of the Earth during the day. The stars and constellations are always present. Stars aren't able to be seen during the day because our Sun appears bigger and brighter because it is relatively so much closer.

Students might believe that constellations are stars that are physically grouped together in Space. However the night sky as we see it from the surface of the Earth is a 2D representation of a 3D galaxy. Stars of the same constellation might in fact be thousands of light years distant from each other. The stars, apart from the Sun, are far outside our Solar System. Stars that appear dim might be brighter than our Sun; however they are so far away that very little of the light that they produce reaches our eyes.

Students might believe that stars are capable of rapid movement across the night sky because of the term 'shooting stars'. However, what we call 'shooting stars' has nothing to do with actual stars. They are meteoroids (rocks or dust) entering the Earth's atmosphere and burning up. The combustion of the space object leaves trails of light called meteors that appear bright to our eyes, hence the term 'shooting stars'.

Equipment

FOR THE CLASS

- class science journal
- word wall
- TWLH chart
- team roles chart
- team skills chart
- 1 enlarged copy of 'Star-crossed story' (Resource sheet 7)

FOR EACH TEAM

- role wristbands or badges for Director, Manager and Speaker
- each team member's science journal
- 1 copy of 'Star-crossed story' (Resource sheet 7)
- scissors
- 2 pieces of string (15cm in length)
- tape

Preparation

- *Optional:* Download multimedia material including:
  - different explanations of stars in films, for example, the segment from 'The Lion King' (G rating) where Simba, Pumbaa and Timon discuss their views on stars
  - photos of the night sky for students to identify constellations, for example, from Stellarium (www.stellarium.org)
  - photos of star trails, for example, those of Lincoln Harrison taken in the Australian outback.
- Enlarge a copy of 'Star-crossed story' (Resource sheet 7).
- *Optional:* Display the enlarged copy of 'Star-crossed story' (Resource sheet 7) on an interactive whiteboard or a computer connected to a projector. Check the Primary**Connections** website to see if an accompanying interactive resource has been developed: www.science.org.au/primaryconnections

Lesson steps

1. Review the previous lessons focusing students' attention on their observations of space objects and their apparent movement in the sky (see Lesson 2). Review how stars also appear to rise (like the Sun) and set, and can only be seen at night.
2. Discuss with students how scientists believe stars to be space objects like our Sun, emitting light many light years away in Space. This claim is supported by many observations of the light emitted by the stars.

   Optional: View multimedia material with different views of stars (see 'Preparation').
3. Ask students to share what they know about the appearance of the night sky, for example, the names of different constellations.

   Optional: Introduce pictures of the night sky (see 'Preparation') to allow students to point out the constellations that they recognise.

EXPLAIN

4 Discuss how the constellations named in the Northern Hemisphere, for example, Orion, appear upside down in Australia (see 'Teacher background information').

5 Ask students if they have heard of the constellations Scorpius and Orion. Introduce the enlarged copy of 'Star-crossed story' (Resource sheet 7), and read through with students.

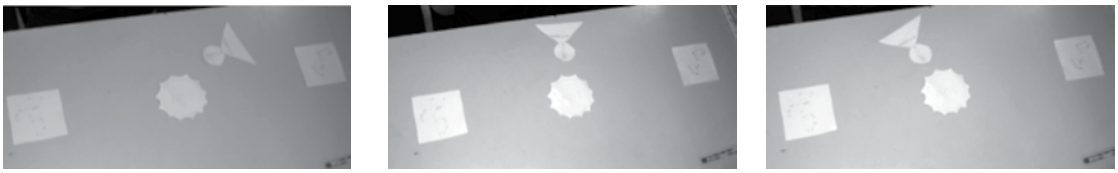
6 Explain that students will work in collaborative learning teams to explore how to explain the observations using science. Discuss the different science claims that they will need to consider when creating their explanation:

- The Earth travels around the Sun in a year.
- The Earth rotates on its axis in a day.
- The stars are very far away from the Solar System.
- When an observer on Earth can see the Sun they cannot see the stars in the sky.

Record these claims in an easily visible area of the classroom so teams can refer to them.

7 Model how to create an explanation using the cut-outs of 'Star-crossed story' (Resource sheet 7). Explain that the eye with lines leading out from it represents what the viewer can see from Earth. Ask students to fix strings on the lines to extend them. Explain that when something is within the strings, it can be seen by the viewer. Remind students that if the viewer can see the Sun, then even if the stars are in their range of vision they cannot 'see' them because the Sun appears so bright.

EXPLAIN



Investigating using the cut-outs of 'Star-crossed story'

8 Form teams and allocate roles. Ask Managers to collect team equipment.

9 Allow time for teams to complete their modelling task. Ask questions such as:

- What if...?
- That's interesting, can you explain more about...?

10 Ask Speakers to share their solution with the class. Discuss with students how the appearance of the night sky depends on where the Earth is in relation to the Sun.

11 Discuss how some constellations are affected by the position of the Sun, for example, the Zodiac, and some are not, for example, the Southern Cross. Explain that the cut-out model students used is 2D and constellations such as the Southern Cross would be above the desk, out of the path of the Sun.

Optional: Introduce pictures of star trails (see 'Preparation') to help students see how different stars move across the sky in the course of a night.

12 Discuss how these observations help support the model that the Earth rotates on its axis (otherwise the entire Galaxy would be turning around the Earth every day), and the model that the Earth moves around the Sun (otherwise sections of the Galaxy would be turning around the Earth every year).

13 Discuss how to measure a full year, for example, the amount of time it takes for a certain constellation to be visible at the exact same place at the exact same time. Explain that Indigenous people have used this knowledge for thousands of years, for example, to know when seasonal food sources are available.

Optional: Explore Indigenous constellations important to the Indigenous people of your region (see 'Australian Curriculum links').

14 Review the TWLH chart. Record what students have learned and any questions that can be answered.

15 Update the word wall with words and images.

Australian Curriculum links

English

- Read and compare different constellations identified in different cultures, including Australia's Indigenous cultures. Explore mythologies linked to different constellations.
- Ask students to create their own myths associated with the constellations that they made in the previous session.

Indigenous perspectives

- Some Indigenous people still use the stars as a guide for hunting and food gathering. Astronomical observations of the positions of stars and constellations and their apparent movement across the sky correlate with particular weather conditions and the availability of certain foods. Certain stars and constellations representing various spirits can also act as a celestial reminder of the social rules of the group.

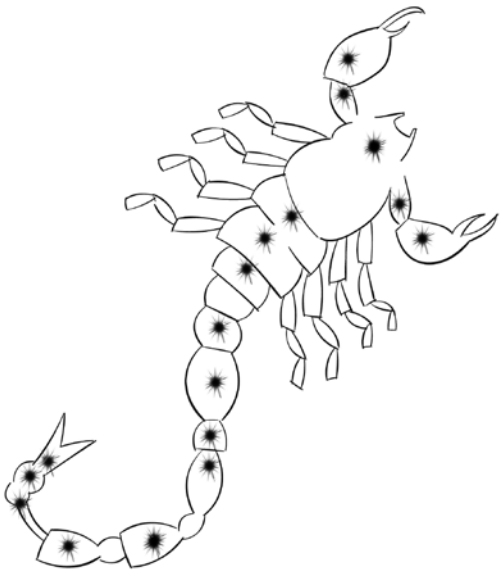
  Contact local Indigenous community members and/or Indigenous Education Officers to access local Indigenous knowledge about stars and constellations. If they deem it appropriate, explore the Emu in the Sky constellation and its significance for Indigenous people. Discuss the possible connection between the position of the Emu constellation, the breeding season for emus and an ancient rock engraving of an emu at Kurringai Chase National Park. See www.atnf.csiro.au/research/AboriginalAstronomy and www.questacon.edu.au/starlab/the_emu.html

- View Burarra Gathering (see burarra.questacon.edu.au/home.html). Select the Dry season, which contains information about navigating using the stars. Listen to Wala Wala as he uses the stars to go home.

