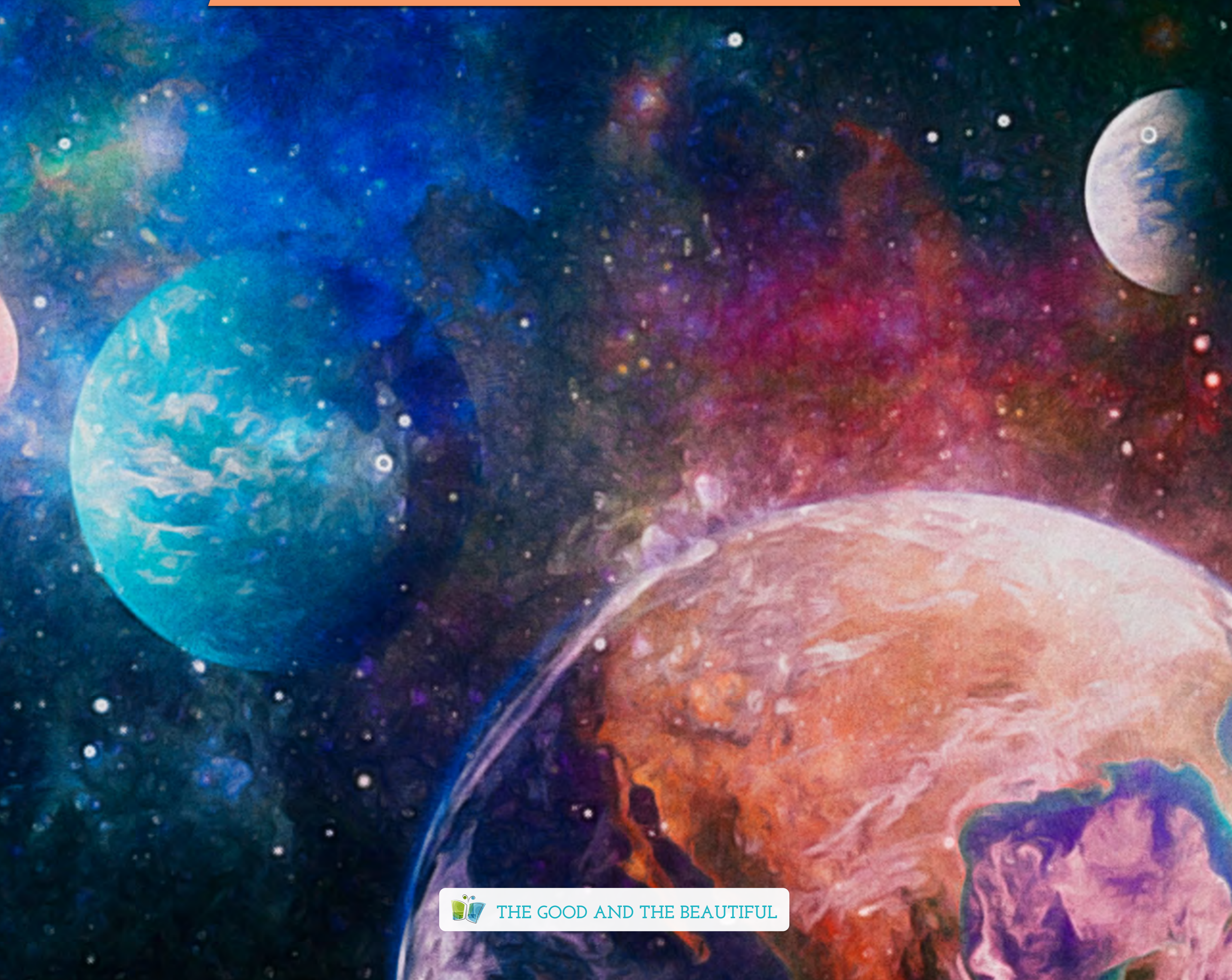
SPACE SCIENCE

3–8 Science Unit Study

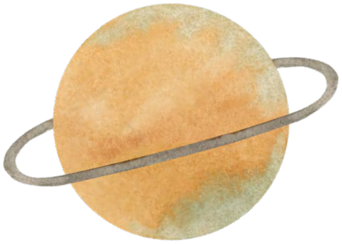


THE GOOD AND THE BEAUTIFUL

SPACE SCIENCE

CREATED BY THE GOOD AND THE BEAUTIFUL TEAM

Table of Contents



UNIT INFORMATION

Science Journal

All The Good and the Beautiful science units include activities in a student journal. Each student should have his or her own student journal, and the parent or teacher will direct the student regarding when to complete the activities in the lessons. The journal can be purchased by going to **goodandbeautiful.com/science** and clicking on the *Space Science* unit link.

Science Wall

All science units include vocabulary words to be placed on your science wall, which is a wall or trifold presentation board in your learning area on which you can attach the vocabulary words and other images. **Cut out the vocabulary word cards at the beginning of the unit.** The course will indicate when to place them on the wall.

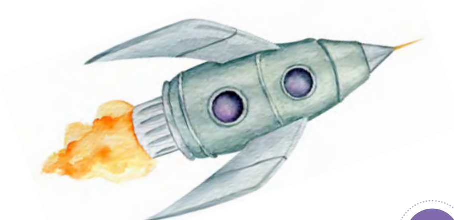
Lesson Preparation

All science units include easy-to-follow lesson preparation directions at the beginning of each lesson.

Activities

Many of The Good and the Beautiful science lessons involve hands-on activities. The *Space Science* unit features activities that involve potentially messy and/or harmful materials.

An adult should always closely supervise children as they participate in the activities to ensure they are following all necessary safety procedures.



Unit Videos

Some lessons include videos that were created by The Good and the Beautiful. Have a device available that is capable of playing the videos from **goodandbeautiful .com/sciencevideos** or from the Good and Beautiful Homeschool app.

Content for Older Children

Some lessons include extra content that is more applicable for older children (grades 7–8). Parents or teachers may choose to skip this content if instructing only younger children.

Content for Younger Children

Some lessons include extra content that is more applicable for younger children (grades 3–6). Parents or teachers may choose to skip this content if instructing only older children.

Worldview

The unit takes a general Christian worldview that supports creationism. The unit does not attempt to define how long it took God to make items in the universe, thus allowing for use by both those who believe in a young earth theory and those who believe in an old earth theory. If parents want to get into more detail on dates and time periods, they can include the doctrines specific to their own beliefs.

Versions

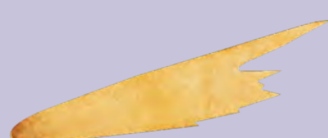
New discoveries are being made on an ongoing basis. This course is reviewed and revised periodically to keep information as up to date as possible. This version is the third edition of this unit.

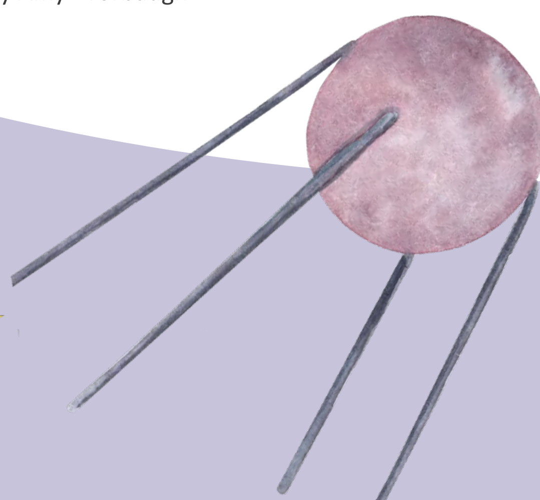
READ-ALOUD BOOK PACK

The two books below are optional read-aloud books that complement this unit. These books can be purchased as a book pack by going to **goodandbeautiful.com/science** and clicking on the *Space Science* unit product page.

Mars Exploration: 1960–2016
By Megan Noel

The Story of Mae Jemison
By Amy Drorbaugh





CORRELATED BOOKS

The Good and the Beautiful Library has several books that correlate well with the *Space Science* unit. It can be a wonderful experience for children to read books on their level related to the subjects they are learning in science. The library includes both fiction and nonfiction books that are organized according to reading level. Find these correlated books by going to **goodandbeautiful.com/science** and clicking on the *Space Science* unit product page.

GRADES 7–8
LESSON EXTENSIONS

How the Extensions Work

Each lesson has an optional lesson extension for children in grades 7–8. Complete the lesson with all the children, and then have the older children complete the self-directed lesson extension. These extensions are located in the *Grades 7–8 Student Journal*.

Answer Key

The answer key for the lesson extensions can be found on the free Good and Beautiful Homeschool app in the science section. Visit **goodandbeautiful.com/apps** for information on accessing the app. The app can be accessed from a computer, phone, or tablet.

Flexibility

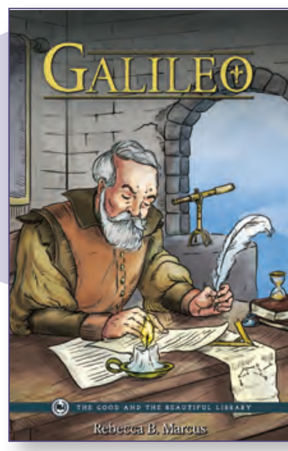
The amount of time it will take to complete each lesson extension will vary for each child. The average time is about 10–15 minutes per extension. Parents, teachers, and children may choose to omit parts of the lesson extension if desired. Encourage the children to stretch their capabilities, but also reduce work if needed.

Taking Notes

Some of the grades 7–8 lesson extensions have the children summarize the material read. Teach the children to look for key information, summarizing the most important points. Students can also add notes with their thoughts and the facts that are most interesting to them.

Optional Grades 7–8 Reading Book

We recommend *Galileo* by Rebecca B. Marcus as extra reading for students in grades 7–8. This book can be purchased by going to **goodandbeautiful.com/science** and clicking on the *Space Science* unit link.



SUPPLIES NEEDED

You will need the following supplies for activities. There are no experiments in this unit.

Lesson 1

- 4 plastic storage bags of varying sizes: one snack size, two sandwich size, one gallon size
- 1 small ball that will fit in the smallest plastic bag
- 6-sided die
- Glue stick or glue
- Pan, water, and a flashlight (optional)

Lesson 2

- Piece of chalk or masking tape
- Stopwatch or timer
- 2 pennies
- Scissors
- Glue stick or glue

Lesson 3

- 7 pennies or pebbles per child
- 12 marshmallows per child (regular- or mini-sized) or small balls of play dough
- 12 toothpicks per child
- 1 empty paper towel tube per child (optional)
- 1 piece of black tissue paper per child (optional)
- 1 safety pin or pushpin (optional)
- Black or dark blue paint (optional)
- Paintbrush (optional)
- 1 rubber band for each child (optional)
- Small star stickers (optional)

Lesson 4

- 1 foam or paper cup per child
- 1 pencil per child
- 1 roll of toilet paper
- 9 small objects, such as pebbles or pennies
- 1 medium-sized object, such as a tennis ball or rock

Lesson 5

- "Getting To Know the Planets Cards"—located in the student journals
- Planet Cards Set #1
- 1 coin per child
- 1 sandwich-sized plastic storage bag

Lesson 6

- 1 red and 1 blue colored pencil, marker, or crayon per child
- 2 c Kinetic Sand® or 2 balls of play dough (same color)
- Small pebbles or rocks
- 1 round metal cake pan or pie tin
- Plastic wrap
- Glue stick or glue
- "Getting To Know the Planets Cards"—located in the student journals

Lesson 7

- Glue stick or glue
- 8 OREO® cookies or similar chocolate cookies with white filling per child (or substitute with black and white play dough)
- Red and blue crayons or colored pencils
- Butter knife (optional)
- Lamp, basketball, and tennis ball (optional for extension)
- Scissors

Lesson 8

- 1 Hula Hoop® or 2 pool noodles taped together into a circle
- Pillow (any size)
- Scissors

SUPPLIES NEEDED
CONTINUED

Lesson 9

- Glue stick or glue

Lesson 10

- ½ c milk (any kind)
- Red and yellow food coloring
- Dish soap
- Small bowl
- "Getting To Know the Planets Cards"—located in the student journals
- Planet Cards Set #1

Lesson 11

- Play dough (any colors)
- 1-tsp and 1-Tbsp measuring spoons
- Red, blue, and green food coloring (optional)
- 2 c shaving cream (foam, not gel) (optional)
- 1 c white glue (optional)
- 3 disposable bowls (optional)
- "Getting To Know the Planets Cards"—located in the student journals

Lesson 12

- 1 plastic sheet protector per child (optional)
- Dry-erase marker or other writing utensil per child (optional)
- Scissors
- Glue stick or glue

Lesson 13

- None

Lesson 14

- Timer (optional)

Lesson 15

- 6-sided die
- Small objects to use as game tokens, such as pennies or pebbles; 1 per child

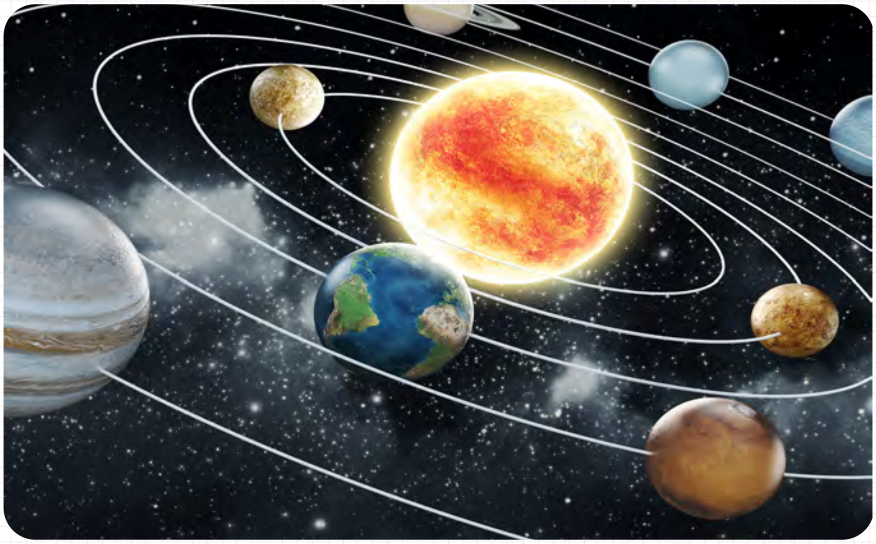
VOCABULARY

Instructions: Cut out the vocabulary cards in this section. Place them on your science wall when prompted to do so in the lessons. Review the vocabulary words several times during this unit and, if desired, at various times throughout the school year.

Planet

a round body that orbits a star. A planet may have a rocky surface or be made of gases.

Solar System



the sun and all the planets, asteroids, moons, and other objects that revolve around it

Planet Cards Set #1

Cut out the cards on this page and store them in a zipper bag. You will be prompted to use the cards in several lessons to help the children memorize the planets of the solar system in the order of their proximity to the sun.

MERCURY

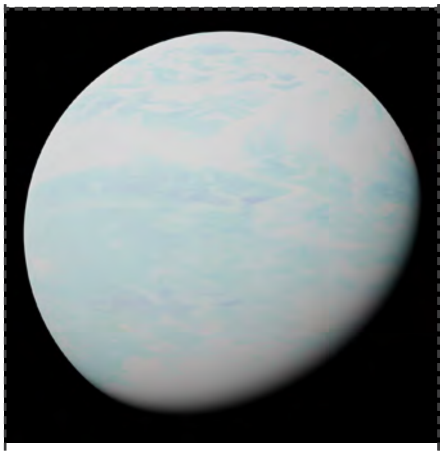
VENUS

EARTH

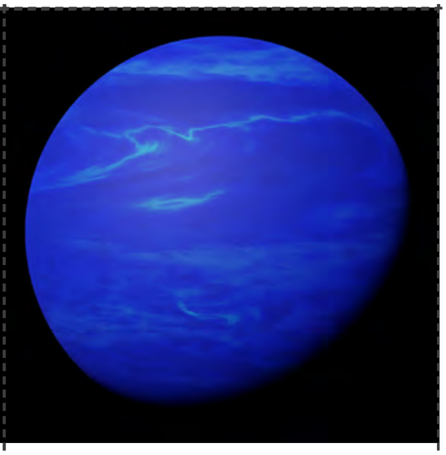
MARS

JUPITER

SATURN



URANUS



NEPTUNE

Planet Cards Set #2

Cut out the cards and store them in a zipper bag. You will be prompted to use the cards in several lessons to help the children match the names of the planets to the correct images.

INTRODUCTION TO SPACE

Objective Help the children feel the wonder of the universe that God created and understand the basic terminology of space science.

Preparation:

- ☐ Cut out "Universe Organization Cards" and tape them onto plastic bags. Tape the "Solar System" picture to a snack-sized plastic bag, the "Galaxy" picture to a sandwich-sized bag, and the "Universe" picture to a gallon-sized bag.
- ☐ Cut out the "Planet Cards Set #1," found after the vocabulary cards in the front of this unit.

Activity Supplies:

- 4 plastic storage bags of varying sizes: one snack size, two sandwich size, one gallon size
- 1 small ball that will fit in the smallest plastic bag
- 6-sided die
- Glue stick or glue
- Pan, water, and a flashlight (optional)

☐ Introduction to Space Video

WATCH ONLINE

Watch the "Introduction to Space" video at goodandbeautiful.com/sciencevideos or on the Good and Beautiful Homeschool app.

Read to the children: In this unit we are going to explore the great wonder and vastness of space. God created all the bright stars we can see in the night sky, the bountiful earth we live on, and a multitude of other galactic marvels. From the tiny ladybug to the massive galaxy, all are creations of God.

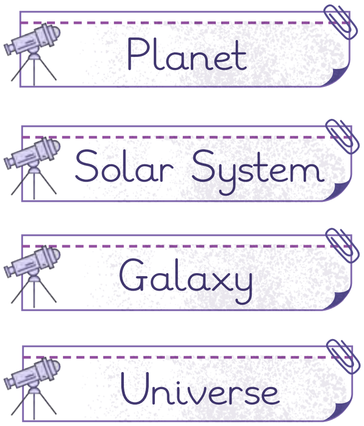
☐ Hubble Space Photograph

Have the children observe the photo included in this lesson titled "A Photograph Captured by the Hubble Space Telescope." Discuss the grandeur of God, who can create such majestic things.

Have the children observe the photo included in this lesson titled "Rose." Discuss the grandeur of God that is displayed in something as tiny as this spider inside the delicate, velvety, perfumed petals of a single rose.

Science Wall: Vocabulary Words

Place the vocabulary cards PLANET, SOLAR SYSTEM, GALAXY, and UNIVERSE on your science wall. Read and discuss the words and definitions.



Universe Organization Activity

Give the children the small ball. Read to the children: This ball represents a ***planet.*** A planet is a round body that orbits a star. Planets may be rocky, like our earth, or they may be made of gases, like Jupiter.

Give the children the snack-sized bag with the picture of the solar system on it. Have them put the ball inside the bag. Read to the children: Planets are part of a solar system. Our ***solar system*** is the sun and all the planets, asteroids, moons, and other objects that revolve around it. Look at the illustration on the vocabulary card titled "Solar System" to answer these questions:

1. <u>What is the center of our solar system?</u> [the sun]
2. <u>How many planets revolve around the sun, and what are their names?</u> [There are eight planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune.]

All the planets except for Mercury and Venus have at least one moon.

Give the children the sandwich bag with the picture of a galaxy on it. Have the children put the smaller bag inside the larger one. Read to the children: Scientists used to think that there was just one huge group of stars. In 1924 scientists realized that there were actually many large groups of stars. Each group became known as a ***galaxy***.

A galaxy may contain many solar systems. Galaxies are systems of stars, gas, dust, and other matter held together by gravity. Scientists think there are billions of galaxies of all shapes and sizes in the universe.

Give the children the gallon-sized bag with the picture of the universe on it. Have the children put the smaller bags inside the larger one. Read to the children: All the galaxies make up the ***universe***. The universe is everything that exists: animals, people, planets, stars, and galaxies.

Order of the Planets

Give the children the cut-out "Planet Cards Set #1." Lay the cards on the floor a few steps apart from each other, starting with the sun. Place the planets in order of distance from the sun. [Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune] Have the children "visit" each planet by walking from one card to the next in order while saying the planet names aloud. *Note: These cards will be used in additional lessons.*

Next, have the children take turns practicing putting the planets in order. You can use this mnemonic device to help the children remember the order: My Very Enthusiastic Mother Just Served Us Noodles. (Each word stands for the first letter of a planet's name.)

Milky Way Facts

Read to the children: Earth's galaxy is known as the *Milky Way*. Our solar system—made up of the sun and everything that orbits around it, including planets, moons, asteroids, comets, and meteoroids—is only a tiny part of the Milky Way.

The Milky Way galaxy has a barred, spiral shape. It is also huge. Just how big is our galaxy? Imagine this: If you were to travel at the speed of light, 299,792 km per second (186,282 mi per second), it would take 100,000 years to travel across the galaxy.

Milky Way Facts Game

Have the children turn to the "Milky Way Fact Cards" page in Lesson 1 of their student journals. Have them cut out the fact cards. Have the children take turns rolling the die, reading the fact on the matching number card, and then gluing the card on one of the spots on the "Milky Way Facts" page. If the child rolls a number that has already been completed, read the card with the number 7 on it or review the rolled number.

It's Dark Up There!

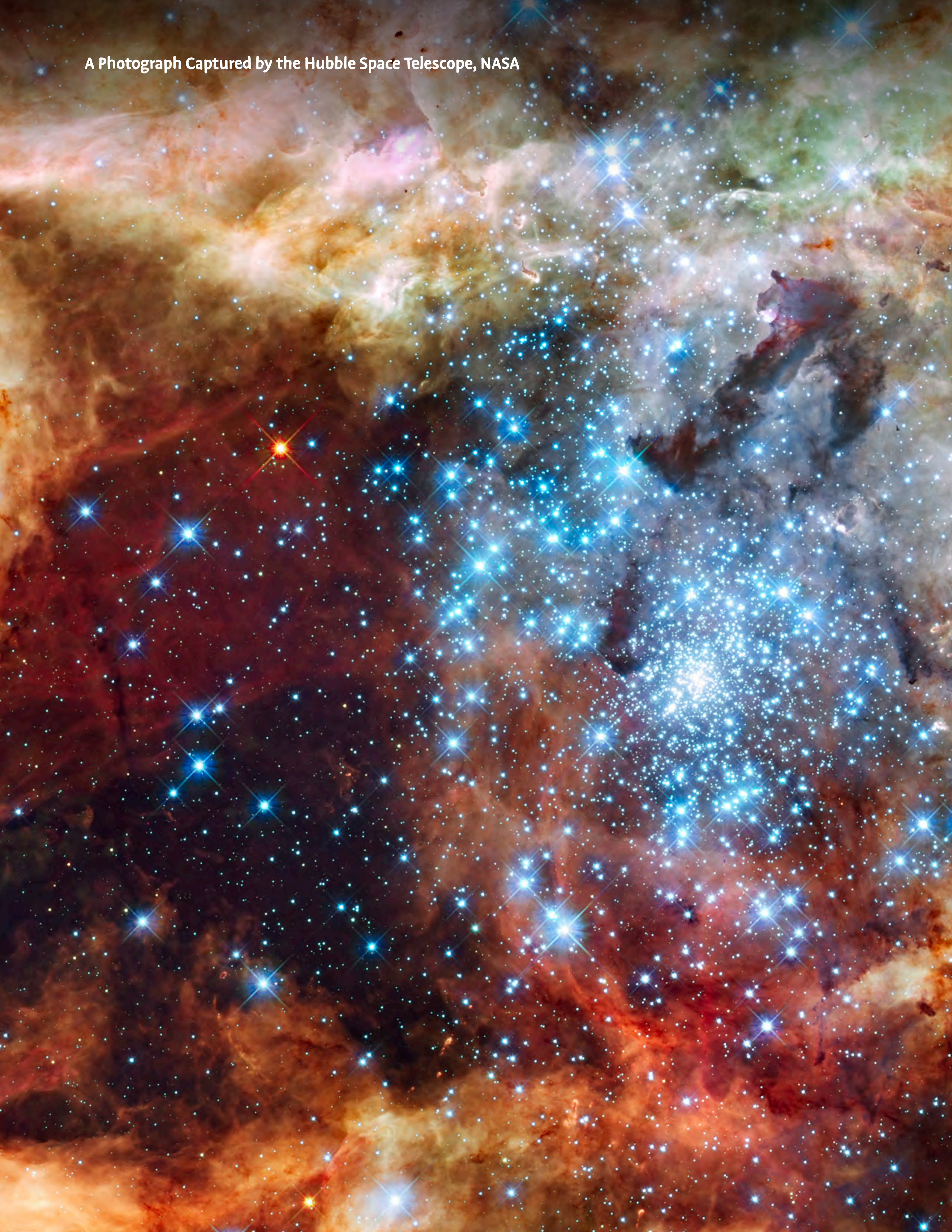
Read to the children: Stars shine so brightly that we are able to see their light from very far away. So why is it dark in space? We can see light only when it hits an object and bounces off, and God designed our planet with an atmosphere full of tiny particles for light to bounce off of, making it bright. There are hardly any of those particles in space, so there isn't much for light to bounce off of.

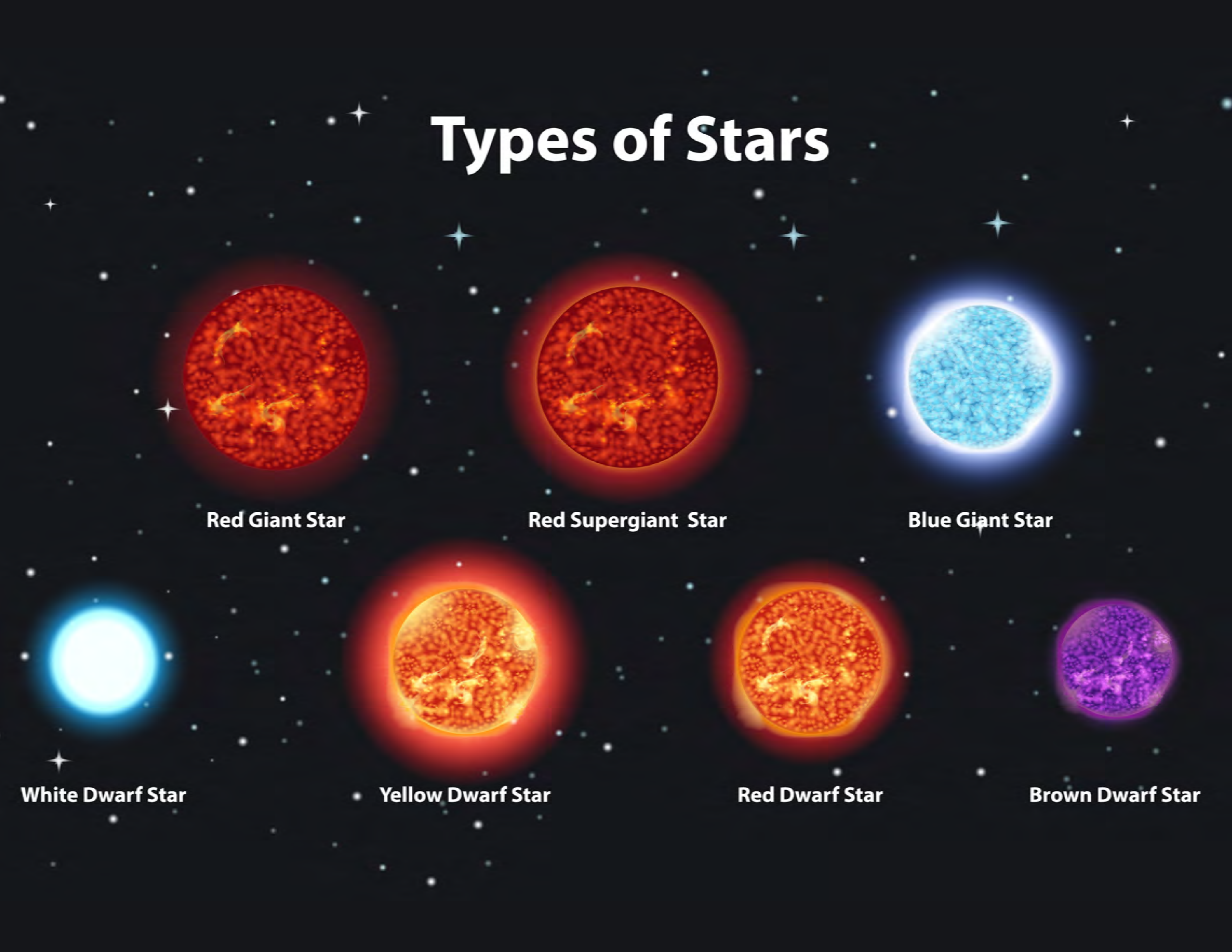
Optional Activity: Bring a pan of water to boil on the stove. Have a child shine a flashlight through the steam from the boiling water (make sure the child stands a safe distance away from the hot stove and pan). Read to the children: You can see the light of the flashlight bouncing off the small droplets of water in the steam. This is similar to what happens when the light of the sun hits Earth's atmosphere.

Lesson 1 Extension

7–8

Have children grades 7–8 complete the self-directed Lesson 1 extension titled "Measuring Space" in their student journals.

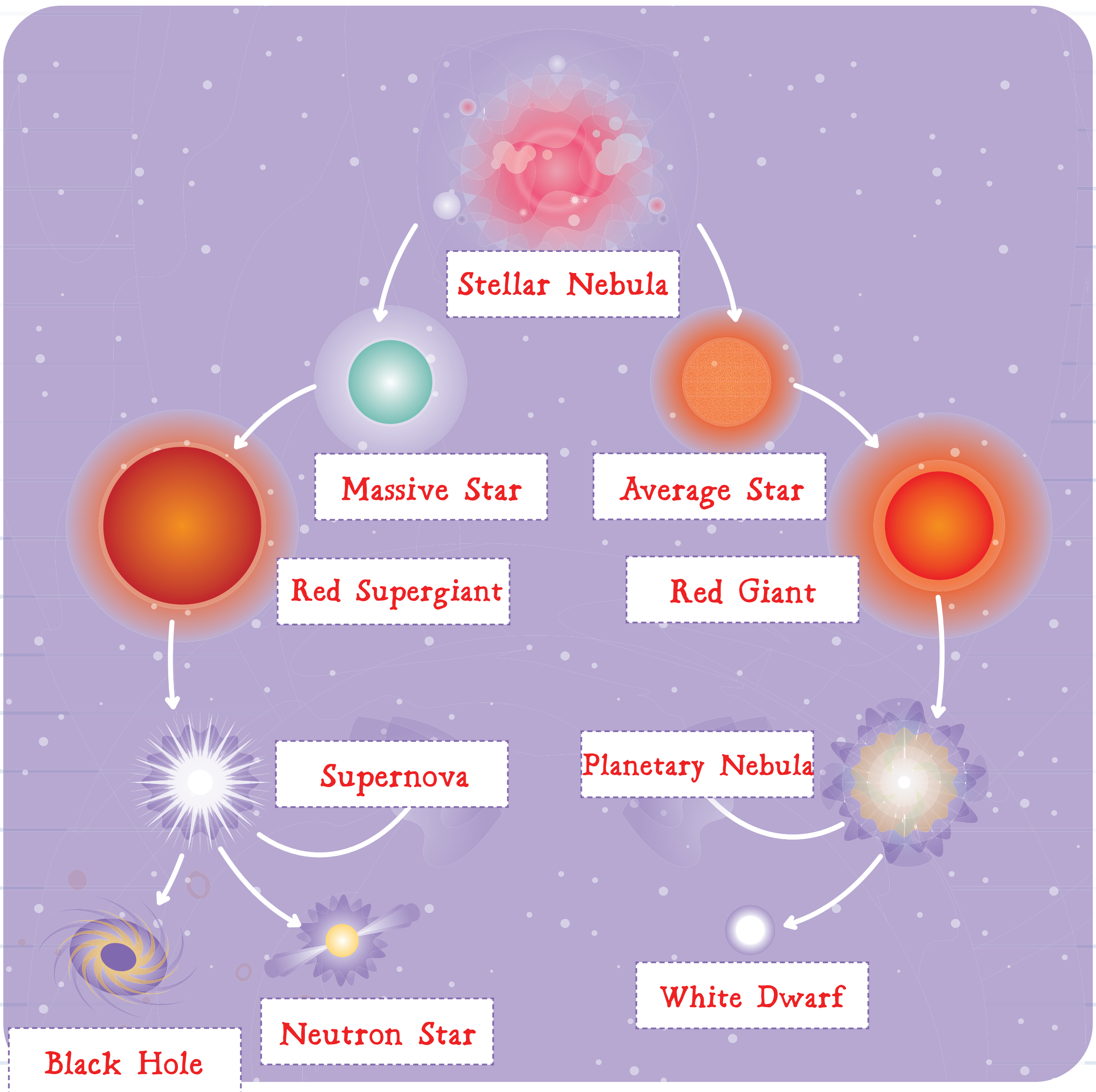

A Photograph Captured by the Hubble Space Telescope, NASA


Types of Stars
Red Giant Star
Red Supergiant Star
Blue Giant Star
White Dwarf Star
Yellow Dwarf Star
Red Dwarf Star
Brown Dwarf Star

Lesson 2

LIFE CYCLE OF STARS KEY

Cut out the name strips (on the next page), and glue them in the correct places on the life cycle chart below.



THE SOLAR SYSTEM AND OUR SUN

Objective Help the children gain a general overview of and appreciation for the solar system, including our sun.

Preparation:

- [ ] None

Activity Supplies:

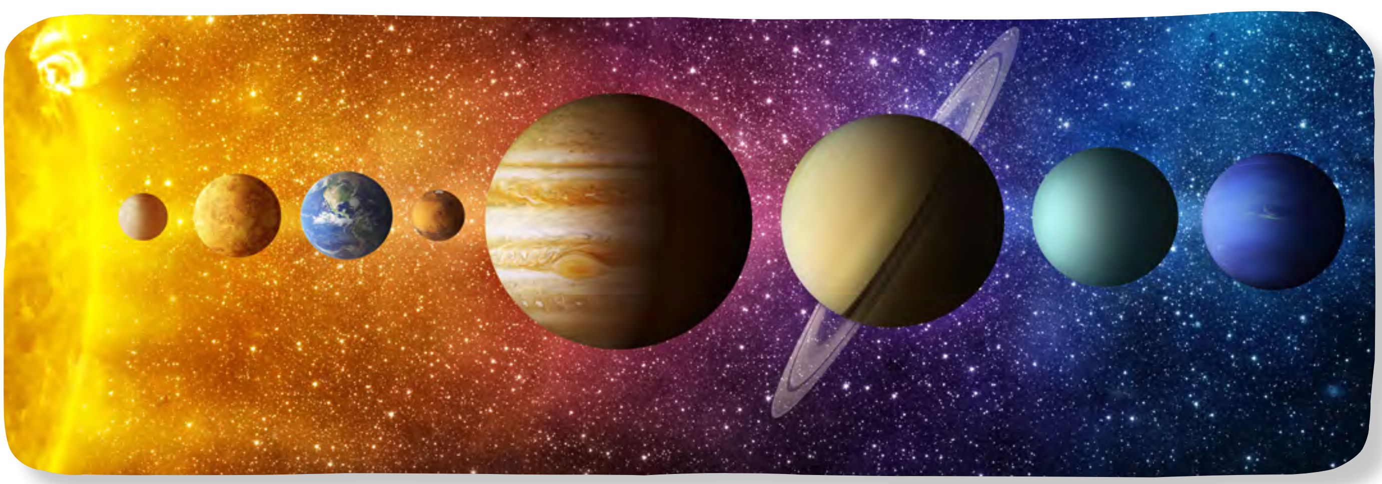
- 1 foam or paper cup per child
- 1 pencil per child
- 1 roll of toilet paper
- 9 small objects, such as pebbles or pennies
- 1 medium-sized object, such as a tennis ball or rock

The Solar System

Read to the children: What contains one star, eight major planets, over two hundred moons, hundreds of thousands of asteroids, and billions of comets? [our solar system]

Hundreds of years ago, most people believed the earth stood still and the sun, moon, and stars all orbited around the earth. A scientist named Copernicus was the first man to promote the idea that the sun is in the center of a system of planets that circle around it, not the earth. He was right! Gravity pulls the planets in a circular path, known as an ***orbit***, around the sun. Think of a ball tied to a string attached to a pole. If you swing the ball, it will circle the pole. All planets in our solar system orbit the sun. The time it takes for a planet to go all the way around the sun makes a year on that planet.

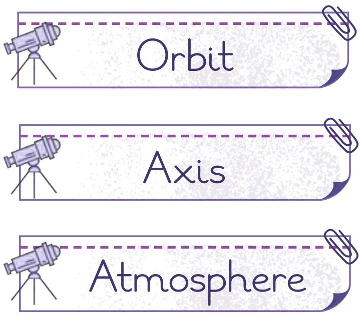
Planets also spin like a top around an imaginary line called an ***axis***. The time it takes for the planet to turn completely around on its axis makes a day on that planet. Some planets have very short days, and some have very long days.



Each planet is unique, but there are some similarities. A few planets, including our own, have ***atmospheres*** composed of layers of gas surrounding them. Moons or other small round bodies can be seen orbiting a number of planets, such as Earth and Jupiter. Beautiful rings made of small pieces of rock or ice orbit some planets, including Saturn and Uranus.

Science Wall: Vocabulary Words

Review the card SOLAR SYSTEM, which you put on your science wall previously. Place the vocabulary cards ORBIT, AXIS, and ATMOSPHERE on your science wall. Read and discuss the words and definitions.



Orbiting the Sun

Read to the children: The orbital path of each of the planets varies, but each planet stays on its own path as it travels around the sun. In the early 1500s, astronomer Copernicus proposed that the planets move around the sun in a circle. Almost 100 years later, in 1601, Johannes Kepler correctly theorized that planets orbit the sun in ellipses, or ovals, not circles. The time it takes for a planet to go around the sun one time is called its planet year. The farther a planet is from the sun, the longer it takes to complete its orbit.

Have the children turn to the "Orbiting the Sun" page in Lesson 4 of their student journals and complete the page.

Order of the Planets

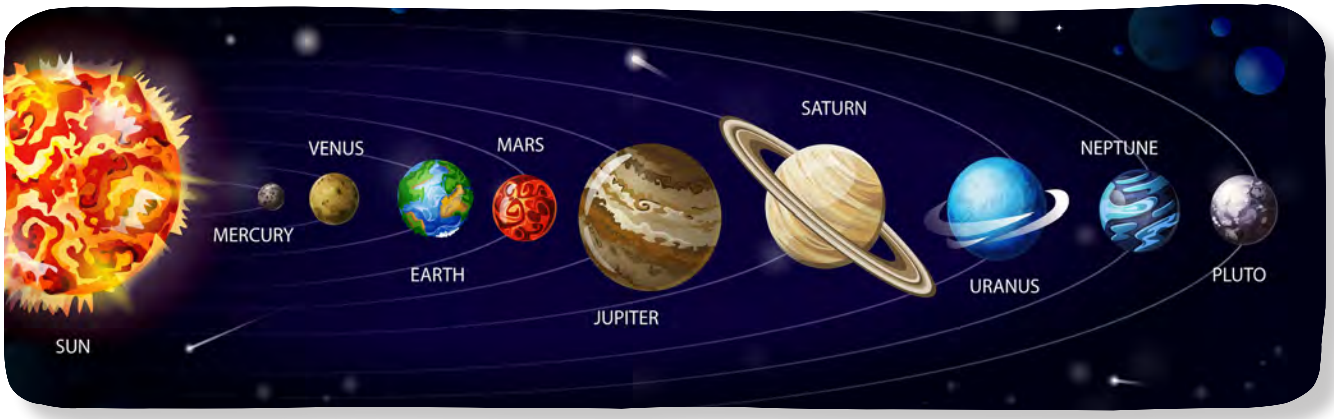
Have the children use the concepts they just learned and the picture at the bottom of this page to answer the following questions:

1. Which planets are closer to the sun than Earth? [Mercury and Venus]
2. Which planet orbits the sun faster—Venus or Earth? [Venus. The closer a planet is to the sun, the faster it moves.]
3. Which planet takes more time to orbit once around the sun—Saturn or Neptune? [Neptune. The farther a planet is from the sun, the longer its orbit is.]

Classifying a Planet

Read to the children: Rocketing through space in orbits around the sun are a variety of objects in addition to planets. These include asteroids, comets, meteoroids, and even dwarf planets. Out of all of these objects, how did astronomers decide what could be called a planet?

The definition of what a planet is has changed over time. In 2006 the International Astronomical Union—a group of scientists from around the world—decided on a new definition. They said that a planet must be

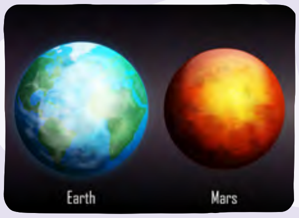


SPACE SCIENCE
LESSON 6

TERRESTRIAL PLANETS: EARTH AND MARS

Objective

Help the children explore some of the characteristics of Earth and Mars.



Preparation:

- [ ] None

Activity Supplies:

- 1 red and 1 blue colored pencil, marker, or crayon per child
- 2 c Kinetic Sand® or 2 balls of play dough (same color)
- Small pebbles or rocks
- 1 round metal cake pan or pie tin
- Plastic wrap
- Glue stick or glue
- "Getting to Know the Planets Cards"—located in the student journals

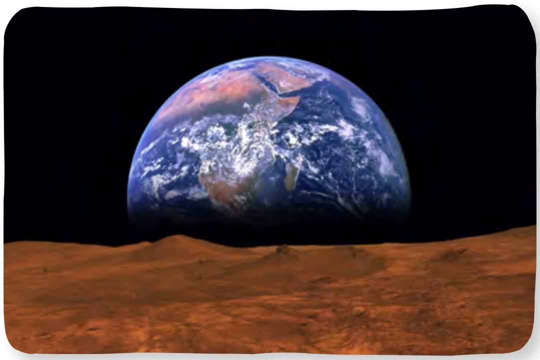
Optional Read Aloud

At any point in the lesson, you may read *Mars Exploration: 1960–2016* by Megan Noel, available in the optional read-aloud book pack for this unit.

Blue Planet, Red Planet Journal Activity

Read to the children: People often refer to our planet, the earth, as the Blue Planet because it is covered in water. <u>Do you know which planet is called the Red Planet?</u> Mars is called the Red Planet because its surface is covered with rusty rocks—rocks with a lot of iron oxide in them. Mars has been studied more than any other planet in our solar system except for Earth. Both Earth and Mars are terrestrial planets.

Have the children turn to the "Blue or Red Planet?" page in Lesson 6 of their student journals. Have them follow the directions to complete the activity as you read the following facts about Earth and Mars.



1. Earth is the third planet from the sun and the only known planet with liquid water on its surface. Seventy-one percent of the earth's surface is covered with water.
2. Mars is the fourth planet from the sun. Its rocky surface has extinct volcanoes, polar ice caps, and the highest mountain in the solar system.
3. Earth takes approximately 365 days to orbit the sun and 24 hours to complete a rotation on its axis. Because those numbers aren't exact, we have to make up the difference with leap years and even leap seconds to keep our clocks correct.

Now remove the rocks from the play dough or Kinetic Sand® and smooth out the craters. Place a layer of plastic wrap tightly across the top of the cake pan or pie tin.

When rocks come near Earth, the atmosphere protects it, and most meteoroids burn up before ever striking the surface. What do you think will happen if you drop rocks onto the surface now? **Have the children toss the small pebbles or rocks onto the pan or tin and observe how the plastic wrap blocks the meteorites from hitting the surface or slows them down before they can hit the surface.**

Challenges of Living on Mars

Read to the children: Living on Mars would be difficult. How would it be different from living on Earth? **Have the children turn to the "Challenges of Life on Mars" page in their student journals. Discuss some of the problems listed below. As you discuss each problem, have the children complete the corresponding section on their student journal pages.**

- **There is very little oxygen**; humans would need a way to create oxygen and use it to breathe.
- Mars has a very **thin atmosphere** and is not as well protected from the sun's radiation as the earth.
- There is **no food or water** on Mars.
- The **temperature** on Mars gets much colder than on Earth. The average temperature is −60 °C (−81 °F). A summer day may be as warm as 20 °C (68 °F), but at night the temperature can plummet to −73 °C (−100°F). At the poles it can be as cold as −125 °C (−195 °F).
- Scientists estimate that Mars gets hit by around 200 rocks, or **meteorites**, every year. This could cause big problems for people living on the planet.
- It takes a long time to get to Mars because it is very **far from Earth**. It takes an unpiloted spacecraft at least five months to get to Mars. No person has ever been to Mars.

Show the children the "Life on Mars" page found at the end of this lesson. Read to the children: Look at the pictures on the "Life on Mars" page, which show how different artists think life might look on Mars in the distant future. **Have the children draw what they believe a space station might look like on Mars on the student journal page.**

Getting to Know the Planets Cards

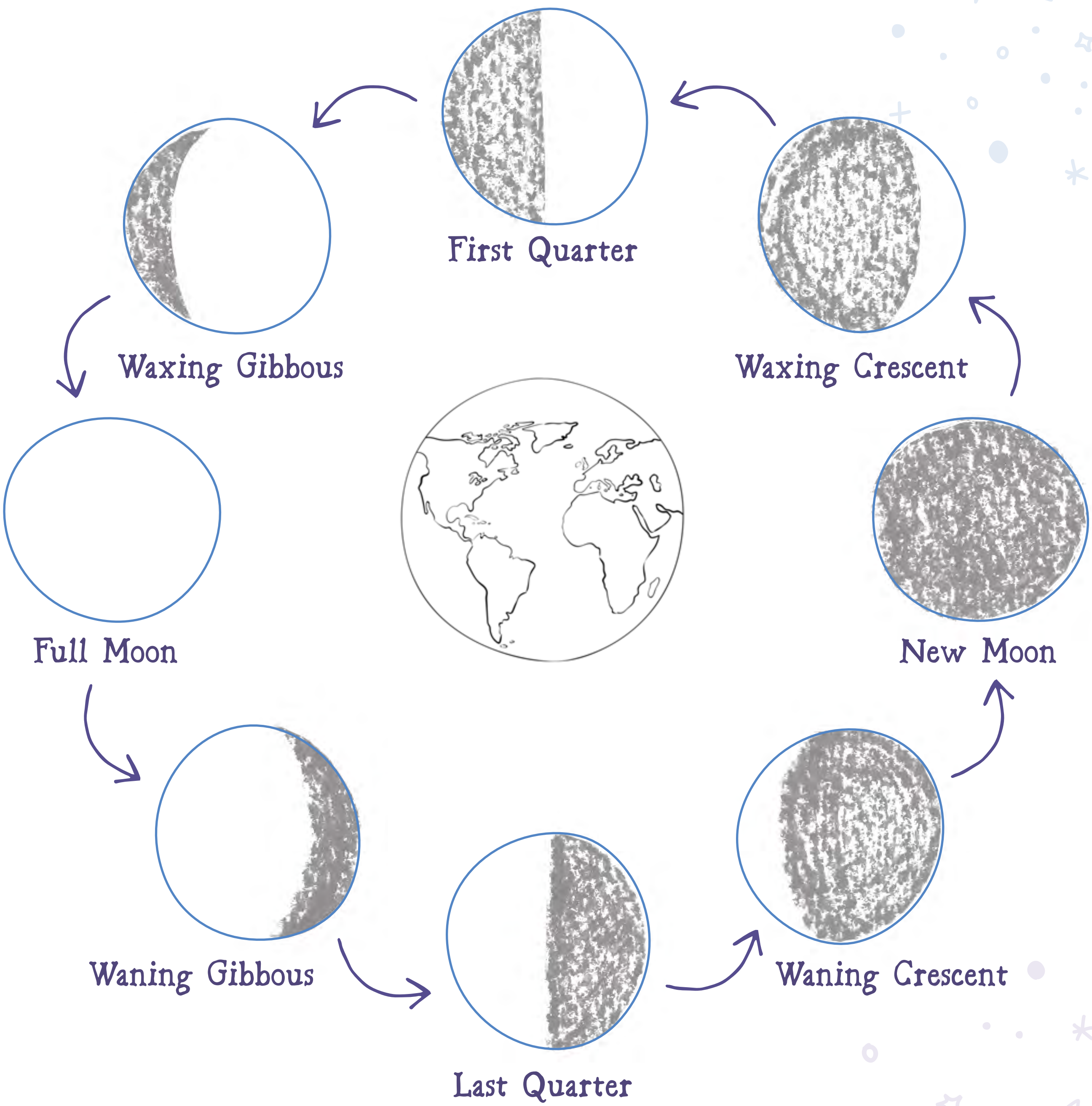
Provide the children with the "Getting to Know the Planets Cards," found at the end of each child's student journal. Have the children complete the Earth and Mars cards, using the information from the lesson. The other cards will be completed in future lessons.

Lesson 6 Extension

7–8

Have children grades 7–8 complete the self-directed Lesson 6 extension titled "Our Favorite Martians" in their student journals.

MOON PHASES CHART



SPACE SCIENCE
LESSON 8

THE TIDES AND GRAVITY

Objective: Help the children understand tides and what causes them. Help the children understand what gravity is in relation to space science.

Preparation:

- ☐ Cut out the "What Would You Weigh?" cards for children grades 3–6 in the 3–6 student journal.

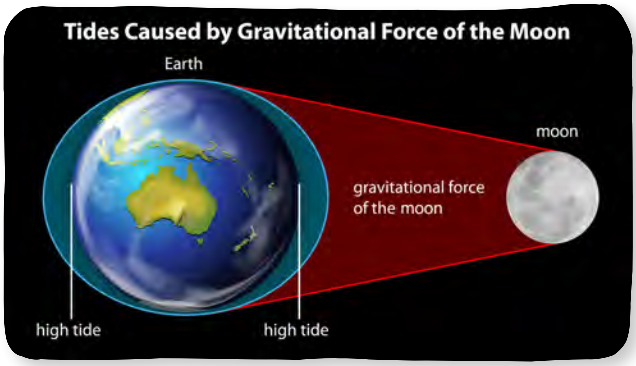
Activity Supplies:

- 1 Hula-Hoop® or 2 pool noodles taped together into a circle
- Scissors
- Pillow (any size)

☐ Introduction to Tides

Read to the children: Imagine you are at the beach making a big sandcastle. You start to notice that the water is getting closer and closer to your sandcastle until the waves finally crash into it. What happened? Why do waves go higher up the beach at different times of day? Would you believe it has to do with the moon and sun? It does! *Tides* are the twice-daily swelling and ebbing of the oceans.

As we learned in the last lesson, the moon orbits the earth. As it moves around the earth, gravity from the moon pulls water in the moon's direction. Typically, water will rise for about six hours and then fall back down for six hours.



☐ Tides Activity

Have one child stand holding the Hula-Hoop® (or pool noodles) around his or her waist. Have yourself or another child stand facing him or her and pull gently on the Hula-Hoop®.

Read to the children: When the moon pulls on the earth, it pulls the water toward it. This pull causes a high tide on the side of the earth facing the moon. <u>When the Hula-Hoop® was pulled, did you feel yourself move slightly too?</u> The moon also pulls the earth slightly toward it. That is why the far side of the earth also has a high tide at the same time as the side closest to the moon. The water on the far side of the earth is also the least affected by the moon's gravity, so it bulges out. Low tides occur on the parts of the earth that are not lined up with the moon. **Give each of the other children a turn being the earth (holding the**

THE GAS GIANTS: JUPITER AND SATURN

Objective

Help the children explore the characteristics of Jupiter and Saturn.

Preparation:

- ☐ Remove the pages "Jupiter" and "Saturn" from the end of this lesson and cut out the "Fact Cards."

Activity Supplies:

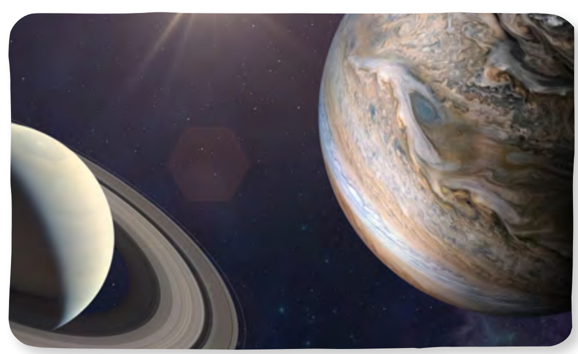
- ½ c milk (any kind)
- Red and yellow food coloring
- Dish soap
- Small bowl
- "Getting to Know the Planets Cards"—located in the student journals
- Planet Cards Set #1

☐ Introduction and Review Activity

Lay out the "Planet Cards Set #1" saved from Lesson 1 in front of the children. Have the children select the correct card as you ask each question. Which planet is closest to the sun? [Mercury] Which planet is the hottest because of its thick atmosphere? [Venus] Which planet is the only one with liquid water? [Earth] Which planet is called the Red Planet? [Mars] These are the four planets that are closest to the sun. Do you remember what we call these four planets? [inner planets, rocky planets, or terrestrial planets] After the planet Mars is a region where we find most of the asteroids in our solar system. Do you remember what that area is called? [the asteroid belt]

Have the children place the cards for Jupiter, Saturn, Uranus, and Neptune in order. Because Jupiter, Saturn, Uranus, and Neptune lie outside the asteroid belt, they are known as the outer planets. They are also called *gas giants* because they are mostly made of gas, and they are massive in size compared to the other four planets. These four planets farthest from the sun account for 99% of the total mass of all celestial bodies that orbit the sun. Because of their distance from the sun, each of these planets is colder than Earth.

Turn the Planet Cards facedown and practice saying the planets in order. You can remind the children of the mnemonic device: My Very Enthusiastic Mother Just Served Us Noodles.



☐ Jupiter and Saturn Moon Match Activity

Lay the pages "Jupiter" and "Saturn" in front of the children. Lay out the cut-out "Fact Cards" with the moon images facing up. Read to the children: Did you know that Jupiter and Saturn have at least 79 and 82 moons respectively? These cards have the four biggest moons of each planet on them. We're going to learn about these two planets as we place their moons in orbit around them. **Have the children take turns choosing a moon card and reading the planet fact on the back. Have them place the card next to the picture of the correct planet.**

❑ Swirling Clouds of Gas

Read to the children: Despite their name, gas giants are not composed completely of gas and do have a core of liquid metal and rock. However, they are most well-known for their beautiful swirling clouds, as shown in the picture below. These swirling clouds are constantly in motion, which is easy to see with the various colors. Look at the stripes on Jupiter in the picture below. What do you think causes these different colors?

Swirling clouds of Jupiter

The different colors are caused by different chemicals in the gas. For example, Neptune, a gas giant we will explore in the next lesson, has a greenish-blue hue that is a result of the methane gas found in its atmosphere.

Scientists believe Jupiter's reddish-orange color is a result of the chemicals ammonia and acetylene. Also, lighter-colored bands exist where gas in the atmosphere is rising upwards, and darker bands exist where gases are drifting downwards.
As the planet spins and winds whip the gaseous atmosphere, the bands of color twist and twirl. We are going to recreate this ourselves in the next activity.

❑ Jupiter Storm Activity

This activity can be done as a group or with a single child. Help the children complete the steps below.

1. Pour ½ c milk into a small bowl.
2. Add one drop of yellow food coloring and one drop of red food coloring.
3. Put a drop of dish soap in the middle of each color.
4. Pick up the bowl and gently swirl it around a few times, and you have something that looks like a storm on Jupiter!

❑ Getting to Know the Planets Cards

Provide the children with the "Getting to Know the Planets Cards," found at the end of each child's student journal. Have the children complete the Jupiter and Saturn cards, using the information from the lesson. The other cards will be completed in future lessons.

❑ Lesson 10 Extension

7–8

Have children grades 7–8 complete the self-directed Lesson 10 extension titled "Icy Eruptions" in their student journals.

FIRST MAN IN SPACE

April 12, 1961

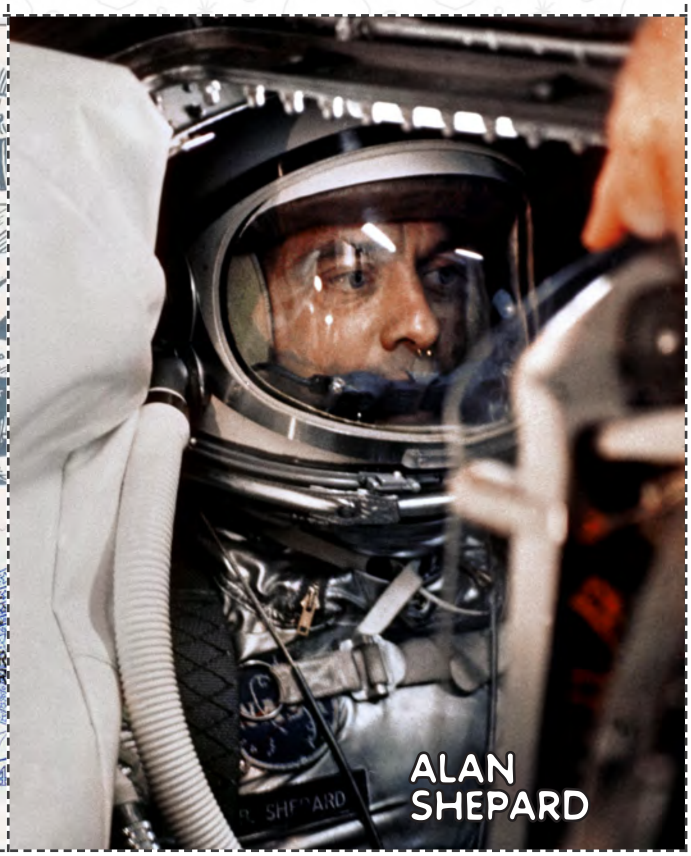
Yuri Gagarin, from the Soviet Union, was launched into space aboard the *Vostok I* spacecraft. He completed one orbit around the earth before reentering the earth's atmosphere, ejecting from the spacecraft, and landing by parachute in Kazakhstan near the Volga River.

FIRST AMERICAN IN SPACE

May 5, 1961

Alan Shepard became the first American to launch into space aboard the *Freedom 7*. His flight was successful, and he splash-landed in the Atlantic Ocean.

YURI GAGARIN


ALAN SHEPARD

SPACE EXPLORATION PART 1: THE PAST

Objective

Help the children understand how humanity has met some of the challenges of space exploration as we have begun to explore the universe.

Preparation:

- [ ] Cut out the "Living on the International Space Station" pictures.
- [ ] Place the cut-out "Living on the International Space Station" pictures throughout the room.
- [ ] Take the "ISS Facts" sheet out of the course book.

Activity Supplies:

- Timer (optional)

Blastoff!

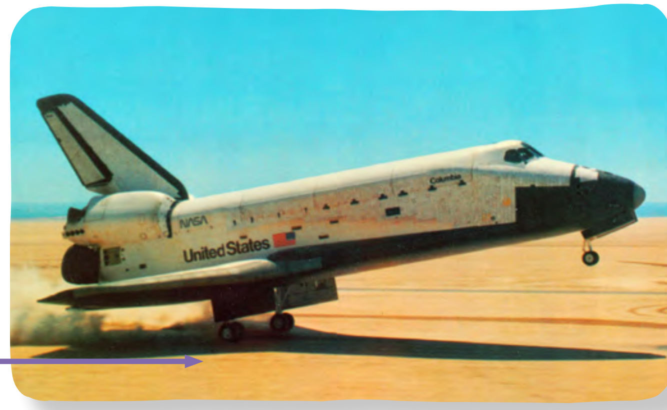
Read to the children: Have you ever heard the phrase, "3, 2, 1, blastoff!"? When we think of rockets launching into the sky, these might be the words that come to mind. But the countdown clock for a space launch actually starts 43 hours before the launch, and those 43 hours are busy with safety checks, weather updates, and systems activations. As the clock ticks down, an astronaut gets ready to take an adventure unlike any other. What do you think it would be like to travel into space? Would you ever want to travel into space? Why or why not?

Show the children the image to the right. In early space missions by the Apollo program, astronauts were crammed into a tiny capsule and launched into space atop a powerful rocket. These missions demonstrated that people could travel into space, perform useful tasks there, and return safely to Earth. With every launch, scientists and engineers developed better and better technology to make space more accessible until finally, on April 12, 1981, the first *space shuttle* took off.

Parts of a Space Shuttle

Turn to the "Parts of a Space Shuttle Key" and have the children point to each space shuttle part every time you say its name.

Read to the children: Would you rather go into space in the Apollo rocket above or the space shuttle? Space shuttles were not only the first partially reusable spacecraft, but they were much easier to navigate, more comfortable, and able to transport more material.



These amazing aircraft require a lot of power and fuel! The shuttle itself, also called an *orbiter,* had three *main engines* that burned liquid hydrogen and liquid oxygen. The *vertical stabilizer* acted like a rudder on a boat, allowing the shuttle to turn left or right. To provide enough fuel, the shuttle was strapped to a large *external tank*. **Show them the orange tank in the image on the previous page.** To help the space shuttle get off the ground, two *solid rocket boosters* were attached to the fuel tank. When their fuel was used up, the boosters separated from the main fuel tank, and the shuttle flew the rest of the way to space using its own engines. Once in space, the external tank was ejected and burned up as it fell back into the atmosphere. The solid rocket boosters splashed down in the ocean and were recovered and reused. When the space shuttle's mission was complete, it reentered Earth's atmosphere and landed on a runway, just like an airplane.

COLUMBIA SPACE SHUTTLE

REPAIRING HUBBLE SPACE TELESCOPE

Have the children turn to the "Parts of a Space Shuttle" page in Lesson 14 of their student journals and complete the page. If desired, have the children try to complete the page before a timer goes off, just like each part of a space shuttle must be checked before launch.

The first space shuttle built was named *Enterprise* after the spaceship in the TV show *Star Trek*. This was a prototype used for testing and never actually flew in space. The following five shuttles did fly into space: *Columbia*, *Challenger*, *Discovery*, *Atlantis*, and *Endeavor*. Over their lifetimes they flew a total of 135 missions in space, carrying satellites and scientific instruments like the Hubble Space Telescope into orbit. Shuttle astronauts also made repairs to satellites and, when necessary, brought them back to Earth. They also performed countless scientific experiments in space.

The last American shuttle flew in 2011. NASA's space shuttle program was shut down for a variety of reasons, including lack of funding. To continue to contribute to the building of the International Space Station, American astronauts flew on Soviet shuttles to the space station. In 2020 the private company SpaceX launched astronauts to the space station from American soil.

ISS Facts Tour

Read to the children: Space shuttles carried components of the International Space Station into space, where shuttle astronauts helped construct it. This amazing outer-space laboratory is the only place where experiments can be conducted under unique conditions, such as zero gravity. There are facilities on Earth that have reduced gravity to perform experiments, but they are unable to replicate the exact conditions of space. At any given time, there are an average of 200 experiments underway on the ISS. We are going to take a photo tour of the International Space Station to get an idea of what life is like living on board.

Have the children move together from one "Living on the International Space Station" photo to the next, study each image, discuss anything they find interesting, and read a fact about the ISS from the "ISS Facts" page. Discuss the information where applicable. When the children have completed their tour, ask them the following questions:

1. What would you like about living on the ISS?
2. What challenges do you think astronauts face living on board? [lack of gravity, being away from family, having to make all their own repairs, never being able to go outside, etc.]

Lesson 14 Extension

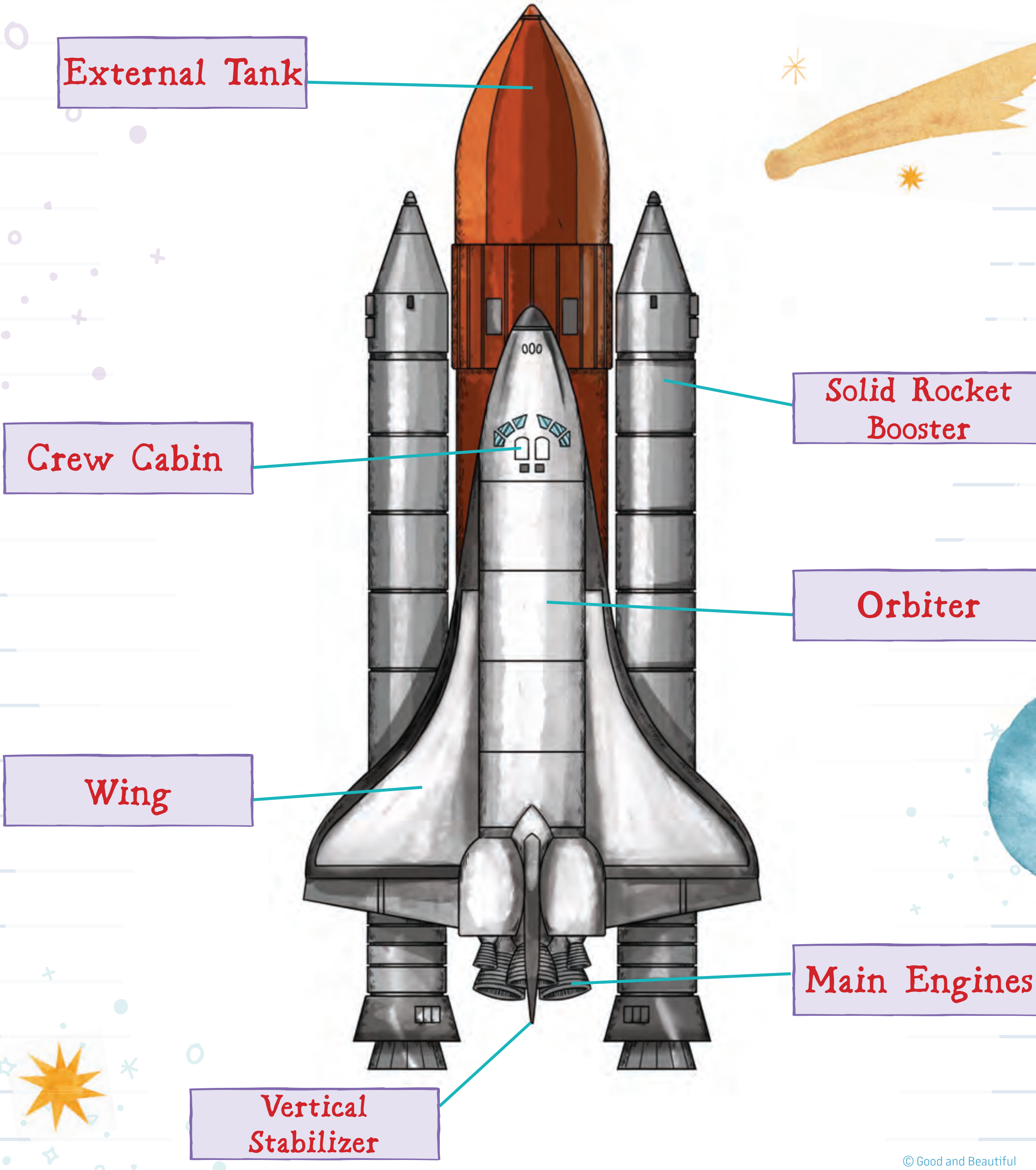
7–8

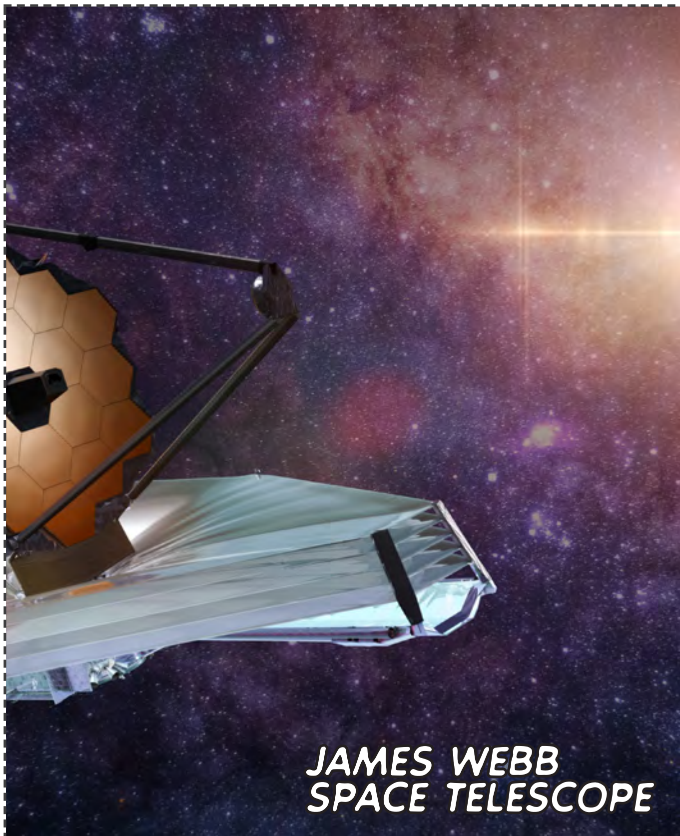
Have children grades 7–8 complete the self-directed Lesson 14 extension titled "Telescopes" in their student journals.

The International Space Station on May 23, 2010, as seen from the departing space shuttle *Atlantis*

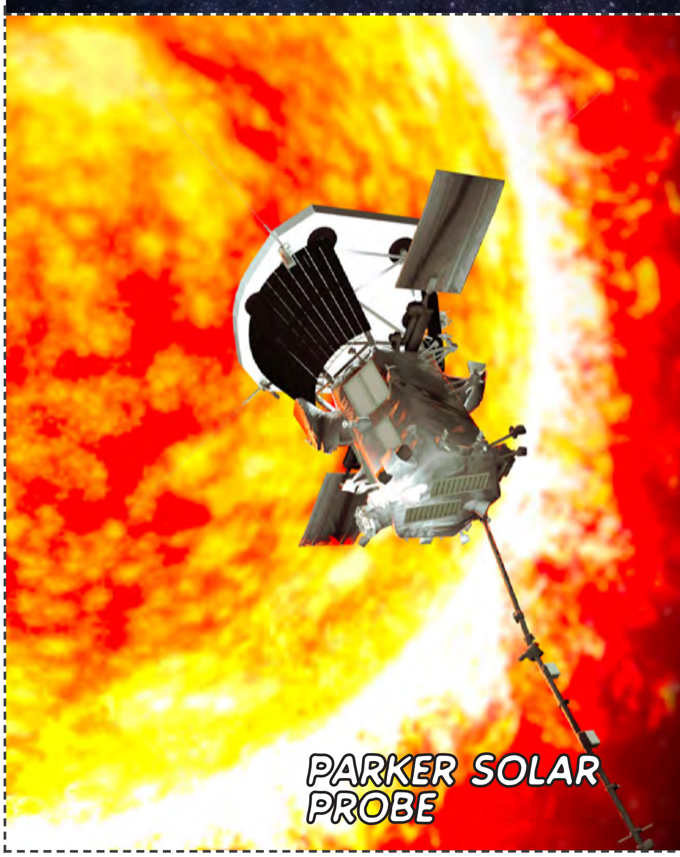
PARTS OF A SPACE SHUTTLE KEY

The Apollo program demonstrated that people could travel into space, perform useful tasks there, and return safely to Earth. But space had to be more accessible. This led to the development of the space shuttle. Label the parts of the space shuttle using the following words: External Tank, Solid Rocket Booster, Crew Cabin, Wing, Orbiter, Main Engines, and Vertical Stabilizer. Color or decorate your space shuttle if desired.




JAMES WEBB
SPACE TELESCOPE


JUNO MISSION
TO JUPITER


PARKER SOLAR
PROBE


ARTEMIS RETURN
TO THE MOON

SPACE SCIENCE

Grades 3-6

STUDENT JOURNAL

This journal belongs to:

THE GOOD AND THE BEAUTIFUL

INSTRUCTIONS

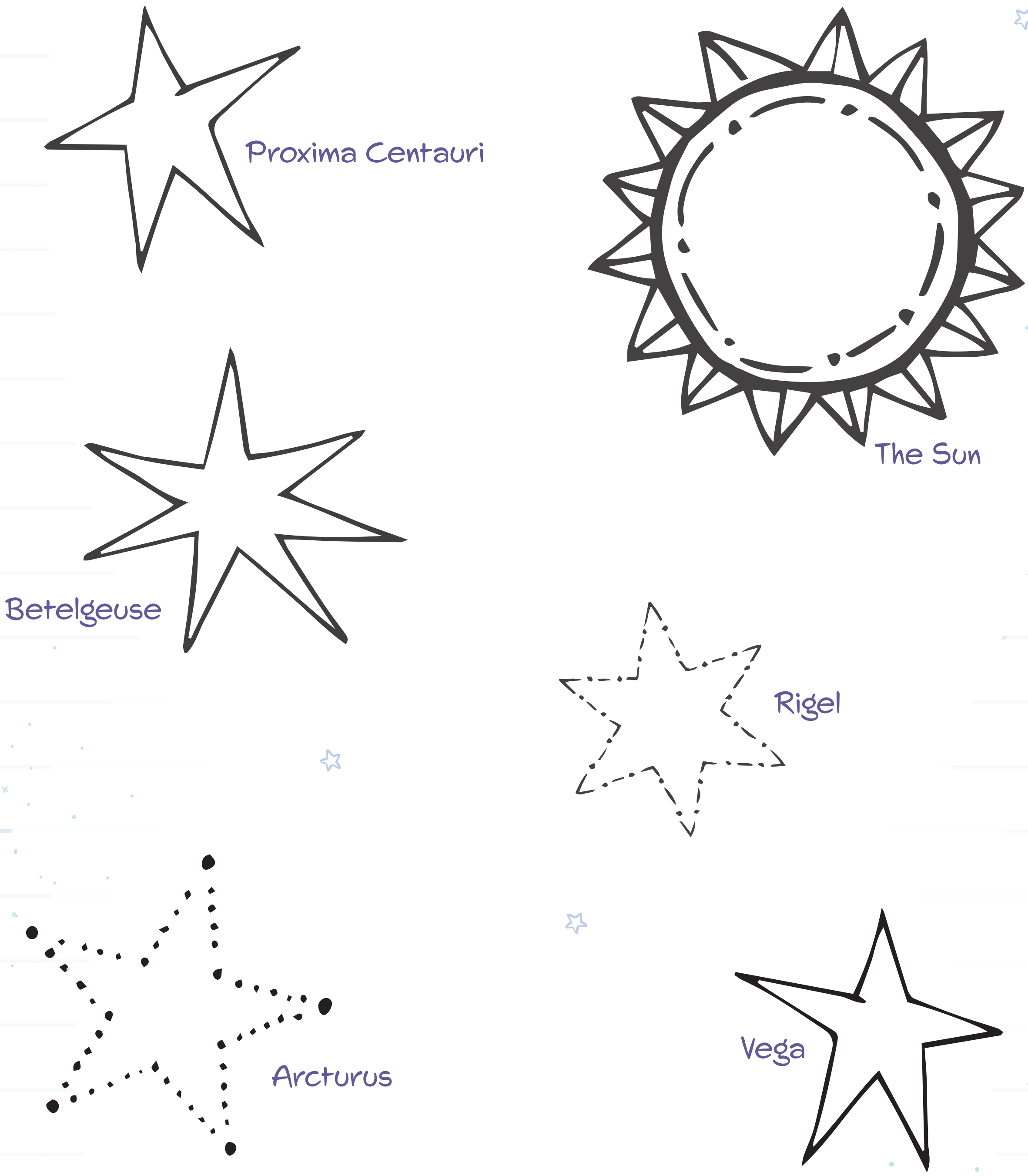
This student journal accompanies *The Good and the Beautiful Space Science* unit. It contains all the worksheets and journal pages that are needed to complete the unit. Each student will need his or her own copy of the science journal.

Have each student take his or her time to create high-quality work as the activities and worksheets are completed. Students may enjoy looking back on their past discoveries when they've finished.

TABLE OF CONTENTS

COLOR OF STARS

Color the stars the correct color based on their temperature and the descriptions on the next page.



COLOR OF STARS

STAR COLOR TEMPERATURE CHART IN KELVINS

Proxima Centauri

is a dwarf star. Red dwarfs are the coolest stars, at 2,500 Kelvin. Color Proxima Centauri dark red.

The Sun

is a dwarf star. It is not as hot as blue or white stars, at about 5,700 Kelvin. Color our sun yellow.

Betelgeuse

is a supergiant star. It is one of the coolest stars, at 3,500 Kelvin. Color Betelgeuse bright red.

Vega

is a main sequence star. It is hot, about 9,600 Kelvin. Color Vega white.

Arcturus

is a giant star. It is a cooler star, about 4,200 Kelvin. Color Arcturus red-orange.

Rigel

is a supergiant star. It is a very hot star, about 11,000 Kelvin! Color Rigel light blue.

CONSTELLATION NAMES

Draw a line to match each constellation picture to its official name. Do you think it looks like what it is named for? What would you call each constellation? Give each one a new name.

Bootes (herdsman)

Southern Cross

Pisces (fish)

Leo (lion)

Taurus (bull)

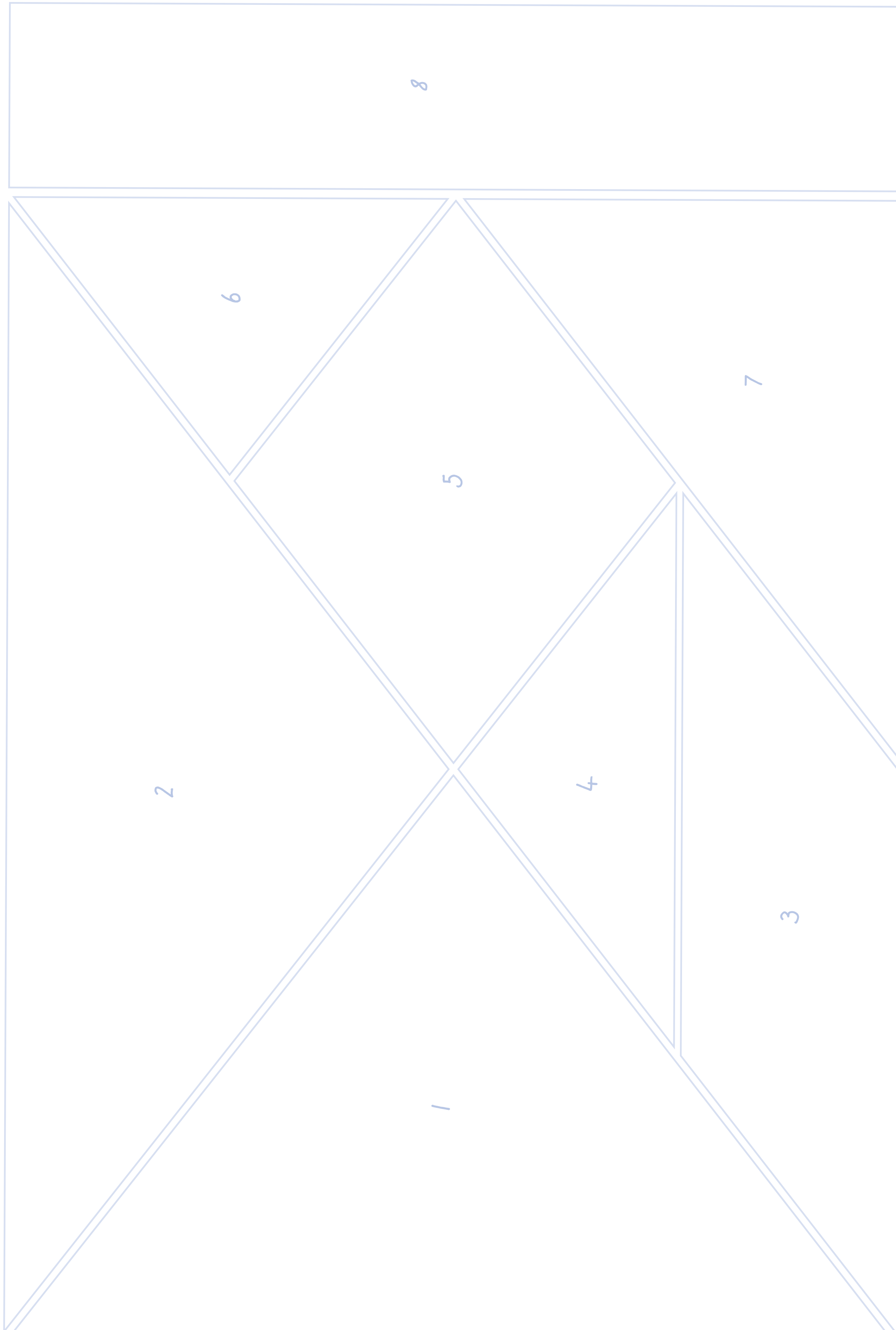
Scorpio (scorpion)

Hints

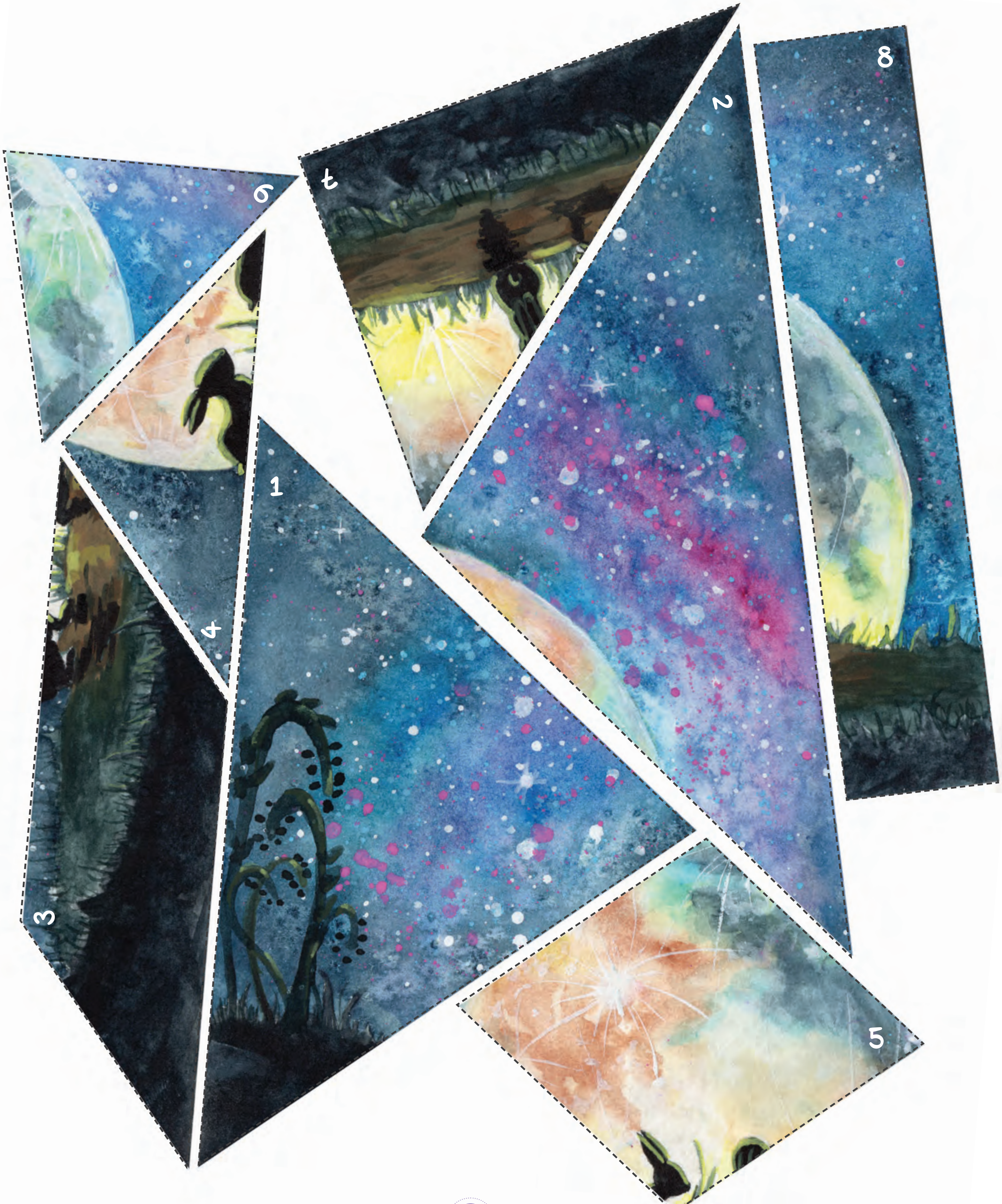
- Bootes (kite shape)
- Southern Cross (cross shape)
- Pisces (V-shape)
- Leo (coat hanger shape)
- Taurus (line with V for horns)
- Scorpio (scorpion tail)

Moon Puzzle

Cut out the puzzle pieces on the next page. As your parent or teacher reads the moon facts, glue the corresponding puzzle piece in the correct spot.

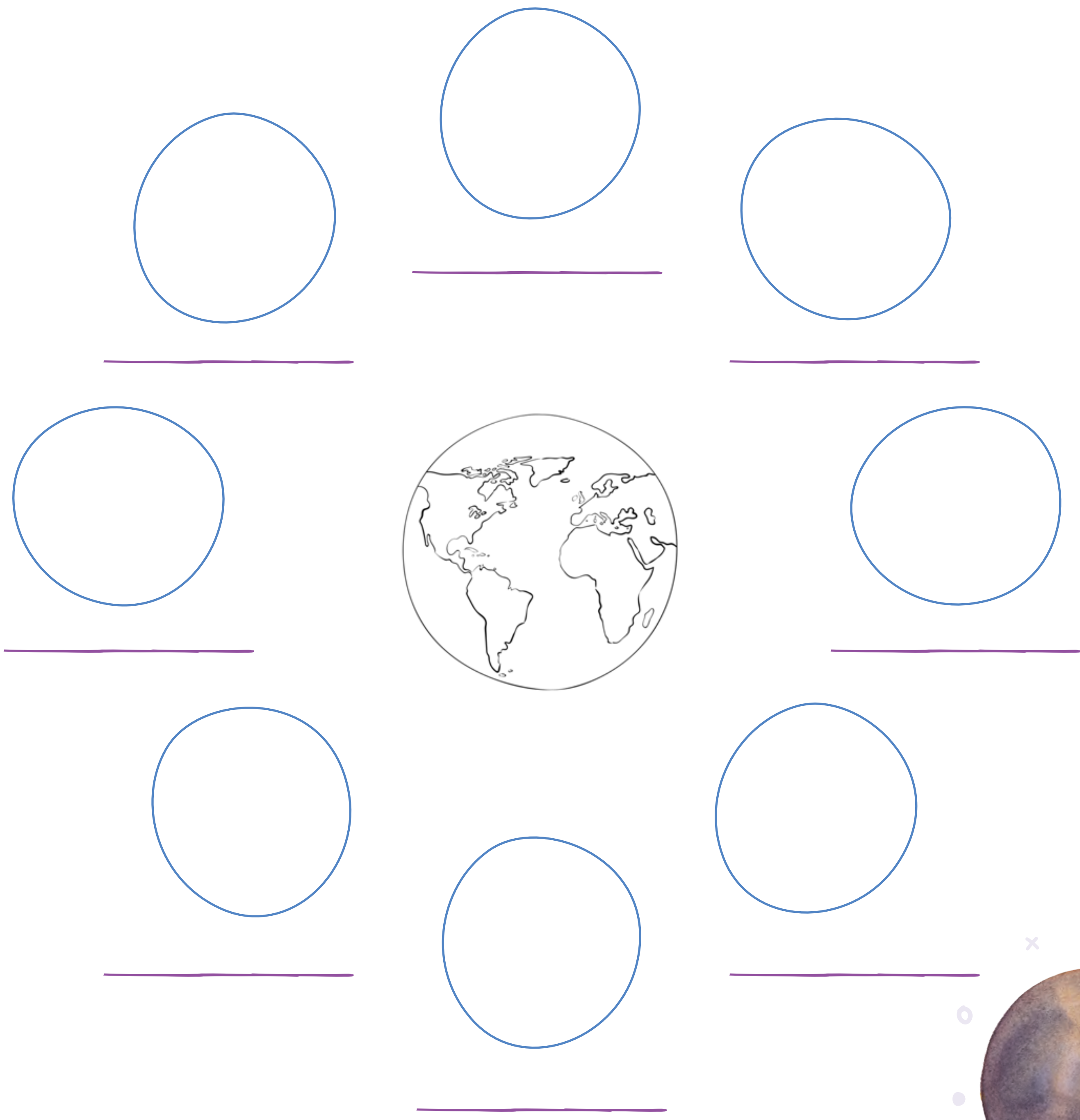


Moon Puzzle Pieces



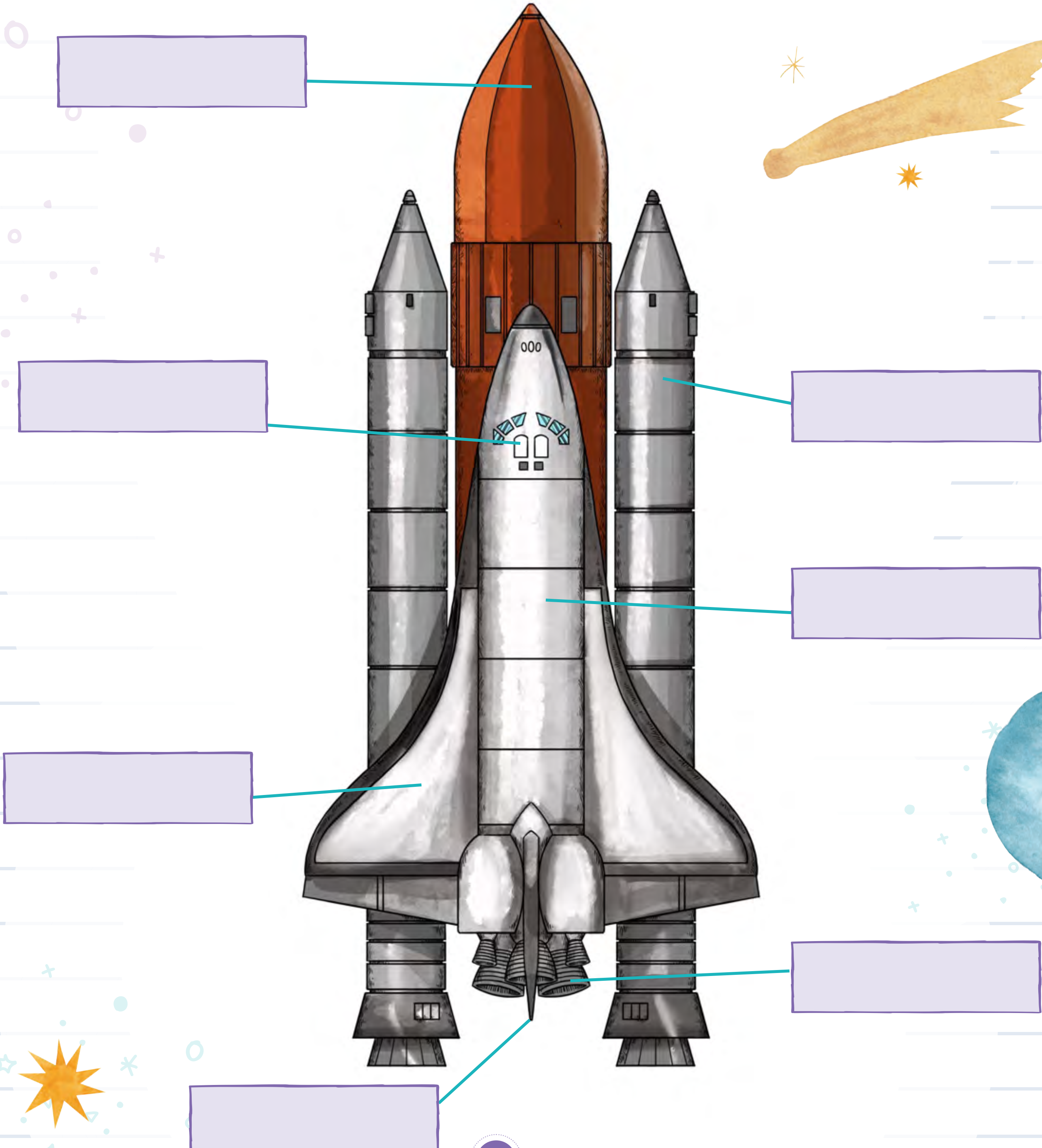
MOON PHASES

Use the circles to show the different phases of the moon. Begin with the Last Quarter at the bottom and label each circle. Continue counterclockwise.



PARTS OF A SPACE SHUTTLE

The Apollo program demonstrated that people could travel into space, perform useful tasks there, and return safely to Earth. But space had to be more accessible. This led to the development of the space shuttle. Label the parts of the space shuttle using the following words: External Tank, Solid Rocket Booster, Crew Cabin, Wing, Orbiter, Main Engines, and Vertical Stabilizer. Color or decorate your space shuttle if desired.



Getting to Know the Planets Cards

MERCURY

Illustration of Planet

FACTS

Circle the best answer:

What ordinal position is it from the sun?

Is it **BIGGER** or **SMALLER** than Earth?

Is it **HOTTER** or **COLDER** than Earth?

VENUS

Illustration of Planet

FACTS

Circle the best answer:

What ordinal position is it from the sun?

Is it **BIGGER** or **SMALLER** than Earth?

Is it **HOTTER** or **COLDER** than Earth?

SPACE SCIENCE

Grades 7–8

STUDENT JOURNAL

This journal belongs to:

THE GOOD AND THE BEAUTIFUL

INSTRUCTIONS

This student journal accompanies *The Good and the Beautiful Space Science* unit. It contains all the worksheets and journal pages that are needed to complete the unit. Each student will need his or her own copy of the science journal.

The lesson extensions are also found here. These extensions are optional for older students (grades 7–8) to complete on their own. Each extension is accompanied by lined paper so the student can keep his or her work in one place.

Have each student take his or her time to create high-quality work as the activities and worksheets are completed. Students may enjoy looking back on their past discoveries when they've finished.

Lesson 1 | Grades 7-8

EXTENSION

Instructions:

1. Read the information.
2. Imagine you are an astronomer who invents a new unit of measure that is greater than light-years to calculate the distance between galaxies. In your science journal, record what you would call it and why.

Measuring Space

In the late 1700s, a young man made significant contributions to the field of astronomy, despite the fact that he left formal school at the age of 14. His name was Friedrich Wilhelm Bessel. He was born in 1784 and loved to learn, particularly about mathematics and astronomy. His quest for knowledge in these two areas would eventually lead him to discover new ways to measure space.

Early Career

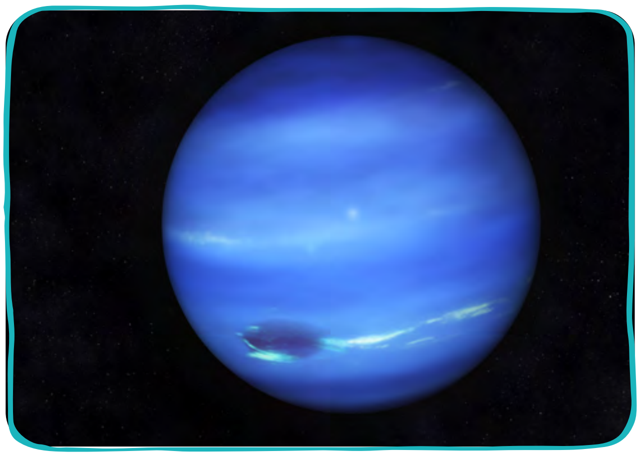
After leaving school, Bessel worked as an apprentice in a trading business. He started studying geography, Spanish, English, and navigation on his own in the evenings. His interest in navigation led him to study astronomy, and he wrote a paper about Halley's Comet that impressed Wilhelm Olbers, the leading expert on comets at that time, so much that Olbers recommended that Bessel become a professional astronomer.

Bessel decided he would like to do that, and he left his job, even though he would have earned a lot of money working in trade. He became an assistant at an observatory in Bremen, Germany, where he was able to devote his time to astronomy. Later, he became a professor of astronomy in Königsberg.

Measuring Space

During his lifetime, Bessel was able to determine the correct positions and motions of over 50,000 stars! He is most famous for figuring out that a star named 61 Cygni is about 10 light-years away from the earth. It was the first time that someone had accurately figured out the distance of a star other than the sun from the earth. Bessel measured the distance in astronomical units, but in his report he added that it would take light about 10.3 years to travel that distance because he thought people would find it interesting to know how long it would take light to travel there. Later, light-years became a common measurement of distances in space.

Bessel used a device called a heliometer, which is a special telescope with two lenses. The device had been designed to measure the diameter of the sun, but Bessel was able to use it to make accurate measurements of the positions and motions of the stars. Bessel adjusted his findings to accommodate imperfections in the telescope and atmospheric interference; therefore, his measurements were the most accurate that had ever been made.



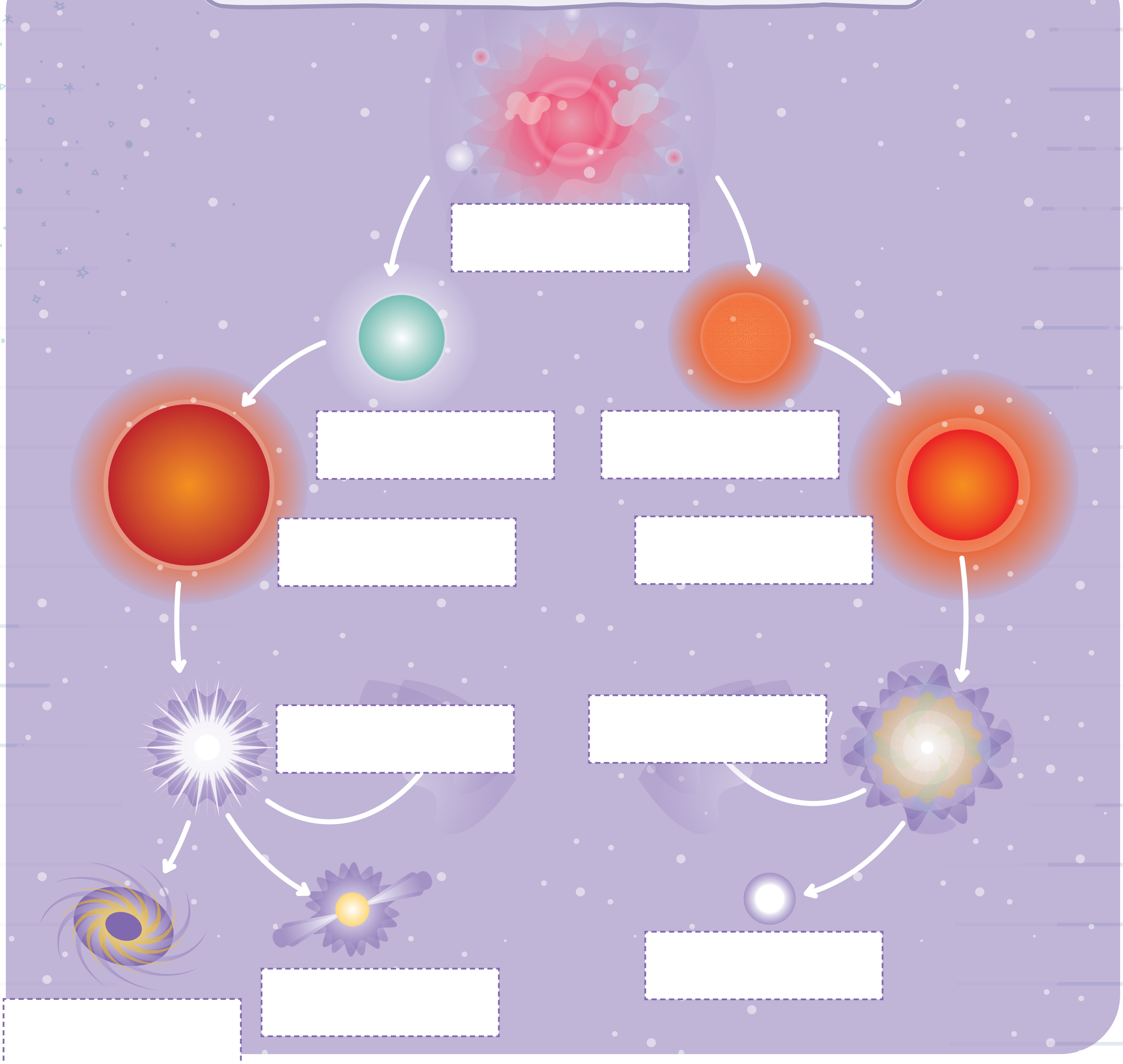
Additional Contributions

Bessel made many other significant contributions to astronomy. Using mathematics he was able to determine the shape of the earth, predict that there was a yet undiscovered planet past Uranus, and give evidence to Copernicus' theory that the earth orbited the sun. Although he did not discover Neptune himself, his work pushed—and continues to push—astronomers to further discovery using mathematics to measure space.

LIFE CYCLE OF STARS

Using the word bank, label each stage of the life cycle of stars chart below.

Stellar Nebula	Red Supergiant	Planetary Nebula
Massive Star	Red Giant	White Dwarf
Average Star	Supernova	
Neutron Star	Black Hole	



EXTENSION

Instructions

1. Read the information about Polynesian navigation.
2. Would you want to go on a trip between the Polynesian islands on a traditional canoe? Imagine that you are taking such a voyage. Write a paragraph describing what it would be like to be on a Polynesian boat, including the navigation methods used.

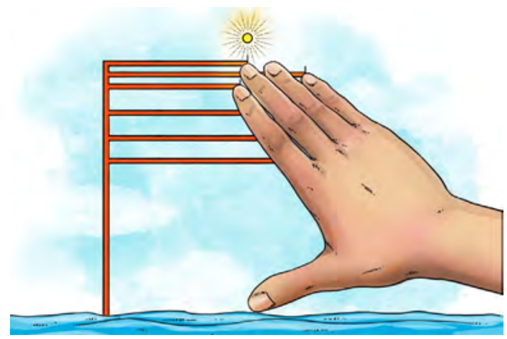
Wayfinding: Polynesian Star Navigation

Long before the invention of the compass or ***sextant***, a tool used to measure the distance of a star from the horizon for navigation, ancient Polynesian cultures sailed the vast expanse of the Pacific Ocean, discovering and colonizing many of the ocean's small islands. Despite the immense distances between the islands, these early navigators were able to find their way. How did they accomplish such an amazing feat? They were experts at reading the positions of the stars, sun, and moon, as well as at understanding ocean currents and waves and even the behavior of sea creatures and birds. They also developed skills in remembering how far they had come, creating mental maps of their voyages.

A knowledge of the night sky was essential to these Polynesian navigators. They would use a star compass called a Kapehu Whetu, shown here, to position themselves, memorizing the rising and setting of the brightest stars and planets to help them sail in the right direction. The star compass divides the night sky into four quadrants. A star that rises in a specific quadrant will set in the opposite one, just like the sun rises in the east and sets in the west. Polynesians would steer toward a star on the horizon. When the star either rose too high to be useful or set below the horizon, they would choose another star to navigate by. The positions of the moon and bright planets, such as Venus and Jupiter, were also helpful. Constellation positions change depending on latitude (how far north or south the boat is), so Polynesian navigators had to adjust for those changes.

Wayfinder Hand Navigation

Skilled navigators would measure the distance between the stars and the horizon using only their hands. They would hold one hand out and place the thumb so it was sitting on the horizon. They would use each finger to measure different distances. The width of the pinkie



finger represented one degree and helped the wayfinder determine a location based on the angle between his or her pinkie and the horizon.

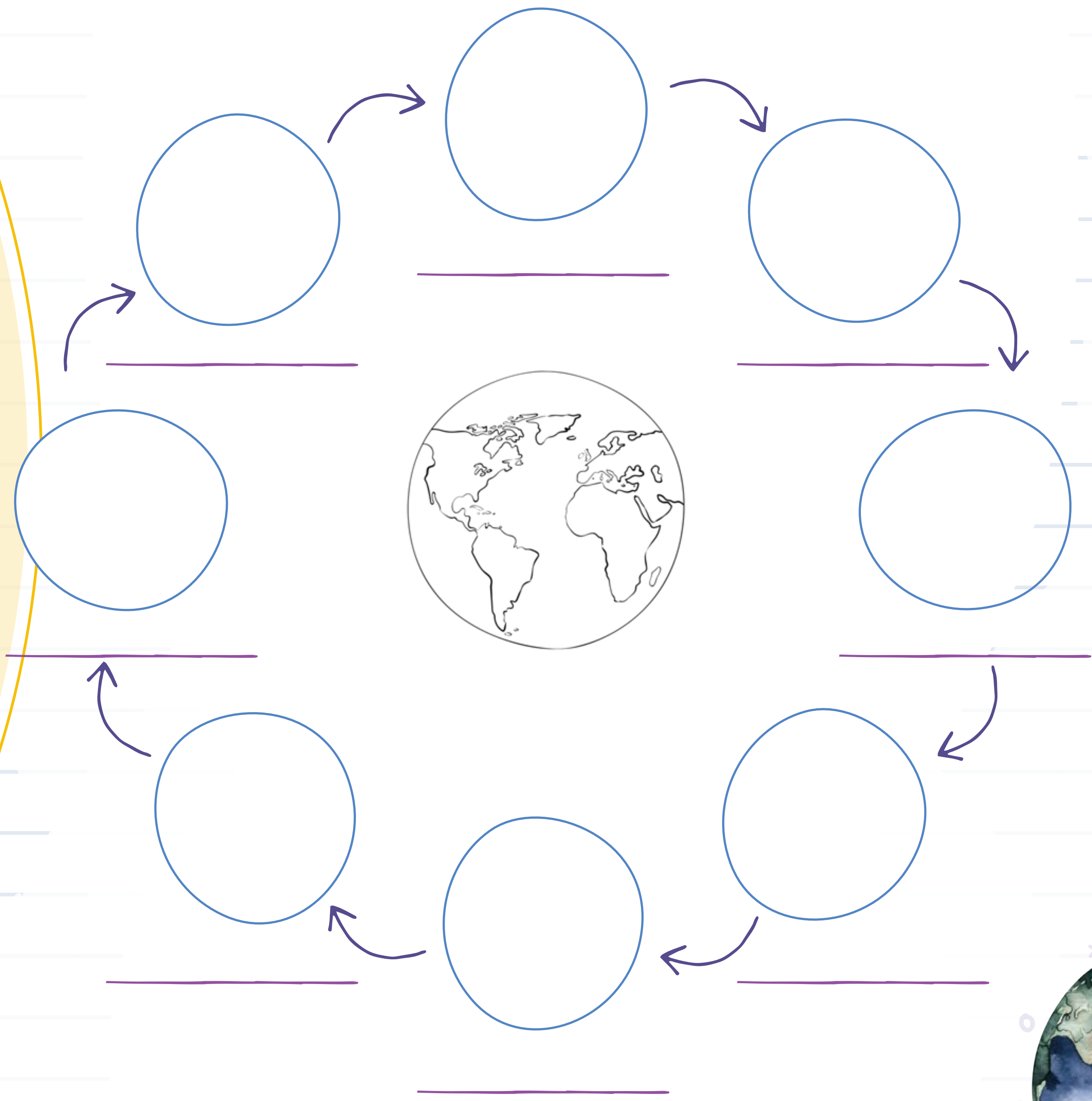
When Europeans first visited Polynesia, they had a hard time believing that the native Polynesians could have crossed such vast ocean distances without any of the tools that Europeans used, like compasses and sextants. After Europeans colonized the islands, the ancient art of wayfinding was in danger of being lost. However, a few people retained the skill, and now the tradition is being revived.

Modern Wayfinder Voyage

In 1976 a traditional double-hulled voyaging canoe called *Hokule'a* (HOW-kuw-LEH-ah), which means "Star of Gladness" in Hawaiian, sailed from Hawaii to Tahiti using only ancient navigation. The voyage of the sailing canoe *Hokule'a* was very exciting for the Polynesian people. In Tahiti 17,000 people gathered on the shore to welcome the boat. Since 1976 these traditional vessels have made other voyages, including one in 1999 to Rapa Nui (Easter Island), one of the most isolated islands on Earth.

MOON PHASES

Use the circles to show the different phases of the moon. Begin with the Last Quarter at the bottom and color and label each circle. Continue clockwise.



EXTENSION

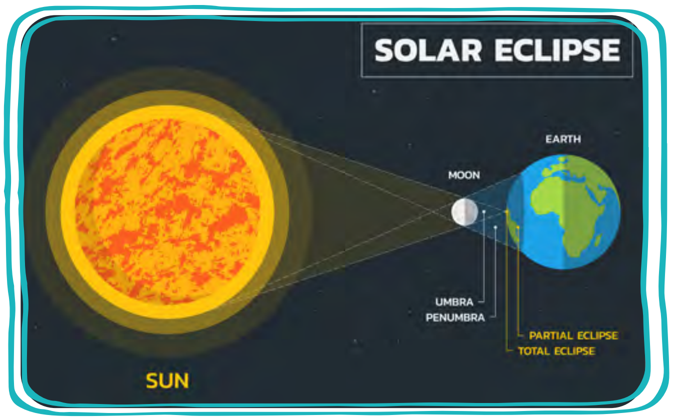
Instructions:

1. Read the information below.
2. If you complete the optional activity, write a paragraph describing the results of your experiment. How did the distance of the tennis ball change the outcome?
3. If you do not complete the activity, imagine you are viewing a solar eclipse and describe in a paragraph what you would see, what you would feel, and what you would need to view the eclipse.

Solar Eclipses

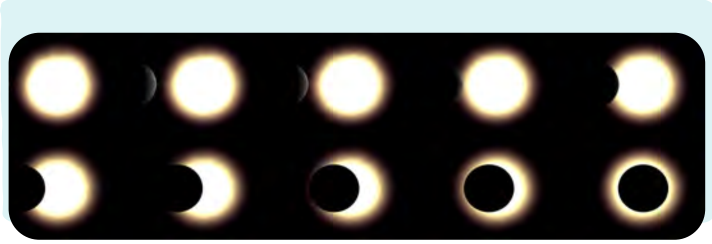
A solar eclipse is an exciting, dramatic event. In the middle of the day, the sky goes dark, temperatures drop, and winds slow down and change direction. Some stars might even be visible! At its height the sun's disk is completely blocked out, allowing you to see the glowing ***corona*** (Latin for "crown") surrounding it when viewed through safety glasses. Even though much of the sun is covered, just a small sliver of the sun is bright enough to damage your eyes if you look at it. You should never look at an eclipse directly; it's just as dangerous as looking at the sun any other time.

What causes this spectacular display of nature? As the moon orbits the earth, it occasionally passes directly between the sun and the earth. When that happens, the moon's shadow falls on the surface of the earth. Since the moon is much smaller than the earth, the shadow covers only a small region. As the shadow passes across the earth, people on the surface see the moon passing in front of the sun. This is a ***solar eclipse***.



If you are watching the event happen, first you'll see the moon's shadow taking a tiny bite out of the edge of the sun. Then, as the moon advances, more and more of the sun vanishes until you're left with a crescent sun. Daylight becomes dimmer and dimmer as the amount of sunlight diminishes. Finally, when the moon's shadow completely covers the sun, you have a total solar eclipse.

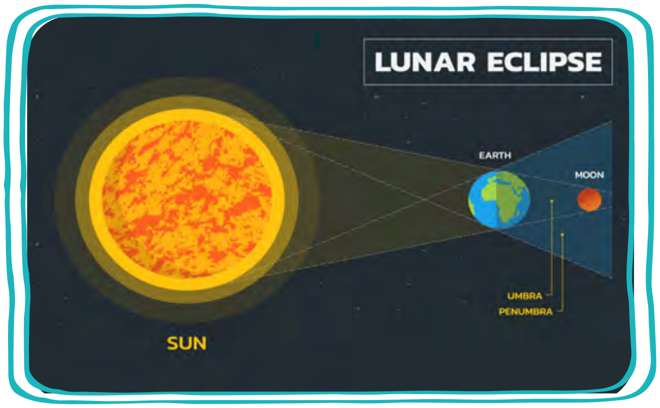
The moon's shadow has two components, the dark ***umbra*** and the lighter ***penumbra*** surrounding it. Within the umbra the eclipse is total; that is, the moon completely covers the sun. Within the penumbra the eclipse is partial, meaning that it never reaches totality. Did you ever notice that the sun and the moon appear to be roughly the same size in the sky? The moon is really much smaller than the sun, of course, but it is much closer. God's perfect placement of the moon is just the right distance away to appear around the same size as the sun in the sky, which allows beautiful solar eclipses to happen. If the moon were farther away, it would appear smaller and never completely block out the sun. Since the moon's orbit is an ellipse rather than a perfect circle, sometimes it is a little farther away than normal and thus appears a bit smaller during an eclipse. At these times a ring of sunlight is visible around the moon's shadow. These are called ***annular eclipses***.



Lunar Eclipses

When the moon passes behind the earth, Earth's shadow falls on its surface, making it dark. This is a ***lunar eclipse***. Since the earth is bigger than the moon, its shadow covers the entire lunar surface. As you watch, you'll see an edge of the full moon go dark. As the earth's shadow advances, more and more of the moon darkens. At totality the moon takes on a dim coppery glow. This is due to light scattering from the earth's atmosphere. Particles in the atmosphere scatter blue light (making the sky blue) and allow red light to pass through and slightly illuminate the eclipsed moon.

The moon orbits the earth roughly once a month, so why don't we see a lunar eclipse every month? The reason is that the moon's orbit is tilted a bit. Imagine placing a ball, representing Earth, at the center of a Hula-Hoop®. Now tilt the Hula-Hoop® at an angle so that it's not parallel with the ground. The Hula-Hoop® is the moon's orbit. You can see how the moon is often either below the earth or above it when it orbits. That means most of the time it passes either above or below the earth's shadow, and therefore no lunar eclipse happens. Only when the moon happens to be level with the earth and directly behind it do we see a lunar eclipse. The same thing happens for solar eclipses, but because the moon's shadow only covers a small portion of the earth's surface, solar eclipses are even rarer.



Gather the following supplies for the optional activity: a lamp, a basketball, and a tennis ball. You can substitute any large ball or very small ball if needed. Just make sure the balls are different sizes.

Eclipse Activity

Let's try to make an eclipse of our own. We'll use a light source like a lamp to represent the sun, a basketball to represent the earth, and a tennis ball to represent the moon.

1. In a darkened room, shine the light source onto the basketball. The basketball represents the earth in space, illuminated by the sun. Note that the side facing the light is brightly lit (day), and the opposite side is dark (night).

2. Now use the tennis ball to represent the moon. Hold the tennis ball between the basketball and the light source. Does it cast a shadow on the basketball? If not, you may need to move the tennis ball closer or farther away. The shadowed region of the basketball is experiencing a solar eclipse.

3. Once you have a shadow, move the tennis ball and see how the shadow moves across the surface of the basketball. Tiny inhabitants on our basketball world would see a solar eclipse as the shadow passes over them.

4. Experiment with moving the tennis ball closer to and farther away from the basketball. What happens to the shadow?

5. Now move the tennis ball so it passes behind the basketball. When the basketball's shadow falls over it, the tennis ball goes dark. This is a lunar eclipse. Again, experiment with moving the tennis ball closer and farther away to see what happens to it.

proportional distance and size of the earth and moon

Lesson 9

ASTEROIDS, COMETS, & METEOROIDS

Use the word bank to fill in the table below.

Size	Shape	Location	Composition	Examples
* Up to 10 m across * 200 km * Up to 10 km in diameter	* Irregular * Irregular * Oddly shaped	* Asteroid Belt * Deep space * Deep space, Earth's atmosphere, or Earth's surface	* Ice, rock, and frozen gases * Rock, metal, and debris * Rock, ice, and metal	* Arizona Meteor Crater * Halley's Comet * Chicxulub crater, Mexico

	ASTEROIDS	COMETS	METEOROIDS
Size			
Shape			
Location			
Composition			
Famous examples			

Lesson 9 | Grades 7-8

EXTENSION

Instructions:

1. Read the information below.
2. Write a paragraph describing why Halley's Comet returns in a regular pattern and what you think it would be like to view the comet in the year 2061.

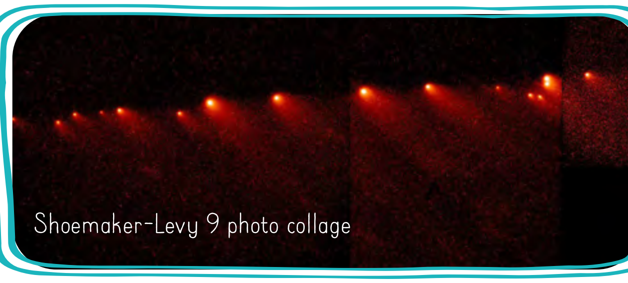
Famous Comets

Perhaps the best known of all comets is **Halley's Comet**. Named after Sir Edmund Halley (rhymes with valley), this comet is a periodic comet that returns every 75 years. Halley observed the comet in 1682. After some calculations, he determined that several previous comets were, in fact, the same comet returning over and over. He predicted that the comet would return in 1757. Although he didn't live long enough to see it, his prediction was correct, and the comet was named in his honor.

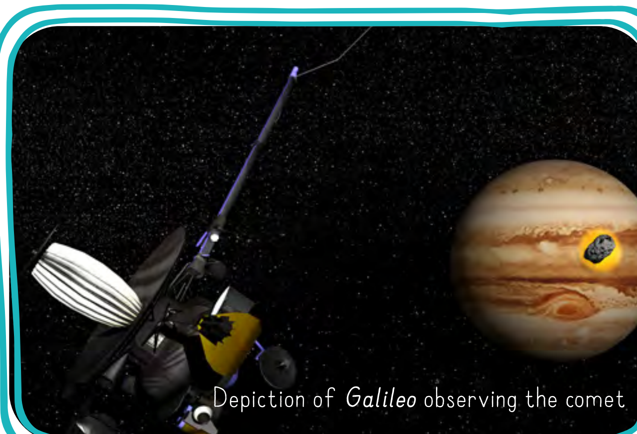
Chinese astronomers recorded sighting Halley's Comet in 239 BC! In 1066 the comet appeared shortly before William the Conqueror's invasion of England, and William believed it was a sign that he would be successful. The comet was woven into the Bayeux Tapestry, a 70-meter-long (230 feet) embroidered cloth depicting the conquest of England. In 1910 Halley's Comet passed particularly close to Earth, giving people of the time an impressive view, and it was photographed for the first time. The most recent appearance of this comet was in 1986. Several space probes were sent to observe the comet as it passed by. Halley's Comet is due to return to our skies in 2061.

Bayeux Tapestry

Shoemaker-Levy 9 is perhaps the most famous comet that is not visible to the naked eye on Earth. The comet passed close to Jupiter in 1992. The planet's gravity broke the comet up into 21 fragments that spread out like a string of pearls in its orbit. Two years later, the fragments crashed into Jupiter one by one. The Hubble Space Telescope, earthbound telescopes, and the space probe *Galileo* all watched the impacts. This was the first time collisions between objects in space had ever been observed. The comet fragments impacted the planet at high speeds, creating massive explosions more powerful than millions of atomic bombs. The impacts sent plumes of hot gases high into the planet's atmosphere and left dark scars in the clouds.



Shoemaker-Levy 9 photo collage



Depiction of *Galileo* observing the comet

Interstellar Comet

Perhaps the strangest comet known is Oumuamua [oh–MOO–ah–MOO–ah], whose name in Hawaiian means "a messenger from afar arriving first." Oumuamua is the first interstellar comet (a comet coming from outside of our solar system) to be discovered. The object surprised astronomers by varying in brightness, which indicates that it is very long and thin. While originally classified as a comet, further observation showed that it probably has very little ice remaining. This strange object is like nothing in our solar system, having characteristics of both comets and asteroids. Oumuamua passed closest to our sun in 2017 and is now headed back out into interstellar space.

EXTENSION

Instructions:

1. Read the information below.
2. In your science journal, write 1–2 sentences about each of the following prompts:
   a. Describe some of the life challenges that Henrietta Swan Leavitt had to overcome.
   b. How did Henrietta Swan Leavitt's discoveries impact the study of astronomy?
   c. What inspired you the most about Henrietta Swan Leavitt?

Astronomer Henrietta Swan Leavitt

Have you ever heard of someone being called a *forerunner*? A forerunner is a person who precedes or leads the way for someone else. Henrietta Swan Leavitt was certainly a forerunner in astronomy: her discoveries influenced the work of famous astronomers who came after her. Despite humble beginnings, prejudices against women, and multiple health challenges, Henrietta Swan Leavitt beat the odds to make far-reaching contributions to astronomy.

Early Life

Born on July 4, 1868, in Lancaster, Massachusetts, Henrietta was the eldest of seven children. Due to her father's work as a minister, her family moved regularly. One of those moves took them to Cleveland, Ohio, where Henrietta attended Oberlin College, beginning at age 17. During her early college years, Henrietta studied music, which she enjoyed, but she had not yet found a subject of study that fully captured her interest.

After her third year of study, the Leavitt family moved back to Massachusetts, where Henrietta hoped to continue her education. However, Harvard University did not admit women at that time. Instead, Henrietta enrolled at the Harvard Annex (later called Radcliffe College). There she shifted her studies to mathematics and, during her final year, stumbled into the field of astronomy. Instantly, she was fascinated by the vastness of space and the limitless discoveries to be made.

Challenges

Upon graduating at age 23, Leavitt volunteered as a research assistant at Harvard's observatory. As one of the human computers at the observatory, Leavitt measured and cataloged the brightness of stars as they appeared on photographic plates. But Leavitt's aspirations of becoming an astronomer soon came to a halt when ongoing health problems confined her to her home for two years. As her illness advanced, she became aware that she was losing her hearing! Over a short period of time, Leavitt became increasingly deaf. At first the realization weighed heavily on her heart, but taking courage and placing her faith in God, Henrietta Swan Leavitt pressed forward toward her goal.

Discoveries

In 1902, with her health finally improving, Leavitt returned to the Harvard College Observatory, this time as an employee. ***Variable stars***, or stars whose brightness varies, remained her central focus. Leavitt worked diligently to discover the relationship between the overall brightness of stars and the time it took them to change from bright to dim and back again (called a ***pulse rate***).

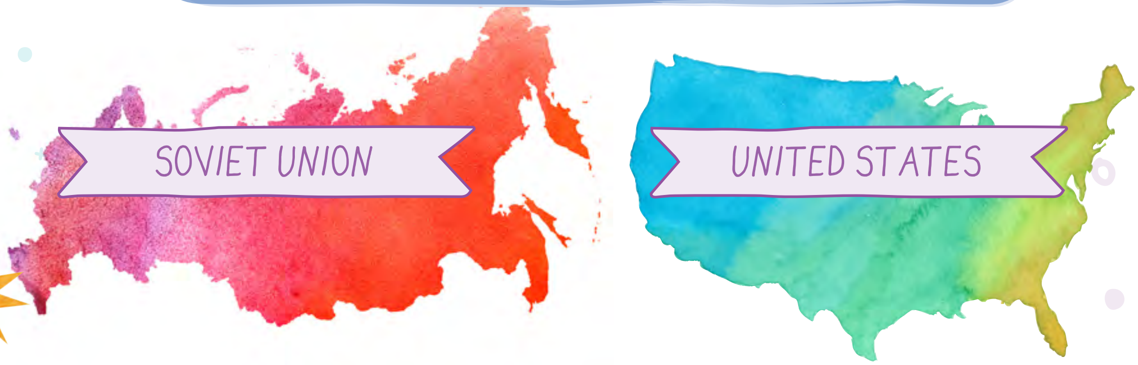
After carefully observing variable stars, she made her breakthrough discovery: the brightness of these stars was directly related to pulse rate! Brighter stars have longer pulse rates, while dimmer stars have shorter pulse rates. Why was this so important? It provided a standard for measuring distances outside our solar system and determining a galaxy's size. She established 17 magnitudes of brightness that were used for decades to order stars by their brightness.

Additionally, Leavitt's discovery advanced the work of other astronomers, such as Harlow Shapley, who proved that our sun was not at the center of the galaxy. Astronomer Edwin Hubble relied on the ***Leavitt law*** when he found Cepheid stars in other galaxies. Leavitt's law helped prove that galaxies existed outside the Milky Way and that our galaxy was not the center of the universe.

Henrietta Swan Leavitt's work was so pivotal to the field of astronomy that she was nominated for a Nobel Prize in 1926. Despite significant social and health-related challenges, Henrietta Swan Leavitt retained a positive attitude and made invaluable discoveries in astronomy. As a forerunner to the many great scientists who built upon her discoveries, she truly paved the way for those who came after her.

SPACE RACE

Draw a line from each achievement to the correct country.



FIRST SATELLITE TO ORBIT THE EARTH

FIRST INTERNATIONAL DOCKING

FIRST ANIMAL IN ORBIT

FIRST SPACE WALK

FIRST MOON LANDING

FIRST AMERICAN WOMAN IN SPACE

FIRST MARS LANDING

FIRST YEAR SPENT IN SPACE

FIRST MAN IN SPACE

EXTENSION

Instructions:

1. Read the information below.
2. In your journal write which job at NASA you would enjoy doing most and why.

The Supporting Cast

A well-known saying in American culture advises the following: "There is no I in TEAM." While Neil Armstrong, Michael Collins, and Buzz Aldrin received recognition for landing on the moon during the Apollo 11 mission, they knew they could not have done it without the work of a huge team of directors, scientists, mathematicians, engineers, and others supporting them back home. Let's take a closer look at some of these people and the roles they played that contributed to the success of the Apollo missions.

Mission Controllers

The Mission Control Center (MCC) is the location where people worked together to coordinate each aspect of a space mission—from prelaunch, launch, and flight through space to lunar landings and reentry. Some of the people in the MCC included the following:

Flight director—oversaw and managed the Mission Control Center, led the planning and coordination of every part of the mission, and approved any instructions or procedures given to the astronauts. Gene Kranz was the flight director who directed the lunar landing of the Apollo 11 mission. Four other directors were in charge of other aspects of that mission (such as the launch).

Spacecraft communicator (also called the CAPCOM)—talked with the astronauts via radio. All messages were relayed by a single person so the radio lines would not become jammed with too many people talking at once, and astronauts had a familiar voice they could rely on. This job was often performed by a fellow astronaut.

Gene Kranz

Flight controller—coordinated and computed the exact times, speeds, and trajectories for the astronauts to stay on the correct flight path. For example, he or she would tell those on the moon exactly when to launch the lunar landing module so they could meet up with the orbiting spacecraft at the right time.

Charles Duke, James Lovell, and Fred Haise—CAPCOMs for Apollo 11

Communications operator—managed all the communications systems, including the video footage that came in from the moon landing.

Flight doctor—monitored the health of the astronauts throughout the mission by the use of little sensors placed on their bodies.

Other Jobs at NASA

Countless others—as many as 400,000 people—contributed to the Apollo missions behind the scenes. Many of those people worked at NASA's Langley Research Center in Virginia.

Human Computers: In the early days of astronomy and space exploration, mathematical computations were all done by hand with a pencil, paper, and slide rule.


Katherine Johnson

Computers and digital calculators capable of processing complex equations had not been invented yet. During this era the people who did these calculations were called "human computers" because they were computing information.

Beginning in the 1940s during WWII, these jobs were increasingly performed by women. The contributions


Mary Jackson

of human computers were brought to the attention of the public when a movie named *Hidden Figures* was made about Katherine Johnson, Dorothy Vaughan, and Mary Jackson, who worked at Langley for decades. One of Johnson's most significant contributions was the computation that synced the Apollo 11 lunar landing module to the orbiting command module.

Geologists: Ahead of the Apollo 11 mission, several geologists studied photographs of the moon's surface, analyzing its qualities in order to determine the best place for the lunar module to land. After the astronauts returned to Earth with soil and rock samples, the geologists studied the samples to increase their understanding of the moon and improve landing recommendations for future Apollo missions.

Tailors: These talented seamstresses were tasked with designing space suits that would protect the astronauts from the extreme conditions of outer space. The suits had to protect them from extremely cold temperatures and be airtight while still allowing the astronauts to move freely enough to climb out of the lunar landing module.

Engineers: From testing and building the Apollo spacecraft


Judy Sullivan

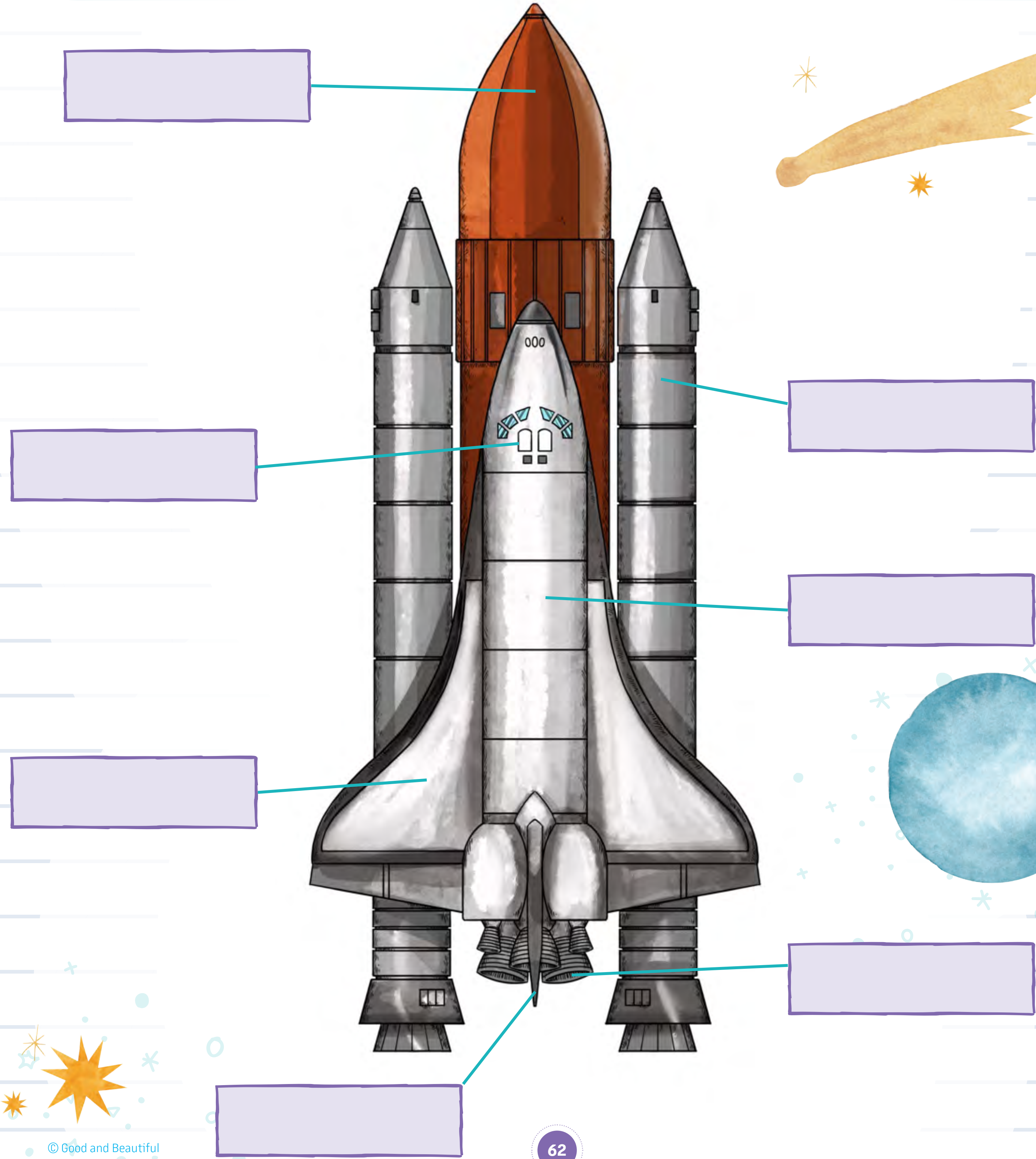
to developing the systems to run them, engineers were involved in almost every aspect of the Apollo missions. Judy Sullivan, one of the first female engineers to be hired by NASA, worked closely with the astronauts to help monitor their vital signs. She was the lead engineer for the Apollo 11 biomedical system.

This article has discussed only a small handful of the countless individuals working behind the scenes at NASA. Even though you may not have known of these people and their jobs before, each person made vital contributions to the success of the Apollo missions and was an important part of the team.


Mission Control Center

PARTS OF A SPACE SHUTTLE

The Apollo program demonstrated that people could travel into space, perform useful tasks there, and return safely to Earth. But space had to be more accessible. This led to the development of the space shuttle. Label the parts of the space shuttle using the following words: External Tank, Solid Rocket Booster, Crew Cabin, Wing, Orbiter, Main Engines, and Vertical Stabilizer. Color or decorate your space shuttle if desired.



Getting to Know the Planets Cards

MERCURY

Illustration of Planet

FACTS

Circle the best answer:

What ordinal position is it from the sun?

Is it **BIGGER** or **SMALLER** than Earth?

Is it **HOTTER** or **COLDER** than Earth?

VENUS

Illustration of Planet

FACTS

Circle the best answer:

What ordinal position is it from the sun?

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Is it **HOTTER** or **COLDER** than Earth?

SPACE SCIENCE

Grades 3-6

STUDENT JOURNAL

This journal belongs to:

THE GOOD AND THE BEAUTIFUL

INSTRUCTIONS

This student journal accompanies *The Good and the Beautiful Space Science* unit. It contains all the worksheets and journal pages that are needed to complete the unit. Each student will need his or her own copy of the science journal.

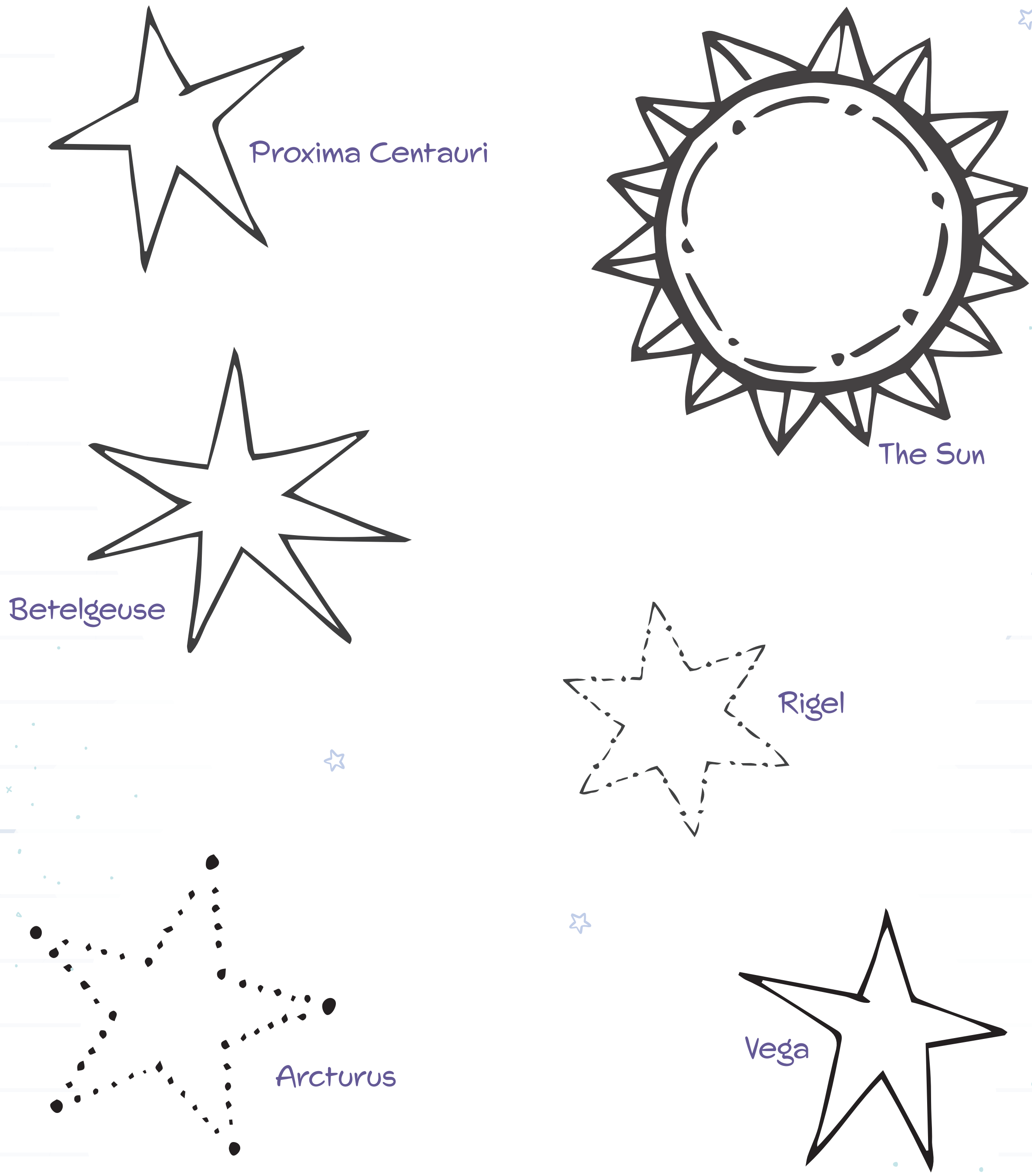
Have each student take his or her time to create high-quality work as the activities and worksheets are completed. Students may enjoy looking back on their past discoveries when they've finished.

TABLE OF CONTENTS

Lesson 2

COLOR OF STARS

Color the stars the correct color based on their temperature and the descriptions on the next page.



COLOR OF STARS

STAR COLOR TEMPERATURE CHART IN KELVINS

Proxima Centauri

is a dwarf star. Red dwarfs are the coolest stars, at 2,500 Kelvin. Color Proxima Centauri dark red.

The Sun

is a dwarf star. It is not as hot as blue or white stars, at about 5,700 Kelvin. Color our sun yellow.

Betelgeuse

is a supergiant star. It is one of the coolest stars, at 3,500 Kelvin. Color Betelgeuse bright red.

Vega

is a main sequence star. It is hot, about 9,600 Kelvin. Color Vega white.

Arcturus

is a giant star. It is a cooler star, about 4,200 Kelvin. Color Arcturus red-orange.

Rigel

is a supergiant star. It is a very hot star, about 11,000 Kelvin! Color Rigel light blue.

CONSTELLATION NAMES

Draw a line to match each constellation picture to its official name. Do you think it looks like what it is named for? What would you call each constellation? Give each one a new name.

Bootes (herdsman)

Southern Cross

Pisces (fish)

Leo (lion)

Taurus (bull)

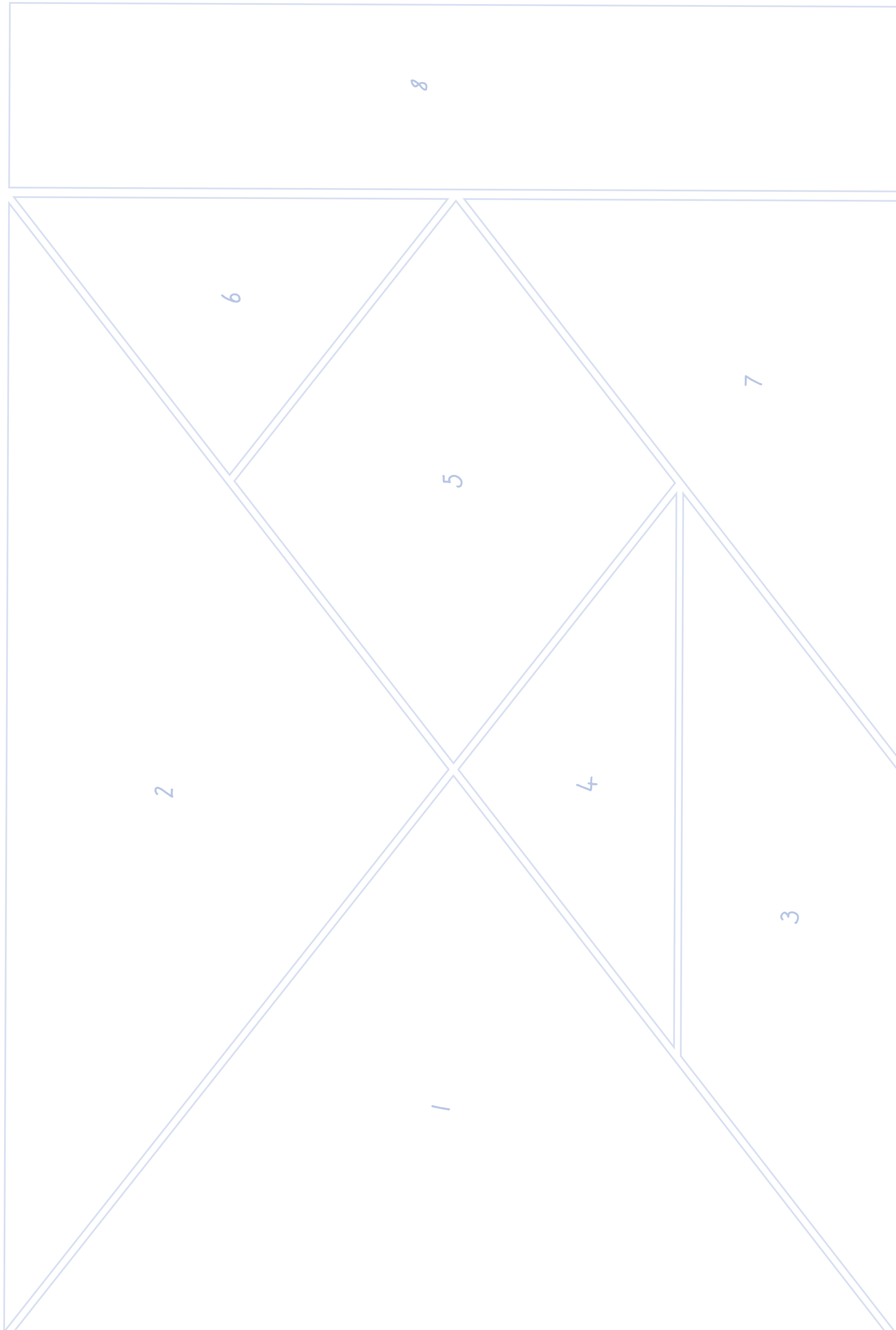
Scorpio (scorpion)

Hints

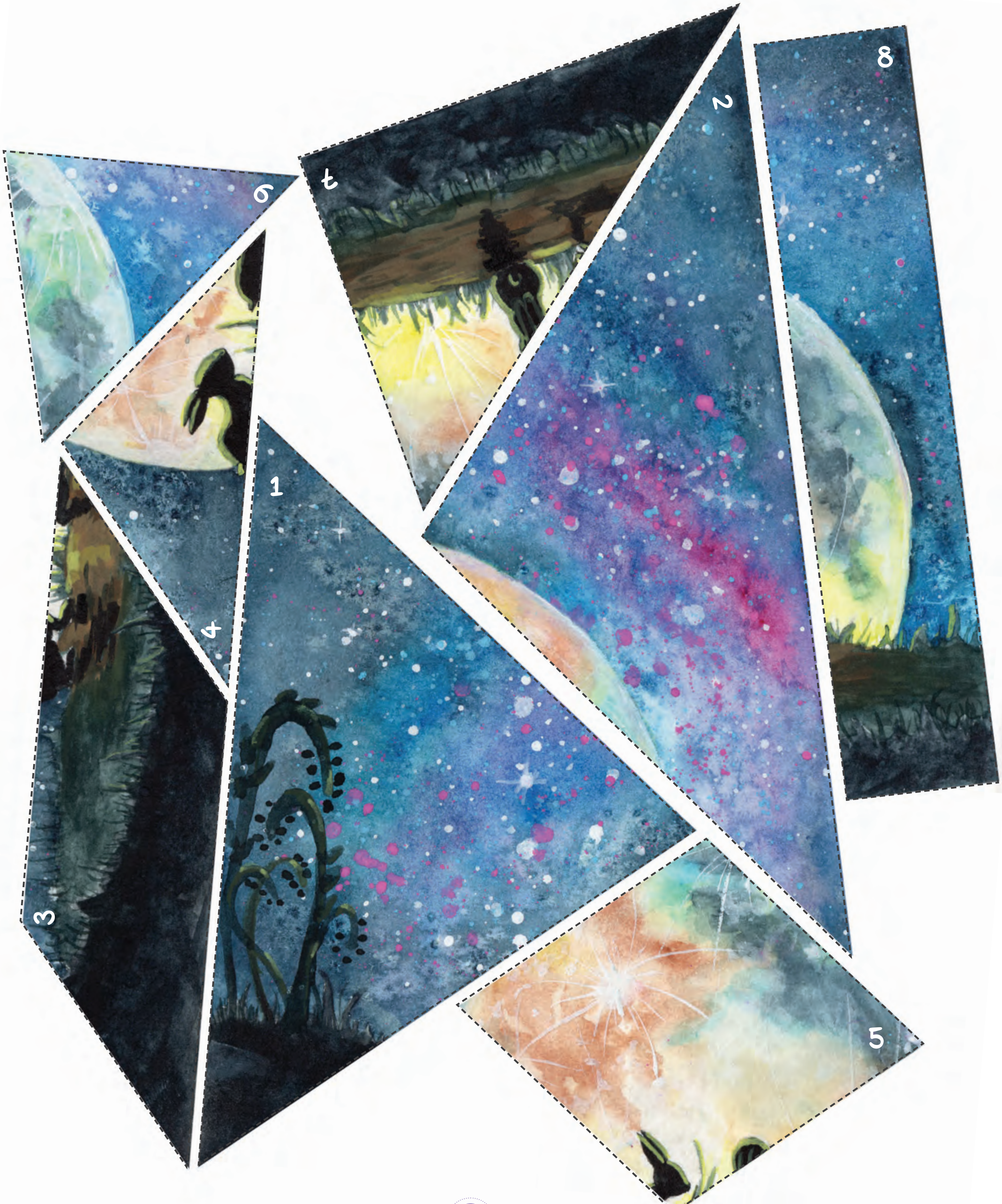
- Bootes (kite shape)
- Southern Cross (cross shape)
- Pisces (V-shape)
- Leo (coat hanger shape)
- Taurus (line with V for horns)
- Scorpio (scorpion tail)

Moon Puzzle

Cut out the puzzle pieces on the next page. As your parent or teacher reads the moon facts, glue the corresponding puzzle piece in the correct spot.

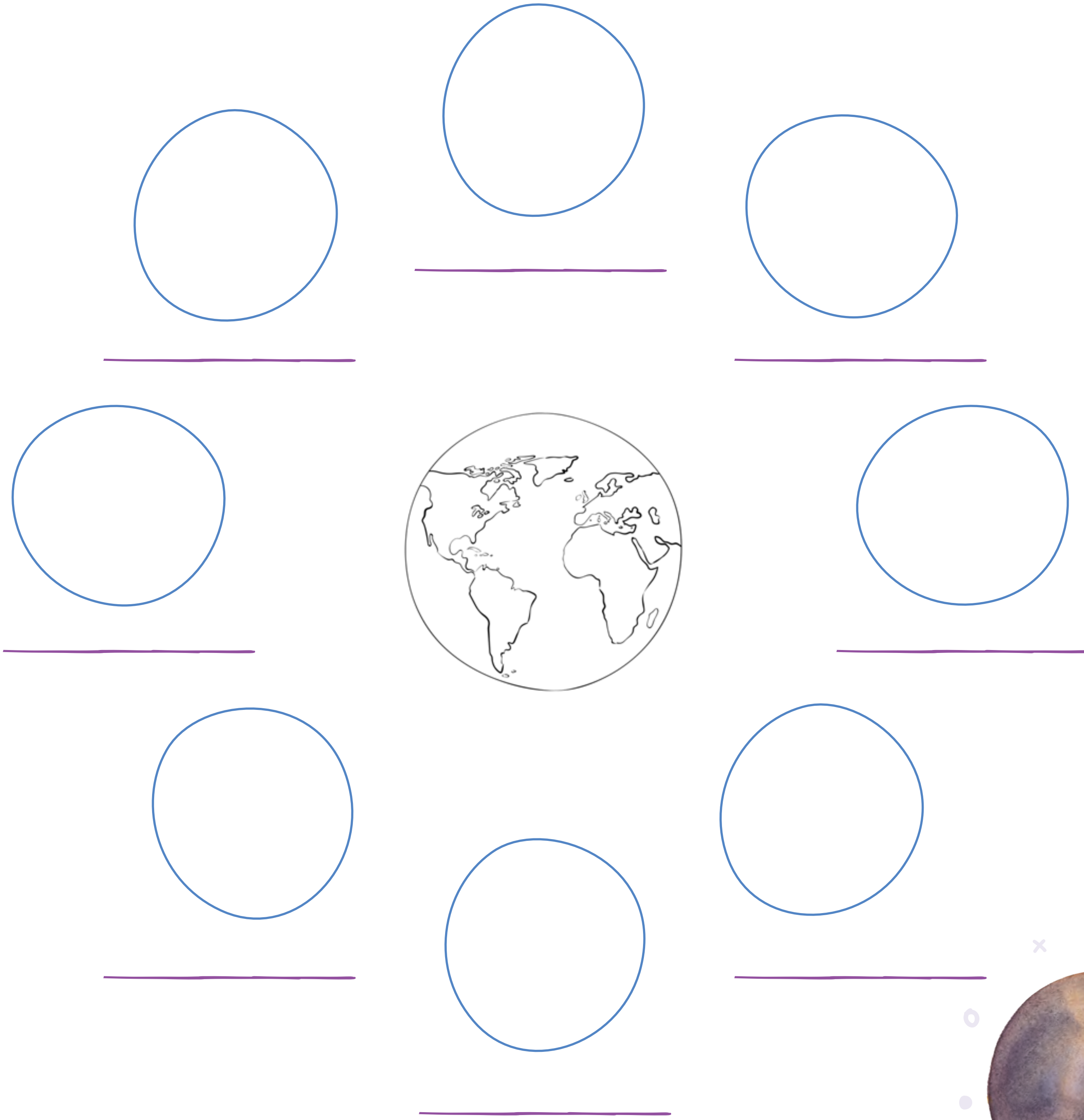


Moon Puzzle Pieces



MOON PHASES

Use the circles to show the different phases of the moon. Begin with the Last Quarter at the bottom and label each circle. Continue counterclockwise.



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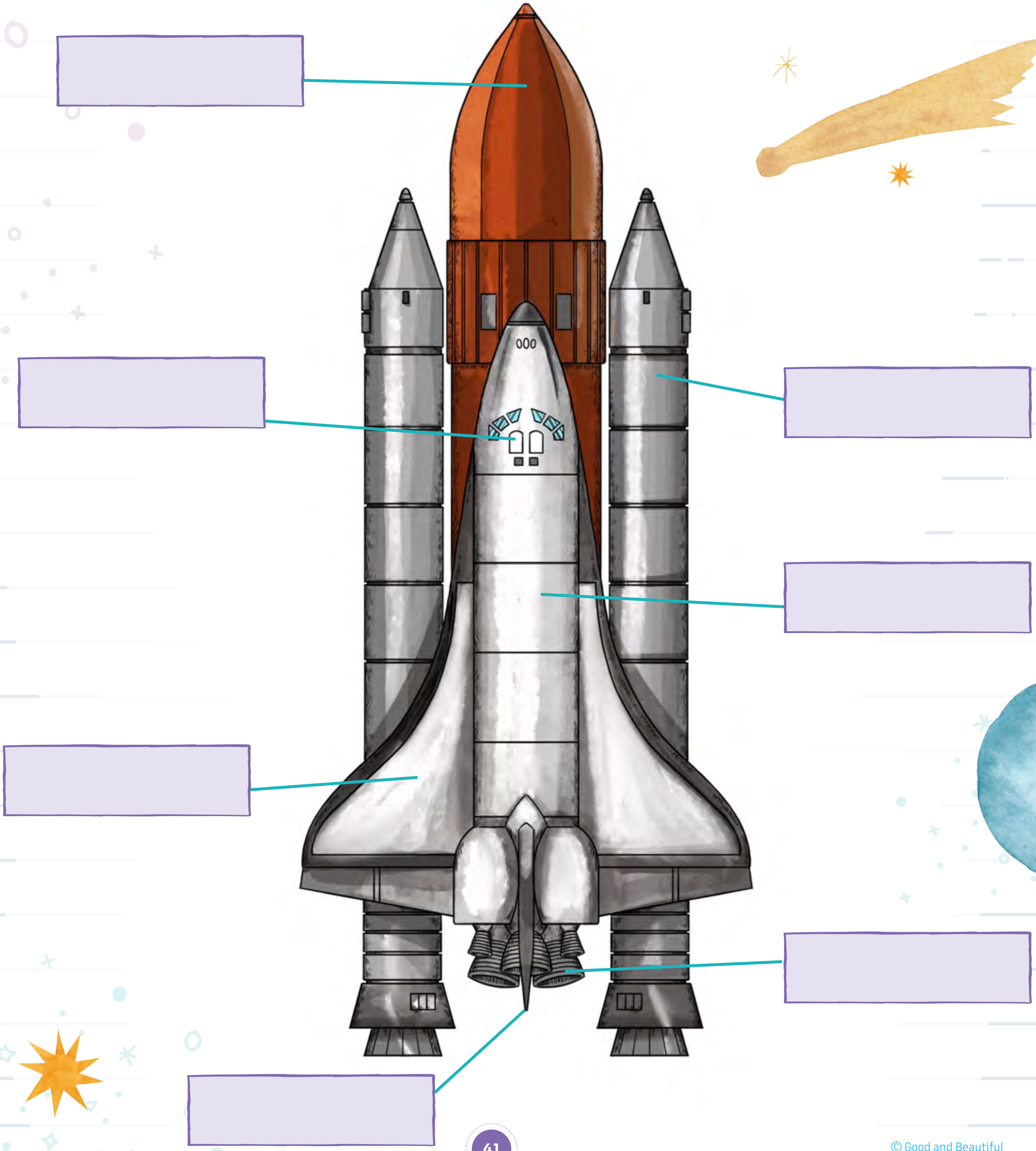

Getting to Know the Planets Cards

MERCURY

Illustration of Planet

FACTS

Circle the best answer:

What ordinal position is it from the sun?

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VENUS

Illustration of Planet

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Circle the best answer:

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SPACE SCIENCE

Grades 7-8

STUDENT JOURNAL

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The lesson extensions are also found here. These extensions are optional for older students (grades 7–8) to complete on their own. Each extension is accompanied by lined paper so the student can keep his or her work in one place.

Have each student take his or her time to create high-quality work as the activities and worksheets are completed. Students may enjoy looking back on their past discoveries when they've finished.

EXTENSION

Instructions:

1. Read the information.
2. Imagine you are an astronomer who invents a new unit of measure that is greater than light-years to calculate the distance between galaxies. In your science journal, record what you would call it and why.

Measuring Space

In the late 1700s, a young man made significant contributions to the field of astronomy, despite the fact that he left formal school at the age of 14. His name was Friedrich Wilhelm Bessel. He was born in 1784 and loved to learn, particularly about mathematics and astronomy. His quest for knowledge in these two areas would eventually lead him to discover new ways to measure space.

Early Career

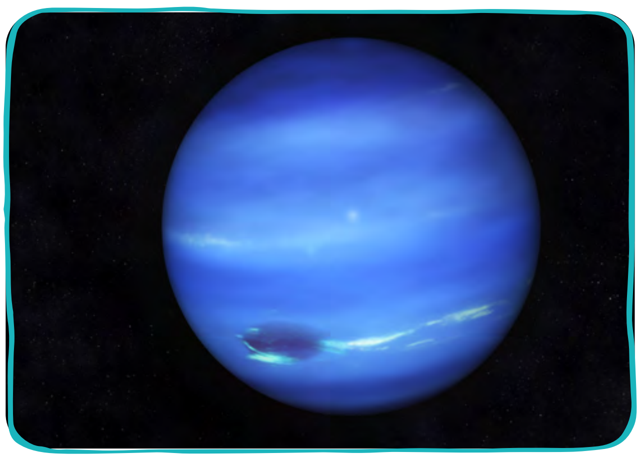
After leaving school, Bessel worked as an apprentice in a trading business. He started studying geography, Spanish, English, and navigation on his own in the evenings. His interest in navigation led him to study astronomy, and he wrote a paper about Halley's Comet that impressed Wilhelm Olbers, the leading expert on comets at that time, so much that Olbers recommended that Bessel become a professional astronomer.

Bessel decided he would like to do that, and he left his job, even though he would have earned a lot of money working in trade. He became an assistant at an observatory in Bremen, Germany, where he was able to devote his time to astronomy. Later, he became a professor of astronomy in Königsberg.

Measuring Space

During his lifetime, Bessel was able to determine the correct positions and motions of over 50,000 stars! He is most famous for figuring out that a star named 61 Cygni is about 10 light-years away from the earth. It was the first time that someone had accurately figured out the distance of a star other than the sun from the earth. Bessel measured the distance in astronomical units, but in his report he added that it would take light about 10.3 years to travel that distance because he thought people would find it interesting to know how long it would take light to travel there. Later, light-years became a common measurement of distances in space.

Bessel used a device called a heliometer, which is a special telescope with two lenses. The device had been designed to measure the diameter of the sun, but Bessel was able to use it to make accurate measurements of the positions and motions of the stars. Bessel adjusted his findings to accommodate imperfections in the telescope and atmospheric interference; therefore, his measurements were the most accurate that had ever been made.



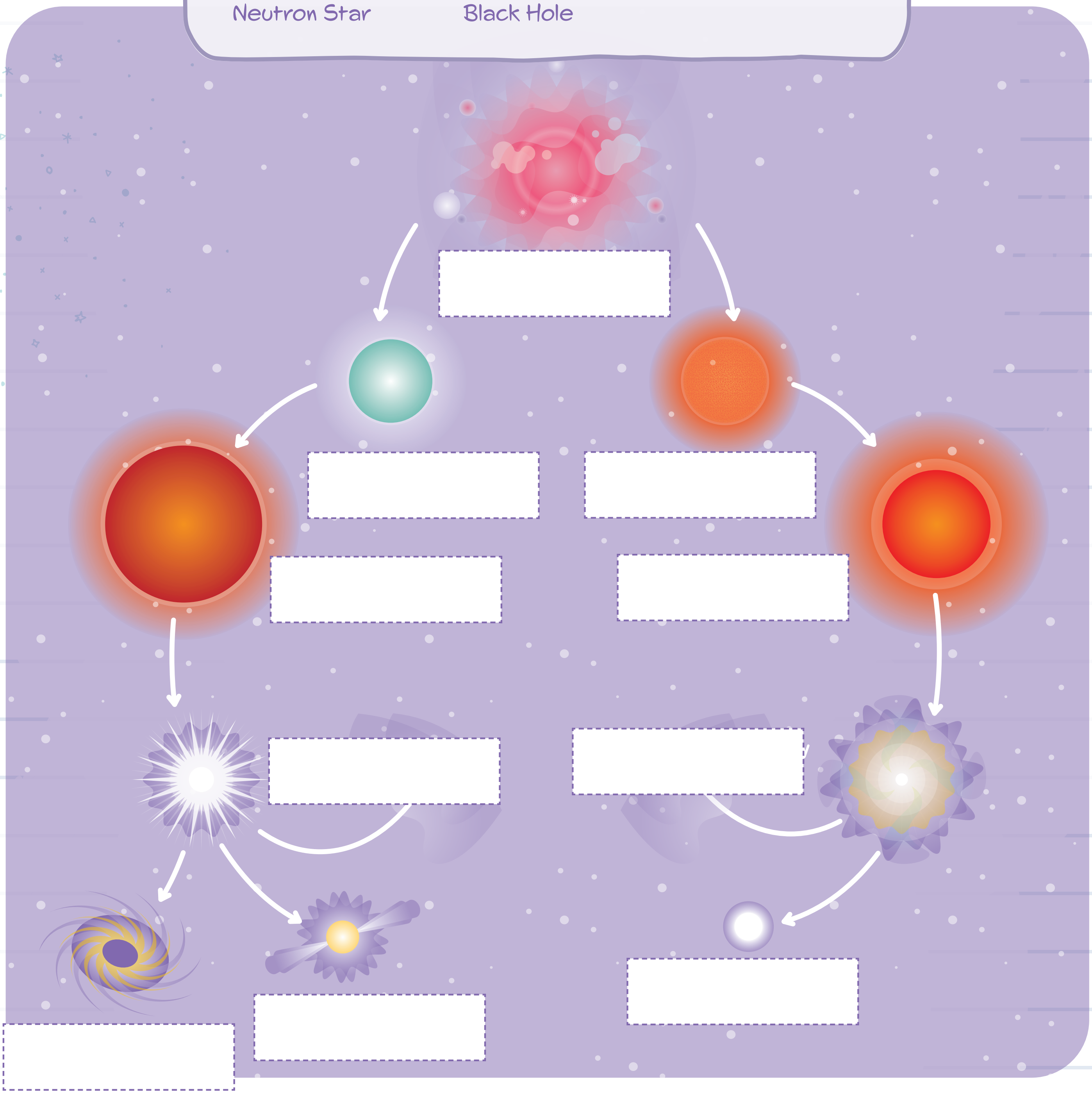
Additional Contributions

Bessel made many other significant contributions to astronomy. Using mathematics he was able to determine the shape of the earth, predict that there was a yet undiscovered planet past Uranus, and give evidence to Copernicus' theory that the earth orbited the sun. Although he did not discover Neptune himself, his work pushed—and continues to push—astronomers to further discovery using mathematics to measure space.

LIFE CYCLE OF STARS

Using the word bank, label each stage of the life cycle of stars chart below.

Stellar Nebula	Red Supergiant	Planetary Nebula
Massive Star	Red Giant	White Dwarf
Average Star	Supernova	
Neutron Star	Black Hole	



EXTENSION

Instructions

1. Read the information about Polynesian navigation.
2. Would you want to go on a trip between the Polynesian islands on a traditional canoe? Imagine that you are taking such a voyage. Write a paragraph describing what it would be like to be on a Polynesian boat, including the navigation methods used.

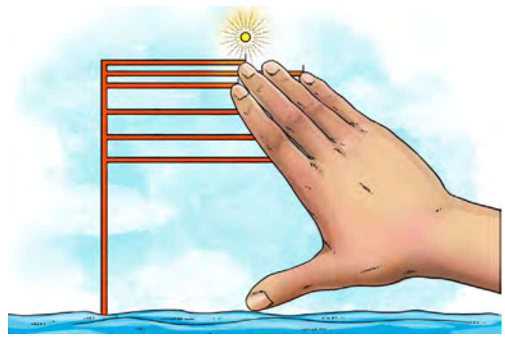
Wayfinding: Polynesian Star Navigation

Long before the invention of the compass or ***sextant***, a tool used to measure the distance of a star from the horizon for navigation, ancient Polynesian cultures sailed the vast expanse of the Pacific Ocean, discovering and colonizing many of the ocean's small islands. Despite the immense distances between the islands, these early navigators were able to find their way. How did they accomplish such an amazing feat? They were experts at reading the positions of the stars, sun, and moon, as well as at understanding ocean currents and waves and even the behavior of sea creatures and birds. They also developed skills in remembering how far they had come, creating mental maps of their voyages.

A knowledge of the night sky was essential to these Polynesian navigators. They would use a star compass called a Kapehu Whetu, shown here, to position themselves, memorizing the rising and setting of the brightest stars and planets to help them sail in the right direction. The star compass divides the night sky into four quadrants. A star that rises in a specific quadrant will set in the opposite one, just like the sun rises in the east and sets in the west. Polynesians would steer toward a star on the horizon. When the star either rose too high to be useful or set below the horizon, they would choose another star to navigate by. The positions of the moon and bright planets, such as Venus and Jupiter, were also helpful. Constellation positions change depending on latitude (how far north or south the boat is), so Polynesian navigators had to adjust for those changes.

Wayfinder Hand Navigation

Skilled navigators would measure the distance between the stars and the horizon using only their hands. They would hold one hand out and place the thumb so it was sitting on the horizon. They would use each finger to measure different distances. The width of the pinkie finger represented one degree and helped the wayfinder determine a location based on the angle between his or her pinkie and the horizon.



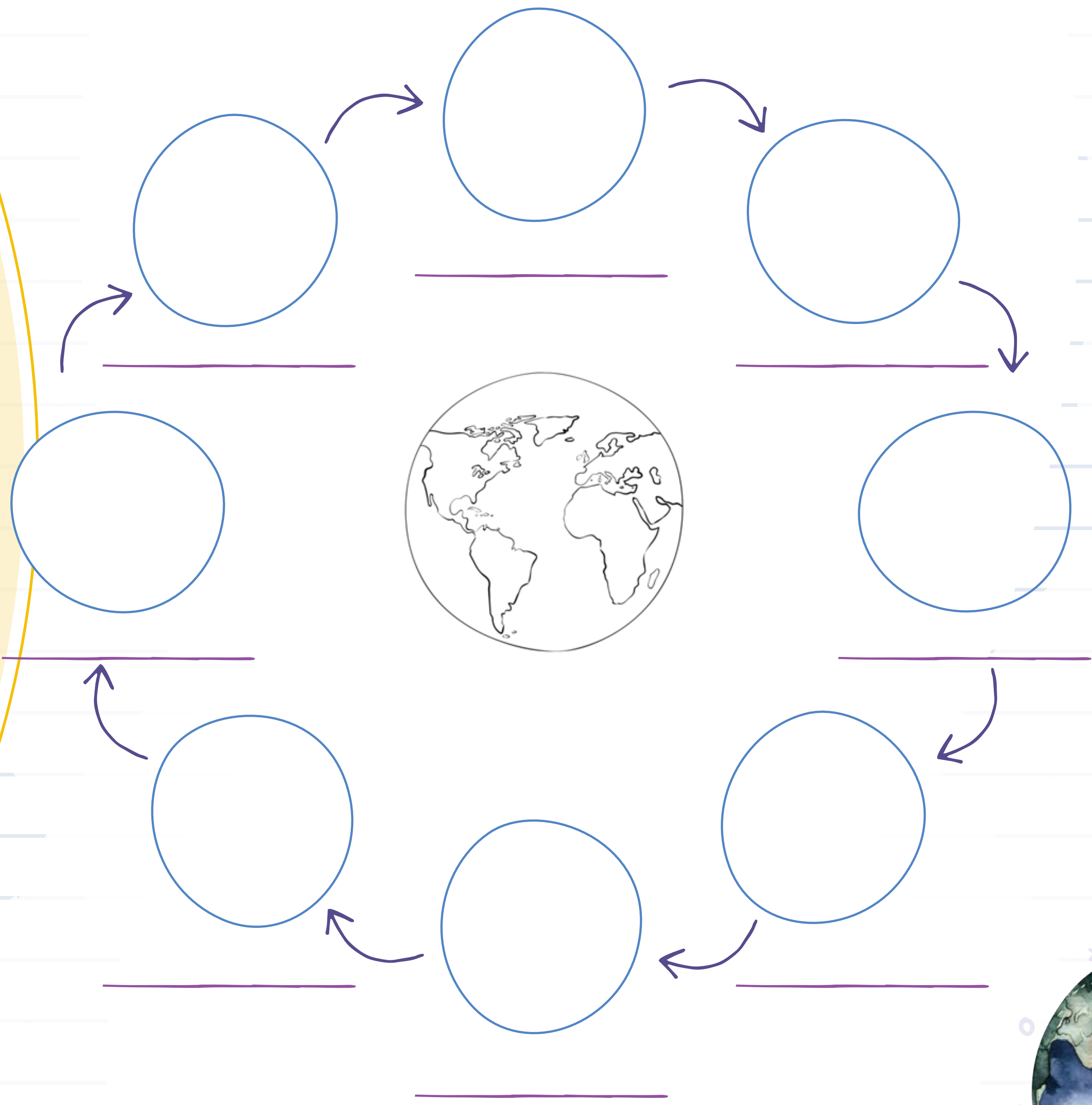
When Europeans first visited Polynesia, they had a hard time believing that the native Polynesians could have crossed such vast ocean distances without any of the tools that Europeans used, like compasses and sextants. After Europeans colonized the islands, the ancient art of wayfinding was in danger of being lost. However, a few people retained the skill, and now the tradition is being revived.

Modern Wayfinder Voyage

In 1976 a traditional double-hulled voyaging canoe called *Hokule'a* (HOW-kuw-LEH-ah), which means "Star of Gladness" in Hawaiian, sailed from Hawaii to Tahiti using only ancient navigation. The voyage of the sailing canoe *Hokule'a* was very exciting for the Polynesian people. In Tahiti 17,000 people gathered on the shore to welcome the boat. Since 1976 these traditional vessels have made other voyages, including one in 1999 to Rapa Nui (Easter Island), one of the most isolated islands on Earth.

MOON PHASES

Use the circles to show the different phases of the moon. Begin with the Last Quarter at the bottom and color and label each circle. Continue clockwise.



Lesson 7 | Grades 7-8

EXTENSION

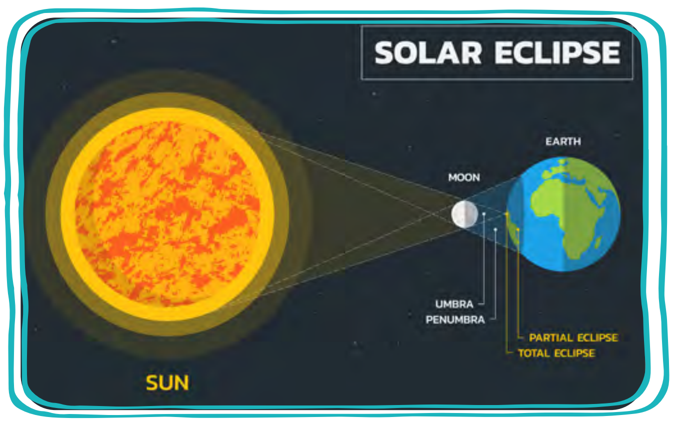
Instructions:

1. Read the information below.
2. If you complete the optional activity, write a paragraph describing the results of your experiment. How did the distance of the tennis ball change the outcome?
3. If you do not complete the activity, imagine you are viewing a solar eclipse and describe in a paragraph what you would see, what you would feel, and what you would need to view the eclipse.

Solar Eclipses

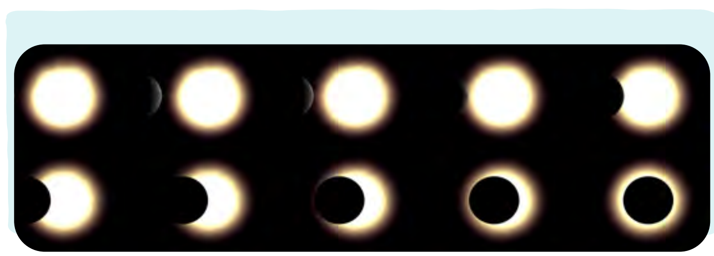
A solar eclipse is an exciting, dramatic event. In the middle of the day, the sky goes dark, temperatures drop, and winds slow down and change direction. Some stars might even be visible! At its height the sun's disk is completely blocked out, allowing you to see the glowing ***corona*** (Latin for "crown") surrounding it when viewed through safety glasses. Even though much of the sun is covered, just a small sliver of the sun is bright enough to damage your eyes if you look at it. You should never look at an eclipse directly; it's just as dangerous as looking at the sun any other time.

What causes this spectacular display of nature? As the moon orbits the earth, it occasionally passes directly between the sun and the earth. When that happens, the moon's shadow falls on the surface of the earth. Since the moon is much smaller than the earth, the shadow covers only a small region. As the shadow passes across the earth, people on the surface see the moon passing in front of the sun. This is a ***solar eclipse***.



If you are watching the event happen, first you'll see the moon's shadow taking a tiny bite out of the edge of the sun. Then, as the moon advances, more and more of the sun vanishes until you're left with a crescent sun. Daylight becomes dimmer and dimmer as the amount of sunlight diminishes. Finally, when the moon's shadow completely covers the sun, you have a total solar eclipse.

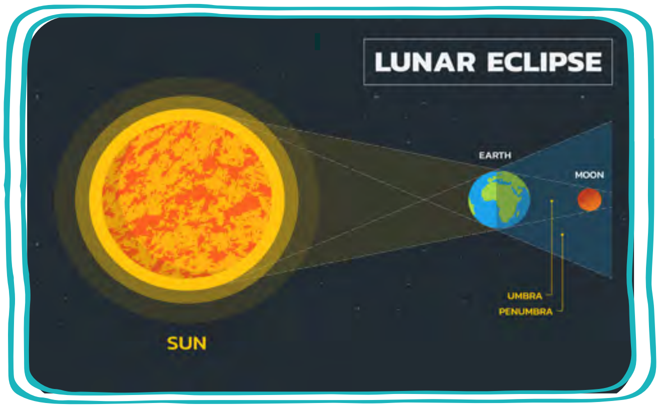
The moon's shadow has two components, the dark ***umbra*** and the lighter ***penumbra*** surrounding it. Within the umbra the eclipse is total; that is, the moon completely covers the sun. Within the penumbra the eclipse is partial, meaning that it never reaches totality. Did you ever notice that the sun and the moon appear to be roughly the same size in the sky? The moon is really much smaller than the sun, of course, but it is much closer. God's perfect placement of the moon is just the right distance away to appear around the same size as the sun in the sky, which allows beautiful solar eclipses to happen. If the moon were farther away, it would appear smaller and never completely block out the sun. Since the moon's orbit is an ellipse rather than a perfect circle, sometimes it is a little farther away than normal and thus appears a bit smaller during an eclipse. At these times a ring of sunlight is visible around the moon's shadow. These are called ***annular eclipses***.



Lunar Eclipses

When the moon passes behind the earth, Earth's shadow falls on its surface, making it dark. This is a ***lunar eclipse***. Since the earth is bigger than the moon, its shadow covers the entire lunar surface. As you watch, you'll see an edge of the full moon go dark. As the earth's shadow advances, more and more of the moon darkens. At totality the moon takes on a dim coppery glow. This is due to light scattering from the earth's atmosphere. Particles in the atmosphere scatter blue light (making the sky blue) and allow red light to pass through and slightly illuminate the eclipsed moon.

The moon orbits the earth roughly once a month, so why don't we see a lunar eclipse every month? The reason is that the moon's orbit is tilted a bit. Imagine placing a ball, representing Earth, at the center of a Hula-Hoop®. Now tilt the Hula-Hoop® at an angle so that it's not parallel with the ground. The Hula-Hoop® is the moon's orbit. You can see how the moon is often either below the earth or above it when it orbits. That means most of the time it passes either above or below the earth's shadow, and therefore no lunar eclipse happens. Only when the moon happens to be level with the earth and directly behind it do we see a lunar eclipse. The same thing happens for solar eclipses, but because the moon's shadow only covers a small portion of the earth's surface, solar eclipses are even rarer.



Gather the following supplies for the optional activity: a lamp, a basketball, and a tennis ball. You can substitute any large ball or very small ball if needed. Just make sure the balls are different sizes.

Eclipse Activity

Let's try to make an eclipse of our own. We'll use a light source like a lamp to represent the sun, a basketball to represent the earth, and a tennis ball to represent the moon.

1. In a darkened room, shine the light source onto the basketball. The basketball represents the earth in space, illuminated by the sun. Note that the side facing the light is brightly lit (day), and the opposite side is dark (night).

2. Now use the tennis ball to represent the moon. Hold the tennis ball between the basketball and the light source. Does it cast a shadow on the basketball? If not, you may need to move the tennis ball closer or farther away. The shadowed region of the basketball is experiencing a solar eclipse.

3. Once you have a shadow, move the tennis ball and see how the shadow moves across the surface of the basketball. Tiny inhabitants on our basketball world would see a solar eclipse as the shadow passes over them.

4. Experiment with moving the tennis ball closer to and farther away from the basketball. What happens to the shadow?

5. Now move the tennis ball so it passes behind the basketball. When the basketball's shadow falls over it, the tennis ball goes dark. This is a lunar eclipse. Again, experiment with moving the tennis ball closer and farther away to see what happens to it.


proportional distance and size of the earth and moon

Lesson 9

ASTEROIDS, COMETS, & METEOROIDS

Use the word bank to fill in the table below.

Size	Shape	Location	Composition	Examples
* Up to 10 m across * 200 km * Up to 10 km in diameter	* Irregular * Irregular * Oddly shaped	* Asteroid Belt * Deep space * Deep space, Earth's atmosphere, or Earth's surface	* Ice, rock, and frozen gases * Rock, metal, and debris * Rock, ice, and metal	* Arizona Meteor Crater * Halley's Comet * Chicxulub crater, Mexico

	ASTEROIDS	COMETS	METEOROIDS
Size			
Shape			
Location			
Composition			
Famous examples			

Lesson 9 | Grades 7-8

EXTENSION

Instructions:

1. Read the information below.
2. Write a paragraph describing why Halley's Comet returns in a regular pattern and what you think it would be like to view the comet in the year 2061.

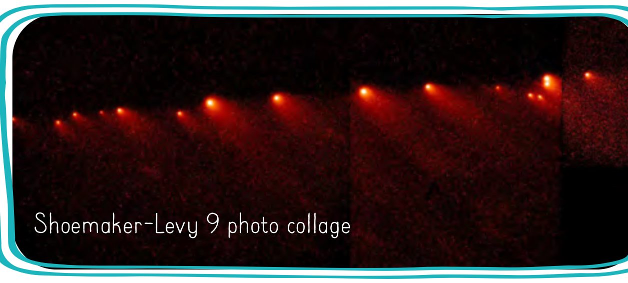
Famous Comets

Perhaps the best known of all comets is **Halley's Comet**. Named after Sir Edmund Halley (rhymes with valley), this comet is a periodic comet that returns every 75 years. Halley observed the comet in 1682. After some calculations, he determined that several previous comets were, in fact, the same comet returning over and over. He predicted that the comet would return in 1757. Although he didn't live long enough to see it, his prediction was correct, and the comet was named in his honor.

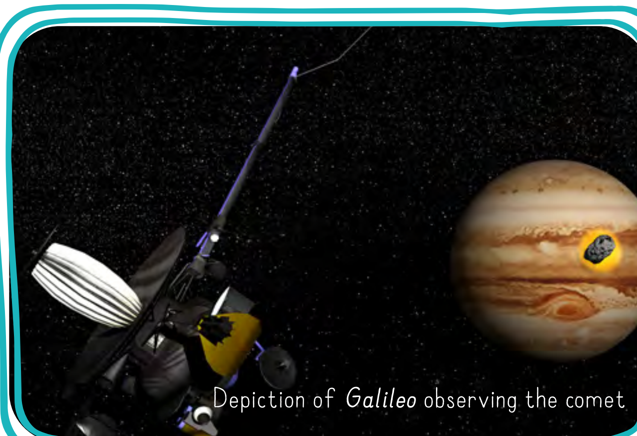
Chinese astronomers recorded sighting Halley's Comet in 239 BC! In 1066 the comet appeared shortly before William the Conqueror's invasion of England, and William believed it was a sign that he would be successful. The comet was woven into the Bayeux Tapestry, a 70-meter-long (230 feet) embroidered cloth depicting the conquest of England. In 1910 Halley's Comet passed particularly close to Earth, giving people of the time an impressive view, and it was photographed for the first time. The most recent appearance of this comet was in 1986. Several space probes were sent to observe the comet as it passed by. Halley's Comet is due to return to our skies in 2061.

Bayeux Tapestry

Shoemaker-Levy 9 is perhaps the most famous comet that is not visible to the naked eye on Earth. The comet passed close to Jupiter in 1992. The planet's gravity broke the comet up into 21 fragments that spread out like a string of pearls in its orbit. Two years later, the fragments crashed into Jupiter one by one. The Hubble Space Telescope, earthbound telescopes, and the space probe *Galileo* all watched the impacts. This was the first time collisions between objects in space had ever been observed. The comet fragments impacted the planet at high speeds, creating massive explosions more powerful than millions of atomic bombs. The impacts sent plumes of hot gases high into the planet's atmosphere and left dark scars in the clouds.



Shoemaker-Levy 9 photo collage



Depiction of *Galileo* observing the comet

Interstellar Comet

Perhaps the strangest comet known is Oumuamua [oh–MOO–ah–MOO–ah], whose name in Hawaiian means "a messenger from afar arriving first." Oumuamua is the first interstellar comet (a comet coming from outside of our solar system) to be discovered. The object surprised astronomers by varying in brightness, which indicates that it is very long and thin. While originally classified as a comet, further observation showed that it probably has very little ice remaining. This strange object is like nothing in our solar system, having characteristics of both comets and asteroids. Oumuamua passed closest to our sun in 2017 and is now headed back out into interstellar space.

EXTENSION

Instructions:

1. Read the information below.
2. In your science journal, write 1–2 sentences about each of the following prompts:
   a. Describe some of the life challenges that Henrietta Swan Leavitt had to overcome.
   b. How did Henrietta Swan Leavitt's discoveries impact the study of astronomy?
   c. What inspired you the most about Henrietta Swan Leavitt?

Astronomer Henrietta Swan Leavitt

Have you ever heard of someone being called a *forerunner*? A forerunner is a person who precedes or leads the way for someone else. Henrietta Swan Leavitt was certainly a forerunner in astronomy: her discoveries influenced the work of famous astronomers who came after her. Despite humble beginnings, prejudices against women, and multiple health challenges, Henrietta Swan Leavitt beat the odds to make far-reaching contributions to astronomy.

Early Life

Born on July 4, 1868, in Lancaster, Massachusetts, Henrietta was the eldest of seven children. Due to her father's work as a minister, her family moved regularly. One of those moves took them to Cleveland, Ohio, where Henrietta attended Oberlin College, beginning at age 17. During her early college years, Henrietta studied music, which she enjoyed, but she had not yet found a subject of study that fully captured her interest.

After her third year of study, the Leavitt family moved back to Massachusetts, where Henrietta hoped to continue her education. However, Harvard University did not admit women at that time. Instead, Henrietta enrolled at the Harvard Annex (later called Radcliffe College). There she shifted her studies to mathematics and, during her final year, stumbled into the field of astronomy. Instantly, she was fascinated by the vastness of space and the limitless discoveries to be made.

Challenges

Upon graduating at age 23, Leavitt volunteered as a research assistant at Harvard's observatory. As one of the human computers at the observatory, Leavitt measured and cataloged the brightness of stars as they appeared on photographic plates. But Leavitt's aspirations of becoming an astronomer soon came to a halt when ongoing health problems confined her to her home for two years. As her illness advanced, she became aware that she was losing her hearing! Over a short period of time, Leavitt became increasingly deaf. At first the realization weighed heavily on her heart, but taking courage and placing her faith in God, Henrietta Swan Leavitt pressed forward toward her goal.

Discoveries

In 1902, with her health finally improving, Leavitt returned to the Harvard College Observatory, this time as an employee. ***Variable stars***, or stars whose brightness varies, remained her central focus. Leavitt worked diligently to discover the relationship between the overall brightness of stars and the time it took them to change from bright to dim and back again (called a ***pulse rate***).

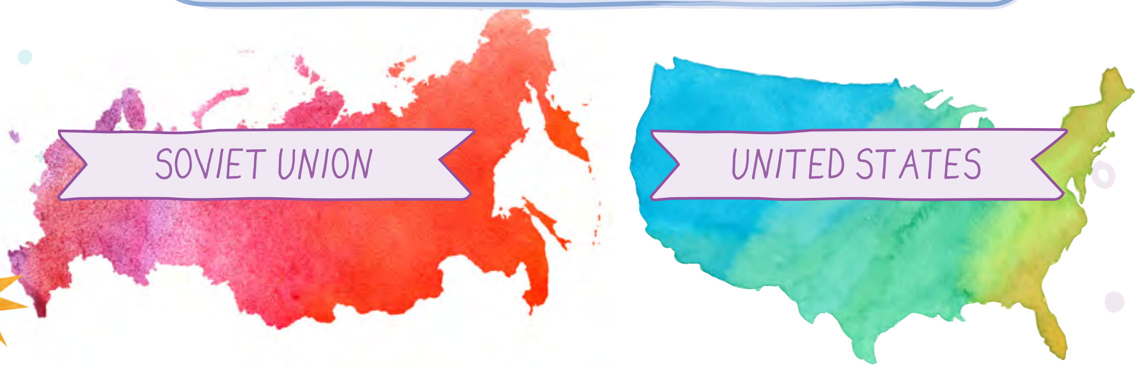
After carefully observing variable stars, she made her breakthrough discovery: the brightness of these stars was directly related to pulse rate! Brighter stars have longer pulse rates, while dimmer stars have shorter pulse rates. Why was this so important? It provided a standard for measuring distances outside our solar system and determining a galaxy's size. She established 17 magnitudes of brightness that were used for decades to order stars by their brightness.

Additionally, Leavitt's discovery advanced the work of other astronomers, such as Harlow Shapley, who proved that our sun was not at the center of the galaxy. Astronomer Edwin Hubble relied on the ***Leavitt law*** when he found Cepheid stars in other galaxies. Leavitt's law helped prove that galaxies existed outside the Milky Way and that our galaxy was not the center of the universe.

Henrietta Swan Leavitt's work was so pivotal to the field of astronomy that she was nominated for a Nobel Prize in 1926. Despite significant social and health-related challenges, Henrietta Swan Leavitt retained a positive attitude and made invaluable discoveries in astronomy. As a forerunner to the many great scientists who built upon her discoveries, she truly paved the way for those who came after her.

SPACE RACE

Draw a line from each achievement to the correct country.



FIRST SATELLITE TO ORBIT THE EARTH

FIRST INTERNATIONAL DOCKING

FIRST ANIMAL IN ORBIT

FIRST SPACE WALK

FIRST MOON LANDING

FIRST AMERICAN WOMAN IN SPACE

FIRST MARS LANDING

FIRST YEAR SPENT IN SPACE

FIRST MAN IN SPACE

Lesson 13 | Grades 7-8

EXTENSION

Instructions:

1. Read the information below.
2. In your journal write which job at NASA you would enjoy doing most and why.

The Supporting Cast

A well-known saying in American culture advises the following: "There is no I in TEAM." While Neil Armstrong, Michael Collins, and Buzz Aldrin received recognition for landing on the moon during the Apollo 11 mission, they knew they could not have done it without the work of a huge team of directors, scientists, mathematicians, engineers, and others supporting them back home. Let's take a closer look at some of these people and the roles they played that contributed to the success of the Apollo missions.

Mission Controllers

The Mission Control Center (MCC) is the location where people worked together to coordinate each aspect of a space mission—from prelaunch, launch, and flight through space to lunar landings and reentry. Some of the people in the MCC included the following:

Flight director—oversaw and managed the Mission Control Center, led the planning and coordination of every part of the mission, and approved any instructions or procedures given to the astronauts. Gene Kranz was the flight director who directed the lunar landing of the Apollo 11 mission. Four other directors were in charge of other aspects of that mission (such as the launch).

Spacecraft communicator (also called the CAPCOM)—talked with the astronauts via radio. All messages were relayed by a single person so the radio lines would not become jammed with too many people talking at once, and astronauts had a familiar voice they could rely on. This job was often performed by a fellow astronaut.


Gene Kranz

Flight controller—coordinated and computed the exact times, speeds, and trajectories for the astronauts to stay on the correct flight path. For example, he or she would tell those on the moon exactly when to launch the lunar landing module so they could meet up with the orbiting spacecraft at the right time.


Charles Duke, James Lovell, and Fred Haise—CAPCOMs for Apollo 11

Communications operator—managed all the communications systems, including the video footage that came in from the moon landing.

Flight doctor—monitored the health of the astronauts throughout the mission by the use of little sensors placed on their bodies.

Other Jobs at NASA

Countless others—as many as 400,000 people—contributed to the Apollo missions behind the scenes. Many of those people worked at NASA's Langley Research Center in Virginia.

Human Computers: In the early days of astronomy and space exploration, mathematical computations were all done by hand with a pencil, paper, and slide rule.

Katherine Johnson

Computers and digital calculators capable of processing complex equations had not been invented yet. During this era the people who did these calculations were called "human computers" because they were computing information.

Beginning in the 1940s during WWII, these jobs were increasingly performed by women. The contributions

Mary Jackson

of human computers were brought to the attention of the public when a movie named *Hidden Figures* was made about Katherine Johnson, Dorothy Vaughan, and Mary Jackson, who worked at Langley for decades. One of Johnson's most significant contributions was the computation that synced the Apollo 11 lunar landing module to the orbiting command module.

Geologists: Ahead of the Apollo 11 mission, several geologists studied photographs of the moon's surface, analyzing its qualities in order to determine the best place for the lunar module to land. After the astronauts returned to Earth with soil and rock samples, the geologists studied the samples to increase their understanding of the moon and improve landing recommendations for future Apollo missions.

Tailors: These talented seamstresses were tasked with designing space suits that would protect the astronauts from the extreme conditions of outer space. The suits had to protect them from extremely cold temperatures and be airtight while still allowing the astronauts to move freely enough to climb out of the lunar landing module.

Engineers: From testing and building the Apollo spacecraft

Judy Sullivan

to developing the systems to run them, engineers were involved in almost every aspect of the Apollo missions. Judy Sullivan, one of the first female engineers to be hired by NASA, worked closely with the astronauts to help monitor their vital signs. She was the lead engineer for the Apollo 11 biomedical system.

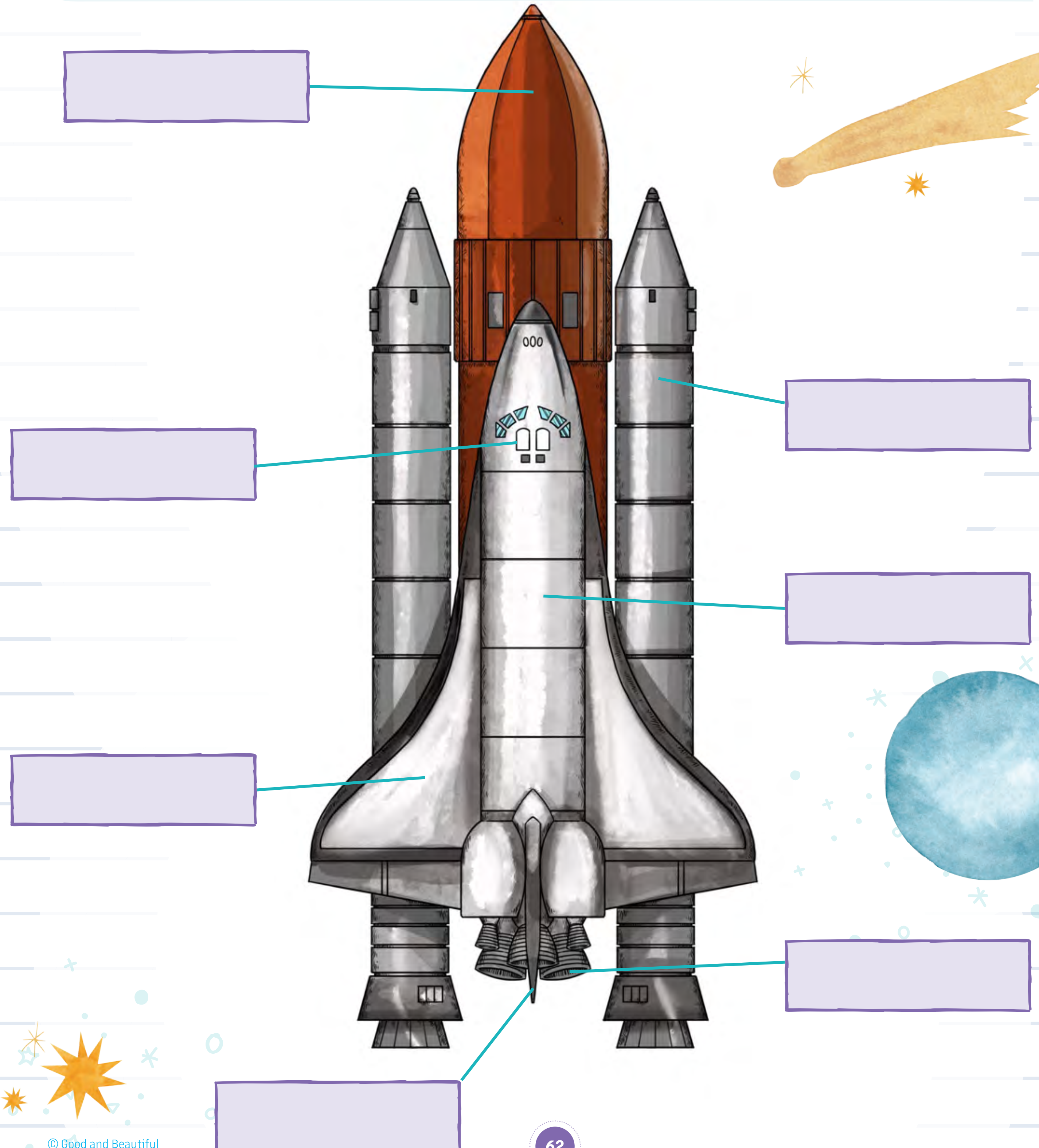
This article has discussed only a small handful of the countless individuals working behind the scenes at NASA. Even though you may not have known of these people and their jobs before, each person made vital contributions to the success of the Apollo missions and was an important part of the team.

Mission Control Center

Lesson 14

PARTS OF A SPACE SHUTTLE

The Apollo program demonstrated that people could travel into space, perform useful tasks there, and return safely to Earth. But space had to be more accessible. This led to the development of the space shuttle. Label the parts of the space shuttle using the following words: External Tank, Solid Rocket Booster, Crew Cabin, