Everyday Encounters with Science

Art Matching

Program Type: Demonstration or Classroom Program	*Audience Type:* Grade 4–adult

Description: Students explore how artists from different cultures have used art to represent space-related phenomena.

Topics: Moon, space travel, art, stars, sky-watching

Process Skills Focus: Critical thinking, observing, creativity.

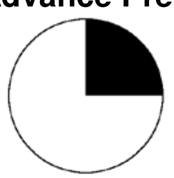
LEARNING OBJECTIVES

For Next Generation Science Standards alignment, see end of outline.

- Many artists are inspired by astronomy and the universe.
- Cultures often have their own interpretations of the sky and celestial phenomena.
- Art is one of many ways to capture our observations of and reflections on the sky.

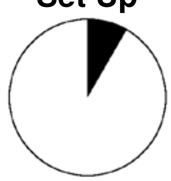
TIME REQUIRED

Advance Prep



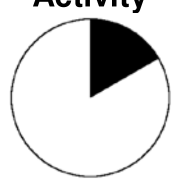
15 minutes

Set Up



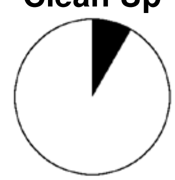
5 minutes

Activity



10 minutes

Clean Up



5 minutes

SITE REQUIREMENTS

- Table or other flat surface
- Chairs (optional, but helpful for elderly or young audiences)

PROGRAM FORMAT

Segment	Format	Time
Introduction	Large group discussion	2 min
Art Matching	Group Activity	5 min
Wrap-Up	Large group discussion	3 min

SUPPLIES

Permanent Supplies	Amount	Notes
Laminated pages showing the artists and their work	5	
Laminated cards showing astronomical images	5	

ADVANCE PREPARATION

- Print out, cut, and laminate the pages showing the artists and their work (at the end of the document).
- Print out, cut, and laminate the five cards showing the astronomical images (at the end of the document).
- Complete the activity to familiarize yourself with the process.

SET UP

Spread out the five pages showing the artists and their work on the table. Below the pages, place the five cards showing the astronomical objects.

INTRODUCTION

2 minutes

Let students speculate before offering answers to any questions. The answers given are provided primarily for the instructor's benefit.

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics*.

Invite participants to explore how art and science are related.

Do you think of yourself as an artist?

How about as a scientist?

Did you know that some artists are inspired by science? And some scientists use art to capture their observations and ideas. The same principles of keen observation and creative thinking are needed for both types of work.

In this activity, we'll be exploring how artists from different cultures portray the sky in their art.

If you were creating artwork about astronomy, what would you make or draw?

GROUP ACTIVITY

Art Matching

5 minutes

Point to the pages showing the artists and their work.

Take a look at these cards. Here are five different artists that have all been inspired in some way by astronomy and the sky.

Point to the cards showing the astronomical images.

And these cards show astronomical images of the night sky. Look closely. Can you figure out which image might have inspired each of the artists? Put the cards together once you think you have a match.

Key:
Margaret Nazon=The Eskimo Nebula
Owusu-Ankomah=Night Sky Watching
Stephanie Smith=Morning Star
Galileo Galilei=The Moon
Alan Bean=Earth from the Moon

WRAP-UP

3 minutes

Ask for student observations. There is no correct answer. Let students guide the discussion and present their hypotheses before discussing explanations.

What helped you match the art and the artist? Was there one of the matchings that was the easiest? Which one was the hardest? Why?

Which piece of artwork interested you the most?

How do think the artist brought their own experience and culture into their artwork?

What observations about the sky do you think each artist incorporated into his or her art?

CLEAN UP

- Collect and put away the laminated pages and cards

RESOURCES

https://iaaa.org
International Association of Astronomical Artists website of "space art."

GLOSSARY

Apollo 11	NASA spaceflight that safely landed the first two humans on the Moon in July 1969.
Apollo 12	NASA spaceflight that again safely landed two humans on the Moon in November 1969.
Lunar Module	Spacecraft to carry astronauts orbiting around the Moon to the lunar surface.
Moon phases	Names for the apparent changes in the Moon's shape over the course of one month (e.g., "full Moon," "new Moon").

Planetary nebula	An expanding shell of gas and dust surrounding a star at the end of its life.

NEXT GENERATION SCIENCE STANDARDS

Practices
1. Asking questions and defining problems
2. Developing and using models

Crosscutting Concepts
1. Patterns

DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
	Physical Science								
PS1	Matter and Its Interaction	n/a	n/a		n/a	n/a			
PS2	Motion and Stability: Forces and Interactions		n/a	n/a		n/a			
PS3	Energy		n/a	n/a	n/a				
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	n/a		n/a		
	Life Science								
LS1	From molecules to organisms: Structures and processes			n/a					
LS2	Ecosystems: Interactions, Energy, and Dynamics	n/a	n/a			n/a			
LS3	Heredity: Inheritance and Variation of Traits	n/a		n/a		n/a	n/a		
LS4	Biological Evolution: Unity and Diversity	n/a	n/a			n/a	n/a		
	Earth & Space Science								
ESS1	Earth's Place in the Universe	n/a	✔		n/a				
ESS2	Earth's Systems		n/a						
ESS3	Earth and Human Activity		n/a	n/a					
	Engineering, Technology, and Applications of Science								
ETS1	Engineering Design								

Thank you to NASA for making the *Lenses on the Sky* project possible!

The material contained in this activity is based upon work supported by the National Aeronautics and Space Administration (NASA) under grant award Number NNX15AB03G. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NASA.

Margaret Nazon

She creates fabric art pieces of nebulae, galaxies, supernovae, and planets based on *Hubble Space Telescope* images.

Tsiigehtchic
Northwest Territories, Canada

OMSI™
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Margaret Nazon

Margaret crea piezas de arte con cuentas en tela de nébulas, galaxias, supernovas y planetas, basándose en imágenes del telescopio espacial Hubble.

Tsiigehtchic
Territorios noroestes, Canadá

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Owusu-Ankomah

His paintings include traditional adinkra symbols from Ghana, Africa and icons from his own imagination. The images illustrate humanity's connection to the cosmos and the night sky.

Sekondi, Ghana

OMSI
Everyday Encounters with Science

Owusu-Ankomah

Sus pinturas incluyen símbolos tradicionales adinkra de Ghana, África, e íconos de su propia imaginación. Las imágenes muestran la conexión de la humanidad al cosmos y al cielo nocturno.

Sekondi, Ghana

OMSI
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Stephanie Smith

Her bead work reflects a common theme in Sioux designs, the Morning star and the gift of a new day.

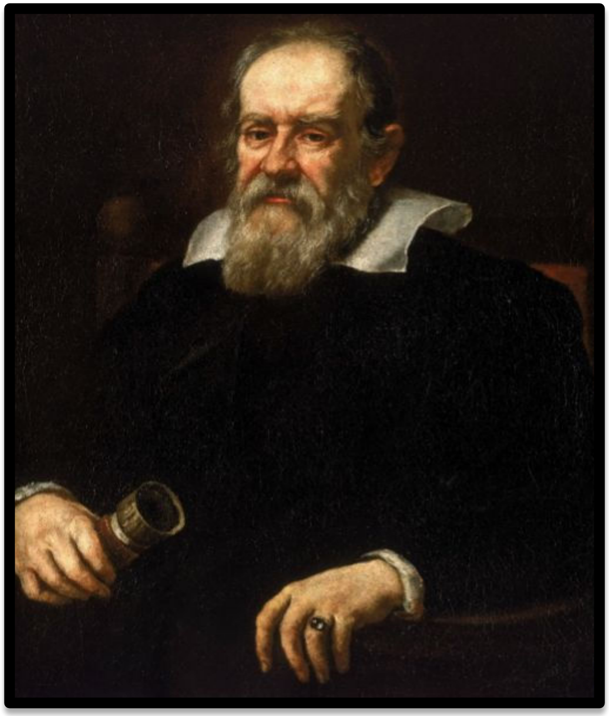
Hunkpapa Lakota
Standing Rock Sioux
North and South Dakota, USA

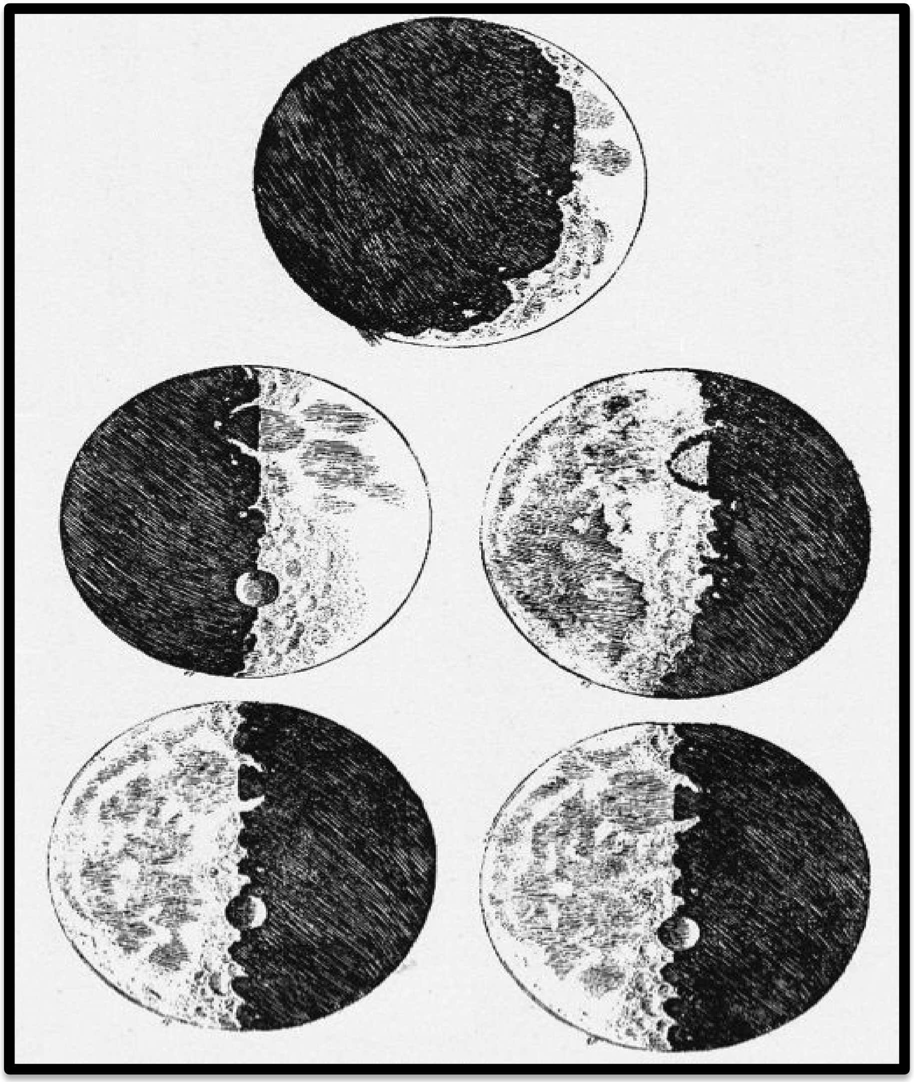
Everyday Encounters with Science

Stephanie Smith

Su trabajo de cuentas refleja una temática común en diseños Sioux: el lucero del alba y el regalo de un nuevo día.

Hunkpapa Lakota
Standing Rock Sioux
Dakota del Norte y Dakota del Sur, EE.UU.

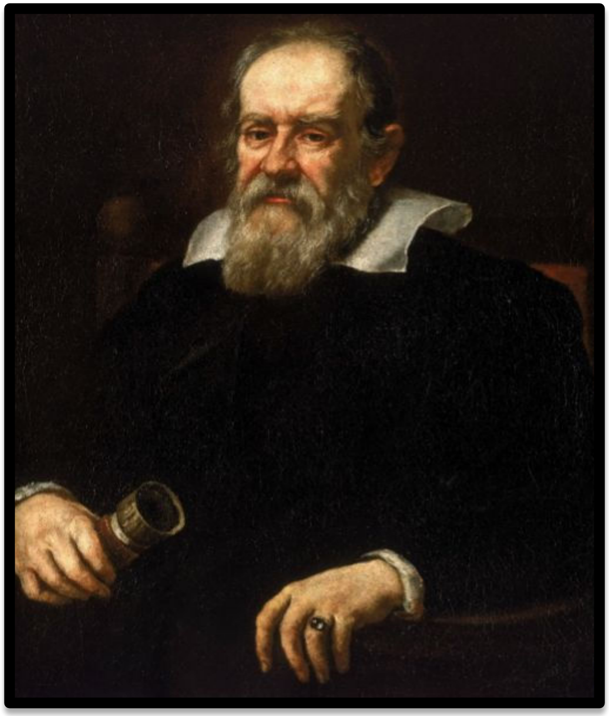




Galileo Galilei

He was the first person to use a telescope to make observations and sketches of the Moon and other objects.

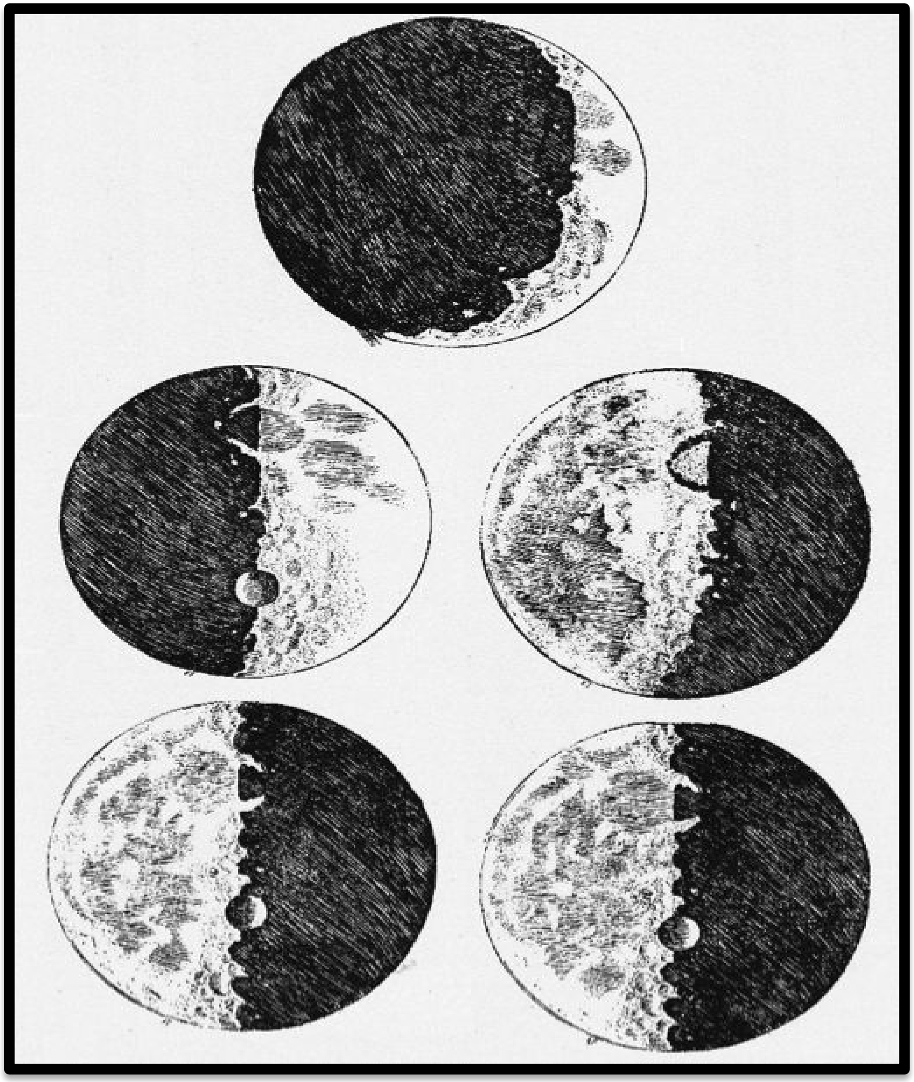
Pisa, Italy



Galileo Galilei

Fue la primera persona en usar un telescopio para hacer observaciones y bosquejos de la luna y otros objetos.

Pisa, Italia



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Everyday Encounters with Science

Alan Bean

He was an Apollo 12 astronaut. After retiring, he created acrylic paintings, sprinkled with Moon dust, on aircraft plywood showing his unique view from the surface of the Moon.

Texas, USA

OMSI
Everyday Encounters with Science

Alan Bean

Alan fue un astronauta de Apolo 12. Después de jubilar, creó pinturas acrílicas salpicadas con polvo lunar en madera de la aeronave. Aquellas pinturas mostraban su singular vista desde la superficie de la Luna.

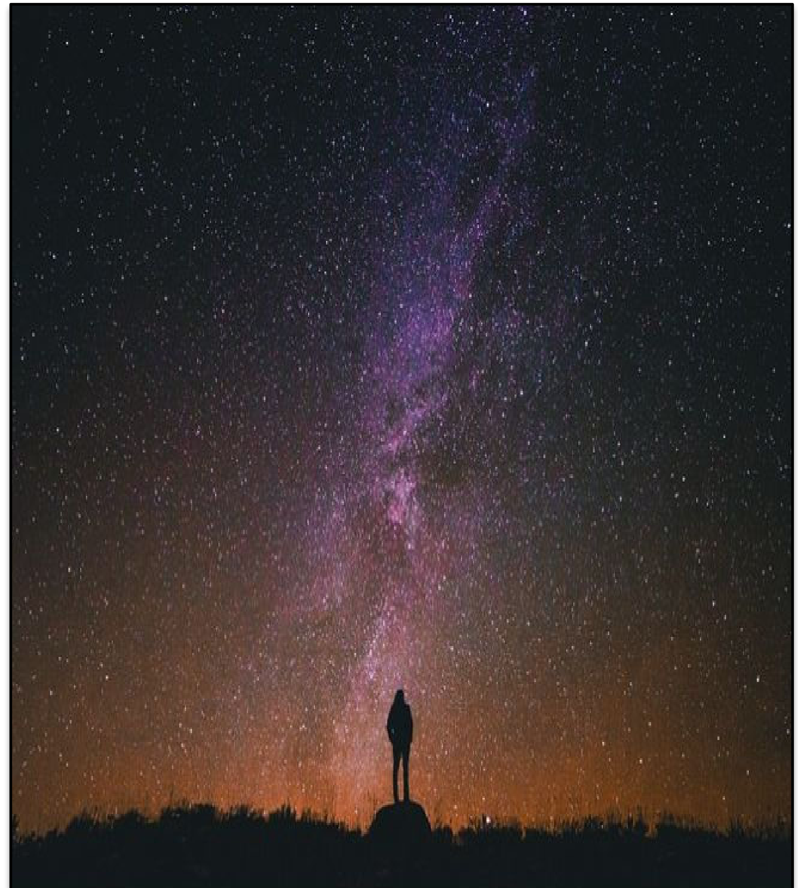
Texas, EE.UU.

OMSI
Everyday Encounters with Science

The Eskimo Nebula

This planetary nebula—an expanding shell of gas and dust—is 2,870 light-years away and visible in the constellation of Gemini.

Night Sky Watching

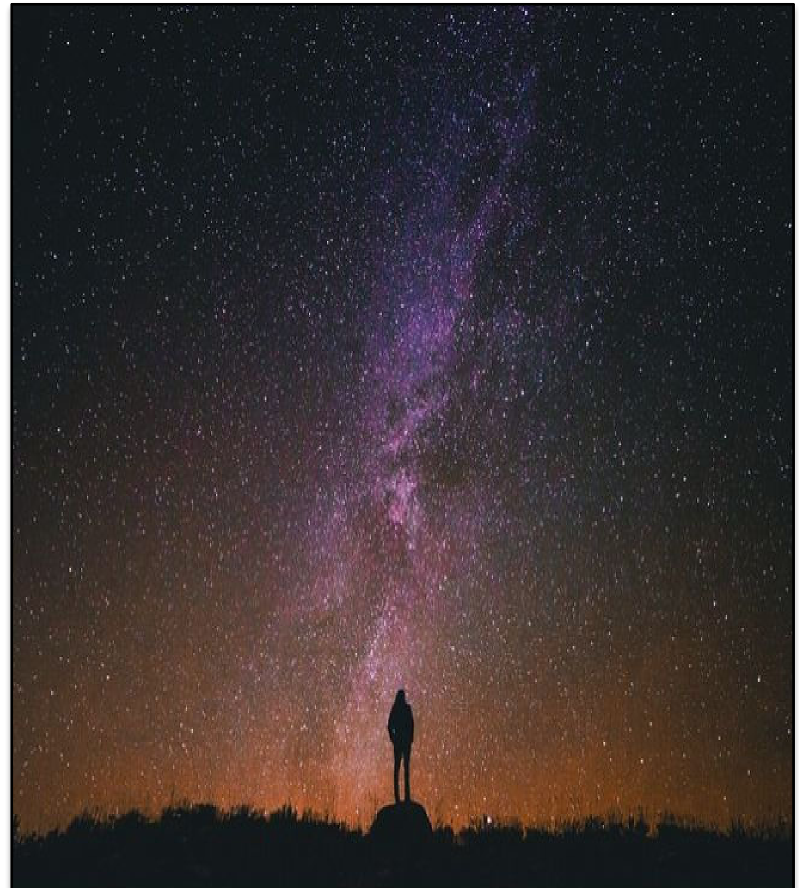


Even without a telescope, we can use our eyes to make observations of the night sky.

La nebulosa esquimal

Esta nébula planetaria (una capa en expansión de gas y polvo) está a 2.870 años luz, y es visible en la constelación de Géminis.

Observación del cielo nocturno



Incluso sin un telescopio, podemos usar nuestros ojos para hacer observaciones del cielo nocturno.

Morning Star

The planet Venus is known as the Morning Star when it appears in the east just before sunrise.

The Moon

The Moon is our closest neighbor in space. It goes through phases. At times, it looks bright all over. Other times, only a crescent of light is visible.

El lucero del alba

El planeta Venus es conocido como el lucero del alba cuando aparece en el este justo antes del amanecer.

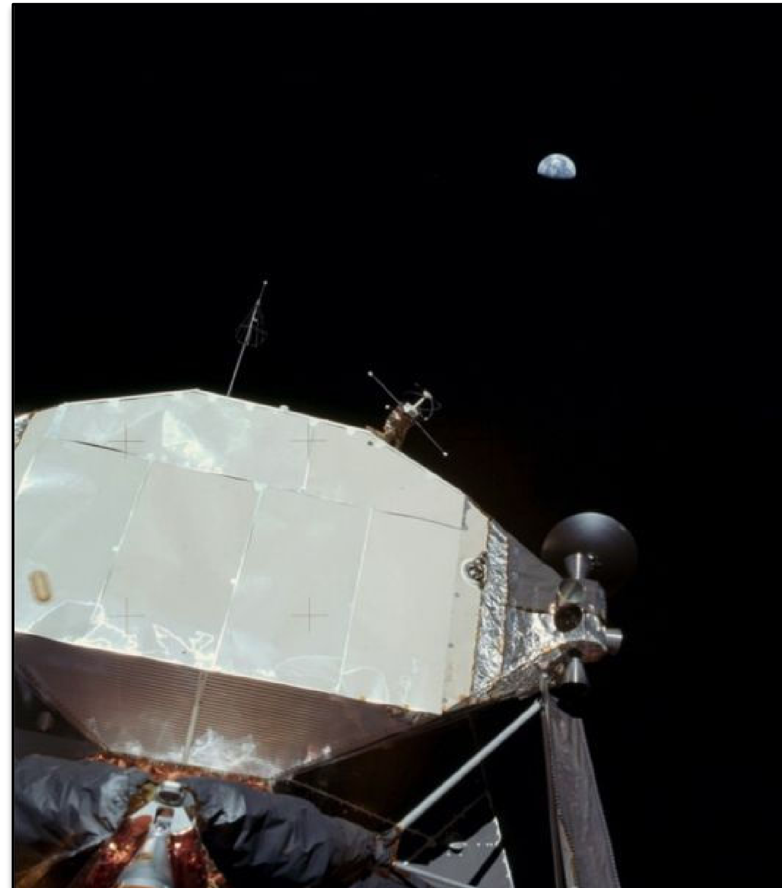
La Luna

La Luna es nuestra vecina más cercana en el espacio. La Luna tiene diferentes fases: algunas veces resplandece entera, pero otras veces sólo se ve un crescente de luz.

Earth from the Moon

This NASA image, taken from the surface of the Moon, captures the Apollo 11 Lunar Module in the front and Earth shining above.

La Tierra desde la Luna



Esta imagen de NASA, tomada desde la superficie de la Luna, muestra el módulo lunar Apolo 11 con el planeta Tierra brillando por encima.

Constellation Puzzle

Program Type: Demonstration or Classroom Program	**Audience Type:** Grade 1–5

Description: Students learn how people have used star patterns to map the sky by completing a constellation puzzle and learning stories from different cultures.

Topics: Stars, constellations, patterns, culture, Earth's place in the universe

Process Skills Focus: Critical thinking, predicting, observing, using models, communicating ideas.

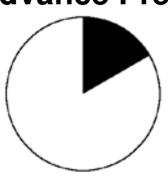
LEARNING OBJECTIVES

For Next Generation Science Standards alignment, see end of outline.

- Constellations are groups of stars that form an image or represent a story.
- Skywatchers map the sky using constellations and stories.
- Different cultures view the sky differently and tell unique stories.

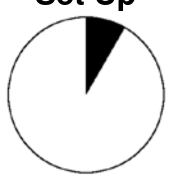
TIME REQUIRED

Advance Prep



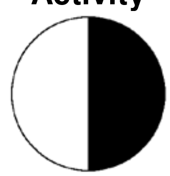
10 minutes
Add 30 min if need to cut puzzle pieces

Set Up



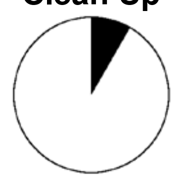
5 minutes

Activity



30 minutes

Clean Up



5 minutes

SITE REQUIREMENTS

- Standard size classroom
- Desks or tables

PROGRAM FORMAT

Segment	Format	Time
Introduction	Large group discussion	5 min
Constellation Puzzle	Small group activity	15 min
Wrap-Up	Large group discussion	5 min

SUPPLIES

Permanent Supplies	Amount	Notes
Scissors	1/student	
Projector (optional)	1	
Screen (optional)	1	
Document camera (optional)	1	

Major Consumables	Amount	Notes
Story handouts (Maya, Greek, and Navajo sheets)	1 set/group	At the end of the document
Puzzle cutouts	1/group	At the end of the document, print on cardstock
Story image overlays	1 set	At the end of the document, print on plastic sheets

ADVANCE PREPARATION

- Print one puzzle and story sheet for each group.
- If children are too small to cut pieces out accurately, cut out the puzzle pieces ahead of time.

SET UP

- Place materials in a convenient location for students to collect during the activity.
- Prepare the document camera and projector.

INTRODUCTION

5 minutes

Let students speculate before offering answers to any questions. The answers given are provided primarily for the instructor's benefit.

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics*

Today, we are going to talk about stars and constellations. **What is a constellation?** *A grouping of stars that some cultures believe forms a shape or image.*

A constellation is a group of stars in the night sky that looks like a shape or is connected to a story. It also refers to the region of the sky that contains these stars.

Have you ever seen a constellation? Can you name a few constellations? *Leo the Lion, Cassiopeia the Queen, Orion the Hunter, Taurus the Bull…*

Does anyone know what constellations are used for? *To map the sky, to tell apart the seasons or times of year, to indicate a special event such as a ceremony or time to plant or harvest, to tell stories, to see pictures in the sky, and for navigation (tell direction).*

The constellations that most of us are familiar with are the ones that scientists use today. These constellations are based on ancient Greek stories, but other cultures have different constellations with their own stories. For example, one culture may see a set of stars as a hunter, while another culture sees the same stars as a turtle carrying the world on its back.