EXPLAIN

Star-crossed story

Constellation of Orion



Constellation of Scorpius

In Europe, thousands of years ago people saw the two star constellations pictured above, and thought they resembled a hunter (Orion) and a scorpion (Scorpius). We can see them in Australia but they look upside down and back to front to us.

People also noticed that the two constellations are never seen at the same time in the night sky: as Scorpius appears in the East, Orion disappears in the West.

They came up with the following mythology to explain what they saw:

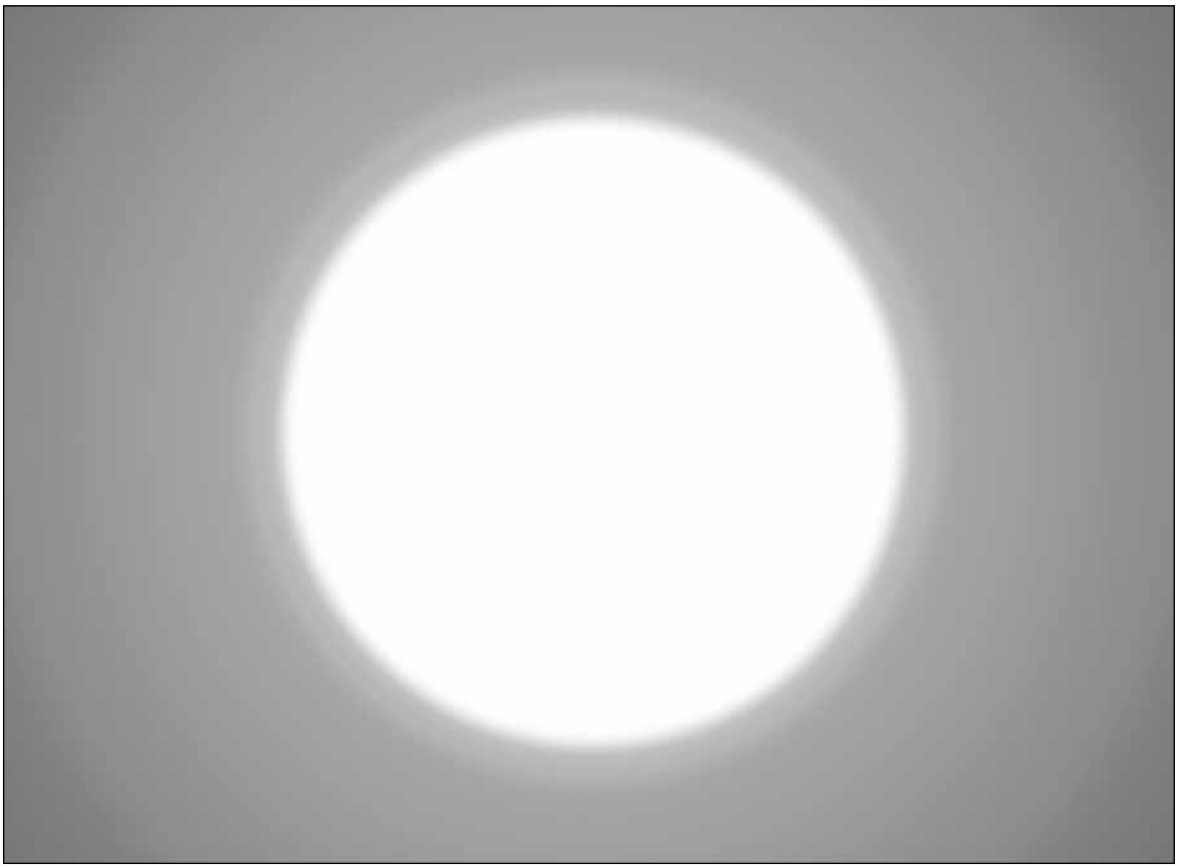
> *'Orion went away to Krete and spent his time hunting in company with Artemis (the god of hunting) and Leto (Artemis' mother). It seems that he threatened to kill every beast there was on earth; whereupon, in her anger, Ge (the Earth) sent up against him a Scorpion of very great size by which he was stung and so perished. After this Zeus (king of the gods), at the prayer of Artemis and Leto, put him among the stars, because of his manliness, and the Scorpion also as a memorial of him and of what had occurred.'*
>
> *(Greek epic, 8th or 7th century BC)*

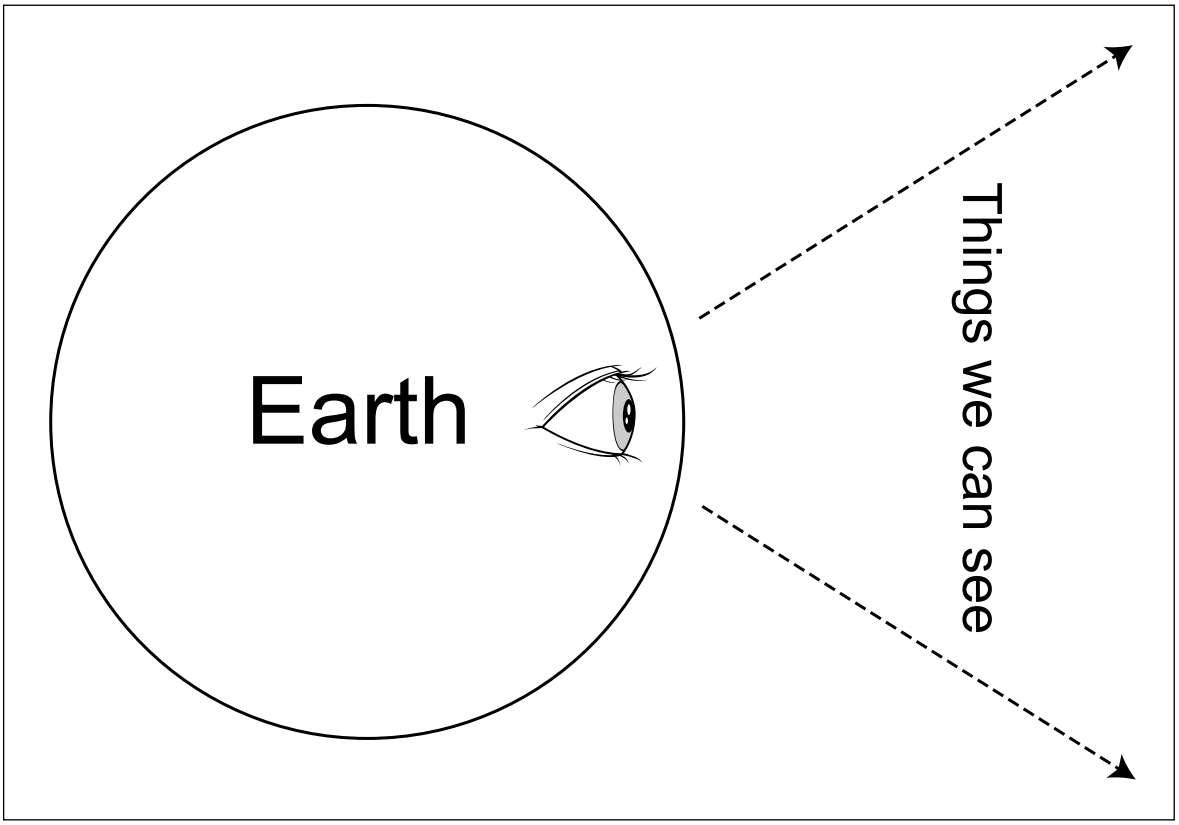
Your challenge

Can you explain the observations from the point of view of a scientist?

