Education and Outreach

# Orange CREST AwardOrange CREST Award

## Science Investigation: What causes eclipses? – Teacher Guidance

In this three-part science investigation, students will explore concepts related to **eclipses.** They will generate questions about the occurrence and causes of eclipses. They will consider the **relative positions** of **Moon, Earth and Sun** and the effect that this has on the appearance of the Moon or the Sun. Students will undertake research activities to explore possible answers to their questions. Students will then simulate the occurrence of **eclipses** as viewed from Earth, by physically modelling with balls and a light source, the positions and movements of Earth, Sun and Moon. Finally, students will evaluate their models and suggest improvements.

Carefully scaffolded, this activity will motivate students, and engage them in critical and creative thinking. Working collaboratively with their peers, students will apply their understandings of the relative position and movement of the Sun, Moon and Earth during ecliptic events. Students will also be engaged in evaluating the models and reflecting on their collaboration skills.

### Australian Curriculum Alignment

This investigation presents opportunities for students to develop, practise, and apply understandings, skills, and capabilities from across the Australian Curriculum. A suggested list of Science content descriptions and General Capabilities appears at the end of this document.

### Teacher Background Information

The Moon orbits Earth approximately once per month, and at the same time, Earth orbits the Sun, taking approximately a year to do so. The complex interactions between these three bodies result in several fascinating phenomena, including the **phases of the Moon**, **eclipses**, and **tidal movements** of Earth’s land and water.

**Eclipses** occur when the Sun, Earth, and Moon are aligned. However, the relative sizes of the Moon, Earth and Sun, and the distances between each body, are such that alignment is very fleeting. Moreover, as Earth is spinning, the eclipse is observable only briefly, and only from locations on Earth in the narrow path of the eclipse.

A **solar eclipse** occurs when the New Moon obscures our view of the Sun. It can only be observed during the day, when the Sun is observable in the sky. During a solar eclipse, the daytime sky darkens almost completely as the Moon passes in front of the Sun, then lightens as it passes away again.

A **lunar eclipse** occurs when Earth passes between the Moon and the Sun during a Full Moon. Earth passing in front of the Moon prevents light from the Sun from reaching the Moon, and we observe the Moon darken.

The Moon appears to turn red immediately before and following the full eclipse, as the light from the Sun passes through Earth’s atmosphere, is **refracted** and only the shorter wavelengths of light, which we view as red, strike and are reflected from the surface of the Moon.

Yet, we don’t observe alternating solar and lunar eclipses each month. Why? This is because each orbit occurs on a **plane**. The plane of orbit of the Moon around Earth is not the same as that of Earth around the Sun. In fact, the plane of orbit of the Moon around Earth is **tilted** approximately 5° from the plane of orbit of Earth around the Sun. This tilt is just enough to prevent most eclipses. Eclipses occur only when the two planes of orbit are not tilted relative to each other and the Sun, Moon, and Earth are aligned.

Information about the **phases of the Moon** is presented in the Green CREST Award Science Investigation: How does the Moon’s appearance change? – Teacher Guidance, while information about the **tides** is presented in the Blue CREST Award: Tides – Teacher Guidance.

## Teaching and Learning Activities, Part 1 – Preparing to Investigate

For these activities, you will require:

* A tetherball (a ball on a short length of rope or string)
* A collection of balls of different sizes
* Per group: a lamp, torch or other source of light (a light bulb on a stand with no shade is best)

### Engage and Explore

1. Invite students to share any experiences of eclipses that they’ve had. They might have photos to share or stories to tell. Ask students what they think causes these eclipses. Collate any questions or ideas that arise during the discussion.
2. Show the tetherball to students. Stand in the middle of the classroom and carefully spin it around your head. This is to represent the Moon orbiting the Earth. Try to keep the ball spinning sufficiently fast that the string is perpendicular to the direction of the spin. Invite students to share what they can see from their perspective.
Change the angle of the spin slightly and ask if their perspectives change. Ask if your head or the ball are ever out of their view. Explain that this is what an eclipse is: the obscuring of one body by another, when three are in a line.
Invite students to draw a diagram of their head, your head and the ball when one object is eclipsed, and another diagram of an instance when there is no eclipse. They should do this in their science journals or notebook. You might also invite them to record what they think they know about eclipses, and any questions they have.
3. Invite students work in groups of three to build physical models of eclipses. Show students the equipment they have available.
If necessary, suggest to students that they begin with what they know about the phases of the Moon.
4. Monitor and facilitate the students’ development of their models, using questions to guide students as appropriate. Try not to give away any hints about how to build the model!