SMALL GROUP ACTIVITY

Constellation Puzzle

30 minutes

This puzzle includes the most visible constellations around the North Star. These are just a few of the 88 official constellations recognized by International Astronomical Union (IAU)—an organization of space scientists from around the world. Astronomers use constellations to make a map of the stars and name different sections of the sky.

Many cultures use constellations to create maps of the sky and track the stars throughout the year. The constellations often have stories attached to them. Sometimes, the stories of more than one constellation are connected and help us remember how the constellations fit together like a puzzle.

So, what better way to learn about which stars go where than to actually make the sky into a puzzle of constellations?

Give each group of 2–3 students a set of the constellation puzzle pieces printed on cardstock and scissors. [If kids are too young to cut them out on their own, do this step ahead of time. It can be time consuming, so it is a great activity for older students.]

Do you recognize any of these constellations?
The names used by scientists are on the back. Most of these names are the same as the Ancient Greek names.

Cut out the pieces and see if you can put your puzzle together.

Students cut out the pieces along the lines.

Students mix up the pieces and then put the puzzle together.

Once most or all of the groups have completed the puzzle, show the students the completed puzzle in front of the room with a document camera and projector. If you do not have a document camera, you can gather around one group's table and look at their puzzle.

Place the relevant cultural image overlay on top of the puzzle while sharing the stories below.

Want to learn some of the stories in the stars?

Let's start with one of the Greek stories that inspired the scientific names.

Greek Story: **Andromeda** (an-drom-e-da) was a princess and the daughter of King **Cepheus** (see-fee-us) and Queen **Cassiopeia** (cas-ee-o-pee-ah) in Northern Africa. Cassiopeia bragged that Andromeda was more beautiful than the sea nymphs, relatives of Poseidon and the other sea gods. Insulted, Poseidon sent a sea monster to terrorize the kingdom. To stop the monster, Andromeda's parents would have to sacrifice their daughter. So, Andromeda was tied to a rock on the shore. As she waited for the monster, the hero Perseus flew by on his winged horse, Pegasus. He fell in love with Andromeda, and rescued her. That is why the constellations of Cepheus, Cassiopeia, Andromeda, and Pegasus are all next to each other.

But other cultures have stories and constellations that are different than the Greek stories. Let's learn about a constellation from a Native American tradition.

Diné/Navajo Story: Navajo people, who call themselves Diné, are originally from Northern Arizona, Utah, Colorado, and New Mexico. For the Diné, the area around the North Star is one constellation with three parts. The **Female Revolving One** (the IAU constellation called Cassiopeia) is considered to be a mother, or grandmother, who shows strength, motherhood, and regeneration. She reflects stability and peace and also provides food and nutrition for her family. The **Male Revolving One** (the Big Dipper part of the IAU constellation Ursa Major) is considered to be a warrior, leader, and father (sometimes grandfather). He provides for and protects his family and community. The **Central Fire** (the North Star or Polaris) connects these two. Like the fire in a traditional Navajo home (hogan), the North Star acts as the center of the sky that other stars move around. The central fire adds stability, security, peace, warmth, and light. This constellation helps people navigate (by locating the North Star) and track time as the Male and Female Revolving Ones rotate around their fire during the year.

The Maya peoples of Mexico and Central America have been keen observers of the sky for centuries. As part of their observations, they track the movements of the Milky Way, the dense band of stars that crosses the sky.

Maya Story: Maya people associate the Milky Way with several things, many of which focus on how the Milky Way connects the worlds of Earth and Sky. In particular, the Milky Way is often seen as the World Tree—a tree that has its roots in the underworld, its trunk in the middle world, and its branches in the highest layer of the sky. The symbol of a World Tree looks a bit like a cross or lower-case “t.”

The association between the World Tree and the Milky Way comes from several cultural and astronomical connections. First, the Milky Way touches the horizon—where earth and sky meet—crosses the sky and then reaches the horizon in the opposite direction. Second, closer to the equator, where Maya people traditionally live, the Milky Way connects with the Southern Cross. (The Southern Cross is not visible in Oregon but is located below the horizon past Orion and Canis Major). The cross is also a symbol for the connection between worlds and the World Tree. Third, the Milky Way cuts across the sky in different places at different times of the year. When you compare the Milky Way’s path at the same time of the night at the equinoxes (March and September) and the solstices (June and December), the paths make a cross, reinforcing the symbolism of the World Tree.

Give one story sheet to each group of students.

Have students put the puzzle together again, this time thinking about how certain constellations go together in the stories.

Inquire about how the students felt using the stories to build a picture of the sky.

Was it easier to put together the puzzle with the stories?

Will you be able to use these stories to remember the constellations and which ones are close to one another?

WRAP-UP

5 minutes

Ask for student observations. There is no correct answer. Let students guide the discussion and present their hypotheses before discussing explanations.

Now that you've learned more about the night sky, why do you think that people from lots of cultures, including scientists, use constellations?
Constellations help map the sky by relating one constellation to another through a story. Constellations help us find stars and other things that we are looking for. Constellations help us track how the sky changes or rotates throughout the day and year.

What did you learn about the sky that you didn't know before and you thought was interesting?

What do you want to learn more about?

Where can you go to look at the stars? How many constellations do you think you can find? Do you have someone you can ask about constellations or star stories?

CLEAN UP

- Clean up paper scraps and return materials.

OPTIONAL EXTENSIONS

- Have students research other constellation stories from diverse cultures. Ask them to illustrate a story and share it with the class.
- Coordinate a Star Party or participate in one hosted by a local astronomy group or science center. Portland area residents can check out the Rose City Astronomers website (http://www.rosecityastronomers.net/) under the "Observing" pull-down menu.
- Have students research what the sky looked like on a specific day in history or on the day they were born.

BACKGROUND INFORMATION

Stars appear to rotate around the North Celestial Pole—an imaginary point in the sky where the Earth's axis of rotation is pointed. Polaris—the North Star and the end of the handle of the Little Dipper—is very close to the pole. This means that it appears to stay still as the other stars rotate around it. Consequently, Polaris is always in the northern sky. The constellations closest to Polaris are visible (above the horizon) throughout the entire year at this latitude (Oregon is in the range of 42–46 degrees north). Major constellations that are always visible include Ursa Major (which includes the Big Dipper), Ursa Minor (which includes the Little Dipper), Cassiopeia, Cepheus, and Draco. Other constellations are visible for only a few months every year.

The Big and Little Dippers are not actually officially constellations. They are **part** of two constellations known as Ursa Major and Ursa Minor, respectively. There are 88 official constellations recognized by the International Astronomical Union. In this activity, we have only included 19 of the most recognizable constellations visible around 45 degrees north.

RESOURCES

Greek constellation stories
http://www.comfychair.org/~cmbell/myth/myth.html

International Astronomical Union constellation information
http://www.iau.org/public/themes/constellations/

Make your own star wheel (planisphere)
www.lawrencehallofscience.org/sites/default/files/pdfs/starwheels/NorthStarwheel.pdf

Spanish version of a star wheel
https://docs.google.com/file/d/0Bx6nTKcFyOzBaTM2empZcW9EU0k/edit

Video on how to use a star wheel
www.youtube.com/watch?v=RzzxsoCql2k

An interactive sky map for exploring the stars and planets by Neave Planetarium
http://neave.com/planetarium/

A website and widget that creates a sky map for specific times, dates, and places.
http://www.wolframalpha.com/widgets/view.jsp?id=dbb4e34a68c5b97c287c953d74fe1d5e

Books:
Follow the Drinking Gourd by Jeanette Winter—A story about how African Americans escaping slavery used the stars to find their way.

Sharing the Skies: Navajo Astronomy–A Cross-Cultural View by Drs. Nancy Maryboy and David Begay—A beautifully illustrated book sharing both Navajo and Greek constellation stories.

Sq' Baa Hane' Story of the Stars: Educational Activities Weaving NASA Science and Navajo Knowledge
https://astrobiology.nasa.gov/uploads/filer_public/d7/fd/d7fdeb5d-549c-4248-b219-02e3e125b56e/storystars-2.pdf —A set of lesson plans for teachers aimed at inspiring people to learn about space science and Navajo traditional knowledge about the stars.

Tales of the Shimmering Sky: Ten Global Folktales with Activities retold by Susan Milord—Lovely stories and activities about the sky.

The Power of the Stars: How Celestial Observations have Shaped Civilization by Bryan Penprase —Concise explanation of constellation lore from around the world, organized by cultures.

The Stars by H. A. Rey—A beautifully illustrated guide to observing constellations by the author of the original Curious George books.

GLOSSARY

Constellation	A traditional or recognizable group of stars in the night sky, or the region of the sky containing them.
North Star (Polaris)	A star in the constellation of Ursa Minor that's just about perfectly above the Earth's North Pole. This star appears to move very little as the Earth turns.
Star	A hot sphere of plasma (hot, dense gas) held together by its own gravity. It is so hot that it produces light.

NEXT GENERATION SCIENCE STANDARDS

Practices
1. Asking questions and defining problems
2. Developing and using models

Crosscutting Concepts
1. Patterns
4. Systems and system models
6. Structure and function

DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
	Physical Science								
PS1	Matter and Its Interaction	n/a	n/a		n/a	n/a			
PS2	Motion and Stability: Forces and Interactions		n/a	n/a		n/a			
PS3	Energy		n/a	n/a	n/a				
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	n/a		n/a		
	Life Science								
LS1	From molecules to organisms: Structures and processes			n/a					
LS2	Ecosystems: Interactions, Energy, and Dynamics	n/a	n/a			n/a			
LS3	Heredity: Inheritance and Variation of Traits	n/a		n/a		n/a	n/a		
LS4	Biological Evolution: Unity and Diversity	n/a	n/a			n/a	n/a		
	Earth & Space Science								
ESS1	Earth's Place in the Universe	n/a	✓		n/a		✓		
ESS2	Earth's Systems		n/a						
ESS3	Earth and Human Activity		n/a	n/a					
	Engineering, Technology, and Applications of Science								
ETS1	Engineering Design								

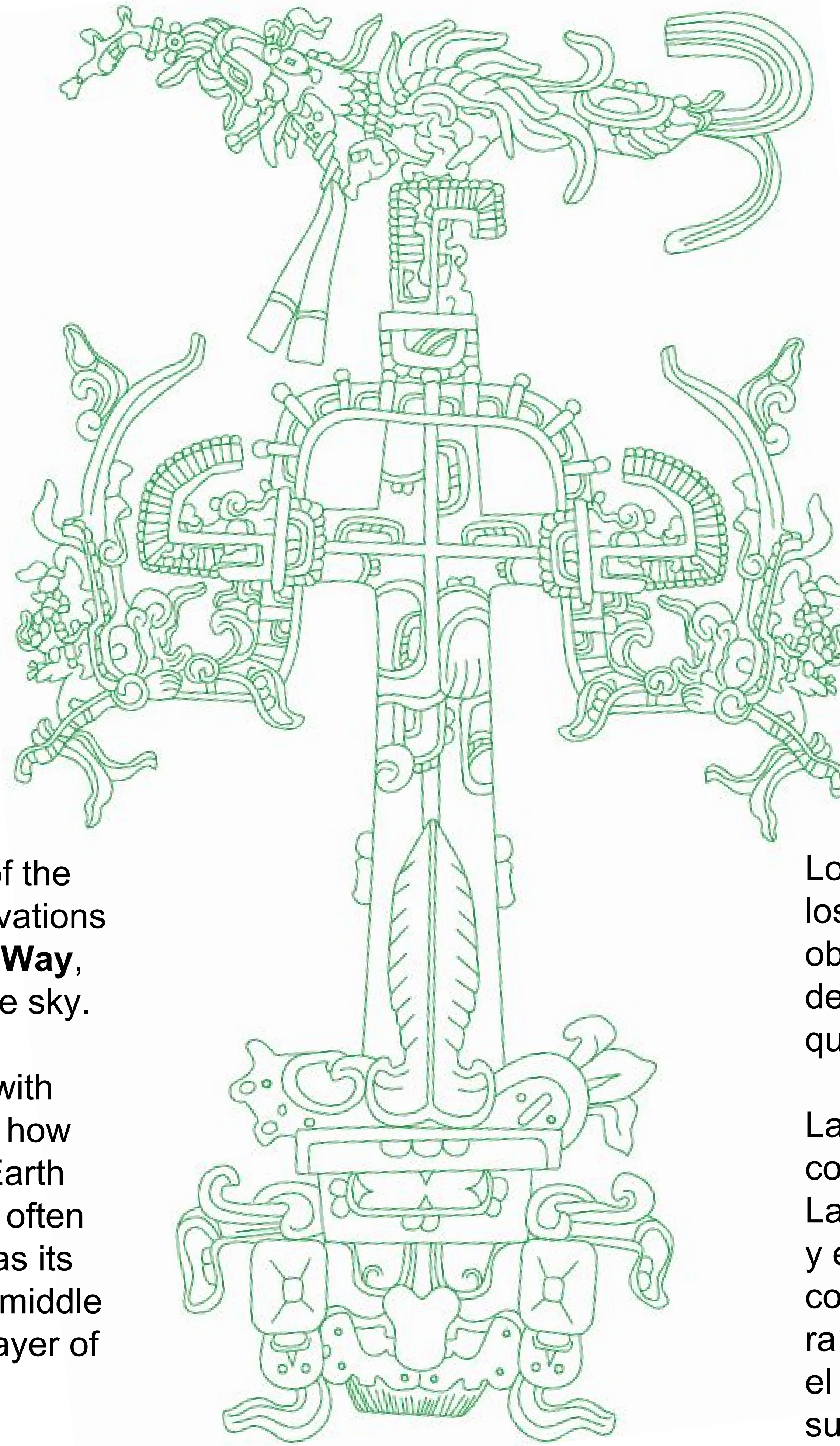
Thank you to NASA for making the *Lenses on the Sky* project possible!

The material contained in this activity is based upon work supported by the National Aeronautics and Space Administration (NASA) under grant award Number NNX15AB03G. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NASA.

Thank you also to the Indigenous Education Institute for allowing us to use images from their book Sharing the Skies: Navajo Astronomy–A Cross-Cultural View *by Drs. Nancy Maryboy and David Begay as the inspiration for the Diné constellation illustrations.*

Maya

Maya



The Maya have been keen observers of the sky for centuries. As part of their observations they track the movements of the **Milky Way**, the dense band of stars that crosses the sky.

Maya people associate the Milky Way with several things, many of which focus on how the Milky Way connects the worlds of Earth and Sky. In particular, the Milky Way is often seen as the **World Tree**—a tree that has its roots in the underworld, its trunk in the middle world, and its branches in the highest layer of the sky.

Los mayas han sido grandes observadores de los cielos durante siglos. Como parte de sus observaciones, han seguido los movimientos de **La Vía Láctea**, la densa franja de estrellas que cruza el cielo.

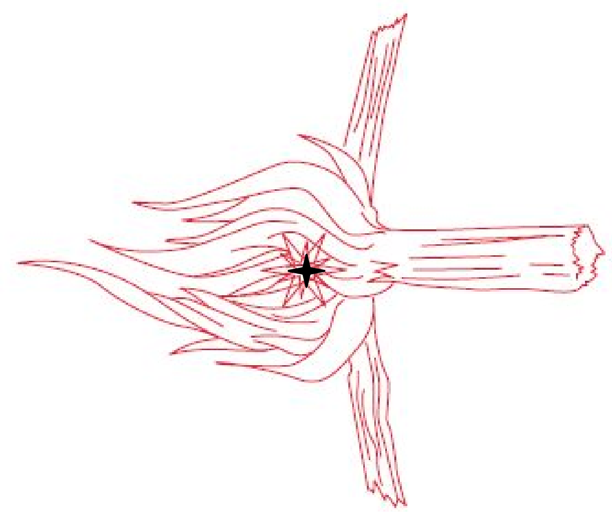
La gente maya asocia La Vía Láctea con varias cosas, y muchas de ellas se enfocan en cómo La Vía Láctea conecta los mundos de la Tierra y el Cielo. La Vía Láctea es vista en particular como el **Árbol Mundial**, un árbol que tiene sus raíces en el mundo subterráneo, su tronco en el mundo medio, y sus ramas en la capa superior del cielo.

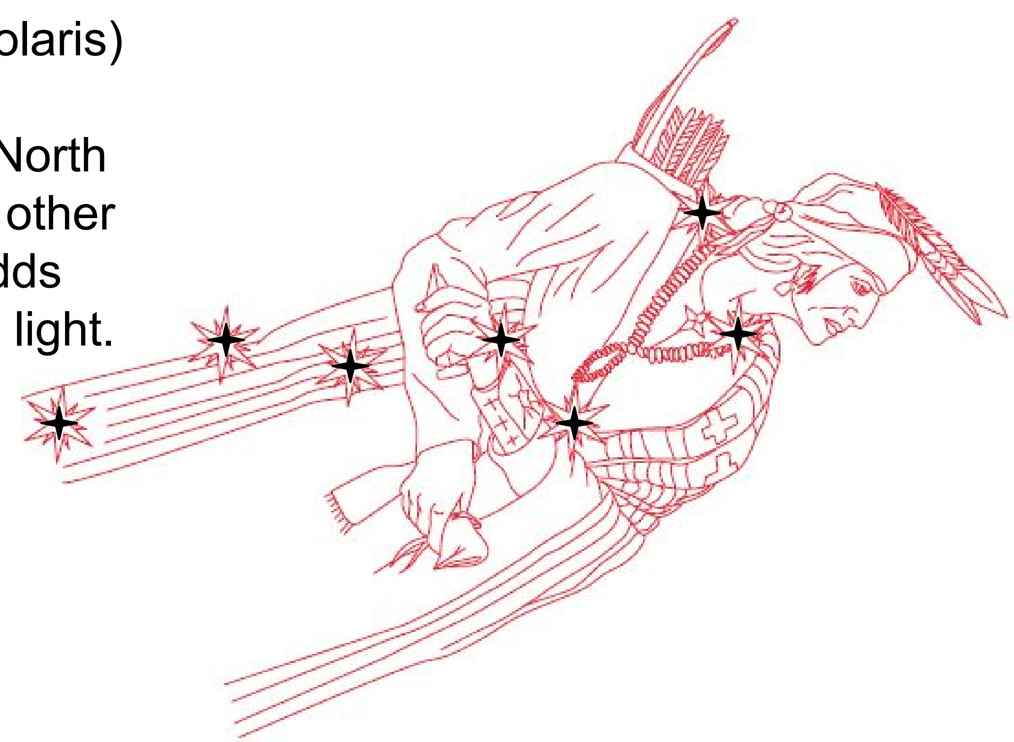
Navajo

For Navajo (Diné) people, the area around the North Star is one constellation with three parts. The **Female Revolving One** (called Cassiopeia by the International Astronomical Union) is considered to be a mother, or grandmother, who shows strength, motherhood, and regeneration.

The **Male Revolving One** (the Big Dipper) is considered to be a warrior, leader, and father (or grandfather). He provides for and protects his family and community.

The **Central Fire** (the North Star or Polaris) connects these two. Like the fire in a traditional Navajo home (hogan), the North Star acts as the center of the sky that other stars move around. The central fire adds stability, security, peace, warmth, and light.





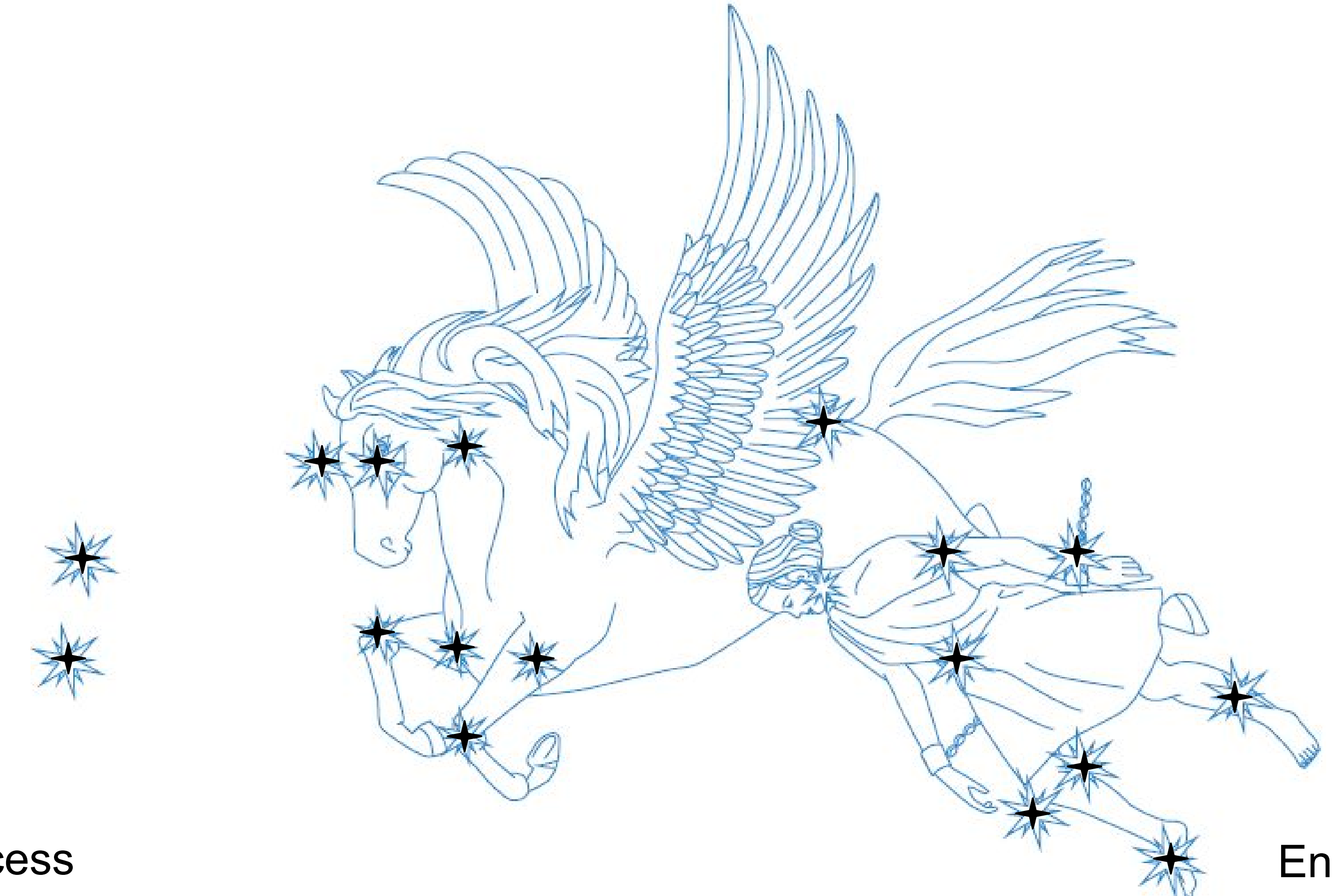
Navajo

Para el pueblo Navajo (Diné), el área alrededor de la Estrella del Norte es una constelación de tres partes. **La Parte Rotatoria Femenina** (conosida como Cassiopeia por la Unión Astronómica Internacional) es considerada una madre o abuela que muestra fortaleza, maternidad y regeneración.

A **la Parte Rotatoria Masculina** (la Osa Mayor) se le considera un guerrero, un líder y un padre o abuelo. Ampara y protege a su familia y comunidad.

El Fuego Central (Polaris, o la Estrella del Norte) conecta a ambos. Tal como el fuego en un hogar navajo tradicional (hogan), la Estrella del Norte actúa como el centro del cielo alrededor del cual giran las otras estrellas. El fuego central añade estabilidad, seguridad, paz, calor y luz.

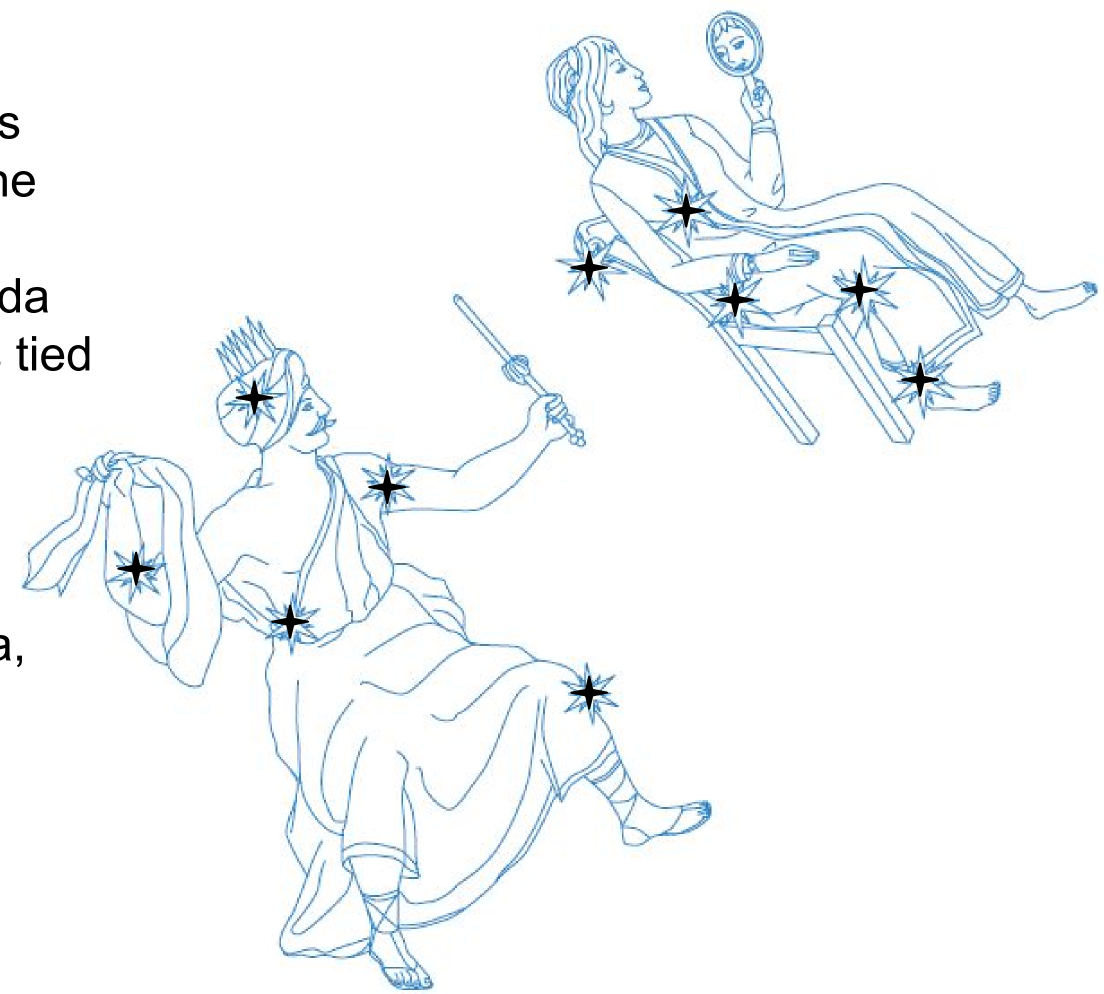
Greek



In ancient Greek stories, princess **Andromeda** was the daughter of King **Cepheus** and Queen **Cassiopeia**.

Cassiopeia bragged that Andromeda was more beautiful than the gods. Insulted, the gods sent a sea monster to terrorize the kingdom. To stop the monster, Andromeda had to be sacrificed. So Andromeda was tied to a rock on the shore.

As she waited for the monster, the hero Perseus flew by on his winged horse, **Pegasus**. He fell in love with Andromeda, and rescued her.