Cut out Scorpius, Orion, the Sun and the Earth and place them on your desk in different positions. Use the cut-outs to determine what an observer on Earth can see.

Star-crossed story





Lesson 6 Solar System scientists

AT A GLANCE

To support students to investigate characteristics of objects in the Solar System and create an accurate model of the Solar System

Session 1 Dealing with data

Students:

- investigate characteristics of objects in the Solar System, in particular their size and distance from the Sun.

Session 2 Size matters

Students:

- create a 3D scaled model of the Solar System
- discuss the pros and cons of different forms of representation
- visualise the Solar System's place in Space.

ELABORATE

Lesson focus

In the *Elaborate* phase students plan and conduct an open investigation to apply and extend their new conceptual understanding in a new context. It is designed to challenge and extend students' Science Understanding and Science Inquiry Skills.

Assessment focus

Summative assessment of the Science Inquiry Skills is an important focus of the *Elaborate* phase. Rubrics are available on the website to help you monitor students' inquiry skills.

Key lesson outcomes

Students will be able to:
• research information on objects in the Solar System
• compare findings and discuss discrepancies in collected data
• interpret data to create scaled models of the Solar System
• discuss how different models serve different purposes in science.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page 5).

Teacher background information

The Solar System

The Sun is a rather ordinary star in an immense Galaxy, the Milky Way, which contains about 100,000 million stars. Our Galaxy is shaped like a flat spiral, and our Sun is about two-thirds of the way out from its centre. The Galaxy is so immense that light takes about 100,000 years to cross it. Our Galaxy is only a tiny part of the Universe. The estimated number of galaxies out to the edge of what we can see with our largest telescope is about 100,000 million.

The Solar System comprises the Sun and all the space objects that are in orbit around it (or orbiting something that is orbiting the Sun, for example, the Moon orbits the Earth, which is orbiting the Sun).

Planets are kept to their orbits around the Sun by the force of gravity between them and the Sun. The further a planet is from the Sun, the longer it takes to go once around the Sun (its year). The four inner planets (Mercury, Venus, Earth and Mars) consist of dense rocky material. The four outer planets (Jupiter, Saturn, Uranus and Neptune) are collections of gases and are much less dense. Earth is the only planet to have liquid water at its surface.

Moons of planets are kept in orbit by the planets' gravity. Mercury and Venus do not have moons; Saturn and Jupiter have dozens. Saturn and Uranus have rings made of a huge collection of small orbiting fragments. Generally moons are made of rock and have little or no atmosphere. However some moons of gas planets, such as Jupiter, are very large and are almost like small rocky planets themselves. There are more than 160 known moons in the Solar System.

Between Mars and Jupiter there is a belt of asteroids that are orbiting the Sun. Asteroids are smaller, rocky space objects. Some are quite large and have other asteroids orbiting them. The largest asteroid, Ceres, has been classified as a dwarf planet, similar to Pluto. Beyond the last planet, Neptune, there is another ring of small bodies similar to the asteroid belt called the Kuiper belt. Space objects within the Kuiper belt are rocks and ice objects. Three of the larger bodies within the Kuiper belt — Pluto, Haumea and Makemake — are currently classified as dwarf planets. The Solar System also includes human-made objects, such as space probes (robotic spacecraft sent to collect information), space stations and satellites.

Sizes and characteristics of space objects

The distances between the major objects, such as planets, in the Solar System can be difficult to imagine because they are so large. Light, which is the fastest thing in the Universe, takes about eight minutes to travel from the Sun to Earth. In this lesson students are asked to investigate the characteristics, including sizes and distances, between the planets and the Sun.

Data on the eight planets in our Solar System

Space object	Average distance from Sun (in millions of km)	Approximate year length (in Earth units)	Approximate day length (in Earth units)	Diameter
Mercury	58	88 days	176 days	4,879km
Venus	108	225 days	243 days	12,100km
Earth	150	1 year	1 day	12,756km
Mars	228	686 days	25 hours	6,780km
Jupiter	778	12 years	10 hours	142,984km
Saturn	1,427	30 years	10 hours	120,540km
Uranus	2,870	84 years	17 hours	51,118km
Neptune	4,497	165 years	18 hours	49,528km

Students' conceptions

Students often have little understanding of the sizes of different space objects and the distances between them.

Some students might believe that the Solar System only contains the Sun, planets and moons. However it also contains other natural objects, such as comets and asteroids, and human-made objects, such as space probes.

Students might think that the Solar System contains the stars they see in the night sky. However the Solar System only contains one star, the Sun. The lights we see in the sky come from stars many light years distant, which might have systems of their own.

Students might have little awareness of the difference between stars and planets. Stars are massive space objects and produce their own light through nuclear fusion. Planets can be rocky or gaseous, but they are much smaller and colder than stars and do not produce their own light.

Session 1 Dealing with data

Equipment

FOR THE CLASS

- class science journal
- word wall
- TWLH chart
- team roles chart
- team skills chart
- 1 enlarged copy of 'Solar System information organiser' (Resource sheet 8)

FOR EACH TEAM

- role wristbands or badges for Director, Manager and Speaker
- each team member's science journal
- 6 copies of 'Solar System information organiser' (Resource sheet 8)

Preparation

- Enlarge a copy of 'Solar System information organiser' (Resource sheet 8).

Lesson steps

1 Review the previous lessons and focus students' attention on their orreries. Ask students questions such as:

- What does your orrery represent accurately (the relative positions and movements of the Sun, Moon and Earth)?
- Does your model accurately represent the relative sizes of the Sun, Earth and Moon? How do you need to change it to make it accurate?
- Does your model accurately represent the distances between the Sun, Moon and Earth? How do you need to change it to make it accurate?
- What would you need to add to your orrery to make it a representation of the Solar System?

Record students' ideas in the class science journal.

2 Explain that students will work in collaborative learning teams to gather information to help them make a complete and accurate orrery of the Solar System, including information on how to make their models to scale.

3 Discuss with students what making something to scale means, for example, ensuring that all parts of the model are the correct size relative to each other. Add an agreed description to the glossary in the class science journal.

4 Introduce the enlarged copy of 'Solar System information organiser' (Resource sheet 8). Explain to students that they will be using the tables provided to organise the information that they collect. Review the purpose and features of a table (see Lesson 3).

5 Discuss what units to use when collecting information, for example, kilometres. Discuss how to measure the length of a 'day' (the time it takes to rotate once on its axis) and the length of a 'year' (the time it takes to orbit the Sun once) for a different planet than Earth.

6 Highlight the 'Information sources' section of the 'Solar System information organiser' (Resource sheet 8). Discuss with students the importance of recording where secondary information comes from to help readers judge the reliability of the information.

7 Ask students to focus their investigation on the planets in the Solar System, although they can also research other space objects in the Solar System if they get the time, for example, moons of other planets and asteroids.

8 Form teams and allocate roles. Ask Managers to collect their team's equipment.

9 Allow time for teams to complete the task. Ask questions such as:

- That's interesting, why have you…?
- Can you tell me more about…?
- Have you thought about…?

10 Ask teams to compare their findings with other teams. If there are discrepancies between findings, discuss how to determine which source is more accurate. Encourage students to use 'Science question starters' (see Appendix 5) to question each other about their investigation.

11 Explain that the information gathered will be used in the next Session to make models to scale.

12 Review the TWLH chart. Record what students have learned and any questions that can be answered.

13 Update the word wall with words and images.

Australian Curriculum links

Science

- Explore the composition and properties of different objects of the Solar System, including planets, moons, comets and meteorites.
- Research the reclassification of Pluto to a dwarf planet and discuss the differences between a planet and a dwarf planet.