### Explain

1. Give students time to record notes and diagrams relating to their model in their science journals or notebooks. Ask them to explain, in some way, their model and how it works.
2. Invite at least two groups of students to present their models to the class. Invite students to compare the two models – what is the same? What is different? What is accurate? What fails to be accurate, and why? Could the model be improved? How? Draw out students’ ideas in the dialogue. Remind students that models can never be perfect – there will always be some aspects of the model that cannot represent reality, for one reason or another. Relative scale – that is, the sizes of, and distance between, astronomical bodies – are particularly challenging to represent in models. Again, invite them to record any ideas and critique in their science journals or notebooks.
3. Ask students to make predictions about when we should observe eclipses, based on their models. It is likely that their models will predict a lunar eclipse each Full Moon, and a solar eclipse each New Moon. However, point out that this is not what we observe; lunar eclipses happen infrequently, and solar eclipses are actually very rare. Why? What are our models missing?

## Teaching and Learning Activities, Part 2 - Investigating

### Elaborate

1. Present the new inquiry question to students: Why do we observe eclipses only infrequently? Ask students to identify variables that had to be considered in their models. These might include:
* The relative sizes of the Moon, Sun and Earth
* The relative distances between the Moon, Sun and Earth
* The changing distances between the Moon, Sun and Earth
* The planes of orbit of the Moon around Earth and Earth around the Sun

Invite students to consider how changing these variables might impact on the frequency with which we observe eclipses. Students might have some ideas to try to explain their predictions regarding these variables. Some ideas may be more scientific than others.

1. Distribute the *Student Guidance*. Clarify your expectations for the activity. Outline the procedure and inform students of any time limits.
2. Give students enough time to undertake the investigation.

|  |
| --- |
| The investigation may stimulate students to ask other questions. Value students’ questions by recording them on post-it notes somewhere visible in the classroom (writing students’ initials or names on the back will help you to determine the authors of the questions later). Questions that can be investigated scientifically may be suitable for students interested in achieving a Blue CREST Award.  |

1. Monitor students’ modelling efforts. Draw their attention to the need to record their observations, notes about their models, any decisions made, or disagreements and how these were resolved, as well as any of their questions, ideas, frustrations, and thoughts about this activity. This will help them to complete an evaluation in the next part of this investigation.

#### Hint!

* Students can use a ball to represent Earth in their model, or they can place themselves in the centre of the model, using their head to represent Earth, and their eyes to make observations of what they see! Each has advantages and disadvantages.

#### Safety considerations:

* Ensure students don’t look directly at the light source for any extended period.
1. In this inquiry, as different groups may be investigating different variables and the effect of these on their model, each group should give a presentation to the rest of the class about their findings. Use the presentations as stimulus to discussion regarding what factors are involved in eclipses. Facilitate the dialogue, guiding students toward an understanding that alignment between the three astronomical bodies occurs only infrequently due to the two planes of orbit being tilted slightly relative to each other.
This dialogue is essential for students’ sense-making about the phenomenon they’re investigating. Students bring many non-scientific conceptions about astronomical phenomena to the classroom, and these can be difficult to challenge and address. Be ready to guide students using questions, keep students on topic, and facilitate turn-taking in the dialogue, but as much as possible, allow students to engage constructively with the dialogue.
2. Facilitate students to explain the findings of the investigation. Explanations may be written, spoken, drawn, dramatically portrayed, animated, filmed, or otherwise creatively presented. The *CREST Snapshot: Constructing explanations* outlines the Claim - Evidence - Reasoning framework, which may be a useful scaffold for students in developing their explanations.