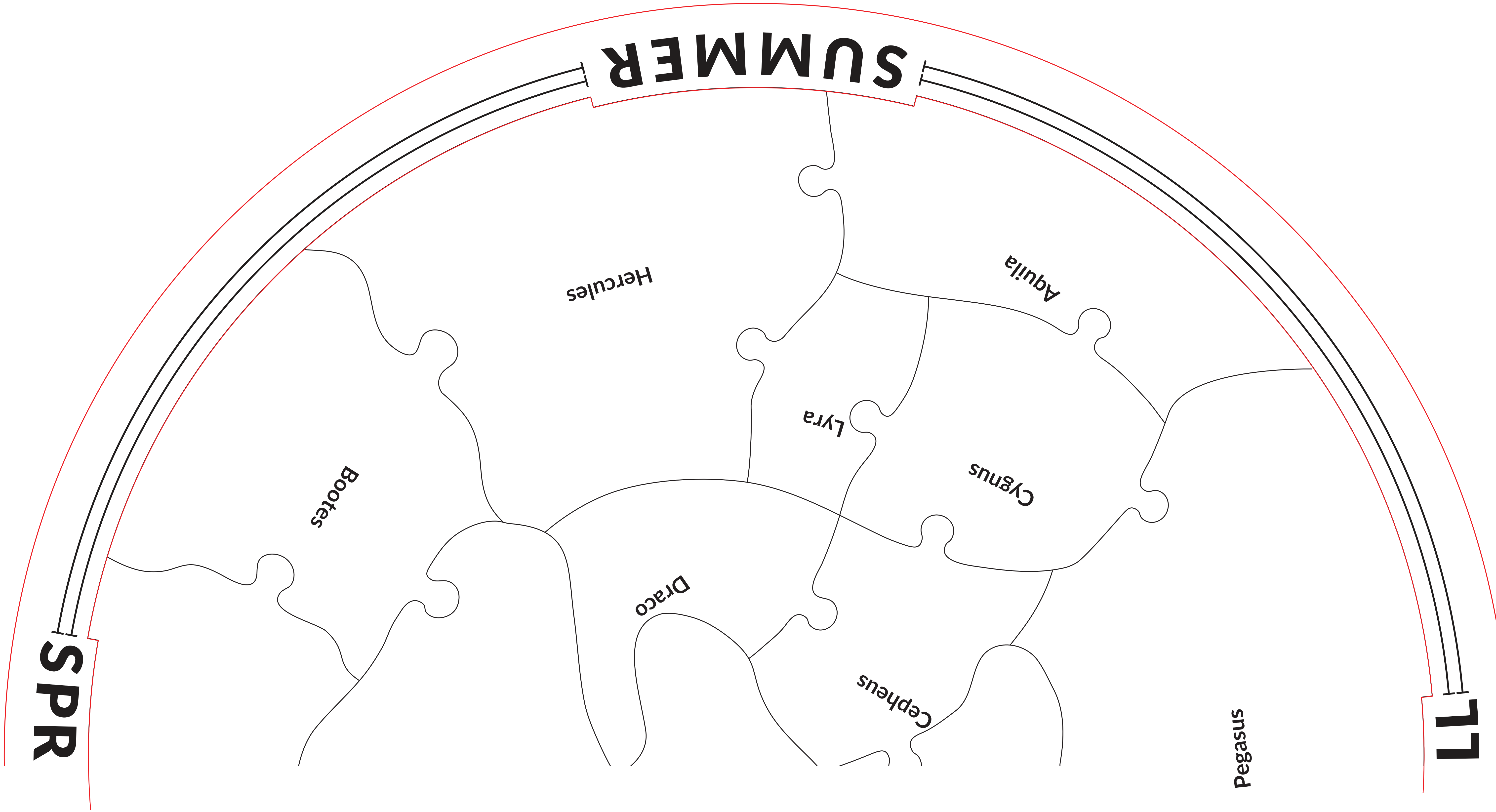


Griego

En la antigua Grecia, la princesa **Andrómeda** era la hija del Rey **Cepheus** y de la Reina **Cassiopeia**.

Cassiopeia presumía que Andrómeda era más bella que los dioses. Los dioses se ofendieron y enviaron un monstruo de agua para aterrorizar al reino. La única forma de detener al monstruo era sacrificar a Andrómeda, por lo que fue atada a una roca a la orilla del mar.

Mientras Andrómeda esperaba al monstruo, el héroe Perseus pasó volando en su caballo con alas, **Pegasus**. Se enamoró de Andrómeda y la rescató.


SUMMER
SPR
LL
Hercules
Aquila
Lyra
Cygnus
Bootes
Draco
Cepheus
Pegasus


ING
FA
WINTER
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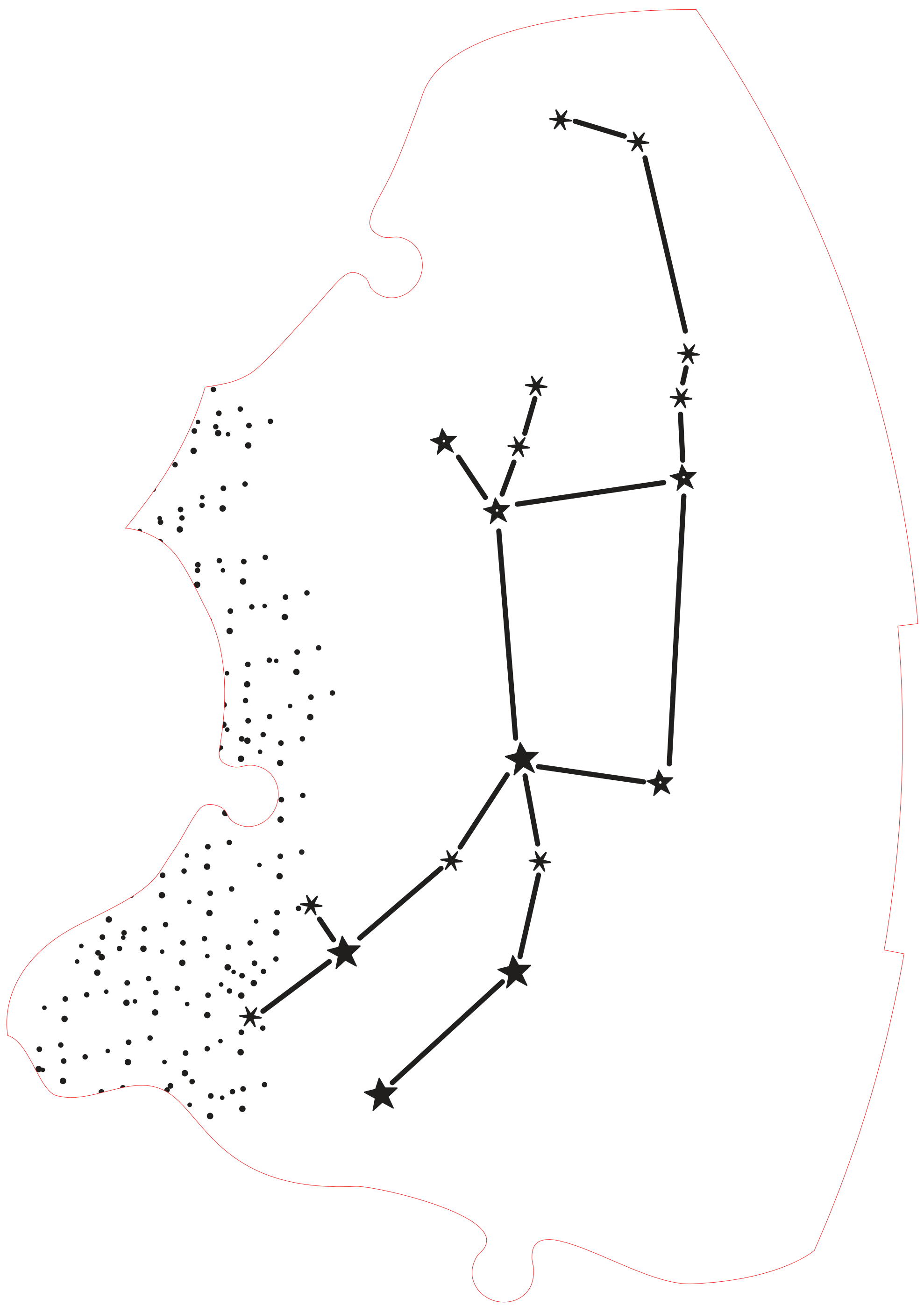
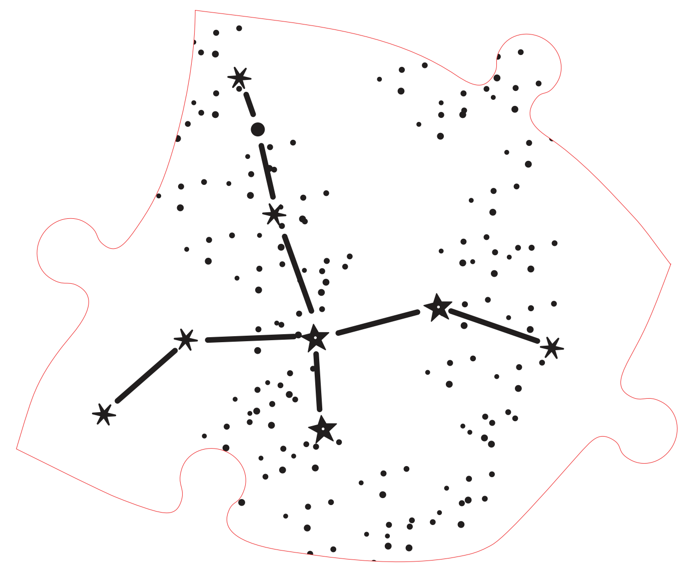
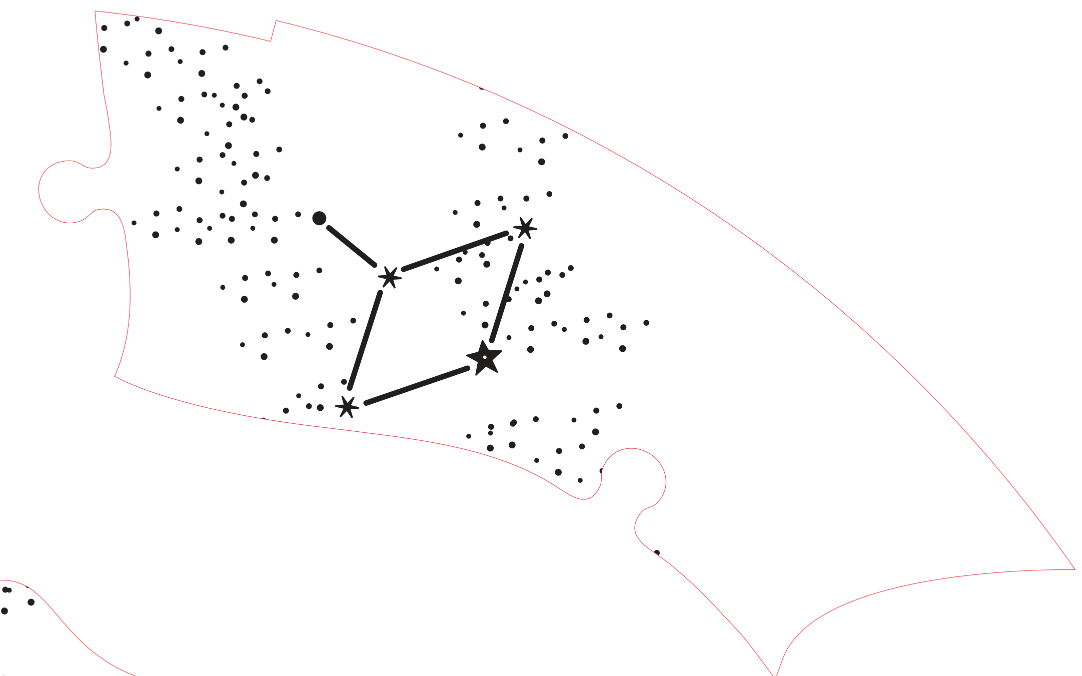
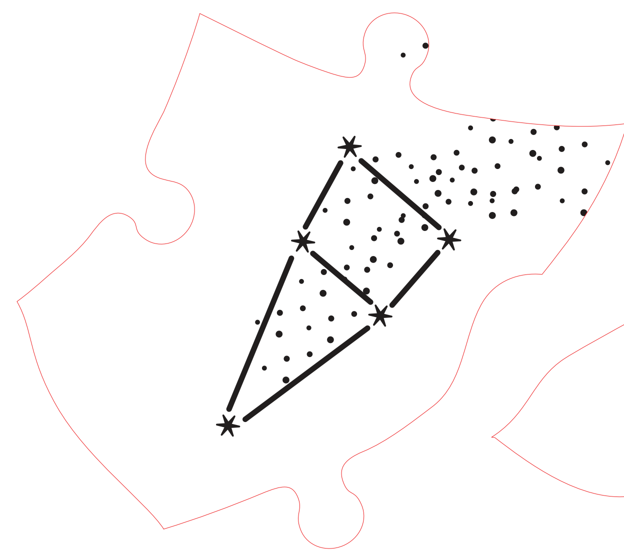
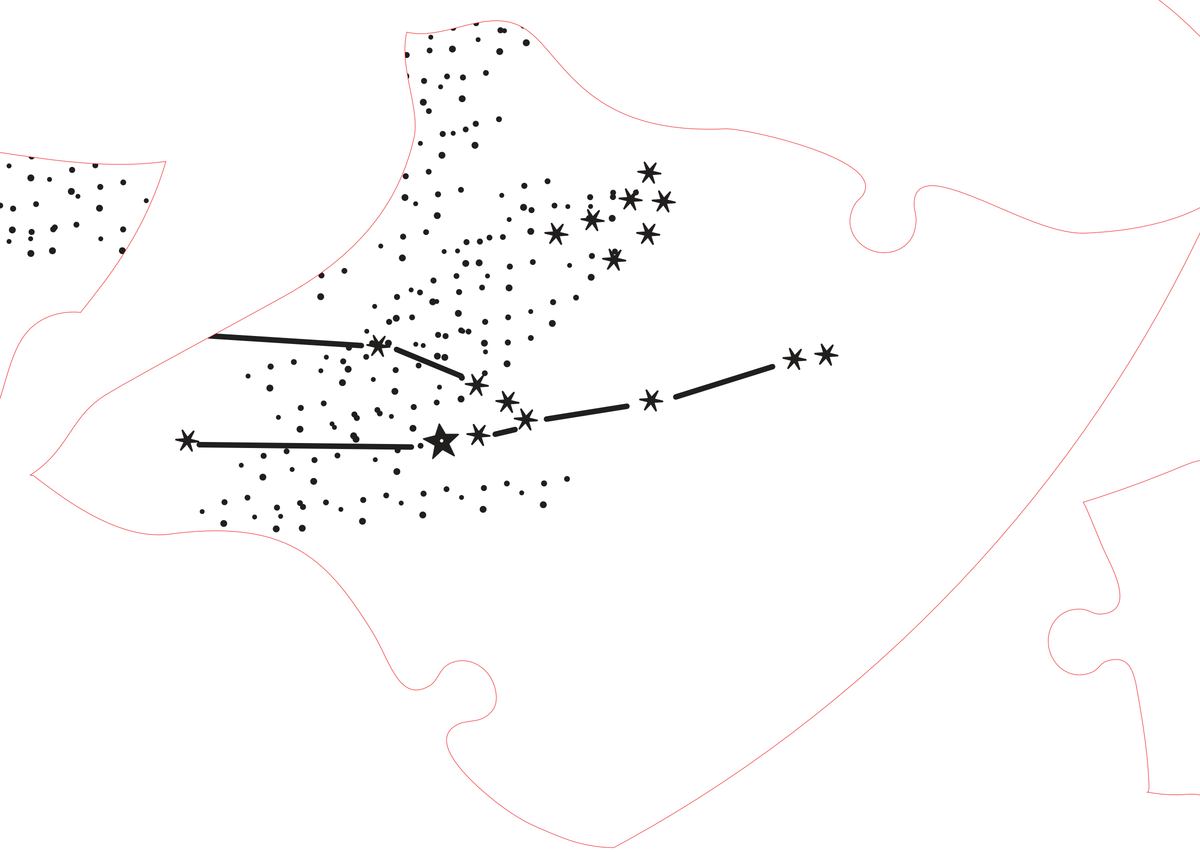
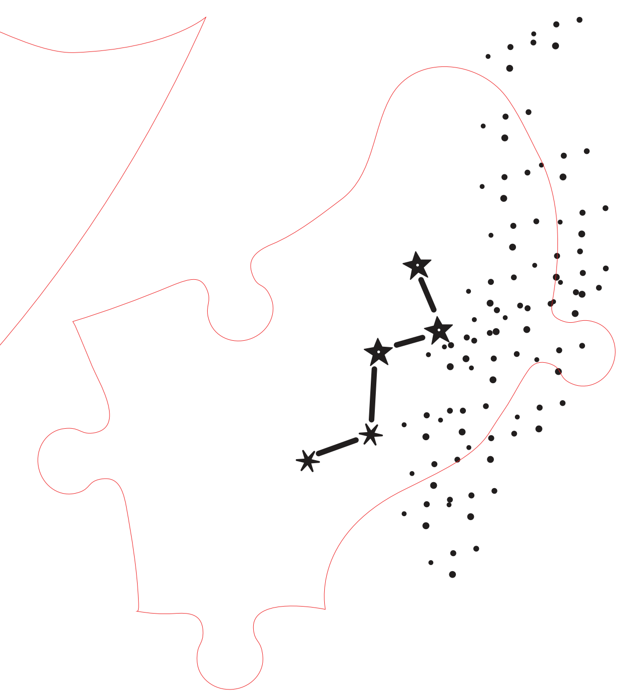
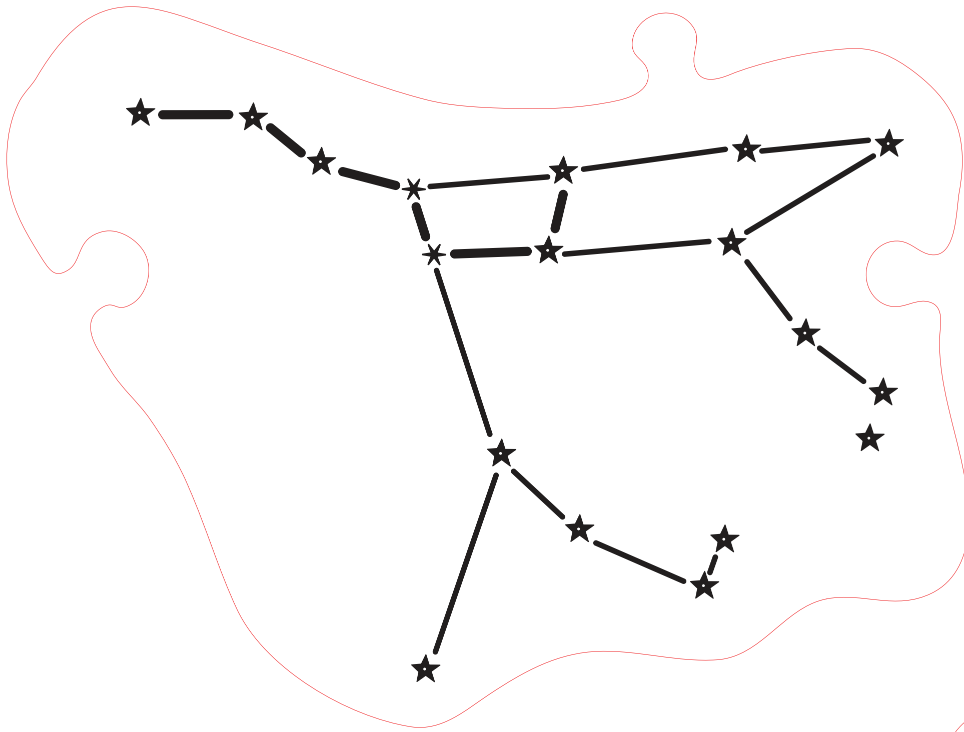
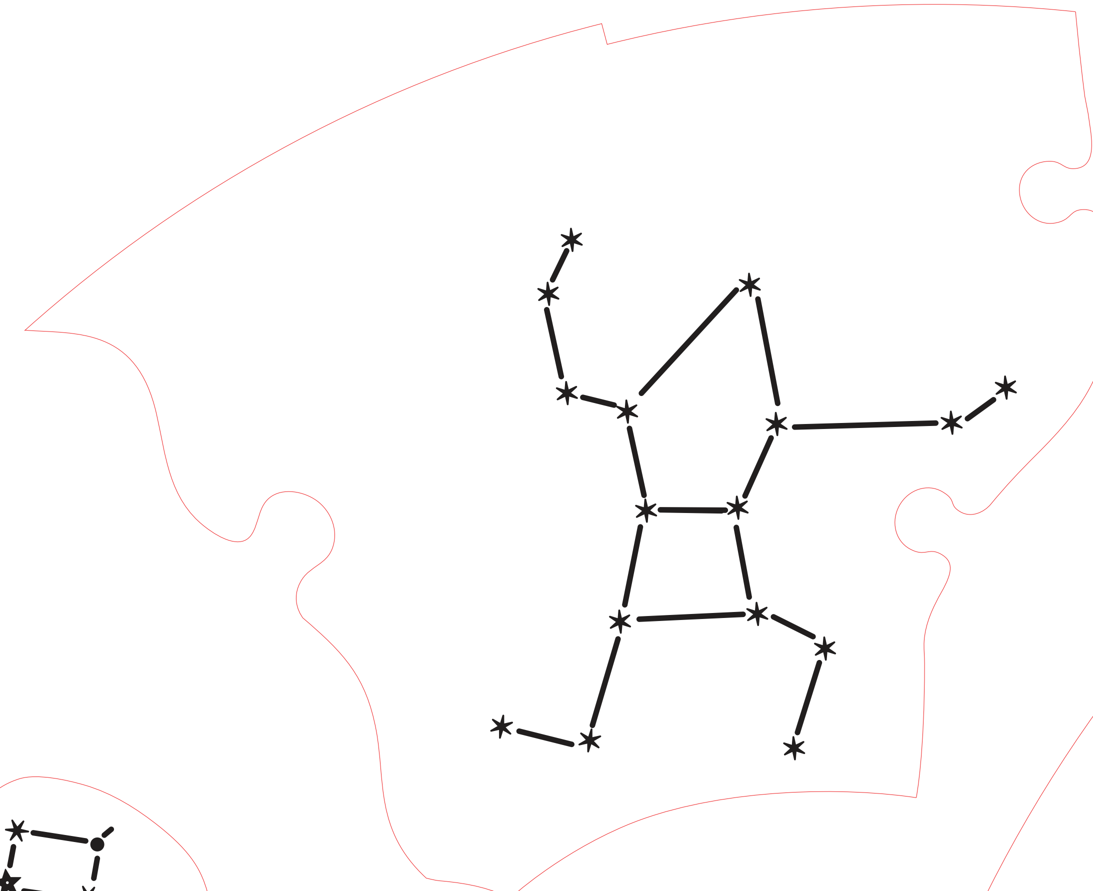
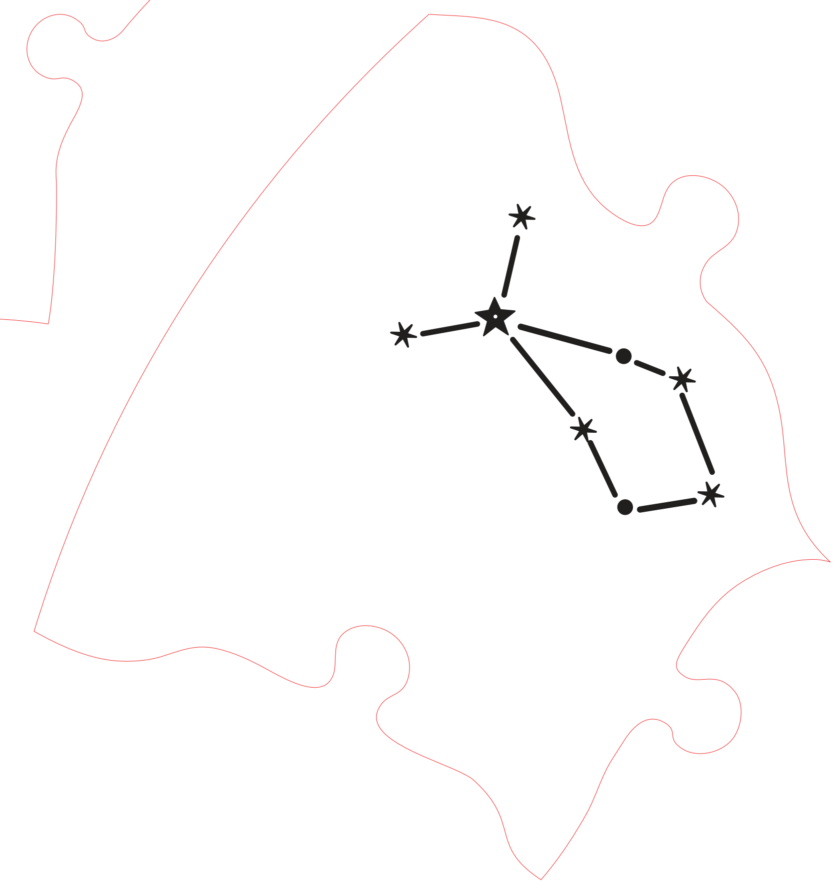
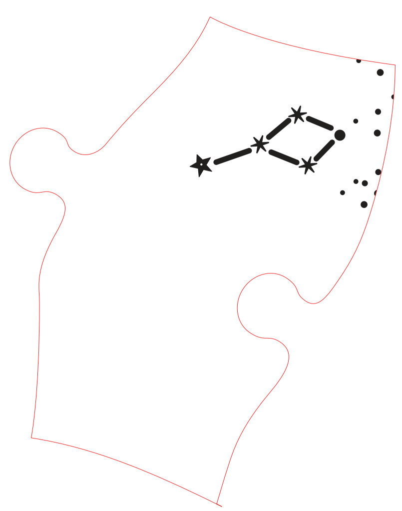
Ursa
Minor
Cassiopeia
Auriga
Cancer
Gemini
Taurus
Canis
Minor
Orion
Canis Major

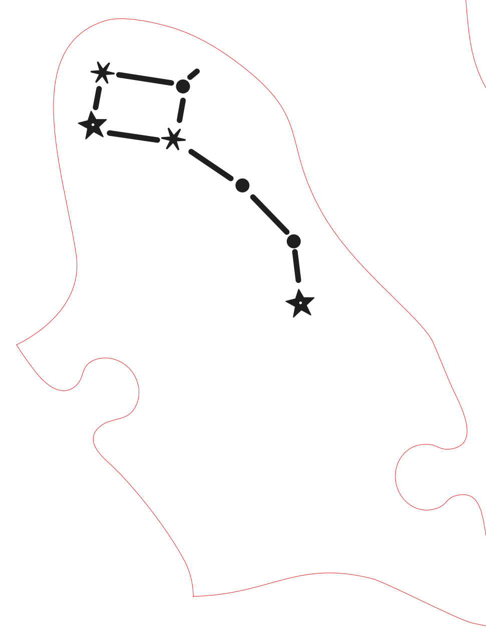

















OMSI
Everyday Encounters with Science

Laser Telescope

Program Type: Demonstration (best for museum educators and science teachers with specialized equipment)	**Audience Type:** Grade 6–12

Description: Students use lenses and mirrors to understand how light travels through reflecting and refracting telescopes.

Topics: Astronomy, light, optics, lens, mirrors.

Process Skills Focus: Critical thinking, observing, design.

LEARNING OBJECTIVES

For Next Generation Science Standards alignment, see end of outline.

- Scientists use telescopes to observe distant objects such as planets.
- Engineers design telescopes to collect and focus light.
- There are two primary kinds of telescopes: reflecting and refracting.

TIME REQUIRED

Advance Prep	Set Up	Activity	Clean Up
15 minutes	10 minutes	15 minutes	10 minutes

SITE REQUIREMENTS

- Area with minimal sources of outside light
- Access to at least one power outlet
- Access to a table

PROGRAM FORMAT

Segment	Format	Time
Introduction	Large group discussion	3 min
Laser Telescope	Instructor-led activity	10 min
Wrap-Up	Large group discussion	10 min

SUPPLIES

Permanent Supplies	Amount	Notes
Laser box with five lasers	1	Arbor Scientific sells a “Laser Ray Box and Lenses” including small lenses
Print out of the planet image	1	
Masking tape	1	
Small concave lens* (8 cm long, 2.5 cm wide, 2 cm tall)	1	
Small convex lens* (8 cm long, 2.5 cm wide, 2 cm tall)	1	
Large convex lens* (14.5 cm long, 4 cm wide, 2.5 cm tall)	1	
Large curved standing rectangular mirror* (15 cm long, 5 cm tall)	1	
Small, flat standing rectangular mirror* (6.5 cm tall, 2 cm wide)	1	
Reflecting Telescope template	1	At the end of the document
Refracting Telescope template	1	At the end of the document

*The sizes included are for the lenses and mirrors that we use at OMSI (see photo below). The exact sizes of the lenses and mirrors are not important, but their relative sizes and focal lengths are. You may have to experiment with the lenses and mirrors available to you to ensure that you can create the proper effects illustrated in the activity description.

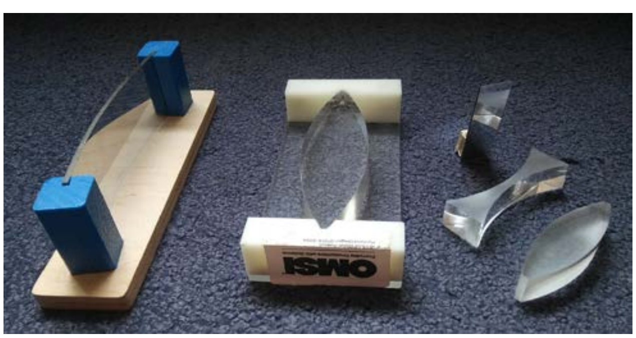


Photo from left to right: large mirror, large convex mirror, small mirror, small concave lens, and small convex lens.

ADVANCE PREPARATION

- Print the Reflecting Telescope template and Refracting Telescope template on 11 × 17” pieces of paper (if possible).
- Familiarize yourself with the lenses and mirrors. Be comfortable assembling the lenses and mirrors to make sure you can make both a reflecting and refracting telescope design.
- Print out the planet on cardstock and cut off the extra paper around the black line.

SET UP

- Set up the table in an area that is as dark as possible.
- Place the Refracting Telescope template on the table.
- Plug in the laser box and turn it on. Set the lasers to five rays.
- Position the laser box so the light appears to come from the stars printed on the template. The rays should be visible all the way to the observer’s eye printed on the template.
- Tape the planet printout onto the top of the laser box. This helps to reduce the risk of people looking directly into the lasers. It also keeps little hands from touching the laser box button and switch.
- Take out the converging (convex) lenses, both big and small, and the diverging (concave) lens. Keep all other lenses out of sight to avoid potential distraction.
- Keep the Reflecting Telescope template and mirrors close at hand.

INTRODUCTION

3 minutes

Let students speculate before offering answers to any questions. The answers given are provided primarily for the instructor’s benefit.

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics*.

Would you like to build a telescope?
Yes!

Why do we make telescopes?
To look at the sky.

Telescopes make it possible to study distant objects such as planets, stars, and galaxies. They're what help us understand the universe. They've been used for hundreds of years, and engineers are always looking to design bigger and better telescopes to help us study space.

Would you like to explore how a telescope works and be a telescope engineer with me?

SAFETY PRECAUTION:
Do not look directly into the lasers. Lasers can damage eyes. Set up the demonstration so that the lasers are facing away from people's eyes, preferably towards a wall to limit opportunities to unintentionally look into the lasers.

INSTRUCTOR-LED ACTIVITY

Laser Telescope

10 minutes

We'll start by investigating a type of telescope that's been around for hundreds of years. It's made of lenses.

Where else have you seen lenses?
Glasses. Cameras.

Yes, just like your glasses or the inside of a camera.

Scientists such as Galileo Galilei used this type of telescope—called a "refracting telescope"—to be the first people to observe our own Moon with a telescope.

[Pick up the concave and convex lenses and show them to the visitor or student.]

What happens to the light when it passes through these lenses? Here, you can experiment.

Guide visitors/students as they hold different lenses in front of the laser's rays.

With the convex lens: This one is called a convex lens. Look, it focuses light by bringing it together at one point. Then, the light spreads out again.

With the concave lens: What does the concave lens do? It's con-*cave* because it goes in like a cave.

Yes, it spreads the light out.

Now, let's imagine this laser light is the light from the distant planet Jupiter. Have you ever seen Jupiter with your naked eyes?
Yes. No.

You probably have, but it just looks like a dot in the sky like a star. That's because only a little bit of the light is going in our eyes, similar to how only one or two beams of laser light are going into this person's eye. [Point to the eye on the template.]

To be able to see the detail on the planet, we need to be able to collect and focus more of the light into our eye. That's what the telescope does.

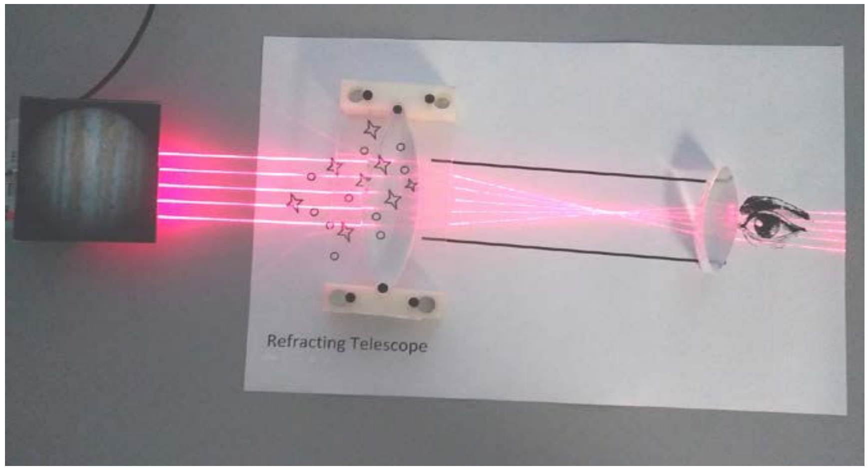
See if you can use two of these lenses to collect and focus more of Jupiter's light (the lasers) into our observer's eye.

Remember that light rays must be parallel to one another in order for us to see anything with our eyeballs. Light at an angle will looked warped like a fun-house mirror!

Let visitors/students try different combinations. Make sure that they remember that the lasers need to be parallel when they hit the eye. If they seem stuck, give them hints about moving the lenses closer and farther apart.

There are two ways for visitors to successfully complete this challenge:

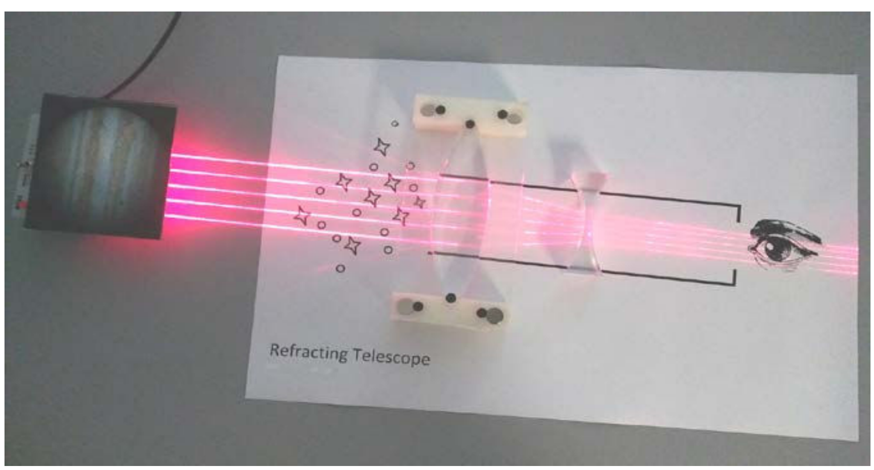
1. Use the large convex lens to collect the light, then use the small **convex** lens to straighten the light out again. For this to work, the small lens must be **past the focal point of the large lens**.



When they figure out this option:
Nice job! This is how Galileo's telescope worked. Note one thing, though. [Cover up the laser closest to you.] What happens to the light when it goes through the telescope?
It gets turned upside down.

Right, the image is reversed. Now, try with the small concave lens to see if you can design a refracting telescope that keeps the image right side up.

2. Use the large convex lens to collect the light, then use the small **concave** lens to straighten the light out again. For this to work, the small lens must be **before the focal point of the large lens**.



When they figure out this option:
Wow, you just designed the second type of telescope made to look at the sky.

Even though reflecting telescopes allowed people to see stars and planets in more detail than before, they have their challenges. Why do you think the problems with this telescope design might be?

It's hard to make and mount really big glass lenses (they're heavy!).

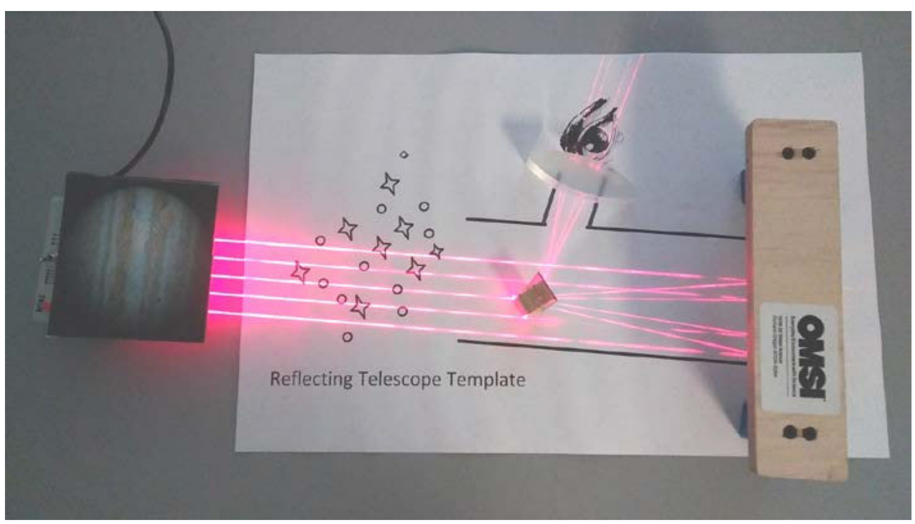
Would you like to now try assembling a different type of telescope? This style is more modern, and it uses mirrors rather than lenses. The world's largest telescopes, like those on mountaintops and in space, are often this style—they are called "reflecting telescopes."

Place the Reflecting Telescope template on the table with the two mirrors and two small lenses. Position the laser box so the light appears to come from the stars printed on the template.

Notice that with this type of telescope we look into the telescope from the side.

Now, can you use mirrors to send Jupiter's light (the laser beams) into the observer's eye? Remember that light rays must be parallel to one another in order for us to see anything with our eyeballs!

To solve this challenge, visitors need to arrange the large mirror, small mirror, and small convex lens like this:



Visitors often struggle with how to arrange the mirrors to get the light into the person's eye. If needed, give them hints by encouraging them to try different positions and placements for the small mirror.

Also, remind them how they made the light become parallel again in the refracting telescope. They need to use a lens at the eyepiece to straighten out the lasers.

Nice! You did it. And the great thing about your reflecting telescope is that you can make it as big as possible to collect more light. Some giant telescope mirrors are over 10 meters across! That's wider than a tennis court!

WRAP-UP

2 minutes

Ask for student observations. There is no correct answer. Let students guide the discussion and present their hypotheses before discussing explanations.

Thank you for being a telescope engineer with me today! Maybe you'll work for NASA someday as an engineer designing telescopes. Or, an astrophysicist, a scientist using one of these huge telescopes to understand the universe.

If you could design any kind of telescope, what would it be? What would you look at?

CLEAN UP

- Turn off the lasers, return the lenses to their kit, and put away the mirrors. Recycle or keep the Reflecting Telescope template and Refracting Telescope template.

OPTIONAL EXTENSIONS

- There are different lenses in the kit (triangular, trapezoidal, etc.). Bring them out and let visitors experiment by placing them in front of the laser box.

- Create a game: mark a target on the template and challenge the visitors/students to direct all the light successfully through that target.

BACKGROUND INFORMATION

Refracting telescopes

Refracting telescopes were used by scientists hundreds of years ago to make some of the first detailed observations of the sky. For instance, they revealed craters on the Moon and the largest moons of Jupiter. The lenses of refracting telescopes must be designed very accurately to bend light in just the right way. Even today, some smaller telescopes in use are refracting telescopes.

Reflecting telescopes

Most of the largest telescopes in use today—those with mirrors measuring several meters in diameter—are reflecting telescopes, which means that they use mirrors rather than lenses. Mirrors are advantageous in that they can be structurally supported along their entire backside (since light doesn't travel through them), which is important when dealing with enormous mirrors that weigh several tons each! Many large reflecting telescopes can be found on the summit of Mauna Kea on Hawaii's Big Island, a site renowned for its clear, dark skies.

RESOURCES

Detailed explanation of the differences between refracting and reflecting telescopes
https://www.britannica.com/science/optical-telescope#ref481091

GLOSSARY

Concave lens	A lens that spreads incident light away from the original path
Convex lens	A lens that brings together incident light into a focal point
Focal point	The point at which converging rays arrive or from where diverging rays leave
Reflecting telescope	A telescope that uses mirrors to produce a smaller, more detailed image of what is being observed
Refracting telescope	A telescope that uses lenses to produce a smaller, more detailed image of what is being observed

NEXT GENERATION SCIENCE STANDARDS

Practices
1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
6. Constructing explanations and designing solutions

Crosscutting Concepts
1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems and system models

DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
Physical Science									
PS1	Matter and Its Interaction	n/a	n/a		n/a	n/a			
PS2	Motion and Stability: Forces and Interactions		n/a	n/a		n/a			
PS3	Energy		n/a	n/a	n/a				
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	n/a		n/a		
Life Science									
LS1	From molecules to organisms: Structures and processes			n/a					
LS2	Ecosystems: Interactions, Energy, and Dynamics	n/a	n/a			n/a			
LS3	Heredity: Inheritance and Variation of Traits	n/a		n/a		n/a	n/a		
LS4	Biological Evolution: Unity and Diversity	n/a	n/a			n/a	n/a		
Earth & Space Science									
ESS1	Earth's Place in the Universe	n/a	✔		n/a			✔	
ESS2	Earth's Systems		n/a						
ESS3	Earth and Human Activity		n/a	n/a					
Engineering, Technology, and Applications of Science									
ETS1	Engineering Design	✔	✔	✔	✔	✔	✔	✔	✔

Thank you to NASA for making the *Lenses on the Sky* project possible!

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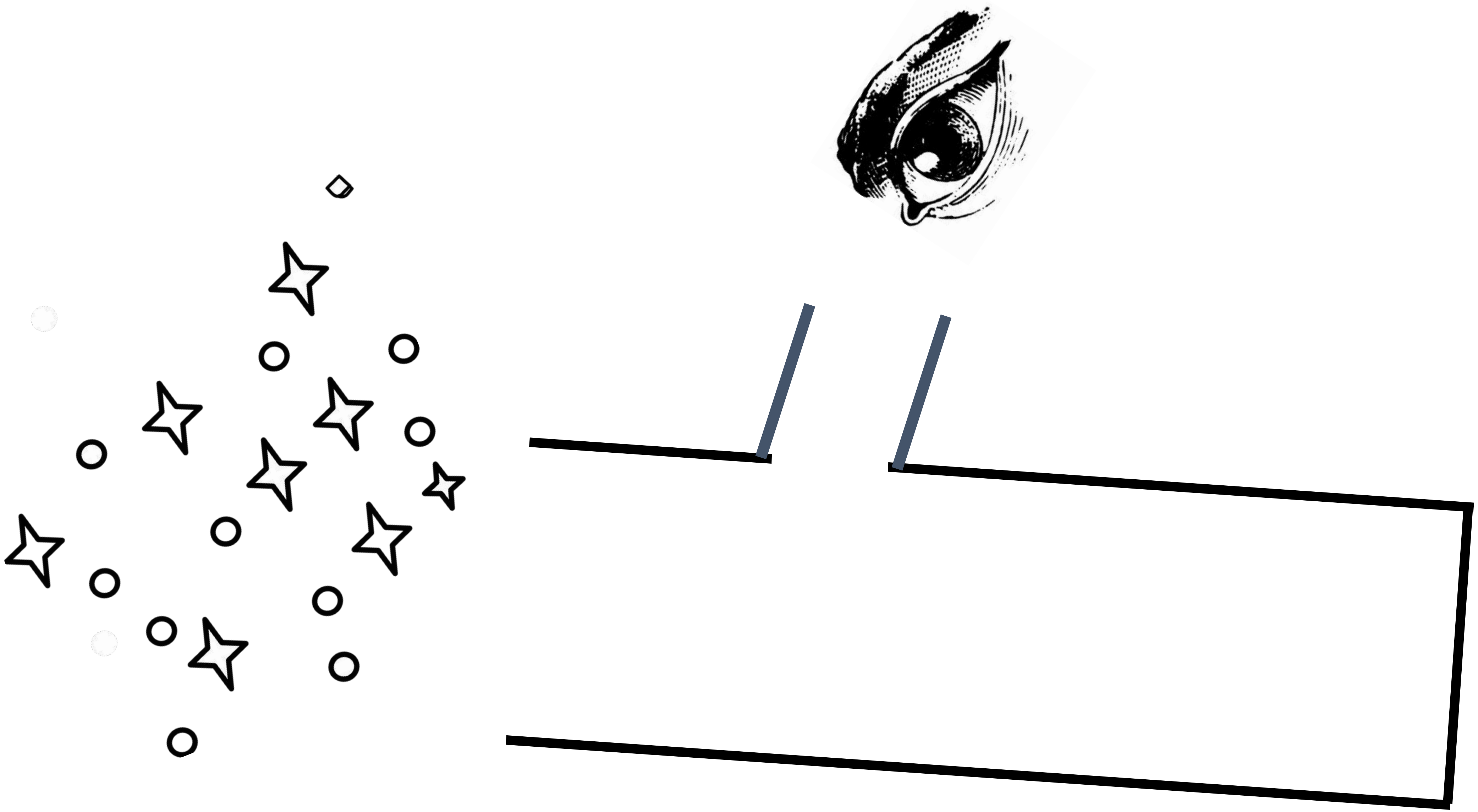
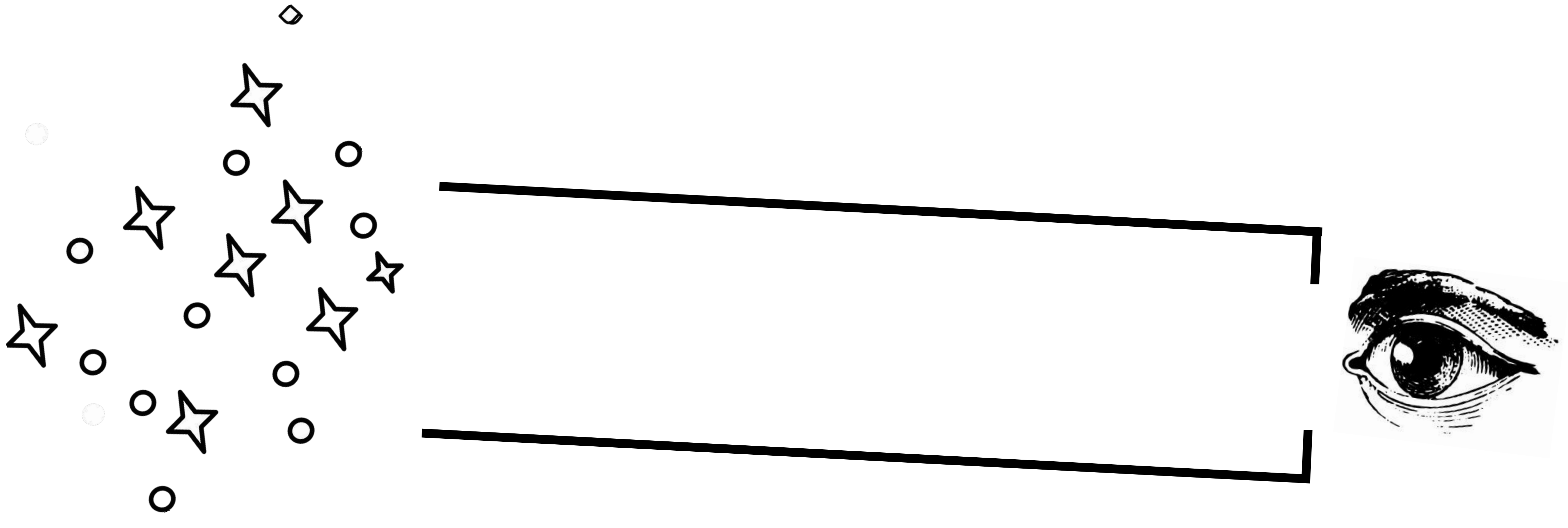
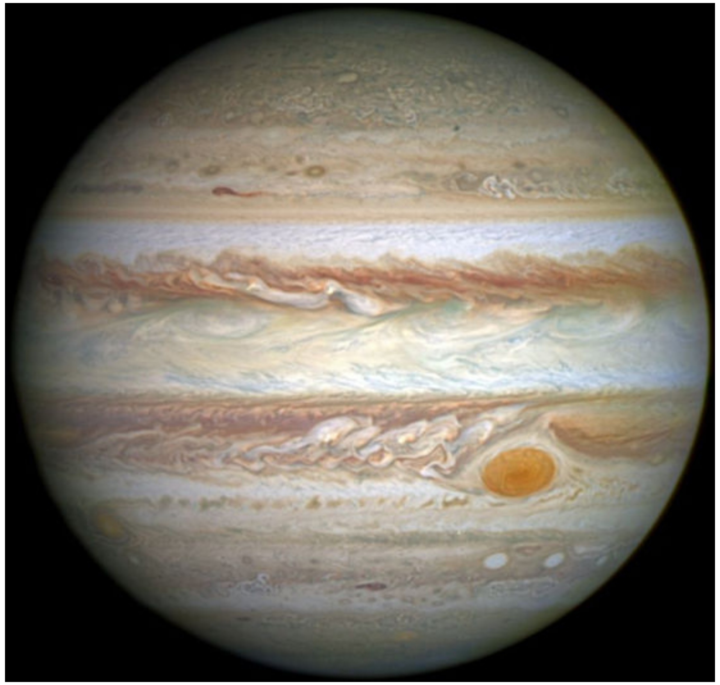
Image credit on diagram for eye: John Bonadies



Reflecting Telescope/Telescopio Reflector



Refracting Telescope/Telescopio Refractor



Jupiter/Júpiter

This image of Jupiter was taken on 21 April 2014 using the *Hubble Space Telescope*.

Imagen de Júpiter tomada el 21 de abril 2014 por el telescopio espacial Hubble.

Photo credit/Fotografía: NASA.

Measure the Sky

Everyday Encounters with Science

Program Type: Demonstration or Classroom Program	**Audience Type:** Grade 4–8

Description: Students assemble a quadrant, a tool for measuring the positions of objects in the sky.

Topics: Sky, observation, astronomy.

Process Skills Focus: Critical thinking, observing, measuring, predicting.

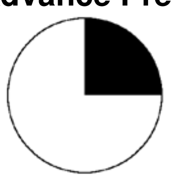
LEARNING OBJECTIVES

For Next Generation Science Standards alignment, see end of outline.

- A quadrant is a tool scientists use to measure how high an object is above the horizon.
- Islamic astronomers during the 11th–13th centuries developed and used quadrants to track the movements of celestial objects, work that led to many scientific discoveries.

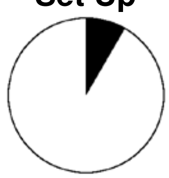
TIME REQUIRED

Advance Prep



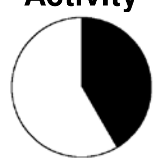
15 minutes

Set Up



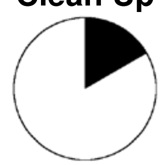
5 minutes

Activity



25 minutes

Clean Up



10 minutes

SITE REQUIREMENTS

- Standard size classroom
- Desks or tables with chairs
- The presence of at least one adult

PROGRAM FORMAT

Segment	Format	Time
Introduction	Large group discussion	5 min
Make a Quadrant	Instructor-led activity	10 min
Quadrant Practice	Partner activity	5 min
Wrap-Up	Large group discussion	5 min

SUPPLIES

Permanent Supplies	Amount	
Pencils	1/student	
Scissors	1/student	
Tape	One roll/4 students	

Major Consumables	Amount	Notes
Quadrant template	1/student	At the end of this document
String, 12”	1/student	
Drinking straw	1/student	
Metal washer, roughly 1” in diameter	1/student	

ADVANCE PREPARATION

- Print the quadrant template on heavy cardstock and cut the page in half to produce one quadrant per student.
- Assemble one quadrant to show the students as an example.
- Depending on the age group, students might have trouble poking a pencil through the quadrant paper. If you think that your students will have trouble, poke the hole in each quadrant paper at the position of the black dot ahead of time.

SET UP

Place the pencils, tape, and scissors within easy reach of the students.

INTRODUCTION

Let students speculate before offering answers to any questions. The answers given are provided primarily for the instructor's benefit.

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics*.

People use many tools to observe and study the night sky. Can you think of any tools?
Eyes, telescopes, binoculars, smartphones, cameras, hands.

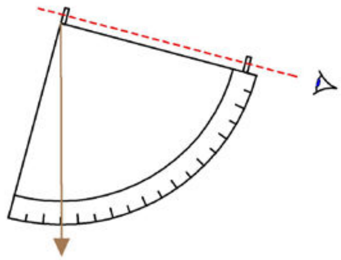
Hold up a completed quadrant.

This tool is called a quadrant. Scientists use quadrants to measure the positions of objects like stars and planets in the sky. Muslim astronomers over 800 years ago invented and used quadrants to make detailed, accurate observations of the sky. Most of these astronomers lived in the Middle East, Central Asia, and Northern Africa. The observations and insights of these astronomers directly influenced the later work of Renaissance astronomers in Europe. For example, Galileo supported the claim that Earth revolved around the Sun, not that the Sun revolved around Earth, using measurements taken by medieval Islamic astronomers.

How would you guess a quadrant works?
Look through the straw. Watch the string.

Look at the diagram to the left for an example (credit Michael Daly).

This is how the quadrant works:
1) Look at an object through the straw.



2) Note which number the string is next to. This number is the object's "altitude," which is how far the object is above the horizon in degrees.

Why do you think that it would be helpful to be able to measure how far an object is from the horizon?
To track something moving in the sky. To tell someone else where to look for something. To help you know where you are on Earth.

Tracking an object's altitude can be helpful for many reasons. It allows you to measure how much an object is moving through the night or at different times of the year. Tracking this can help you understand how the object moves with respect to the Earth.

It can also help you understand where you are on Earth. People traveling across the ocean or land without other landmarks can use the altitude of stars to tell them how far north or south they are—this is also called latitude. For instance, Portland, Oregon is at a latitude of roughly 45 degrees north.

To measure your latitude using a quadrant, you can find the North Star (also known as Polaris) in the night sky. Then align your quadrant with the North Star and read off its altitude. That number is your latitude.

INSTRUCTOR-LED ACTIVITY

Make a Quadrant

10 minutes

Hand out one quadrant pattern to each student. Instruct the students to cut out the pattern. They can cut out the little half circles if they want to, but it's not necessary.

Hand out one straw to each student. Have the students tape the straw along the top of the quadrant, where it says "attach straw along this edge." Instruct the students to trim their straws so they are the same length as their quadrant.

Hand out one piece of string and one washer to each student. Tell the students to use a pencil to carefully poke a hole through their quadrant where the black dot is (consider doing this step beforehand if the students might have difficulty). The students can then thread their piece of string through the hole.

Have the students tape one end of the string to the paper and tie the washer onto the other end of the string. Encourage the students to use a double knot so the washer is securely attached.

PARTNER ACTIVITY

Quadrant Practice

5 minutes

Ask students as a class to identify six objects in the classroom that they want to measure with their quadrants. Write them on the board.

Assign each student to a partner. Instruct one student to name an object in the classroom from the list. Then, the other student should use his or her quadrant to measure the object's altitude with the quadrant and write it down. Each student should measure three objects.

WRAP-UP

5 minutes

Ask for student observations. There is no correct answer. Let students guide the discussion and present their hypotheses before discussing explanations.

What was the altitude of the objects?
S*tudents share their numbers.*

Why are these numbers slightly different for different groups? Shouldn't the altitude of an object be the same?
Our desks are in different places so the angle is different for different groups.

I'm taller than other kids, so my altitude with be less than a shorter person.

The North Star looks like it's at different places in the sky depending on how far north or south you are for similar reasons. If you are at a different location on Earth, the

North Star will appear be at a different altitude from the horizon.

If you were at the North Pole, where would the North Star be in the sky?
90 degrees or straight up.

How can you imagine using your quadrants? What would you want to measure?

CLEAN UP

Return the pencils, scissors, and tape to their respective locations and recycle the paper scraps.

OPTIONAL EXTENSIONS

- Quadrants can be used outside at night to measure the altitudes of stars. Have students track the altitude of a certain star, planet, or the Moon over the course of a few hours or at the same time over several days.
- Host a star party and challenge students to find the North Star and measure its altitude (that value will be equal to your location's latitude).

BACKGROUND INFORMATION

Islamic Astronomy
Islamic astronomers around 1000 CE made important contributions to science by tracking the motions of planets and stars and studying solar and lunar eclipses. These observations helped the scientists determine precise timekeeping and revealed the structure of our solar system. Islamic astronomers used quadrants and other tools to make their observations. Their tools were often ornate versions made of wood or brass.

Celestial Navigation
Sailors at sea must know where on Earth's surface they are. One important aspect to determining location is knowing your latitude (i.e., how far above or below the equator you are). By using a quadrant to measure the altitude of the

North Star, sailors can determine their latitude. *The altitude of the North Star is equal to your latitude.*

RESOURCES

BBC Video about the scientific contributions of Islamic astronomers during the Islamic Golden Age.
https://www.youtube.com/watch?v=FLay7RD3kEw

Short video about Islamic scientists of the Golden Age and their contributions to astronomy.
https://www.youtube.com/watch?v=gLaNf6g11nQ

A short video about how mariners use a quadrant.
https://www.youtube.com/watch?v=uExoQJmAa_w

GLOSSARY

Altitude	The distance, in degrees, of an object above the horizon.
North Star	The bright star that appears directly above Earth's North Pole.
Polaris	Another name for the North Star.
Quadrant	A tool for measuring the altitude of different objects from 0 to 90 degrees above the horizon.

NEXT GENERATION SCIENCE STANDARDS

Practices
1. Planning and carrying out investigations
2. Analyzing and interpreting data
3. Using mathematics and computational thinking
4. Obtaining, evaluating, and communicating information

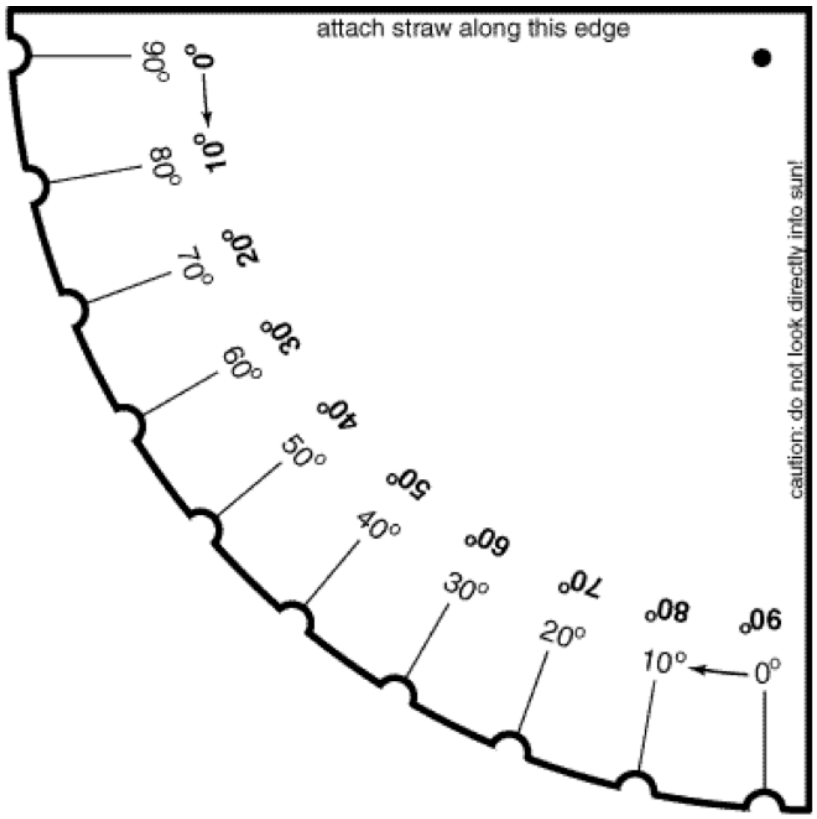
Crosscutting Concepts
1. Scale, proportion, and quantity

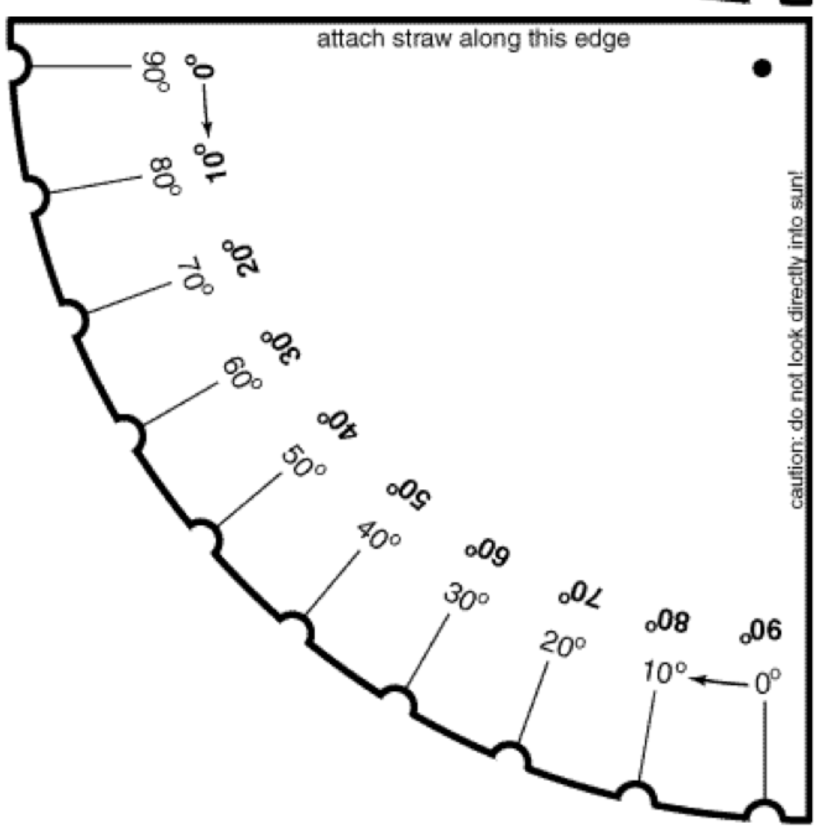
DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
	Physical Science								
PS1	Matter and Its Interaction	n/a	n/a		n/a	n/a			
PS2	Motion and Stability: Forces and Interactions		n/a	n/a		n/a			
PS3	Energy		n/a	n/a	n/a				
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	n/a		n/a		
	Life Science								
LS1	From molecules to organisms: Structures and processes			n/a					
LS2	Ecosystems: Interactions, Energy, and Dynamics	n/a	n/a			n/a			
LS3	Heredity: Inheritance and Variation of Traits	n/a		n/a		n/a	n/a		
LS4	Biological Evolution: Unity and Diversity	n/a	n/a			n/a	n/a		
	Earth & Space Science								
ESS1	Earth's Place in the Universe	n/a	✔		n/a		✔	✔	
ESS2	Earth's Systems		n/a						
ESS3	Earth and Human Activity		n/a	n/a					
	Engineering, Technology, and Applications of Science								
ETS1	Engineering Design							✔	

Thank you to NASA for making the *Lenses on the Sky* project possible!

The material contained in this activity is based upon work supported by the National Aeronautics and Space Administration (NASA) under grant award Number NNX15AB03G. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NASA.





Activity and image adapted from The Center for Science Education, UC Berkeley

OMSI
Everyday Encounters with Science

Moon Phase Flipbook

Program Type: Demonstration or Classroom Program	**Audience Type:** Grade 4–8

Description: Students assemble a flipbook of Moon phases and discuss why the Moon appears to change shape over the course of a month.

Topics: Moon phases, Moon, Earth, Sun, astronomy, patterns.

Process Skills Focus: Critical thinking, inquiry, observing, prediction.

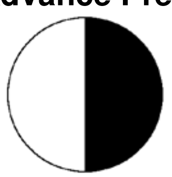
LEARNING OBJECTIVES

For Next Generation Science Standards alignment, see end of outline.

- Moon phases occur in regular patterns that can be predicted.
- The Moon's phases are caused by the relative positions of the Sun, Moon, and Earth.

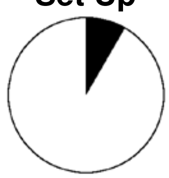
TIME REQUIRED

Advance Prep



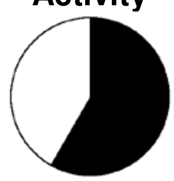
30 minutes

Set Up



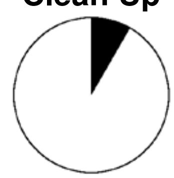
5 minutes

Activity



35 minutes

Clean Up



5 minutes

SITE REQUIREMENTS

- Large open area
- Access to a chalkboard or whiteboard
- The presence of at least one adult (two is helpful)

PROGRAM FORMAT

Segment	Format	Time
Introduction	Large group discussion	10 min
Moon Phases	Instructor-led activity	10 min
Moon Flipbook	Individual activity	15 min
Wrap-Up	Large group discussion	5 min

SUPPLIES

Permanent Supplies	Amount	Notes
Scissors	1/student	
Large ball	1	Basketball, rubber ball, or similarly sized ball
White masking tape or paint	1 roll or bottle	Skip if you can find a white ball
Staplers	2	

Major Consumables	Amount	Notes
Flipbook pages printed single sided on cardstock	1/student	At the end of this document

ADVANCE PREPARATION

- Print out the flipbook pages single-sided and in color on cardstock (English or Spanish versions available). Each student should have two different pages.
- Make a sample flipbook.
- Apply the masking tape or paint to one half of the ball. Any covering method works as long as half of the ball is white.
- Refill the staplers, if necessary.

SET UP

- Place the large ball near the front of the room.

INTRODUCTION

5 minutes

Let students speculate before offering answers to any questions. The answers given are provided primarily for the instructor's benefit.

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics.*

Who has seen the Moon before? What did it look like?
A full circle, a small sliver, half full.

Is the Moon always the same shape? What shapes can it take?
Circle, crescent, disappear.

Why do you think the Moon appears to change shape?
It moves. It gets bigger or smaller.

Today, we're going to investigate why the Moon looks different at different times of the month.

INSTRUCTOR-LED ACTIVITY

Moon Phases

10 minutes

Draw a large Sun on the board on the front of the room. Have the students sit on the floor together in the middle of the room, if possible.

What do you think this might be?
The Sun!

Yes, it's the Sun. And you are the Earth. Why are the Sun and Earth important for determining what shape the Moon appears to be?
The Moon goes around the Earth.

Let's find out. That is the Sun. You are the Earth and all the people on it who love to gaze at the Moon. And this ball in my hand is the Moon.

The Moon revolves around the Earth (you all) like this.

Walk around the kids in a big circle making sure to turn the Moon so the bright side always faces the Sun. Stop at the front of the class again.

But where does the moonlight that we see come from?
The Moon glowing. The Sun.

The Moon is basically a ball of rock covered in dust. Do rocks and dust glow?
No.

Neither does the Moon. So, where does the light come from?
The Sun.

The Sun shines on the Moon. Some of the sunlight bounces off the Moon's surface towards us on Earth.

Stand between the Sun (the board) and the Earth (the class).

Does the Sun's light cover the whole surface of the Moon?
No, just the part facing the Sun.

So, if only the part of the Moon facing the Sun has sunlight on it, which part of my Moon here should be bright (the white part) and which part is dark?
The part facing the Sun is light, and the part facing away is dark.

Hold the Moon so the white part is toward the Sun and away from the kids/Earth.

How much of the bright side of the Moon can you see?
None.

That is what's called a New Moon. That's when you can't see the Moon at all because the bright part is facing away from us.

Where would the Moon be during a Full Moon when you can see all of the bright side and it looks like a full circle?
Behind us! On the other side.

Stand behind the students with them between you and the Sun.

When the Moon is behind the Earth, people on Earth can see all of the bright part of the Moon and it looks full.

Stand on the side of the students.

How much of the bright side can you see now?
One half.

What is that Moon phase called?
A half Moon?

It can be called a Half Moon because half of it is visible. It is also called a Quarter Moon because it is a quarter of the way through its cycle around the Earth. If it getting bigger, it is called a First Quarter Moon. If it is getting smaller, it is called a Third Quarter Moon.

Where would I stand to make a Crescent Moon? One that just shows a sliver of light?
Almost between Earth and the Sun.

Yes, the Moon looks like a crescent when the Moon is mostly between Earth and the Sun, but just a little bit to the side. If the Moon is getting bigger, it is called a waxing crescent. If it is getting smaller, it is called a waning crescent.

Walk to the back of the class and a little to the side.

What is this Moon phase called?

It is a Gibbous Moon. The Moon looks almost full when it is almost on the backside of the Earth, but just a little bit to the side. If the Moon is getting bigger, it is called a waxing gibbous. If it is getting smaller, it is called a waning gibbous.

Slowly walk in a circle to your right around the students. Ask What shape is this? and help them remember the names of each shape as you revolve around them:

- New Moon (front of class, 0°)

- Waxing Crescent Moon (between the right side and the front, 45°)
- First Quarter (right side of the students, 90°)
- Waxing Gibbous Moon (between the right side and the back, 135°)
- Full Moon (behind the students, 180°)
- Waning Gibbous Moon (between the left side and the back, 225°)
- Third Quarter (the left side of the students, opposite the first quarter, 270°)
- Waning Crescent Moon (between the left side and the front, 315°)

INDIVIDUAL ACTIVITY

Moon Flipbook

15 minutes

Now, we're going to make a flipbook showing what we just learned about how the Moon appears to change shape.

Distribute the flipbook pages and scissors to each student.

These pages show positions of the Sun, Earth, and Moon for each phase of the Moon. In the corner, it also shows what the Moon looks like at each position.

Can you find the pages that show the Full Moon and the New Moon?
Page 1 is a New Moon.
Page 5 is a Full Moon.

Carefully cut out each page with scissors. Then stack the pages in order using the page numbers in the lower-left corner. Don't forget the title page!

When you're finished, raise your hand, and I'll come over with a stapler to help you bind your flipbook.

Instructions for facilitators: Staple the flipbooks along their spine with two staples as close to the edge of the paper as possible. (See image to left with red lines for where the staples go.)

WRAP-UP

5 minutes

Ask for student observations. There is no correct answer. Let students guide the discussion and present their hypotheses before discussing explanations.

Has everyone tried using their flipbooks? What does your flipbook show?
The Moon going around Earth. The Moon getting bigger and then smaller.

What did you learn about the Moon that you didn't know before?

What is something that you would like to learn more about?

What do you think it would be like to look up from a planet like Jupiter that has more than 65 moons?

How about if you were on Mercury? This planet has no moons.

CLEAN UP

- Recycle the paper scraps from the flipbooks and collect the scissors and staplers.

OPTIONAL EXTENSIONS

- Students can observe the Moon over the course of a month and mark the dates that they observe each shape of the Moon in their flipbook.

RESOURCES

NASA gallery of Moon phases
https://solarsystem.nasa.gov/galleries/phases-of-the-moon

Moon information for the solar system and additional Moon activities
https://spaceplace.nasa.gov/how-many-moons/en/

GLOSSARY

Full Moon	The Moon phase where the illuminated part of the Moon is fully visible.
New Moon	The Moon phase where the illuminated part of the Moon is not visible.
Waning	A word that means “decreasing.” A “waning Moon” is one that appears to be growing smaller (i.e., less illuminated) over time.
Waxing	A word that means “growing.” A “waxing Moon” is one that appears to be growing larger (i.e., more illuminated) over time.

NEXT GENERATION SCIENCE STANDARDS

Practices
2. Developing and using models
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions

Crosscutting Concepts
1. Patterns
2. Cause and effect
4. Systems and system models

DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
	Earth & Space Science								
ESS1	Earth's Place in the Universe	n/a			n/a		✓	✓	
ESS2	Earth's Systems		n/a						
ESS3	Earth and Human Activity		n/a	n/a					

Thank you to NASA for making the *Lenses on the Sky* project possible!

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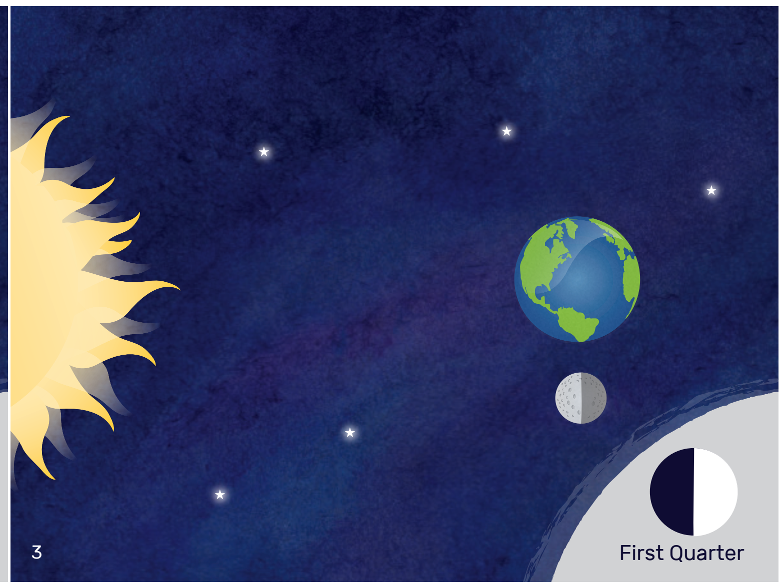
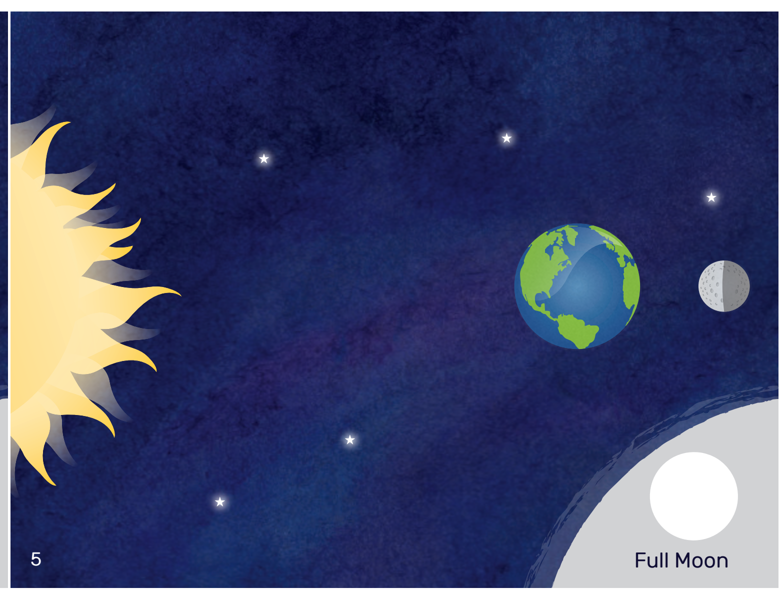
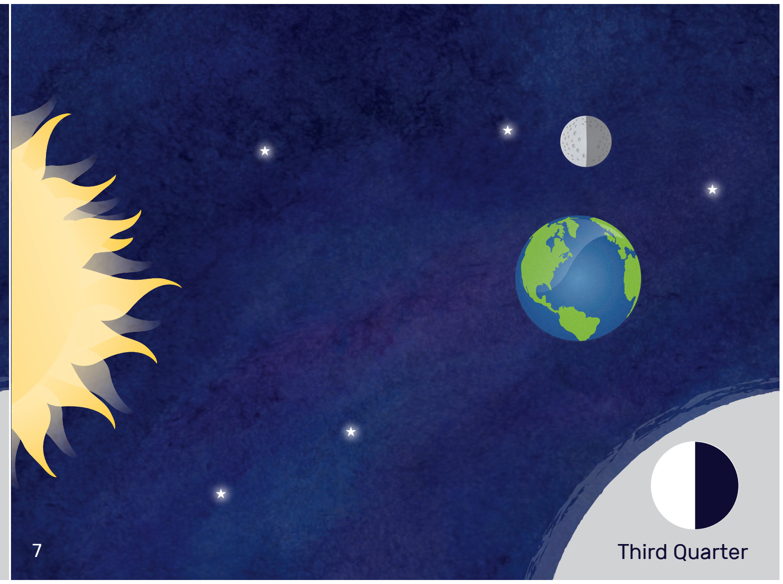
MOON PHASES
Flipbook





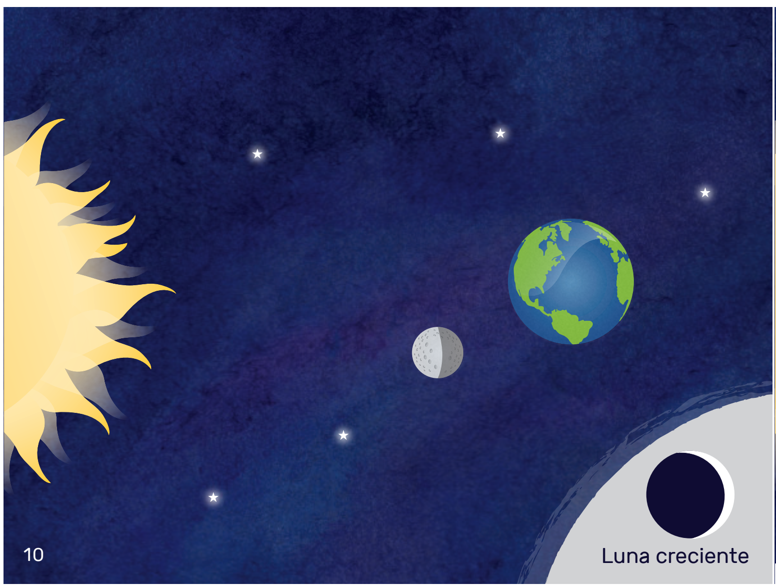

6
Waning Gibbous

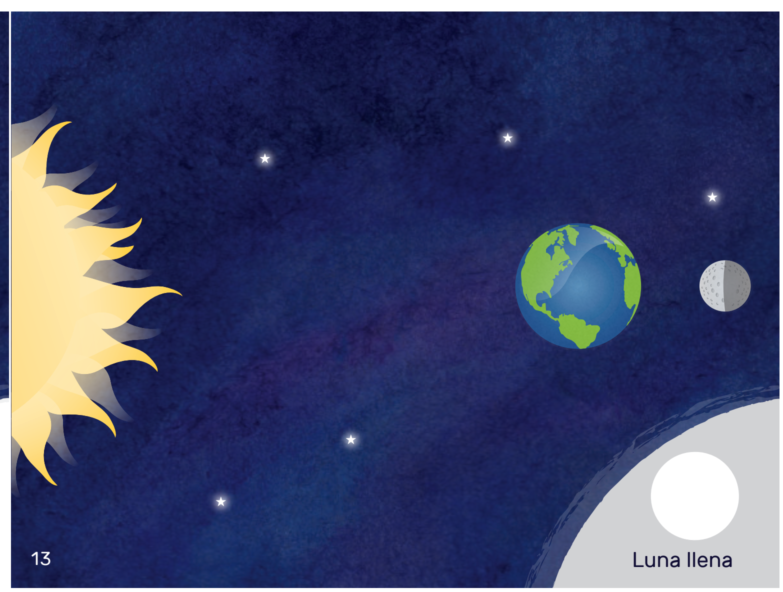

7
Third Quarter

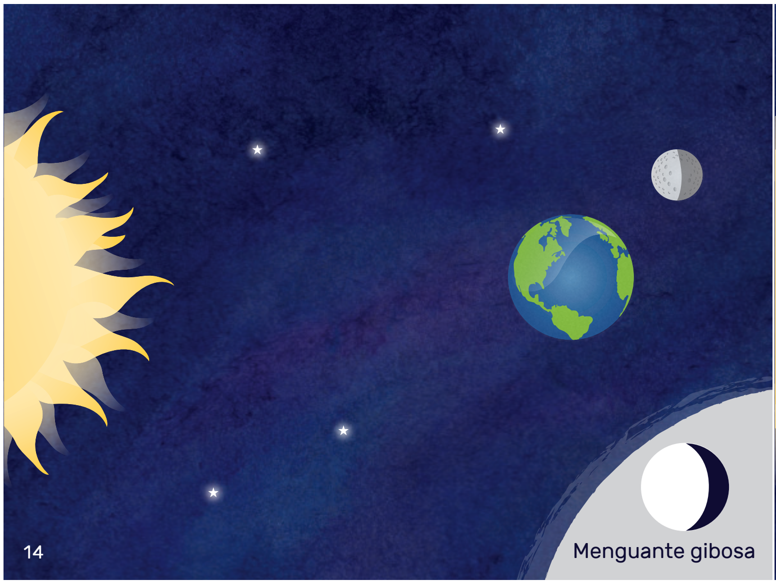

8
Waning Crescent

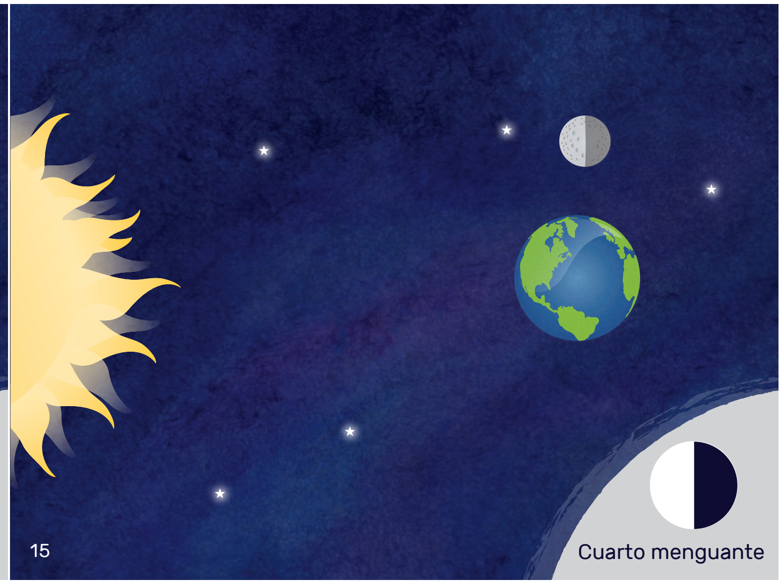
FASES DE LA LUNA

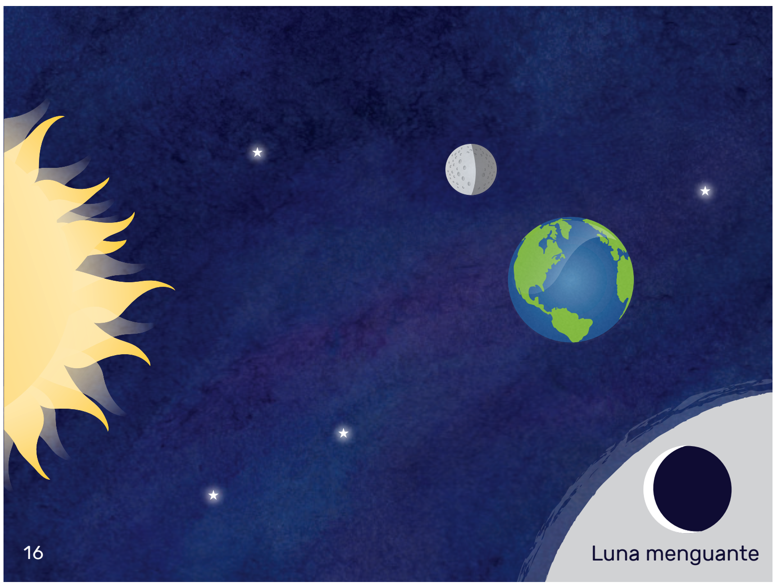
OMSI






14
Menguante gibosa


15
Cuarto menguante


16
Luna menguante

Observing the Sun

Program Type: Demonstration or Classroom Program	**Audience Type:** Grade 6–8

Description: Students learn how to safely observe the Sun and how different cultures have observed the Sun around the world.

Topics: Astronomy, the Sun, solar observing, sunspots, math.

Process Skills Focus: Observing, measuring, prediction.

LEARNING OBJECTIVES

For Next Generation Science Standards alignment, see end of outline.

- People have observed the Sun in many ways for millennia, and we continue to do so today.
- It's important to be very careful when observing the Sun.

TIME REQUIRED

Advance Prep	Set Up	Activity	Clean Up
10–60+ minutes (varies)	15 minutes	30 minutes	15 minutes

SITE REQUIREMENTS

- A sunny day
- A table set up outside in the sunlight

PROGRAM FORMAT

Segment	**Format**	**Time**
Introduction	Large group discussion	5 min
Observing the Sun	Instructor-led activity	10 min
Solar Observatories	Small group activity	20 min
Wrap-up	Large group discussion	5 min

SUPPLIES

Permanent Supplies	Amount	Notes
Sunspotter	1	
Printouts of modern and ancient observatories	1–3	At the end of this document
Printout of a current view of the Sun (see "Advance Preparation" below)	1–3	
Solar viewing glasses	1 per 3 students	

ADVANCE PREPARATION

Step 1: Collect as many types of solar observing materials as possible.
If possible, find or purchase solar viewing glasses. These are cheap and available on-line (http://www.rainbowsymphony.com/eclipse-glasses/).
If you have a Sunspotter (www.teachersource.com/product/ Sunspotter-solar-telescope/astronomy-space), make sure that you have all of the necessary pieces.
If you do not have a Sunspotter, you can easily make one with common materials using one of these resources:

- http://www.exploratorium.edu/eclipse/how-to-view-eclipse
- www.timeanddate.com/eclipse/make-pinhole-projector.html
- www.timeanddate.com/eclipse/box-pinhole-projector.html

Step 2: Print off images of solar observatories and a current solar image from NASA.
Solar observatory images and information about each observatory can be found at the end of this document.

Go to https://sohowww.nascom.nasa.gov/data/realtime/realtime-update.html to find up-to-date images of the Sun taken by NASA observatories. Print the "SDO/HMI Continuum Image" picture, which shows the Sun in visual wavelengths (i.e., the kind of light we can see with our eyes). The other images show the Sun in different wavelengths.

SET UP

If you are using a Sunspotter, set it up on the table in the sunlight:

- Make sure that a piece of white paper is pinned to the interior; the Sun will only be visible if this step is followed.
- Unscrew the "capture" screw so that the main aperture of the Sunspotter can move freely in the cradle.
- Turn the main body of the Sunspotter so that it faces the Sun.
- The gnomon (the stick that extends from the front of the Sunspotter) is right above the objective lens. A shadow may be visible around it. Adjust the Sunspotter's location so the shadow is directly above or below the gnomon. Then move the Sunspotter aperture in the cradle until the shadow disappears completely.
- Look at the interior of the Sunspotter. Near the mirror, there should be two circles. There should also be two spots of light around these circles. Adjust the Sunspotter until these two spots of light fall in the center of the two circles.
- An image of the Sun should appear on the piece of white paper. The Sunspotter requires adjusting every few minutes to ensure that the Sun remains in view.

Place the printouts of the modern and ancient solar observatories and the current view of the Sun on the table as well.

INTRODUCTION

Let students speculate before offering answers to any questions. The answers given are provided primarily for the instructor's benefit.

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics*.

SAFETY PRECAUTION:
• Avoid looking directly at the Sun without proper eye protection.

Today, we are going to talk about observing the Sun. But before we start we need to talk about safety. **We should never look directly at the Sun! Looking at the Sun directly can cause serious, permanent eye damage. To observe the Sun, we need to use tools to protect our eyes.**

Does anyone know of any tools that we can use to safely observe the Sun?
Solar viewing glasses, telescopes with solar filters, pinhole cameras.

We'll use some of these tools today.

INSTRUCTOR-LED ACTIVITY

Observing the Sun

10 minutes

Hold up a pair of solar viewing glasses.
One of the cheapest and easiest ways to look at the Sun is to use solar glasses. These glasses contain a film that blocks the harmful rays that damage our eyes.

Pass out the glasses.

Put them on and look around. What do you see?
Not much.

They also block a very large amount of light, so when we wear them we can only see things that are very, very bright.

Now look at the Sun if you have your solar viewing glasses on. Can you see it? Why?
Yes, because the Sun is shining very brightly.

Do you notice anything on the surface of the Sun?
Some dark spots. No.

If there are sunspots visible on the surface of the Sun, initiate a conversation about sunspots:

The dark areas are called sunspots. They are areas on the Sun's surface that are slightly cooler than surrounding areas—that's why they look dark. There are more sunspots visible when the Sun is going through an "active" phase.

Of course, since the Sun appears relatively small, we can't see a lot of detail. To see more, we need to magnify the image.
This Sunspotter (or homemade solar viewer) projects a larger image so that we can see the Sun in more detail.

Can you see any features that you couldn't see before?
A spot here. A wisp there.

If we wanted to see even more details, what would you suggest? What tools could we use?
A telescope. A satellite.

Show the students the printout of the current view of the Sun.

This image was taken by a NASA's satellite in the last day or so. This satellite is dedicated to taking pictures of the Sun in incredible detail.

How does your view of the Sun compare with this image?
They look similar. The satellite has more details.

Scientists today track the Sun to predict solar cycles that affect life on Earth. For instance, the Sun can emit powerful blasts of energy that can cause blackouts here on Earth.

Of course, people have been observing the Sun long before we had solar glasses and satellites. People from cultures around the globe watched the Sun for the same reasons scientists do today: to predict how solar cycles affect life on Earth. They were not usually looking directly at the Sun but instead watching how the Sun moved through the sky at different times of the day and year.

Why do you think that people around the world would have found it useful to observe and track the Sun?
Tell time. Find their way. Track the seasons.

Tracking the Sun helps people tell time, track the seasons for agriculture and celebrations, find the cardinal directions (North, South, East, West), and fuel their curiosity for understanding how the world works. Tracking the Sun is also often important for religious reasons.

How have people observed and tracked the Sun?
Buildings. Sun dials. Shadows.

Do you know of any examples of solar observatories from around the world?
Temples in Mexico. Drawings on rocks.

Let's learn about a few examples.

SMALL GROUP ACTIVITY

Solar Observatories

10 minutes

Break the students into three groups. Give each group a printout of the modern and ancient solar observatories.

Have each group read their handout and discuss the observatory. Then have the group share interesting information about their observatory with the rest of the class. They should answer these questions:

- What is the name of the observatory?
- Who built it?
- Where is it?
- When was it built?
- Why was it built?
- Is it still being used?
- What is the most interesting fact you learned about this observatory?

WRAP-UP

5 minutes

Ask for student observations. There is no correct answer. Let students guide the discussion and present their hypotheses before discussing explanations.

What did you learn that you didn't know before about the Sun and how people observe it?

Are there any design features or functions that multiple solar observatories had in common?

CLEAN UP

Return the Sunspotter to its box and collect the solar viewing glasses and handouts.

OPTIONAL EXTENSIONS

- Students can make their own solar viewers using the directions referenced in the "Advance Preparation" section.
- Students can research other solar observatories and make presentations to the rest of the class.

RESOURCES

Educational resources about the Sun and how NASA explores it.
https://sohowww.nascom.nasa.gov/explore/

NASA website about modern and ancient solar observatories around the world.
http:// Sunearthday.nasa.gov/2005/index.htm

GLOSSARY

Solar eclipse	Event in which the Moon blocks some or all of the light of the Sun during the day.
Sunspotter	Telescope designed for looking safely at the Sun. The device projects an image of the Sun on a piece of paper.
Sunspots	Spots on the Sun's surface that are slightly cooler in temperature than surrounding areas—they appear dark in color. Sunspots change position every few days.
Total solar eclipse	Event in which the Moon completely blocks the light of the Sun during the day, creating temporary darkness on parts of Earth.

NEXT GENERATION SCIENCE STANDARDS

Practices
1. Asking questions and defining problems
2. Constructing explanations and designing solutions
3. Engaging in argument from evidence
4. Obtaining, evaluating, and communicating information

Crosscutting Concepts
1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity

DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
	Physical Science								
PS1	Matter and Its Interaction	n/a	n/a		n/a	n/a			
PS2	Motion and Stability: Forces and Interactions		n/a	n/a		n/a			
PS3	Energy		n/a	n/a	n/a				
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	n/a		n/a		
	Life Science								
LS1	From molecules to organisms: Structures and processes			n/a					
LS2	Ecosystems: Interactions, Energy, and Dynamics	n/a	n/a			n/a			
LS3	Heredity: Inheritance and Variation of Traits	n/a		n/a		n/a	n/a		
LS4	Biological Evolution: Unity and Diversity	n/a	n/a			n/a	n/a		
	Earth & Space Science								
ESS1	Earth's Place in the Universe	n/a	✓		n/a		✓	✓	
ESS2	Earth's Systems		n/a						
ESS3	Earth and Human Activity		n/a	n/a					
	Engineering, Technology, and Applications of Science								
ETS1	Engineering Design							✓	

Thank you to NASA for making the *Lenses on the Sky* project possible!

The material contained in this activity is based upon work supported by the National Aeronautics and Space Administration (NASA) under grant award Number NNX15AB03G. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NASA.

Chichén Itzá

Location: Pyramid of Kulkulkan (El Castillo). Chichen Itza lies about midway between the towns of Cancun and Merida on the Yucatán Peninsula in Mexico.

Alignments: This square-based, stepped pyramid is approximately 75 feet tall and was constructed by the Mayans around 1000–1200 CE. The diagonal lines that run through the northwest and southwest corners of the pyramid are oriented toward the rising point of the Sun at the summer solstice and its setting point at the winter solstice. The pyramid is unique among all known pyramids worldwide for its central role in a dramatic shadow and light display during the equinoxes. At the appointed hour, the setting Sun casts a shadow of a serpent writhing down the northern steps of the pyramid. Each face of the pyramid has a stairway with ninety-one steps, which, together with the shared step of the platform at the top, add up to 365, the number of days in a year.

Content adapted from
http:// Sunearthday.nasa.gov/2005/locations/chichen_itza.htm

Chichén Itzá

Ubicación: Pirámide de Kulkulkan (El Castillo). Chichén Itzá queda a mitad de camino entre Cancún y Mérida en la Península de Yucatán en México.

Alineación: Esta pirámide de peldaños tiene una base cuadrada, mide aproximadamente 23 metros (75 pies) de alto y fue construida por los Maya alrededor de los años 1.000-1.200 d. C. Las líneas diagonales que pasan a través de las esquinas del noroeste y sudoeste de la pirámide miran hacia el punto donde sale el sol en el solsticio de verano y el punto donde se pone en el solsticio de invierno. La pirámide es única y reconocida en el mundo entero por su rol en un dramático espectáculo de luces durante los equinoccios. A la hora indicada, en la escalera del norte, la puesta de sol proyecta la sombra de una serpiente que desliza hacia la base de la estructura. Cada lado de la pirámide tiene una escalera con 91 peldaños. Si a esas cuatro escaleras se le suma la plataforma compartida en la cúspide, veremos que los peldaños suman 365 –el número de días en un año.

Contenido adaptado de:
http://Sunearthday.nasa.gov/2005/locations/chichen_itza.htm

Nabta Playa

Location: A large basin known as Nabta Playa, located about 100 kilometers west of the village of Abu Simbel near the border between Egypt and Sudan.

Alignments: Nabta Playa is between 6,000 and 6,500 years old and appears to have been constructed by nomadic cattle herders living in southern Egypt. The complex isn't circular like Stonehenge. It is 1.3 by 2.9 kilometers (0.8 by 1.8 miles) in size. It includes 10 slabs roughly 2.5 meters (9 feet) high, 30 rock-lined ovals, nine burial sites for cows, each under a pile of 40 to 50 rocks weighing up to 140 kilograms (300 pounds) each, and a "calendar circle" of stones. Many of these features line up in five radiating lines, one of them running east to west. There is also a section called a “calendar circle” that is a 3-meter (12-foot)-wide arrangement of slabs about 45 centimeters (18 inches) long, most of them lying down. Because Nabta Playa lies near the Tropic of Cancer, at noon the Sun is directly overhead (i.e., at the “zenith”) about three weeks before and three weeks after the summer solstice. During this time interval, upright objects do not cast shadows. For many cultures along the equator, the zenith Sun has been an important event for thousands of years.

Content adapted from
http:// Sunearthday.nasa.gov/2005/locations/egypt_stone.htm

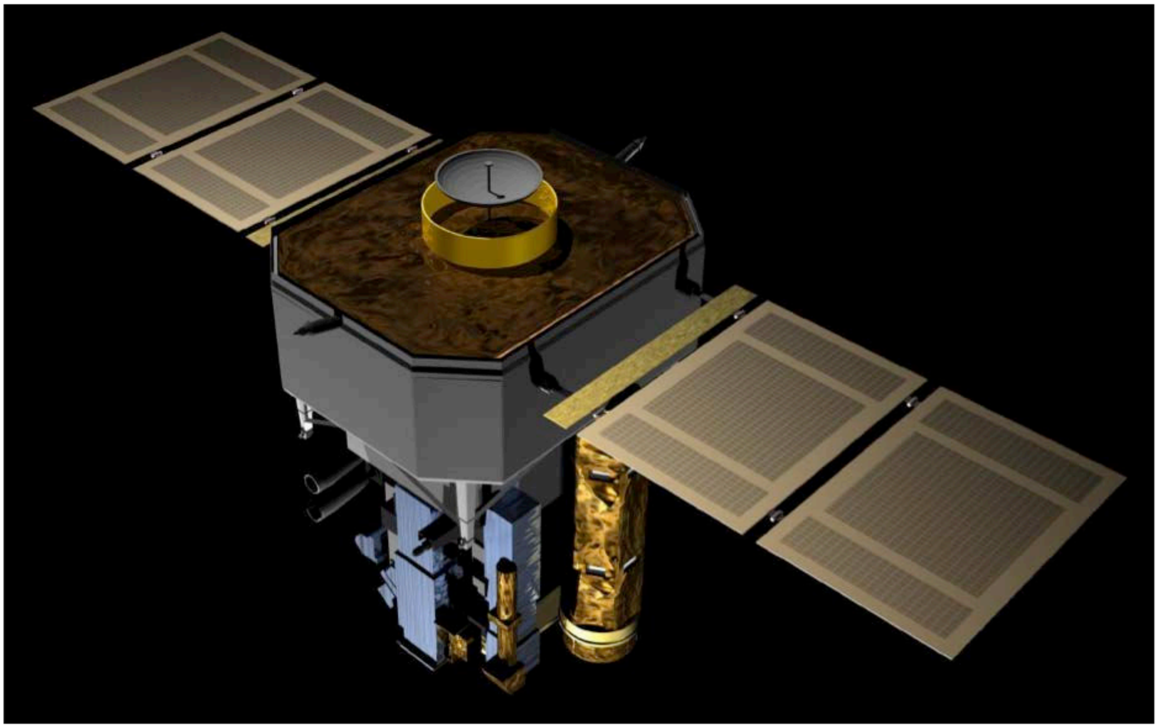
Nabta Playa

Ubicación: Una gran cuenca conocida como Nabta Playa, ubicada a 100 kilómetros hacia el oeste del pueblo Abu Simbel, cerca de la frontera entre Egipto y Sudán.

Alineación: Nabta Playa tiene entre 6.000 y 6.500 años, y parece haber sido construida por pastores nómades viviendo en el sur de Egipto. Este complejo de 1,3 x 2,9 kilómetros (0,8 x 1,8 millas) no tiene forma circular como Stonehenge en el Reino Unido. Contiene diez bloques de 2,5 metros (9 pies) de alto, 30 formaciones ovaladas de rocas, 9 sepulturas para vacas (cada sepultura bajo un amontonamiento de 40-50 rocas que pesan hasta 140 kilos (300 libras) cada una), y un "calendario circular" de piedras. Muchos de estos elementos se alinean en cinco líneas radiales, una de ellas de este a oeste. También hay una sección llamada el "calendario circular" –un arreglo de 3 metros (12 pies) de ancho con bloques de 45 centímetros (18 pulgadas) de largo, en su mayoría acostados. Como Nabta Playa queda cerca del Trópico de Cáncer, al mediodía el Sol está directamente encima (en su "zénit") aproximadamente tres semanas antes y tres semanas después del solsticio de verano. Durante este intervalo de tiempo, objetos en posición vertical no proyectan sombra. Para muchas culturas a lo largo del Ecuador, el zénit del Sol ha sido un evento importante durante miles de años.

Contenido adaptado de: http://
Sunearthday.nasa.gov/2005/locations/egypt_stone.htm

Solar & Heliospheric Observatory

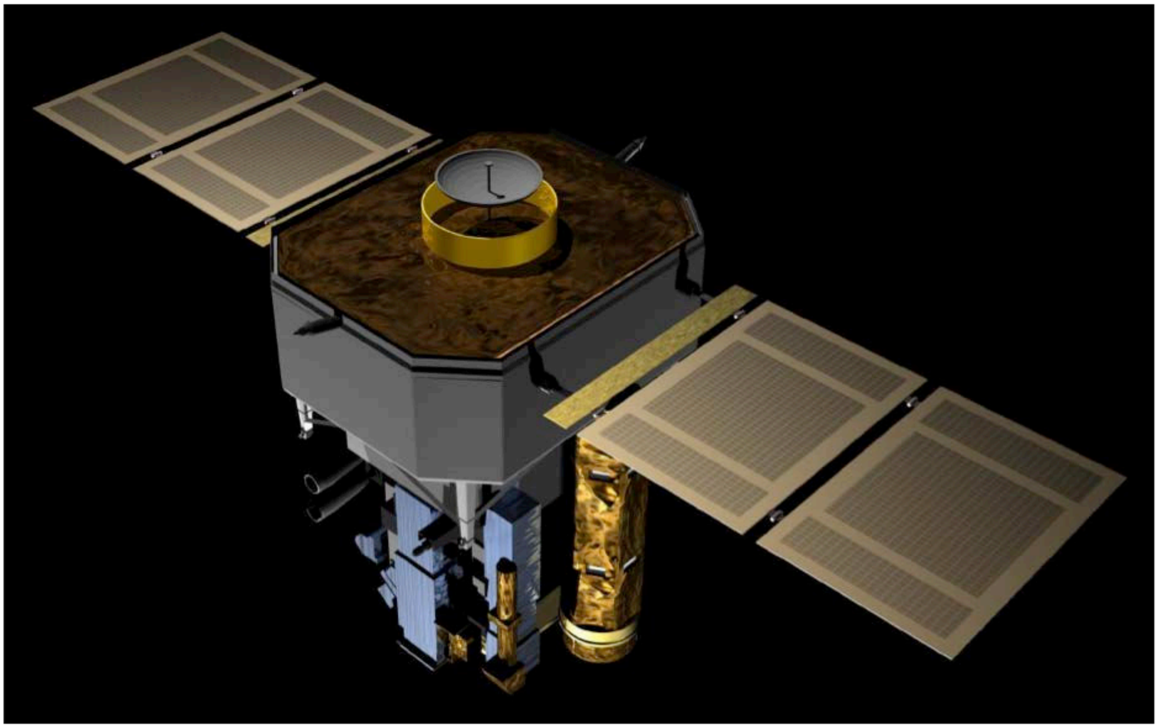


Location: NASA's Solar and Heliospheric Observatory (SOHO) is a remotely operated spacecraft that is positioned 1.5 million kilometers (0.9 million miles) away from Earth in the direction of the Sun.

Research: SOHO contains 12 instruments that monitor the Sun on a minute-by-minute basis. It is designed to study the internal structure of the Sun, its extensive outer atmosphere and the origin of the solar wind, the stream of gas that blows continuously outward from the Sun and into the solar system. SOHO is helping us understand how the Sun affects life on.

Content adapted from http:// Sunearthday.nasa.gov/2005/locations/soho.htm

Observatorio Solar y Heliosférico



Ubicación: El Observatorio Solar y Heliosférico de NASA (SOHO por sus siglas en inglés) es una nave espacial operada remotamente que está ubicada a 1,5 millones de kilómetros (0,9 millones de millas) de la Tierra en dirección al Sol.

Investigación: SOHO contiene doce instrumentos que monitorean el Sol cada minuto. Está diseñado para estudiar la estructura interna del Sol, su extensa atmósfera exterior y el origen del viento solar –un flujo de gas que sopla continuamente desde el Sol y hacia el sistema solar. SOHO nos está ayudando a entender cómo el Sol afecta la vida en la Tierra.

Contenido adaptado de: http:// Sunearthday.nasa.gov/2005/locations/soho.htm

Everyday Encounters with Science

Star Quilts

Program Type: Demonstration or Classroom Program	**Audience Type:** Grade 2–adult

Description: Students learn the cultural significance of star quilts for Native peoples of the Northern Plains. Then, students create and dedicate their own geometric star quilt pattern.

Topics: Sky-watching, astronomy, Native American culture, art, patterns

Process Skills Focus: Creativity, pattern awareness.

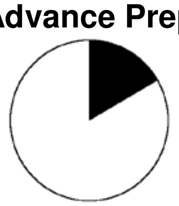
LEARNING OBJECTIVES

For Next Generation Science Standards alignment, see end of outline.

- The night sky is a source of inspiration for artists.
- Native peoples create star quilts to honor their cultural heritage and people in their communities.
- Smaller shapes can be arranged to make larger shapes.

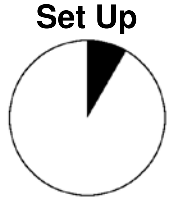
TIME REQUIRED

Advance Prep



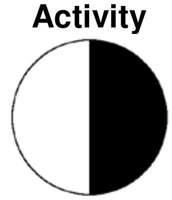
10 minutes

Set Up



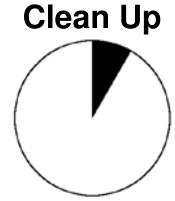
5 minutes

Activity



30 minutes

Clean Up



5 minutes

SITE REQUIREMENTS

- Table or other flat surface
- Chairs (optional, but helpful for elderly or young audiences)

PROGRAM FORMAT

Segment	Format	Time
Introduction	Large group discussion	10 min
Star Quilts	Individual activity	15 min
Wrap-up	Large group discussion	5 min

SUPPLIES

Major Consumables	Amount	Notes
Star quilt coloring sheet and handout printed back-to-back	1/student	At the end of this document
Colored pencil sets	1/student	

ADVANCE PREPARATION

- Sharpen the colored pencils, if necessary
- Familiarize yourself with star quilts by reading over the handout
- Prepare a sample star quilt

SET UP

Give each student a star quilt coloring sheet and handout printed back-to-back.

INTRODUCTION

Let students speculate before offering answers to any questions. The answers given are provided primarily for the instructor's benefit.

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics*.

Who has a quilt or bedspread on their bed at home? What is on it?

Cartoon characters, flowers, etc.

Show the example of the star quilt and pattern on handout.
Has anyone ever seen a quilt that looks like this?
Yes, I got one when I was a baby. No.

We are going to learn about these star quilts today.

Depending on the level of the class, have students read the handout or read the content to them.

What communities make star quilts? What part of North America do these communities come from?
Native Americans in the Northern Plains.

What is does the star on the quilt represent?
The Morning Star, Venus.

Why do you think that the Morning Star is used as a symbol on the quilts? What does it represent?
*New beginnings. A special time in one's life. New experience*s.

What symbols represent new beginnings for you?
The Sun rising. Babies. A blank piece of paper. A blossom.

How did the tradition of star quilts come about?
Native people of the Northern Plains didn't have buffalo hides for blankets anymore. They learned to sew quilts at boarding school. They wanted to keep their traditions of giving important gifts.

The Plains people adapted to a very difficult situation. The bison were gone. But the people were resilient—they found new ways to continue living and maintain their culture. They used sewing skills and cloth to create blankets with the old theme of the Morning Star to share at honoring and Give Away Ceremonies.

How are star quilts important to Native peoples today?
They help them connect with their traditions and cultures. They give them to people when important events happen in their lives.

Even though their way of life has changed, Native peoples are still here today and adapting traditions to modern situations.

What objects have special meaning for your family and community?
We have old things from my grandparents like wedding rings and furniture. We have things that are important for our religion (cross, altar, books). When people get married, we make them a quilt too.

How do you honor people in your community?
We honor our parents on Mothers' and Fathers' Day with presents and cards. We honor veterans on Veterans' Day and Memorial Day with parades and medals.

INDIVIDUAL ACTIVITY

Star Quilts

15 minutes

Who would you like to honor with a star quilt?
Mom, dad, grandma, teacher.

Write your name and the name of the person you would like to honor on the back of the handout in the spaces provided.

Now, think of four colors that you want to use that remind you of that person. For example, if I wanted to honor my mom, I might choose #1 to be red to remind her of my love.

What are some examples of colors you want to use and their meaning?
Brown for my sister's eyes. Green for nature that reminds me of camping with my grandpa.

Color in the sample boxes with the colors you want to use. Write what the color symbolizes or reminds you of on the line.

Now notice that the quilt squares together make a design. When you quilt, you use a series of small shapes to make a larger shape and pattern.

What other situations can you think of where we take individual pieces and make something different when we put them together?
Beading, cooking, a community of people.

What is the name of the small shape?
A rhombus.

What shape do they form together?
An eight-pointed star.

Are there other shapes that form as you color in certain boxes?
Larger rhombuses, arrow points, smaller stars.

For older students, take the opportunity to do some math practice.

If you were really going to quilt your pattern, you would have to cut out and arrange the pieces like Valerie Nelson talks about doing with her grandma. So, let's figure out how many of each piece you'd need.

How many rhombuses are there in total?
128

How many of each color does your pattern have?
#1=16
#2=32
#3=48
#4=32

Can you find two (or three) different ways to calculate this number?
Count each square.
Count how many are in each larger rhombus and multiply by 8.
Count how many are in each circle of rhombuses then add together the circles with the same number.

What fraction of your star is color 1? Color 2? Color 3? Color 4?
#1=16/128=1/8
#2=32/128=2/8=1/4
#3=48/128=3/8
#4=32/128=2/8=1/4

Instruct the students to color in their star quilts.

WRAP-UP

5 minutes

Ask for student observations. There is no correct answer. Let students guide the discussion and present their hypotheses before discussing explanations.

Ask each student to share his or her star quilt with a partner. The students should explain who their star quilt honors and what the colors mean.

Ask the students with a show of hands who they honored: parent, friend, grandparent, teacher, others?

Discuss.
What makes that person special?

How do you feel when you get to honor someone important to you?

CLEAN UP

- Return the colored pencils to their boxes.

OPTIONAL EXTENSIONS

For older students: Instruct them to write a letter to the person they are honoring to accompany their star quilt.

RESOURCES

Education guide from the Smithsonian National Museum of American Indian exhibit about Native American quilters and quilts.
http://nmai.si.edu/sites/1/files/pdf/education/quilts.pdf

GLOSSARY

Rhombus	A geometric shape with four sides of equal lengths. The angles of a rhombus do not have to have right angles (think of a squashed square).
Star quilt	A blanket made out of geometric pieces sewn together to make a star pattern. Native people from the Northern Plains often give the quilts to honor somebody at an important time in their life or at Give Away Ceremonies.

NEXT GENERATION SCIENCE STANDARDS

Practices
1. Using mathematics and computational thinking
2. Obtaining, evaluating, and communicating information

Crosscutting Concepts
1. Patterns
2. Scale, proportion, and quantity

DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
Physical Science									
PS1	Matter and Its Interaction	n/a	n/a		n/a	n/a			
PS2	Motion and Stability: Forces and Interactions		n/a	n/a		n/a			
PS3	Energy		n/a	n/a	n/a				
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	n/a		n/a		
Life Science									
LS1	From molecules to organisms: Structures and processes			n/a					
LS2	Ecosystems: Interactions, Energy, and Dynamics	n/a	n/a			n/a			
LS3	Heredity: Inheritance and Variation of Traits	n/a		n/a		n/a	n/a		
LS4	Biological Evolution: Unity and Diversity	n/a	n/a			n/a	n/a		
Earth & Space Science									
ESS1	Earth's Place in the Universe	n/a	✔		n/a		✔		
ESS2	Earth's Systems		n/a						
ESS3	Earth and Human Activity		n/a	n/a					
Engineering, Technology, and Applications of Science									
ETS1	Engineering Design								

Thank you to NASA for making the *Lenses on the Sky* project possible!

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Create Your Own Star Pattern

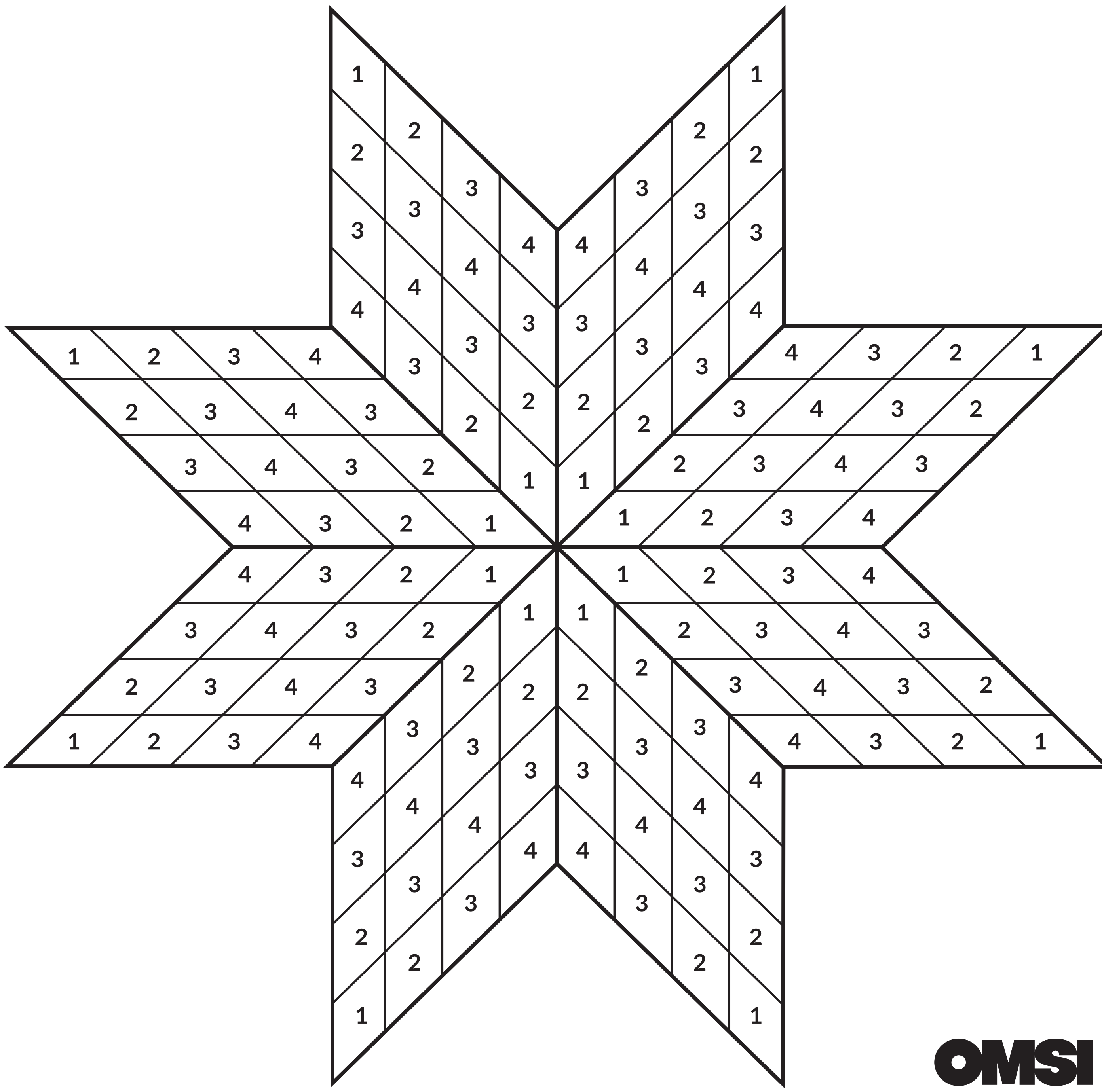
Your Name :____

Who are you honoring? :____

Choose four colors and color the rhombuses below. What do the colors mean to you? :

◇ 1 = ____________________________ ◇ 3 = ______________________________

◇ 2 = ____________________________ ◇ 4 = ______________________________



OMSI

Under a Blanket of Stars

Native quilters honor tradition and change with the Morning Star

The Morning Star Welcomes a New Day

The planet Venus is the bright "Morning Star" that we often see shining in the East at dawn. For many Native Americans from the Northern Plains, the Morning Star represents the gift of a new day.

Honoring and Giveaways

People give star quilts to commemorate important life events such as births, marriages, graduations, and veterans returning from war. Most importantly, star quilts are always part of Sioux Give-Away Ceremonies.

Star Quilts Adapt and Continue Tradition

Before quilts, Native women from the Northern Plains decorated bison hides for Honoring and Give Aways. In the nineteenth and early twentieth centuries, European settlers decimated bison populations. The US government also forced many Native children to attend boarding schools that banned traditional activities and taught domestic skills, like sewing.

Despite the devastating losses, Plains people found ways to adapt and maintain their culture. Women began making star quilts out of necessity to help replace scarce bison hides, to honor their traditions, and for gift giving ceremonies.

"I learned to quilt from my Grandmother when I was twelve years old. I would cut out the pieces and arrange the color palette. After she passed away, I continued the tradition of star quilting. I was able to create the Star in this Dakota Star Shawl."

"Tóhan waníyetu akémanunpa k´un héhan Unci, wicháhpi owínza kahmák hiye. Hanké kin bluksáksa nahán oówa kin hená khichánwaye. Ohákab swupi él ún, wakága owákihi. T´á ehánl wacháhpi owínza wichóh´ an kin otháwaphe wicháhpi sinákaswupi."

Valerie Nelson (Dakota/Lakota), Quilter and PPS Indian Education Community Agent

Thank you to PPS Indian Education!

OMSI would like to thank PPS Indian Education staff Sunshine Guzman (ShoshoneBannock), Karen Kitchen (Osage), and Valerie Nelson (Dakota/Lakota) for sharing their time and expertise to make this project happen.

Crea tu propio diseño de estrella

Tu nombre: ____

¿A quién deseas honrar?:____

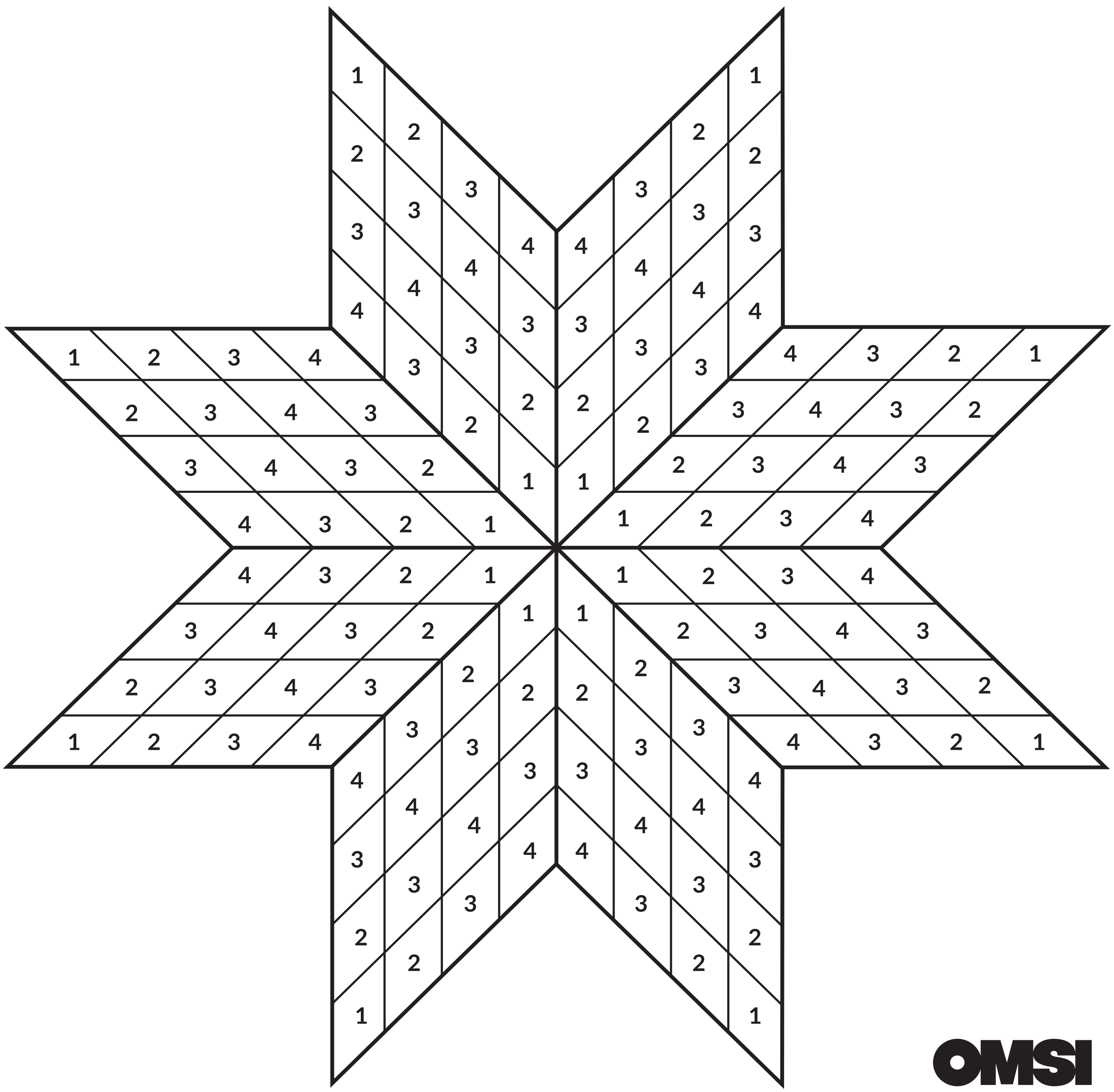
Elige cuatro colores y colorea los rombos debajo. ¿Qué representan los colores para ti?:

1 = ____________________________

3 = ______________________________

2 = ____________________________

4 = ______________________________



Bajo un manto de estrellas

Con el lucero del alba, los bordadores indígenas rinden homenaje a la tradición y al cambio.

El lucero del alba marca el inicio de un nuevo día

El planeta Venus es "el lucero del alba" que frecuentemente vemos brillando hacia el este al amanecer. Para muchos nativo americanos de las llanuras del norte, el lucero del alba representa el regalo de un nuevo día.

Honores y regalo

La gente regala mantas para celebrar eventos importantes en la vida de alguien, como nacimientos, matrimonios, graduaciones y el retorno de veteranos de guerra. Principalmente, las mantas de estrellas siempre son parte de las ceremonias de obsequios de Sioux.

Las mantas de estrellas se adaptan y continúan con la tradición

Antes de las mantas, las mujeres indígenas de las llanuras del norte decoraban pieles de bisonte para honores y regalos. En el siglo 19 y a comienzos del siglo 20, los colonizadores europeos arrasaron con la población de bisontes. El gobierno de los Estados Unidos también obligó a muchos niños indígenas a asistir a internados en donde las actividades tradicionales indígenas estaban prohibidas, y en lugar de ellas enseñaban oficios domésticos, como la costura.

A pesar de las devastadoras pérdidas, la gente de las llanuras halló forma de adaptar y mantener su cultura. Las mujeres comenzaron a hacer mantas estrelladas por necesidad, para reemplazar las escasas pieles de bisonte, con el fin de rendir homenaje a sus tradiciones y para las ceremonias de obsequios.

"Mi abuela me enseñó a bordar cuando tenía doce años. Cortaba las piezas y las arreglaba según la gama de colores. Cuando ella falleció, yo seguí la tradición de bordados estrellados. Pude crear la estrella en esta manta estrellada de Dakota."

"Tóhan waníyetu akémanunpa k´un héhan Unci, wicháhpi owínza kahmák hiye. Hanké kin bluksáksa nahán oówa kin hená khichánwaye. Ohákab swupi él ún, wakága owákihi. T´á ehánl wacháhpi owínza wichóh´ an kin othάwaphe wicháhpi sinákaswupi."

Valerie Nelson (Dakota/Lakota), bordadora y agente comunitaria de educación indígena en las escuelas públicas de Portland

¡Gracias a la educación indígena de las escuelas públicas de Portland!

OMSI quiere agradecer también al personal docente del programa, Sunshine Guzman (Shoshone-Bannock) y Valerie Nelson (Dakota/Lakota) por compartir con nosotros su tiempo y sus conocimientos para hacer de este proyecto una realidad.

Stories of the Moon

Program Type: Demonstration or Classroom Program	**Audience Type:** Grade K–8

Description: Students investigate the stories and pictures that different cultures have used to describe the Moon. Students also conduct activities to explore the scientific principles embedded in the cultural stories that explain the Moon's relationship to the Earth and the Sun.

Topics: Moon, astronomy, culture, sky

Process Skills Focus: Critical thinking, observing.

LEARNING OBJECTIVES

For Next Generation Science Standards alignment, see end of outline.

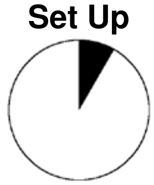
- People from many cultures have made keen observations of the Moon that help us understand the Moon's relationship to the Earth and the Sun.
- Different cultures have viewed and understood the Moon in different ways.

TIME REQUIRED

Advance Prep

10 minutes

Set Up

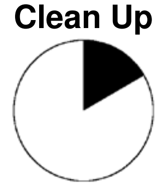


5 minutes

Activity

Flexible: 10–105 minutes total

Clean Up



10 minutes

SITE REQUIREMENTS

- Standard size classroom
- Desks or tables with chairs
- The presence of at least one adult

PROGRAM FORMAT

There are six different activities described in this lesson plan. You can discuss all six images and complete the activities in a row. Or you can spread them out by doing one or two a day for several days. Estimated activity times and appropriate grade levels are provided for each activity.

Segment	Format	Grades	Time
Introduction	Large group discussion	All	10 min
Egyptian Boat Activity	Instructor-led activity	3-6	15 min
Maya Rabbit Activity	Instructor-led activity	K-3	10 min
Maya Hero Twins Activity	Instructor-led activity	4-8	15 min
Islamic Illustration Activity	Instructor-led activity	3-7	15 min
Chinook Frog Activity	Small group activity	4-8	15 min
Native American Turtle Activity	Instructor-led activity	4-8	15 min
Wrap-up	Large group discussion		10 min

SUPPLIES

Permanent Supplies	Amount	Notes
Box of colored pencils	1 box/student	For all activities
Printouts of Moon phases	1 set	For Egyptian Boat Activity, included at end of document
Marbles	1 for every 4 students	For Maya Hero Twins Activity
Exercise ball	1	For Maya Hero Twins Activity
Flashlights	1 for every 4 students	For Islamic Astronomy and Chinook Frog Activities
Balls (about 3–4” in diameter; can use tennis balls, softballs, foam balls, etc.)	1 for every 4 students	For Islamic Astronomy and Chinook Frog Activities
Book: <u>Thirteen Moons on Turtle’s Back: A Native American Year of Moons</u> by Joseph Bruchac	1	For Native American Turtle Activity

Major Consumables	Amount	
Coloring sheets (6 different sheets)	1 set/student	For all activities, included at end of document

ADVANCE PREPARATION

- Print out the Moon phases (1 set for the entire class) and the coloring sheets (each student should receive 6 different sheets)
- Sharpen the colored pencils, as necessary
- Check that the flashlights have functional batteries

SET UP

Place the colored pencils and coloring sheets on each student's desk.

INTRODUCTION

10 minutes

Let students speculate before offering answers to any questions. The answers given are provided primarily for the instructor's benefit.

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics.*

Take a look at the different pages in front of you. Some might look confusing but examine them closely. **Can you guess what sky object is depicted in all of the coloring sheets?**
The Moon.

People from many cultures have made keen observations of the Moon including recording eclipses, tracking Moon phases, and pondering why these things happen. These observations are reflected in the stories and pictures people share about the Moon.

NOTE: If you want, the activity can simply be about looking at the pictures and discussing how different cultures have understood the Moon. During the discussion, stress that people from different cultures noticed that the Moon's phases had patterns that could be observed and predicted. Then, students can color the sheets.

For older students: Have students read the quotations from scholars discussing the Moon and how different peoples have interpreted this celestial body. Ask them what keen observation of the Moon is included in that culture's understanding. The activities below give more details about the cultures and images to incorporate into your discussion. Then, encourage students to incorporate their own ideas and insights as they color the sheets.

INSTRUCTOR-LED ACTIVITY

Egyptian Boat Activity

15 minutes

Does anyone know what culture this image comes from?
Ancient Egypt in Northern Africa

The ancient Egyptians in Northern Africa were very keen observers of the sky. What do you think this image shows us about what they knew about the cycles of the Moon?
They noticed that the Moon changed shape. That the Moon moved through the night. They thought the different versions of the Moon were gods or goddesses.

They noticed that the Moon changed shape each night and that the number of nights made a predictable pattern. Do you know how many nights it takes for the Moon to make a complete cycle from full moon to full moon?
29.5 days

The time between full moons is 29.5 days. In the middle of that cycle, the Moon disappears. This phase is called a "new" Moon.

But how many gods or goddesses are on the picture in the Moon?
14

Why only 14 if there are 29 days in the Moon's cycle?
It only shows the 28 days that the Moon is visible, not the New Moon when it disappears.

The ancient Egyptians associated each night's shape with a

specific god or goddess. There are 14 “ascending” gods/goddesses for the days when the Moon is getting larger (waxing), and 14 “descending” gods/goddesses for the days when the Moon is shrinking (waning).

Hand out the Moon phase sheets in a random order. Instruct the students to line up in the correct order as the Moon transitions from new Moon to full Moon and back to new Moon. For older students, remove the numbers and see if they can just use the shapes to order the pictures.

Raise your hand if the Moon phase you are holding is ascending or getting bigger?
#2–14 are ascending

What is that called again?
Waxing

Raise your hand if the Moon phase you are holding is descending or getting smaller?
#16–29 are descending

What is that called?
Waning

What about #1 where there is no Moon? What is that called?
New Moon

Have students color their sheets and incorporate their Moon phase into their decorations.

INSTRUCTOR-LED ACTIVITY

Maya Rabbit Activity

10 minutes

Does anyone know what culture this image comes from?
Maya

What do you think this image is of?
The Moon goddess holding a rabbit.

Maya people in Mexico and Central American sometimes refer to the Moon as a goddess holding a rabbit.

Why do you think the Moon would be like a rabbit?
It moves. It grows fast.

The relationship between the rabbit and the Moon has two meanings. First, because the Moon rises on a different place on the horizon every night, it looks as if it is hopping like a rabbit. This is different than the Sun, which moves very slowly along the horizon throughout the year.

Have the class get up and stand at the front of the room. Students pretend to be the Sun by walking very slowly along the horizon (edge of the room). Then, they can hop like rabbits to be the Moon every night coming up in a different place on the horizon.

The Maya are keen observers of nature in many ways. They also noticed that the Moon takes 29.5 days to go from a new Moon (one you can't see) to a full Moon and back to a new Moon. 29.5 days is also how long a rabbit is pregnant before it has babies!

Have students color their Maya coloring sheet.

INSTRUCTOR-LED ACTIVITY

Maya Hero Twin Activity

15 minutes

Does anyone know what culture this image comes from?
Maya in Mexico and Central America

What does the picture represent?
The Maya Hero Twins. One is the Sun and one is the Moon.

Why do you think the Maya might think of the Sun and Moon as twins?
Because they are both in the sky. They look like they are the same size.

From Earth, the Sun and Moon appear the same size, almost like twins in the sky. Are the Sun and the Moon really the same size?
No, the Sun is really big, and the Moon is smaller.

Then why do they look like they are the same size?
Because the Moon is close and the Sun is far away.

This phenomenon of the Sun and Moon looking the same size is very special. Even though the Moon is much smaller than the Sun, it is at just the right distance to look the same size as the Sun, which is much farther away.

Hand out the marbles to students. Hold up the exercise ball.

Which is bigger? Which would be the Moon versus the Sun?
The exercise ball is bigger. It would be the Sun. The marble is small like the Moon.

How can we make the marble and the ball look the same size?
By moving them marble closer and the ball farther away.

See if you can make the marble look the same size as the exercise ball by moving the marble close to your eye while moving the exercise ball far away.

In reality, the exercise ball would have to be about 4.5 meters (15 feet) tall to represent the Sun if the Moon was the size of a marble. But I couldn't find a ball that big!

Are there other ways that the Sun and Moon are like brothers?
They are both objects in the sky. They interact and sometimes appear to get in each other's way during a solar eclipse.

By showing the Sun and Moon as brothers, the Maya also recognize that Moon and Sun have a close relationship. The relative position of the Moon and Sun is what creates the phases of the Moon, tides, and eclipses.

INSTRUCTOR-LED ACTIVITY

Islamic Illustration Activity

15 minutes

Does anyone know who originally made this drawing?
An astronomer from a long time ago.

The drawing and quotation are by Al-Biruni, an Islamic astronomer from the 11th century CE.

What does the picture represent?
The Moon. Eclipses. Moon phases.

What did Al-Biruni understand about how the Moon and stars are different?
The stars make light, but the Moon doesn't.

Al-Biruni's drawing illustrates an important scientific finding—the Moon does not produce its own light like stars do. Instead,

the Moon reflects the light of the Sun.

Hand out balls (white foam balls work well, but any sphere works) and flashlights to kids (about 1 of each for every 4 students).

Which of you are stars?
The students holding the flashlights.

Which of you are moons or planets?
The students holding the balls.

Can you see moons and planets if a star is not shining on them?
No

When can we see moons and planets?
When the stars shine on them from the right angle.

Al-Biruni used math and observations of the Moon to understand that the Moon wasn't glowing like a star. He and other Islamic astronomers in Central Asia, the Middle East, and North Africa made many important astronomical discoveries. Their observations and insights led to later discoveries by scientists in Europe and around the world.

[Note: In different places, the drawing is labeled as either a study of lunar eclipses or Moon phases. Ask students what they think it looks like? Remind them that during the 11th century CE, astronomers were still debating if the Sun orbited the Earth or the other way round. How would they make a drawing of what causes eclipses and the phases of the Moon?]

SMALL GROUP ACTIVITY

Chinook Frog Activity

15 minutes

Does anyone know what culture this image comes from?
Native American. Clackamas Chinook.

The Clackamas Chinook are a Native American tribe from around the Willamette Valley in Oregon.

What does the picture represent?
The Moon. Eclipses. A frog.

The Chinook story of the frog swallowing the Moon talks about lunar eclipses.

What happens during a lunar eclipse?
The Moon turns red and sometimes looks like it's disappearing.

During a lunar eclipse, it looks like something is covering or eating the Moon. This is because the shadow of the Earth is blocking the light of the Sun.

Have students get in small groups of 2–3 students each with a ball and a flashlight.

Imagine the flashlight is the Sun, the ball is the Moon, and your head is Earth.

Have one person in your group hold the flashlight as the Sun. Another can hold the ball as the Moon.

Suns—shine your flashlight on the Moon ball in your partner's hand.

Earths with the Moon—face away from the flashlight. Try to block the light of the Sun (flashlight) with the Earth (your head) to create a lunar eclipse on the Moon (your ball).

INSTRUCTOR-LED ACTIVITY

Native American Turtle Activity

15 minutes

Does anyone know what culture this image comes from?
Native Americans. Joseph Bruchac. Abenaki tribe.

There are over 500 Native American tribes, each of which has its own unique culture. This calendar doesn't come from any one tribe, but it represents something that many different cultures in North America have noticed.

What does the picture represent?
A turtle with 13 scales. The number of lunar months in a year.

For many Native people in North America, the 13 large scales on the back of a turtle track how many lunar (or Moon) cycles happen in a year.

Why would people want to track Moon cycles?
To keep track of time.

Noting the Moon cycle, or month, is a way to keep track of time using the phases of the Moon. The turtle shell acts like a lunar calendar.

How many Moon cycles are in a year?
13

How do you know? Let's find out.
How long is a year?
365 days

A full cycle of the Moon is 29.5 days, which is the amount of time it takes for the Moon to go from full to new and back to full. Using math, can you estimate how many Moon cycles fit into a year?
12–13

What is the exact number?

The lunar and solar calendars do not align perfectly—there are actually about 12.4 lunar cycles (each 29.5 days long) in each solar cycle (365.25 days). Some cultures use lunar calendars to keep track of time, and some cultures use solar calendars. Many use a combination of both.

Can you name a holiday that you are familiar with that is tied to the lunar calendar?
Easter, Ramadan (Jewish New Year), Chinese New Year

[Note: please stress with your class that all Native American communities are not the same. There are hundreds of different Native cultures, languages, and communities in North America. Interestingly, though, many of them in different regions made this same observation between the lunar calendar and the turtle's shell.]

Read: <u>Thirteen Moons on Turtle's Back: A Native American Year of Moons</u> by Joseph Bruchac as the students color their sheet.

WRAP-UP

10 minutes

Ask for student observations. There is no correct answer. Let students guide the discussion and present their hypotheses before discussing explanations.

When was the last time you looked up at the sky and saw the Moon? What did it look like? What patterns did you notice? What did the Moon make you think about?

CLEAN UP

- Put away the supplies.

OPTIONAL EXTENSIONS

- Have students research a Moon story from a culture that interests them and have them illustrate the story to share with the class.

RESOURCES

Short video about Moon phases:
https://www.youtube.com/watch?v=NCweccNOaqo

Great interactive website for youth about Maya astronomical observations:
https://maya.nmai.si.edu/the-maya/creation-story-maya

Short animated video of the Maya Hero Twins story from the Smithsonian:
https://www.youtube.com/watch?v=Jb5GKmEcJcw&feature=youtu.be&t=1m40s

GLOSSARY

Lunar eclipse	A phenomenon in which the Sun, Earth, and Moon line up in that order and the Earth blocks sunlight from hitting the Moon.
Moon	A rocky, airless body orbiting the Earth.
Solar eclipse	A phenomenon in which the Sun, Moon, and Earth line up in that order and the Moon blocks sunlight from hitting the Earth.
Sun	Our nearest star, which provides the energy necessary for life on Earth.
Waning Moon	The part of the Moon's cycle of phases in which it appears to be decreasing in size.
Waxing Moon	The part of the Moon's cycle of phases in which it appears to be increasing in size.

NEXT GENERATION SCIENCE STANDARDS

Practices
2. Developing and using models
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence

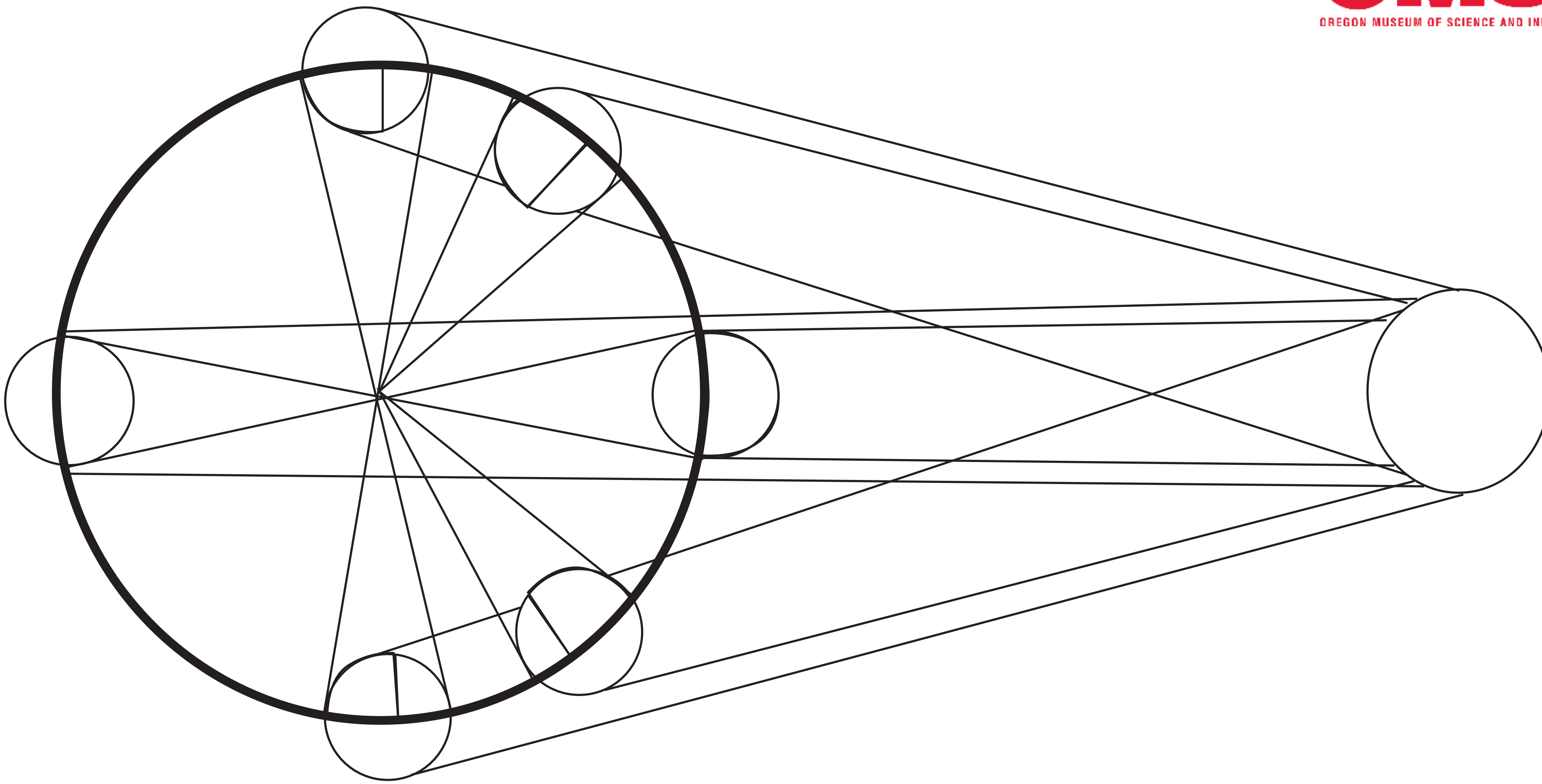
Crosscutting Concepts
1. Patterns
2. Cause and effect
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter

DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
	Earth & Space Science								
ESS1	Earth's Place in the Universe	n/a	✓		n/a		✓	✓	
ESS2	Earth's Systems		n/a						
ESS3	Earth and Human Activity		n/a	n/a					
	Engineering, Technology, and Applications of Science								
ETS1	Engineering Design								

Thank you to NASA for making the *Lenses on the Sky* project possible!

The material contained in this activity is based upon work supported by the National Aeronautics and Space Administration (NASA) under grant award Number NNX15AB03G. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of NASA.



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Islam

Why—why the increase and decrease of the light of the moon is settled while other stars don't behave so? Observing these and not understanding the spirit of these is a misdeed, that the light of the stars is of their own.

—Abū Rayḥān Al-Bīrūnī, Islamic astronomer, writing on moon phases and lunar eclipses. 11th century CE.

Islam

¿Por qué… por qué ocurre un aumento y disminución de la luz de la luna, cuando otras estrellas no se comportan así? Observar esto sin entender su espíritu es un error, ya que las estrellas producen su propia luz.

—Abū Rayḥān Al-Bīrūnī, astrónomo islámico, escribiendo sobre fases y eclipses lunares. Siglo XI d.C

Maya

The Maya people see the image of a rabbit on the face of the Moon. Rabbits hop just like the moon, which jumps forward each night as it moves through the background of the stars.

—Susan Milbrath, archaeologist.
Star Gods of the Maya: Astronomy in Art, Folklore, and Calendars. University of Texas Press, 1999.

Maya

Los mayas ven la imagen de un conejo en la cara de la luna. Los conejos brincan igual que la luna, que salta hacia adelante cada noche al moverse a través de un fondo estrellado.

—Susan Milbrath, arqueóloga. Star Gods of the Maya: Astronomy in Art, Folklore, and Calendars. University of Texas Press, 1999
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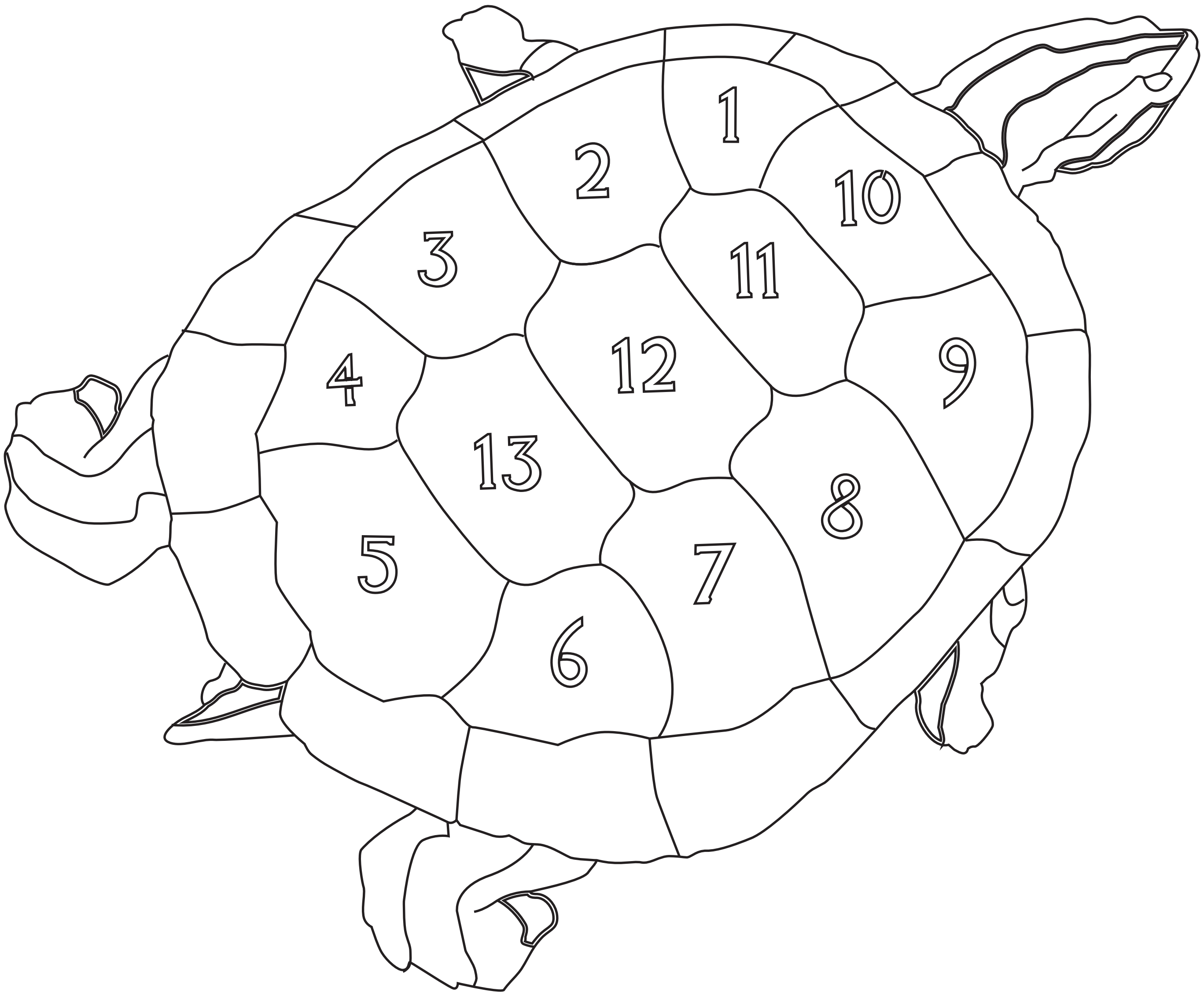


North America

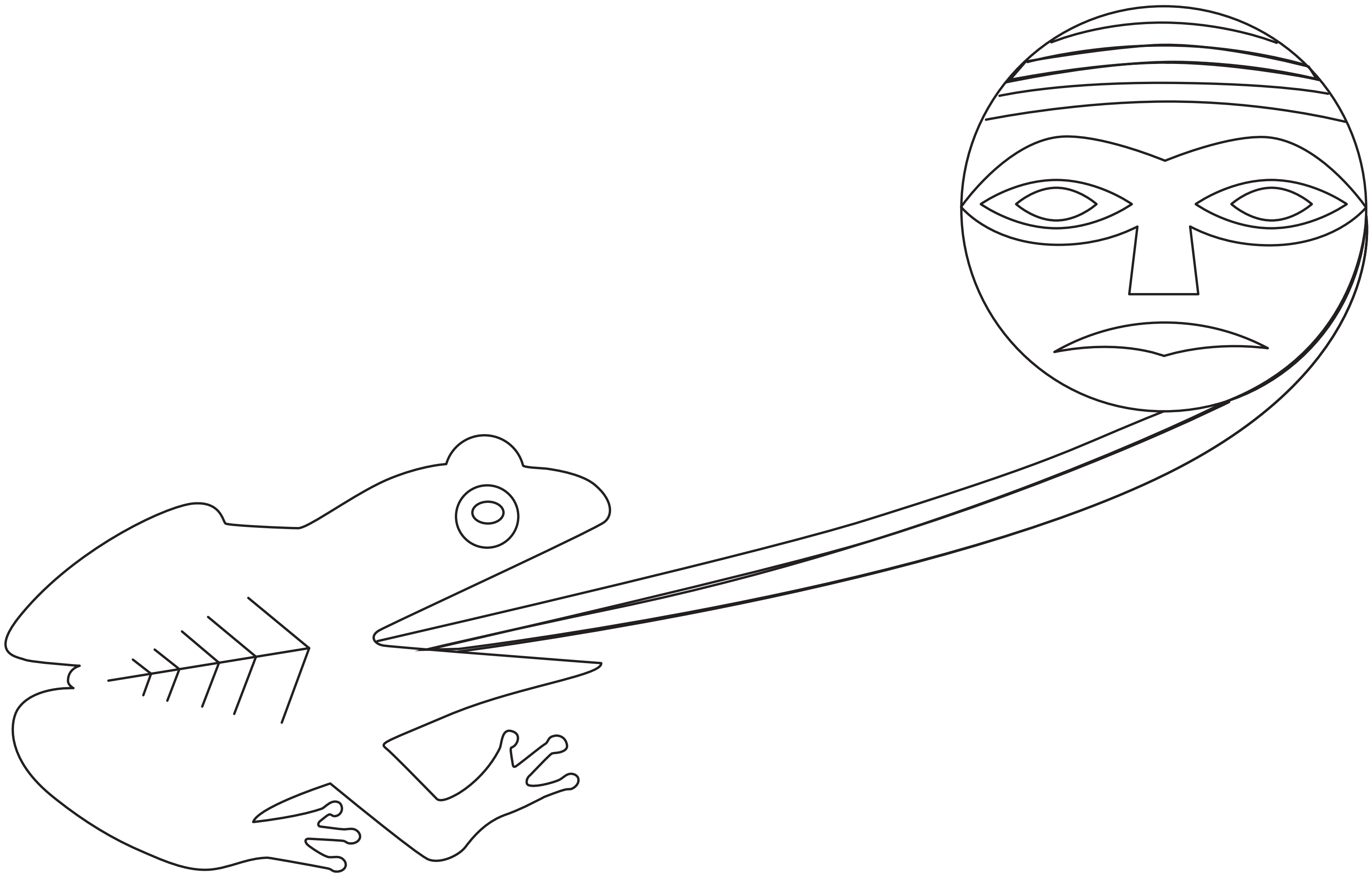
Many Native American people look at Turtle's back as a sort of calendar, with its patterns of thirteen large scales standing in for the thirteen moons in each year.

—Joseph Bruchac, storyteller and writer (Abenaki). Thirteen Moons on Turtle's Back: A Native American Year of Moons. Penguin Random House, 1992.

América del Norte

Muchos nativoamericanos ven el caparazón de una tortuga como una especie de calendario, con su diseño de trece grandes escamas representando las trece lunas del año.

—Joseph Bruchac, cuentista y autor (Abenaki). Thirteen Moons on Turtle's Back: A Native American Year of Moons. Penguin Random House, 1992.



Chinook

In an ancient story of the Clackamas Chinook, Frog had the ability to swallow the Moon, causing an eclipse. However, Coyote took away that ability because of the misdeeds of Frog and the people.

—Victoria Howard, storyteller (Clackamas Chinook). Interviewed in Clackamas Chinook Texts by Melville Jacobs. Indiana University, 1958.

Chinook

En una antigua historia de los indígenas Clackamas Chinook, Rana tenía la habilidad de tragarse la luna, lo que ocasionaba un eclipse. Sin embargo, Coyote le quitó esa habilidad a Rana debido a las fechorías de Rana y la gente.

—Victoria Howard, cuentista (Clackamas Chinook). Entrevistada en Clackamas Chinook Texts por Melville Jacobs. Indiana University, 1958.

OMSI
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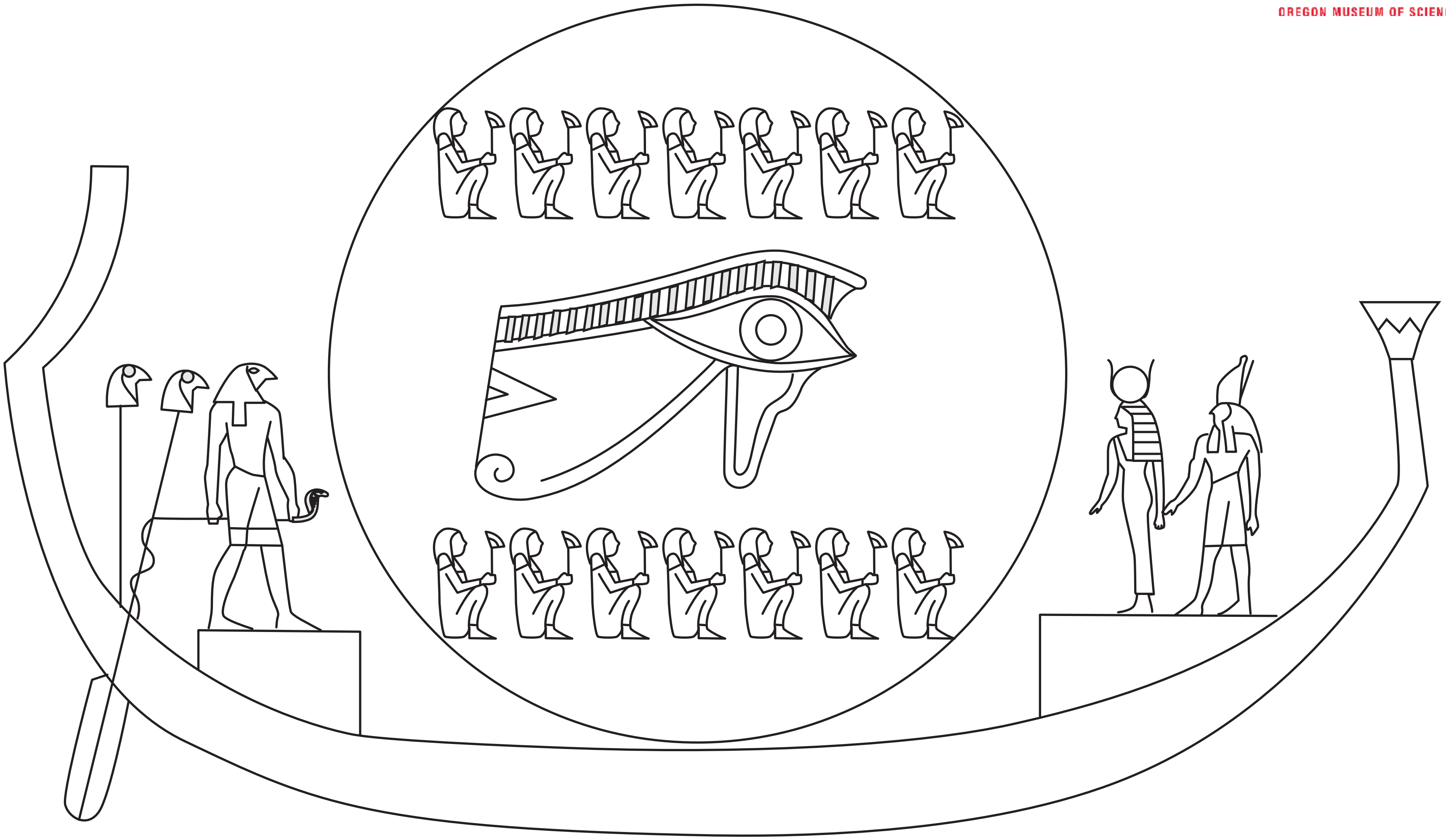

Egypt

Like many cultures, the Egyptians had watched the phases of the Moon… Osiris is associated with the Moon and attended by twenty-eight distinct gods and goddesses—fourteen ascending, fourteen descending.

—Wallace Hooper, historian of science. "The Early History of Astronomy and Cosmology," in African Cosmos: Stellar Arts. National Museum of African Art, 2012.

Egipto

Como muchas culturas, los egipcios observaban las fases de la luna… Osiris se asocia con la luna y es tendido por veintiocho dioses y diosas distintos—catorce ascendiendo y catorce descendiendo.

—Wallace Hooper, historiador de la ciencia. "The Early History of Astronomy and Cosmology"en African Cosmos: Stellar Arts. National Museum of African Art, 2012.

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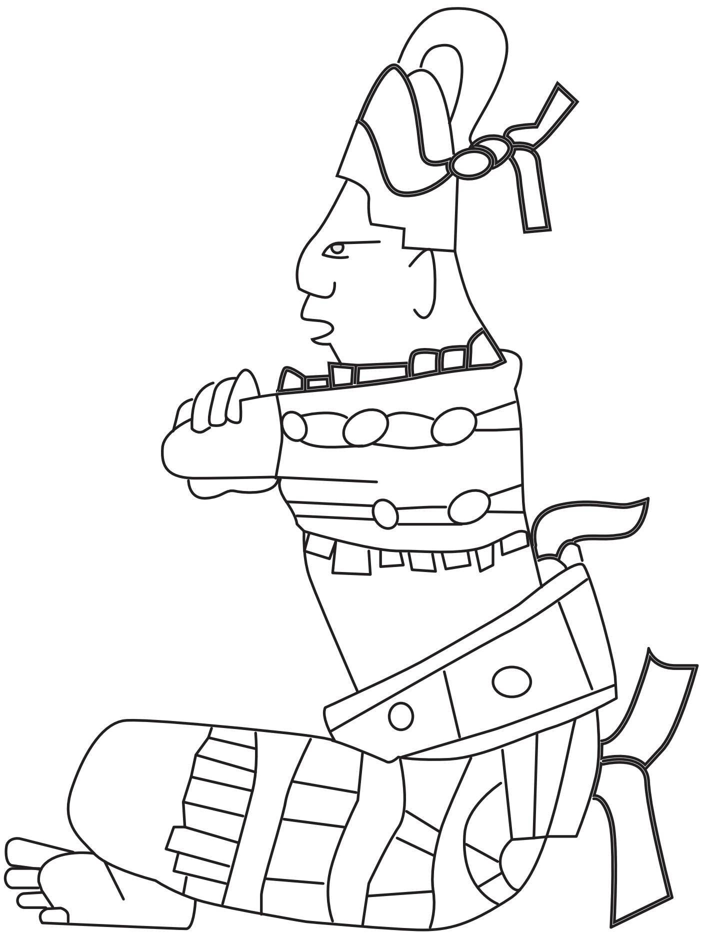

Maya

The Sun and the Moon look about the same size when seen from Earth, and because of this many traditional cultures describe them as siblings. The Maya tales say that the Hero Twins defeated the lords of death and rose into the sky to become the Sun and the Moon.

—Alonso Mendez, cultural astronomer. (Tzetzal Maya)
Personal correspondence, 2016.

Maya

El sol y la luna parecen ser del mismo tamaño cuando se observan desde la Tierra, y es por esto que muchas culturas los describen como hermanos. Los mayas dicen que los Héroes Gemelos vencieron a los dioses de la muerte y subieron al cielo para convertirse en el sol y la luna.

—Alonso Méndez, astrónomo cultural. (Tzetzal maya)
Correspondencia personal, 2016.

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Window Constellations

Program Type: Demonstration or Classroom Program	Audience Type: Grade 2–8

Description: Students create constellation-inspired artwork and learn about how different cultures perceive constellations.

Topics: Astronomy, constellations, patterns, stories, stars.

Process Skills Focus: Critical thinking, observing, design.

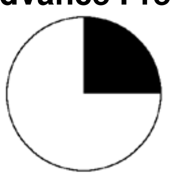
LEARNING OBJECTIVES

For Next Generation Science Standards alignment, see end of outline.

- Different cultures see different images in groupings of stars.
- There are many stories associated with constellations.

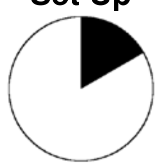
TIME REQUIRED

Advance Prep



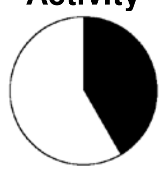
15 minutes

Set Up



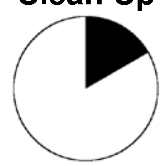
10 minutes

Activity



25 minutes

Clean Up



10 minutes

SITE REQUIREMENTS

- Chairs and tables
- Access to windows that one can easily reach

PROGRAM FORMAT

Segment	Format	Time
Introduction	Large group discussion	5 min
Window Constellations	Individual activity	10 min
Wrap-up	Large group discussion	10 min

SUPPLIES

Permanent Supplies	Amount	
Sharpened pencils	1/student	

Major Consumables	Amount	Notes
Big Dipper template	1/student	At the end of this document
Black construction paper	1/student	
Cardboard (roughly 8.5” × 11”)	1/student	Corrugated cardboard with large cells (spaces) works best
Piece of chalk (white or colored)	1/student	
Masking tape	1 roll	

ADVANCE PREPARATION

- Print out one Big Dipper template for each student.
- Sharpen the pencils, if necessary.
- Gather the cardboard, black construction paper, and chalk.

SET UP

Set out supplies where participants will be able to access them during the activity.

INTRODUCTION

Let students speculate before offering answers to any questions. The answers given are provided primarily for the instructor's benefit.

Suggested script is shaded. Important points or questions are in **bold**. Possible answers are shown in *italics*.

Hold up one of the templates. **Have you seen this group of stars in the night sky? What do people call these stars?** *The Big Dipper, the Drinking Gourd, Male Revolving One, Ursa Major.*

Some people call this group of stars the Big Dipper because it looks like a ladle.

The Navajo view these stars as the Male Revolving One. They see a man going in a circle around the central fire of his home, the North Star.

The Iroquois and some Europeans see a bear, which lead to the scientific name of Ursa Major, which means Great Bear.

Celtic stories talk of a wagon, and some European farmers describe a plough.

In the time of slavery in the United States, African American slaves sang songs about following the drinking gourd to the north, where they could be free.

The International Astronomical Union calls the Big Dipper an asterism (pronounced *aster-ism*), or smaller group of stars inside a constellation (in this case, Ursa Major).

We're now going to make constellation artwork inspired by this grouping of stars.

INDIVIDUAL ACTIVITY

Window Constellations

10 minutes

Place your piece of black construction paper on top of your piece of cardboard. Then place the Big Dipper template on top of that stack. Now, use your sharpened pencil to carefully poke a hole in the construction paper at the location of each star. It's okay if you punch into the cardboard. The holes should be big enough to let a fair amount of light through.

Once your holes are punched, remove the template page and draw a picture on the black construction paper using chalk. Your picture can be inspired by one of the cultures we talked about earlier—for example, a drinking gourd, a plough, or a bear—or you can use your imagination to draw what you see in the stars. If you make your own constellation, perhaps think about where you or your family is from or something that is important to you to inspire your ideas.

WRAP-UP

10 minutes

Ask for student observations. There is no correct answer. Let students guide the discussion and present their hypotheses before discussing explanations.

When you're finished with your drawing, write your name on the black construction paper. Ask a few students to share their constellation designs with the rest of the class.

What will you think of when you see this constellation in the sky?

Hang up the students' artwork on a window using masking tape.

CLEAN UP

- Recycle the Big Dipper templates and collect the pencils, cardboard, and chalk.

OPTIONAL EXTENSIONS

Older students can write a story to accompany their constellation.

RESOURCES

NASA video about how different cultures have interpreted different constellations
https://www.youtube.com/watch?v=Vg1-HFqt-6M

GLOSSARY

Asterism	A grouping of stars within a larger constellation.
Big Dipper	An asterism within the constellation Ursa Major.
Constellation	A grouping of stars in the sky. The International Astronomical Union defines 88 constellations.

NEXT GENERATION SCIENCE STANDARDS

Practices
1. Obtaining, evaluating, and communicating information

Crosscutting Concepts
1. Patterns

DCIs

	Disciplinary Core Idea	K	1	2	3	4	5	MS	HS
Physical Science									
PS1	Matter and Its Interaction	n/a	n/a		n/a	n/a			
PS2	Motion and Stability: Forces and Interactions		n/a	n/a		n/a			
PS3	Energy		n/a	n/a	n/a				
PS4	Waves and Their Applications in Technologies for Information Transfer	n/a		n/a	n/a		n/a		
Life Science									
LS1	From molecules to organisms: Structures and processes			n/a					
LS2	Ecosystems: Interactions, Energy, and Dynamics	n/a	n/a			n/a			
LS3	Heredity: Inheritance and Variation of Traits	n/a		n/a		n/a	n/a		
LS4	Biological Evolution: Unity and Diversity	n/a	n/a			n/a	n/a		
Earth & Space Science									
ESS1	Earth's Place in the Universe	n/a	✔		n/a		✔		
ESS2	Earth's Systems		n/a						
ESS3	Earth and Human Activity		n/a	n/a					
Engineering, Technology, and Applications of Science									
ETS1	Engineering Design								

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Big Dipper Template