English

- Read and compare different mythologies around space objects of the Solar System, such as the planets.

Solar System information organiser

Team members: _____ **Date:** _____

Solar System space object:	
Size:	Description:
How far is it from the Sun?	
How long is its day?	Notes:
How long is its year?	
Information sources:	

Solar System space object:	
Size:	Description:
How far is it from the Sun?	
How long is its day?	Notes:
How long is its year?	
Information sources:	

Solar System space object:	
Size:	Description:
How far is it from the Sun?	
How long is its day?	Notes:
How long is its year?	
Information sources:	

Session 2 Size matters

Equipment

FOR THE CLASS

- class science journal
- word wall
- TWLH chart
- enlarged copy of 'Scaled planets' (Resource sheet 9)
- 100m piece of rope or yarn
- 1 measuring tape
- objects to represent Solar System objects (see 'Preparation')
- 8 A4 pieces of paper

FOR EACH STUDENT

- science journal

Preparation

- Organise use of the school oval.
- Collect a range of objects to represent the relative size of the planets and the Sun. Objects could include: basketball for the Sun, poppy seed for Mercury, peppercorns for Venus and Earth, table tennis ball for Jupiter, large marble for Saturn, and two large peas for Uranus and Neptune. Create eight A4 signs, one for each of the planets.
- *Optional:* View Bill Nye's video demonstration of the distance between planets to familiarise yourself with its information.
- *Optional:* Download Celestia (www.shatters.net/celestia) onto your interactive whiteboard. Familiarise yourself with its functioning so that you can show students the place of the Solar System in the Galaxy.
- Enlarge a copy of 'Scaled planets' (Resource sheet 9).
- *Optional:* Display the enlarged copy of 'Scaled planets' (Resource sheet 9) on an interactive whiteboard or a computer connected to a projector. Check the Primary**Connections** website to see if an accompanying interactive resource has been developed: www.science.org.au/primaryconnections

Lesson steps

1. Review the previous lesson and remind students about how they have investigated characteristics of space objects in the Solar System. Explain that in this lesson they will explore how to create a scaled model of the Solar System.

2 Discuss how models and maps represent real distances, for example, one centimetre on a map might represent one kilometre in actual distance. Explain that in order to create an accurate, scaled model of the Solar System one metre in the model will represent 46,000,000 kilometres in space.

3 Introduce the enlarged copy of 'Scaled planets' (Resource sheet 9), and read through with students. Ask students if the numbers in columns 2 and 4 match the numbers that they have. Discuss rounding of decimals and accuracy of sources in cases of disagreement. Explain that to find the scaled sizes and distances of the model, the numbers were divided by 46,000,000 and recorded in columns 3 and 5. Discuss the different units used in columns 4 and 5 (kilometres and millimetres).

   Optional: visit www.exploratorium.edu/ronh/solar_system for a calculator that will generate sizes of the planets to a set scale.

4 Review the different scales used in 'Scaled planets' (Resource sheet 9). Discuss why the conversion was chosen (so that it will fit into a standard oval). Ask students if they think it is possible to accurately represent the size of the planets at the same time as the distances between the planets, given that Mercury would need to be 0.1 millimetres wide in order to fit the planets on an oval.

5 Explain that the class is going to work together to create a Solar System that accurately represents the distances between planets. Ask students to choose something to represent each planet so that the relative sizes are approximately represented (see 'Preparation'). Discuss that these are ten times bigger than the scaled measurements.

6 Select eight students to each take a sign (see 'Preparation') and the object representing their planet. Ask students to remember their planet's scaled distance from the Sun. Move to a large open space (see 'Preparation').

7 Position the student representing the Sun in the centre of the space and hand them the rope. Ask the student representing Neptune to walk the rope out to 97 metres. Ask the other students to take position along the rope as to where their space object should be. Use the tape measure as necessary.

8 Ask students representing space objects to walk around the Sun, maintaining their distance from the student representing the Sun, and stop when they have completed an orbit. Discuss how long or short the orbits were and what this might mean in terms of 'years' and how fast the planet is moving.

   Note: Depending on the available space, some space objects may not be able to 'orbit' the Sun.

   Optional: Include other information collected by students for the 'day' of the planets in the model.

9 Discuss the model as a class. Ask questions such as:
   - Was everything we know about the Solar System accurately represented in the model?
   - What did you find challenging about making a model to scale?
   - What have you found out?
   - What are the strengths of this model compared to the previous one (for example, it is closer to reality)?
   - What are the weaknesses of this model (for example, some planets are harder to see as they are so small compared to the Sun)?

ELABORATE

10 Discuss how the knowledge of distances might help choose between claims, for example, if the Sun is 150 million kilometres from Earth, then it would need to travel 10,000 kilometres a second to circle the Earth in 24 hours.

Optional: Discuss the lyrics of Monty Python's 'Galaxy Song'.

11 Review the TWLH chart. Record what students have learned and any questions that can be answered.

12 Update the word wall with words and images.

Australian Curriculum links

Mathematics

- Rather than use 'Scaled planets' (Resource sheet 9), ask students to calculate the scaled distances using the numbers that they researched in Lesson 1 using calculators.
- Ask students to calculate how old they are in the years of different planets.

Scaled planets

Space object	Actual distance from the Sun	Scaled distance from the Sun	Actual diameter	Scaled diameter
Sun	0	0	1,391,016km	29.98mm
Mercury	58,000,000km	1.25m	4,879km	0.11mm
Venus	108,000,000km	2.33m	12,100km	0.26mm
Earth	150,000,000km	3.23m	12,756km	0.27mm
Mars	228,000,000km	4.91m	6,780km	0.15mm
Jupiter	778,000,000km	16.77m	142,984km	3.08mm
Saturn	1,427,000,000km	30.75m	120,540km	2.60mm
Uranus	2,870,000,000km	61.85m	51,118km	1.10mm
Neptune	4,497,000,000km	96.92m	49,528km	1.07mm

Lesson 7 Sunning it up

AT A GLANCE

To provide opportunities for students to represent what they know about the Earth as part of a system of planets orbiting a star (the Sun) and to reflect on their learning during the unit.

Students:

- create a dramatic dialogue between two imaginary characters about Earth's place in Space
- reflect on their learning during the unit.

Lesson focus

In the *Evaluate* phase students reflect on their learning journey and create a literacy product to re-represent their conceptual understanding.

Assessment focus

Summative assessment of the Science Understanding descriptions is an important aspect of the *Evaluate* phase. In this lesson you will be looking for evidence of the extent to which students understand that:

- the Earth is part of a system of planets orbiting a star (the Sun).

You will also be able to assess their understanding of how scientists use evidence to develop explanations of events and phenomena. Literacy products in this lesson provide useful work samples for assessment using the rubrics provided on the Primary**Connections** website.

EVALUATE

Key lesson outcomes

Students will be able to:
• identify that the Earth is part of a Solar System orbiting the Sun while it rotates on its axis
• support claims about how to explain everyday observations with evidence in a dramatic dialogue
• contribute to discussions and express their opinions about their learning journey.

This lesson also provides opportunities to monitor the development of students' general capabilities (highlighted through icons, see page 5).

Equipment

FOR THE CLASS

- class science journal
- word wall
- TWLH chart

FOR EACH STUDENT

- science journal

Lesson steps

1. Review the previous lessons using the class science journal and TWLH chart. Ask questions such as:
   - What did we know about Earth's place in Space at the beginning of the unit?
   - What did we know about how humans have sought to understand Space?
   - What questions did we have?
   - What have we learned?
   - What evidence do we have for how we know?
2. Discuss the claim 'The Earth is the centre of the Universe', and what students have found out about why people might have thought that.
3. Discuss the claim 'The Earth is part of a system of planets orbiting the Sun', and what students have learned about how that model was constructed and what we know about the Solar System today.

4 Ask students to reflect on the development of their different models throughout the unit, such as orreries, 3D models and role-plays. Ask questions such as:
   - How did you behave like scientists in these lessons? (By collecting evidence and testing theories using models.)
   - What did you learn about different types of models and how they are used in science?
   - What were the advantages and disadvantages of different models?
   - What are the advantages and disadvantages of making orreries and 3D models to scale?

5 Explain that students will draft their own dialogue between two people each believing a different claim. Remind students of the dialogue in Lesson 1, Session 1 'But it looks flat' (Resource sheet 1). Remind students that Eratosthenes used facts and reasoning to debate his position and did not attack his companion for his beliefs.

6 Explain that the dialogue presentation will need to contain as much of the different information and evidence that students have accumulated throughout the unit as possible, for example:
   - how to explain different observations of the night sky
   - how the Sun, Earth, Moon and planets move in relation to each other
   - information on the characteristics of space objects in the Solar System.

   Remind students to use appropriate scientific terminology in their dialogue, and that the class science journal contains a glossary of terms to assist them.

7 Allow time for students to discuss how they will present their dialogue, for example, as a written play, as a spoken dialogue with a fellow student, or as a cartoon.

8 Describe the criteria to assess the quality of the dialogue:
   - well-organised information
   - clear, concise communication
   - evidence of knowledge of the topic
   - quality/creativity of the presentation.

   Remind students about creating a summary in Lesson 4, and review the purpose and features of a summary.

9 Provide students with time to plan, prepare and publish their dialogues.

   Optional: Invite an audience, for example, another class, parents or a scientist, to view the dialogues and discuss what students have learned throughout the unit.

10 Ask students to conduct a self-assessment of learning by completing sentences in their science journal such as:
   - I really enjoyed...
   - I learned a lot about...
   - I could improve...
   - I'm still wondering about...
   - Next time we work in teams I will...
   - In the future I would like to...

EVALUATE

Australian Curriculum links

English

- Explore writing scripts for dramas and/or plays.

Appendix 1
How to organise collaborative learning teams (Year 3–Year 6)

Introduction

Students working in collaborative teams is a key feature of the PrimaryConnections inquiry-based program. By working in collaborative teams students are able to:

- communicate and compare their ideas with one another
- build on one another's ideas
- discuss and debate these ideas
- revise and rethink their reasoning
- present their final team understanding through multi-modal representations.

Opportunities for working in collaborative learning teams are highlighted throughout the unit. Students need to be taught how to work collaboratively. They need to work together regularly to develop effective group learning skills.

Team structure

The first step towards teaching students to work collaboratively is to organise the team composition, roles and skills. Use the following ideas when planning collaborative learning with your class:

- Assign students to teams rather than allowing them to choose partners.
- Vary the composition of each team. Give students opportunities to work with others who might be of a different ability level, gender or cultural background.
- Keep teams together for two or more lessons so that students have enough time to learn to work together successfully.
- If you cannot divide the students in your class into teams of three, form two teams of two students rather than one team of four. It is difficult for students to work together effectively in larger groups.
- Keep a record of the students who have worked together as a team so that by the end of the year each student has worked with as many others as possible.

Team roles

Students are assigned roles within their team (see below). Each team member has a specific role but all members share leadership responsibilities. Each member is accountable for the performance of the team and should be able to explain how the team obtained its results. Students must therefore be concerned with the performance of all team members. It is important to rotate team jobs each time a team works together so that all students have an opportunity to perform different roles.

For Year 3–Year 6, the teams consist of three students—Director, Manager and Speaker. (For–Year 2, teams consist of two students—Manager and Speaker.) Each member of the team should wear something that identifies them as belonging to that role, for example a wristband, badge, or colour-coded peg. This makes it easier for you to identify which role each student is doing and it is easier for the students to remember what they and their team mates should be doing.

Manager

The Manager is responsible for collecting and returning the team's equipment. The Manager also tells the teacher if any equipment is damaged or broken. All team members are responsible for clearing up after an activity and getting the equipment ready to return to the equipment table.

Speaker

The Speaker is responsible for asking the teacher or another team's Speaker for help. If the team cannot resolve a question or decide how to follow a procedure, the Speaker is the only person who may leave the team and seek help. The Speaker shares any information they obtain with team members. The teacher may speak to all team members, not just to the speaker. The Speaker is not the only person who reports to the class; each team member should be able to report on the team's results.

Director

The Director is responsible for making sure that the team understands the team investigation and helps team members focus on each step. The Director is also responsible for offering encouragement and support. When the team has finished, the Director helps team members check that they have accomplished the investigation successfully. The Director provides guidance but is not the team leader.

Team skills

Primary**Connections** focuses on social skills that will help students work in collaborative teams and communicate more effectively.

Students will practise the following team skills throughout the year:

- move into your teams quickly and quietly
- speak softly
- stay with your team
- take turns
- perform your role.

To help reinforce these skills, display enlarged copies of the team skills chart (see the end of this Appendix) in a prominent place in the classroom.

The development of these team skills aligns to descriptions in the Australian Curriculum: English. See page 7.

Supporting equity

In science lessons, there can be a tendency for boys to manipulate materials and girls to record results. Primary**Connections** tries to avoid traditional social stereotyping by encouraging all students, irrespective of their gender, to maximise their learning potential. Collaborative learning encourages each student to participate in all aspects of team activities, including handling the equipment and taking intellectual risks.

Observe students when they are working in their collaborative teams and ensure that both girls and boys are participating in the hands-on activities.

TEAM SKILLS

1 Move into your teams quickly and quietly

2 Speak softly

3 Stay with your team

4 Take turns

5 Perform your role

TEAM ROLES

Manager

Collects and returns all materials the team needs

Speaker

Asks the teacher and other team speakers for help

Director

Makes sure that the team understands the team investigation and completes each step

Appendix 2
How to use a science journal

Introduction

A science journal is a record of observations, experiences and reflections. It contains a series of dated, chronological entries. It can include written text, drawings, labelled diagrams, photographs, tables and graphs.

Using a science journal provides an opportunity for students to be engaged in a real science situation as they keep a record of their observations, ideas and thoughts about science activities. Students can use their science journals as a useful self-assessment tool as they reflect on their learning and how their ideas have changed and developed during a unit.

Monitoring students' journals allows you to identify students' alternative conceptions, find evidence of students' learning and plan future learning activities in science and literacy.

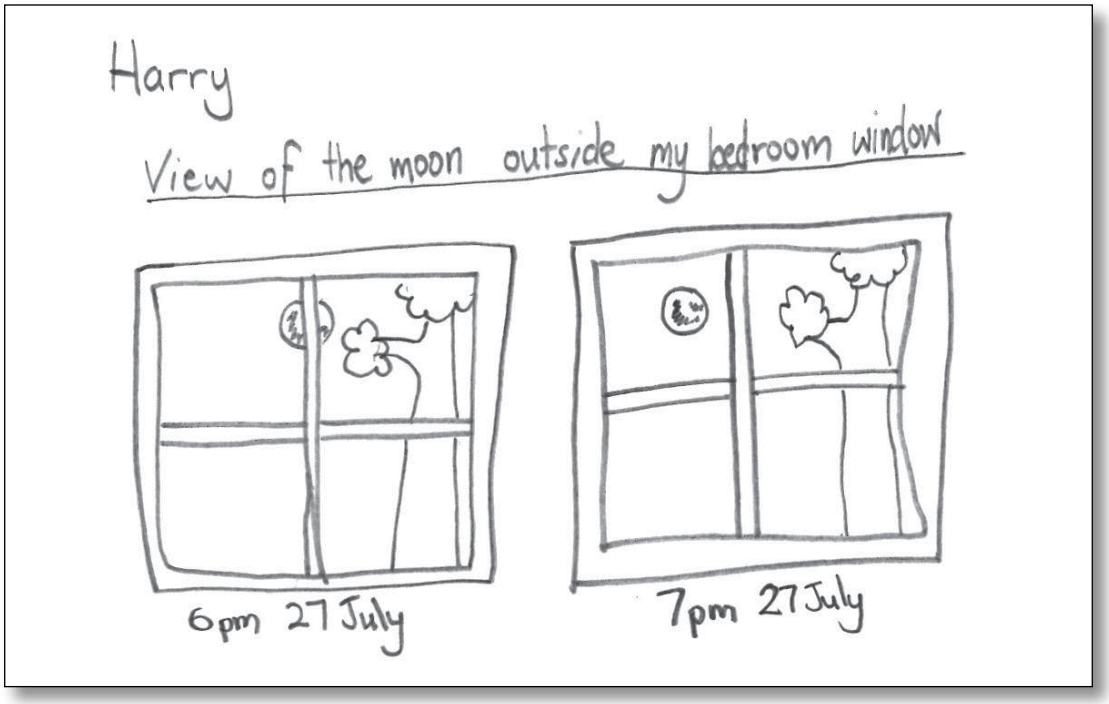
Using a science journal

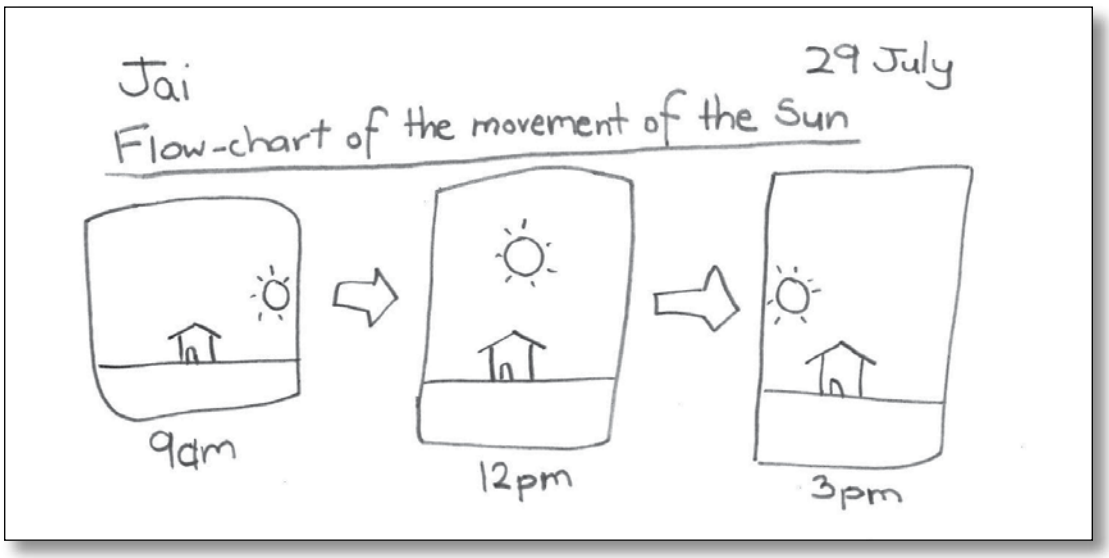
1. At the start of the year, or before starting a science unit, provide each student with a notebook or exercise book for their science journal or use an electronic format. Tailor the type of journal to fit the needs of your classroom. Explain to students that they will use their journals to keep a record of their observations, ideas and thoughts about science activities. Emphasise the importance of including pictorial representations as well as written entries.
2. Use a large project book or A3 paper to make a class science journal. This can be used at all Stages to model journal entries. With younger students, the class science journal can be used more frequently than individual journals and can take the place of individual journals.
3. Make time to use the science journal. Provide opportunities for students to plan procedures and record predictions, and their reasons for predictions, before an activity. Use the journal to record observations during an activity and reflect afterwards, including comparing ideas and findings with initial predictions and reasons. It is important to encourage students to provide evidence that supports their ideas, reasons and reflections.
4. Provide guidelines in the form of questions and headings and facilitate discussion about recording strategies, for example, note-making, lists, tables and concept maps. Use the class science journal to show students how they can modify and improve their recording strategies.
5. Science journal entries can include narrative, poetry and prose as students represent their ideas in a range of styles and forms.
6. In science journal work, you can refer students to display charts, pictures, diagrams, word walls and phrases about the topic displayed around the classroom. Revisit and revise this material during the unit. Explore the vocabulary, visual texts and ideas that have developed from the science unit, and encourage students to use them in their science journals.

7 Combine the use of resource sheets with journal entries. After students have pasted their completed resource sheets in their journal, they might like to add their own drawings and reflections.

8 Use the science journal to assess student learning in both science and literacy. For example, during the *Engage* phase, use journal entries for diagnostic assessment as you determine students' prior knowledge.

9 Discuss the importance of entries in the science journal during the *Explain* and *Evaluate* phases. Demonstrate how the information in the journal will help students develop literacy products, such as posters, brochures, letters and oral or written presentations.





***Earth's place in Space* science journal entries**

Appendix 3
How to use a word wall

Introduction

A word wall is an organised collection of words and images displayed in the classroom. It supports the development of vocabulary related to a particular topic and provides a reference for students. The content of the word wall can be words that students see, hear and use in their reading, writing, speaking, listening and viewing.

Goals in using a word wall

A word wall can be used to:

- support science and literacy experiences of reading, viewing, writing and speaking
- provide support for students during literacy activities across all key learning areas
- promote independence in students as they develop their literacy skills
- provide a visual representation to help students see patterns in words and decode them
- develop a growing bank of words that students can spell, read and/or use in writing tasks
- provide ongoing support for the various levels of academic ability in the class
- teach the strategy of using word sources as a real-life strategy.

Organisation

Position the word wall so that students have easy access to the words. They need to be able to see, remove and return word cards to the wall. A classroom could have one main word wall and two or three smaller ones, each with a different focus, for example, high-frequency words.

Choose robust material for the word cards. Write or type words on cardboard and perhaps laminate them. Consider covering the wall with felt-type material and backing each word card with a self-adhesive dot to make it easy for students to remove and replace word cards.

Word walls do not need to be confined to a wall. Use a portable wall, display screen, shower curtain or window curtain. Consider a cardboard shape that fits with the unit, for example, an apple for a needs unit.

The purpose is for students to be exposed to a print-rich environment that supports their science and literacy experiences.

Organise the words on the wall in a variety of ways. Place them alphabetically, or put them in word groups or groups suggested by the unit topic, for example, words for an *Earth's place in Space* unit might be organised using headings, such as 'Earth', 'Sun', 'Moon' and 'Solar System'.

***Earth's place in Space* word wall**

Using a word wall

1. Limit the number of words to those needed to support the science and literacy experiences in the classroom.
2. Add words gradually, and include images where possible, such as drawings, diagrams or photographs. Build up the number of words on the word wall as students are introduced to the scientific vocabulary of the unit.
3. Encourage students to interact with the word wall. Practise using the words with students by reading them and playing word games. Refer to the words during science and literacy experiences, and direct students to the wall when they need a word for writing. Encourage students to use the word wall to spell words correctly.
4. Use the word wall with the whole class, small groups and individually during literacy experiences. Organise multi-level activities to cater for the individual needs of students.

Appendix 4
How to use a TWLH chart

Introduction

A learning tool commonly used in classrooms is the KWL chart. It is used to elicit students' prior **k**nowledge, determine questions students **w**ant to know answers to, and document what has been **l**earned.

PrimaryConnections has developed an adaptation called the TWLH chart.

T 'What we **think** we know' is used to elicit students' background knowledge and document existing understanding and beliefs. It acknowledges that what we 'know' might not be the currently accepted scientific understanding.

W 'What we **want** to learn' encourage students to list questions for investigation. Further questions can be added as students develop their understanding.

L 'What we **learned**' is introduced as students develop explanations for their observations. These become documented as 'claims'.

H '**How** we know' or 'How we came to our conclusion' is used in conjunction with the third column and encourages students to record the evidence and reasoning that lead to their new claim, which is a key characteristic of science. This last question requires students to reflect on their investigations and learning, and to justify their claims.

As students reflect on their observations and understandings to complete the third and fourth columns, ideas recorded in the first column should be reconsidered and possibly confirmed, amended or discarded, depending on the investigation findings.

***Earth's place in Space* TWLH chart**

What we **think** we know	What we **want** to learn	What we **learned**	**How** we know
Some think the Sun goes around the Earth. Some think the Earth goes around the Sun.	Does the Sun go around the Earth?	The Earth goes around the Sun.	We made models of how the Sun and Earth move and tested them.

Appendix 5
How to facilitate evidence-based discussions

Introduction

Argumentation is at the heart of what scientists do — they pose questions, make claims, collect evidence, debate with other scientists and compare their ideas with others in the field.

In the primary science classroom, argumentation is about students:

- articulating and communicating their thinking and understanding to others
- sharing information and insights
- presenting their ideas and evidence
- receiving feedback (and giving feedback to others)
- finding flaws in their own and others' reasoning
- reflecting on how their ideas have changed.

It is through articulating, communicating and debating their ideas and arguments that students are able to develop a deep understanding of science content.

Establish norms

Introduce norms before starting a science discussion activity. For example:

- listen when others speak
- ask questions of each other
- criticise ideas not people
- listen to and discuss all ideas before selecting one.

Claim, evidence and reasoning

In science, arguments that make claims are supported by evidence. Sophisticated arguments follow the QCER process:

Q What **question** are you trying to answer? For example, 'Why do we only see Orion at certain times of the year?'

C The **claim**, for example, 'As the Earth moves around the Sun, the apparent position of the constellations changes, which means that sometimes Orion is not visible'.

E The **evidence**, for example, 'We showed in our model that sometimes the Sun is between the Earth and Orion'.

R The **reasoning** — saying how the evidence supports the claim. For example, 'When the Sun is between the Earth and Orion, the stars in Orion would need to be viewed during the daytime. We know from observations that you cannot see the stars during the day, because the Sun's light overpowers the light from the stars because the Sun is so close to the Earth.'

Students need to be encouraged to move from making claims only, to citing evidence to support their claims. Older students develop conclusions that include a claim, evidence and reasoning. This is an important characteristic of the nature of science and an aspect of scientific literacy. Using 'Science question starters' (see next section) helps to promote evidence-based discussion in the classroom.

Science question starters

Science question starters can be used to model the way to discuss a claim and evidence for students. Teachers encourage team members to ask these questions of each other when preparing their claim and evidence. They might also be used by audience members when a team is presenting its results (see *PrimaryConnections 5Es* DVD, Chapter 5).

Science question starters

Question type	Question starter
Asking for evidence	I have a question about _____ . How does your evidence support your claim_____ ? What other evidence do you have to support your claim _____ ?
Agreeing	I agree with _____ because _____.
Disagreeing	I disagree with _____ because _____. One difference between my idea and yours is _____.
Questioning further	I wonder what would happen if _____? I have a question about _____ . I wonder why _____? What caused _____? How would it be different if _____? What do you think will happen if _____?
Clarifying	I'm not sure what you meant there. Could you explain your thinking to me again?

Appendix 6
How to use a glossary

Introduction

A glossary is a list of technical terms that relate to a particular subject matter or topic, generally accompanying a document. Each term is accompanied by a description or explanation of the term within the context of the subject. A glossary entry is generally more descriptive than a dictionary definition.

Creating a class glossary can be used to:

- elicit students' prior understanding of subject-specific terms
- develop a growing bank of descriptions to help students understand and use new words in written and oral tasks
- support students' understanding of scientific descriptions and explanations
- develop the strategy of using word sources as a real-life, valuable investigative research strategy.

Using a class glossary

1. Introduce a term and discuss what it might mean within the context of the unit. Possible strategies include: students connecting the word to a feature or aspect of the topic, and students using the word in a spoken sentence to explain topic, concept or context.
2. Create a shared understanding of the term and record it in the science journal or as part of the word wall.
3. Introduce the conventional technical meaning of the term where appropriate.
4. Encourage students to practise using the terms in the glossary to become familiar with them. Students may wish to amend a description of a word after becoming more familiar with how it is used in a particular context. This may occur when writing, talking or making annotations to diagrams.
5. Integrate the glossary across all curriculum areas where appropriate. For example, in a literacy lesson discuss various meanings of the term.
6. The glossary could be a part of the science journal or the word wall for a particular unit.

   Note: It is important to ask students for 'descriptions' of the terms, rather than 'definitions'. 'Definitions' are often viewed as fixed and unchangeable, whereas 'descriptions' support students to see that ideas can change as their understanding develops.

Appendix 7
Earth's place in space equipment list

EQUIPMENT ITEM	QUANTITIES	Lesson	1	1	2	3	4	5	6	6	7
		Session	1	2					1	2	
Equipment and materials											
100m piece of rope or yarn	1 per class									●	
15cm piece of string	2 per team							●			
A4 paper	3 per class		●								
A4 paper	8 per class									●	
camera (*optional*)	1 per class			●							
cards or paper strips for word wall labels (*optional*)	ongoing		●								
clipboard with pen	1 per team					●					
digital camera with tripod (*optional*)	1 per class				●						
material for making models, such as plasticine, polystyrene balls, table tennis balls, wooden skewers, toothpicks, string, cardboard, foam, wire and split pins	1 per team			●							
measuring tape	1 per class									●	
multimedia resources on Eratosthenes (*optional*)	1 per class		●								
multimedia resources on the movement of the Moon and Sun	1 per class				●						
objects to represent the Solar System eg, basketball, poppy seed, 2 peppercorns, large marble, table tennis ball, 2 peas	1 per class									●	
orreries created in Lesson 1	1 per team						●				
projector or interactive whiteboard (*optional*)	1 per class		●	●	●	●	●	●	●	●	●
scissors	1 per team							●			
softball or baseball	1 per team					●					
tape	1 per team					●		●			
1 torch or lamp	1 per team					●					
world globe or soccer ball with a map of Australia attached	1 per team					●					

EQUIPMENT ITEM	QUANTITIES	Lesson	1	1	2	3	4	5	6	6	7
		Session	1	2					1	2	
Resource sheets											
'But it looks flat' (RS1), enlarged	1 per class		●								
'But it looks flat' (RS1)	1 per student		●								
'Debating our place' (RS2), enlarged	1 per class		●								
'Debating our place' (RS2) (*optional*)	1 per student		●								
'Information note for families' (RS3), enlarged	1 per class			●							
'Information note for families' (RS3)	1 per student			●							
'Revolving role-plays' (RS4), enlarged	1 per class					●					
'Revolving role-plays' (RS4)	1 per team					●					
'Role-play observations' (RS5), enlarged	1 per class					●					
'Role-play observations' (RS5)'	1 per team					●					
'Perplexing planets' (RS6)	1 per student						●				
'Star-crossed story' (RS7), enlarged	1 per class							●			
'Star-crossed story' (RS7)	1 per team							●			
'Solar System information organiser' (RS8), enlarged	1 per class								●		
'Solar System information organiser' (RS8)	6 per team								●		
'Scaled planets' (RS9), enlarged	1 per class									●	
Teaching tools											
class science journal	1 per class		●	●	●	●	●	●	●	●	●
word wall, science chat-board	1 per class		●	●	●	●	●	●	●	●	●
student science journal	1 per student		●	●	●	●	●	●	●	●	●
team roles chart	1 per class			●	●	●	●	●	●		
team skills chart	1 per class			●	●	●	●	●	●		
TWLH chart	1 per class		●	●	●	●	●	●	●	●	●
role wristbands or badges	1 set per team			●	●	●	●	●	●		

Appendix 8
Earth's place in Space unit overview

		LESSON SUMMARY	LESSON OUTCOMES*	ASSESSMENT OPPORTUNITIES
		Students	Students will be able to	
ENGAGE	**Lesson 1** Model arguments	• discuss a historical debate about whether the Earth is flat • identify the way scientists use claims and evidence to test their theories • create a 3D, moving model of the Earth, Sun and Moon • start a glossary of scientific terms to do with Space.	represent their current understandings as they: • identify features of scientific dialogues and debates • discuss different theories about the movements of the Earth, Sun and Moon • contribute to discussions about Earth's place in Space • identify the purpose and features of a science journal and word wall • contribute to the beginning of a TWLH chart • work in teams to create orreries to represent their understanding of the movements of the Earth, Sun and Moon.	**Diagnostic assessment** • Science journal entries • Class discussions • TWLH chart • Orreries
EXPLORE	**Lesson 2** Rising and setting	• present their observation from the home 'sky viewing' task • use observations to describe how space objects move across the sky • relate the apparent movement of the Sun to the notion of a 24 hour day.	• identify the paths of space objects in the sky as seen on Earth • predict what position space objects will be in after an hour and compare observations to predictions • work in collaborative learning teams to represent their observations as flow charts • contribute to discussions about their results and how they relate to their everyday lives.	**Formative assessment** • Science journal entries • Class discussions • TWLH chart • Flow charts

* These outcomes are linked to relevant descriptors of the Australian Curriculum: Science and are provided at the beginning of each lesson.

		LESSON SUMMARY	LESSON OUTCOMES*	ASSESSMENT OPPORTUNITIES
		Students	Students will be able to	
EXPLORE	**Lesson 3** Going in circles	• work in teams to explore different models to explain why the Sun and Moon appear to move across the sky • record, discuss and interpret their findings.	• work in collaborative learning teams to follow a procedural text to generate observations to test different claims • record their observations in a table and compare them to 'real life' observations from Lesson 2 • contribute to discussion about their results and whether the evidence can support different claims • identify the features and purpose of a role-play, as well as its advantages and disadvantages as a model to explain the movement of the Sun, Earth and Moon.	**Formative assessment** • Science journal entries • Class and discussions • TWLH chart • 'Role-play observations' (Resource sheet 5)
EXPLAIN	**Lesson 4** Galvanising Galileo	• review and update their orreries, identifying how they relate to everyday timescales • read and discuss Galileo's story and evidence to support the theory that the Earth orbits the Sun • brainstorm objects that can be found in the Solar System.	• review and update their orreries, identifying observations and evidence that support their point of view • read and discuss a text about Galileo • identify that the Earth orbits the Sun in a year, the Moon orbits the Earth in a month and the Earth rotates on its axis in a day • brainstorm space objects present in the Solar System.	**Formative assessment** • Science journal entries • Class discussions • TWLH chart • Orreries

* These outcomes are linked to relevant descriptors of the Australian Curriculum: Science and are provided at the beginning of each lesson.

		LESSON SUMMARY	LESSON OUTCOMES*	ASSESSMENT OPPORTUNITIES
		Students	Students will be able to	
EXPLAIN	**Lesson 5** Chasing constellations (*Optional*)	• discuss constellations in the sky • read a text about how different constellations are not always visible in the sky • use models to explore how to explain this observation.	• identify different constellations and the nature of stars • read and discuss a factual text about Scorpius and Orion • work in teams to create models to explain the observations of the story • discuss the results of their investigations and how the appearance of constellations at different times of the year supports the model of the Earth orbiting the Sun • discuss how Indigenous Australians recognised constellations and used them for various purposes, including navigation and calendars.	**Formative assessment** • Science journal entries • Class discussions • TWLH chart • Cut-out models from 'Star-crossed story' (Resource sheet 7)
ELABORATE	**Lesson 6** Solar System scientists	• investigate characteristics of objects in the Solar System, in particular their size and distance from the Sun • create a 3D scaled model of the Solar System • discuss the pros and cons of different forms of representation • visualise the Solar System's place in Space.	• research information on objects in the Solar System • compare findings and discuss discrepancies in collected data • interpret data to create scaled models of the Solar System • discuss how different models serve different purposes in science.	**Summative assessment** of Science Inquiry Skills • Science journal entries • Class discussions • TWLH chart • 'Solar System information organiser' (Resource sheet 8)

* These outcomes are linked to relevant descriptors of the Australian Curriculum: Science and are provided at the beginning of each lesson.

		LESSON SUMMARY	LESSON OUTCOMES*	ASSESSMENT OPPORTUNITIES
		Students	Students will be able to	
EVALUATE	**Lesson 7** Sunning it up	• create a dramatic dialogue between two imaginary characters about Earth's place in Space • reflect on their learning during the unit.	• identify that the Earth is part of a Solar System orbiting the Sun while it rotates on its axis • support claims about how to explain everyday observations with evidence in a dramatic dialogue • contribute to discussions and express their opinions about their learning journey.	**Summative assessment** of Science Understanding • Science journal entries • Class discussions • TWLH chart • Multimedia texts

* These outcomes are linked to relevant descriptors of the Australian Curriculum: Science and are provided at the beginning of each lesson.

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Year	Biological sciences	Chemical sciences	Earth and space sciences	Physical sciences
F	*Staying alive*	*What's it made of?*	*Weather in my world*	*On the move*
1	*Schoolyard safari*	*Spot the difference*	*Up, down and all around*	*Look! Listen!*
2	*Watch it grow!*	*All mixed up*	*Water works*	*Push pull*
3	*Feathers, fur or leaves?*	*Melting moments*	*Night and day*	*Heating up*
4	*Plants in action*	*Material world*	*Beneath our feet*	*Smooth moves*
	Friends and foes	*Package it better*		
5	*Desert survivors*	*What's the matter?*	*Earth's place in space*	*Light shows*
6	*Marvellous micro-organisms*	*Change detectives*	*Earthquake explorers*	*It's electrifying*
				Essential energy

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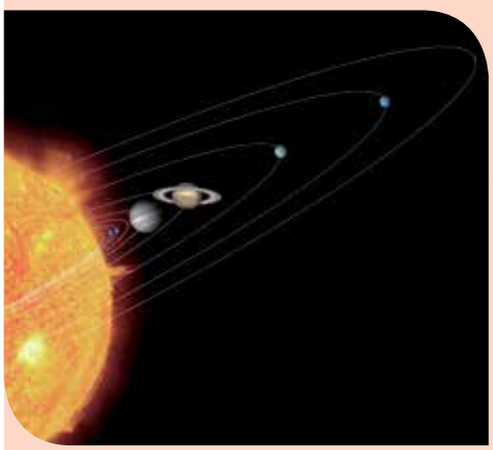

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