## Teaching and Learning Activities, Part 3 - Evaluating the Investigation

### Evaluate

1. Guide students to complete both written and verbal evaluation of their modelling process and their learning, using the evaluation questions in the Student Guidance. Suggested discussion questions include:
* How accurately did your model represent the occurrence of an eclipse?
* What fails to be accurate, and why?
* Could the model be improved? How?
* How did the model and your observations from it help you to understand eclipses?
* Did you learn anything else about the dynamic system of interactions between the Moon, Earth and Sun from your model and observations?
* What questions do you still have about the Moon?
1. Present each student who has met the *Consolidating* standard in the *Introductory CREST Science Evaluation Rubric* with their Green CREST Award. Please visit CREST Online to provide the details of the Awards, order stickers for the certificates, and download the Green CREST Award Certificate for distribution to students. Consider whether your students are ready to move on to the Blue CREST Award. Encourage students to submit their investigation to your local Science Teachers’ Association Awards.

## Resources for Students

Some useful online resources include:

* Source 1: Pink moon rising (Short article from CSIROscope about fast eclipse with links to some images)
* Source 2: Our favourite images of the super blue blood moon (Article from Cosmos Magazine about the January 31, 2018 Lunar Eclipse)
* Source 3: [What is an eclipse](https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-an-eclipse-58) (An article from the NASA Knows! education series)
* Source 4: An eclipse of the Moon (Animation from ABC Education explaining a lunar eclipse)
* Source 5: Longest lunar eclipse of the 21st century to shine bright red in Australia’s early morning sky (ABC news article about 2018 lunar eclipse with explanation of phenomena)
* Source 6: Total lunar eclipse (NASA blog article explaining eclipses with reference to why they don’t occur each month)
* Source 7: [Missed the eclipse? Here’s where you can catch one](https://www.abc.net.au/news/2017-08-22/total-solar-eclipse-when-where-australia/8813250) (Article from ABC News about future solar eclipses)

## Australian Curriculum Outcomes

### Prior knowledge and skills

* Year 3 Science Understanding Earth and Space ACSSU048: Earth’s rotation on its axis causes regular changes, including night and day
* Year 5 Science Understanding Earth and Space ACSSU078: The Earth is part of a system of planets orbiting around a star (the sun)

### Science Understanding (Year 7)

* Earth and Space ACSSU115: Predictable phenomena on Earth, including seasons and eclipses, are caused by the relative positions of the sun, Earth and the moon

### Science as Human Endeavour (Years 7 & 8)

* Nature and Development of Science ACSHE119/134: Scientific knowledge has changed peoples’ understanding of the world and is refined as new evidence becomes available

### Science Inquiry Skills (Years 7 & 8)

* Questioning and predicting ACSIS124/139: Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge
* Planning and conducting ACSIS125/140: Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed
* Planning and conducting ACSIS126/141: Measure and control variables, select equipment appropriate to the task and collect data with accuracy
* *Processing and analysing data and information ACSIS129/144:* Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate
* *Processing and analysing data and information ACSIS130/145:* Summarise data, from students’ own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence
* *Evaluating* *ACSIS131/146:* Reflect on scientific investigations including evaluating the quality of the data collected, and identifying improvements
* *Evaluating* *ACSIS132/234:* Use scientific knowledge and findings from investigations to evaluate claims based on evidence
* *Communicating ACSIS133/148:* Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate

### General capabilities

* *Critical and Creative Thinking*: In this activity, students will **pose questions** and **organise and process information** about the dynamic system of the Sun, Earth and Moon. They will **apply logic and reasoning** and **evaluate models** against their observations of reality.
* *Personal and Social Capability*: This activity presents an opportunity for students to practice, develop and apply their capabilities to **work independently and show initiative** (as a small group), to **become confident, resilient, and adaptable** in their interactions with others, and to **communicate effectively** and **work collaboratively** as they build and test models of the phases of the Moon and eclipses.
* *Literacy*: During this investigation, students may **comprehend texts**, and **compose texts**, applying their **understanding of scientific vocabulary**, in order to explain their understandings.

## Did you find this resource useful?

We appreciate your feedback. Please email the team at crest@csiro.au to tell us how this resource supported your teaching or your students’ learning, or how it can be improved. Thank you!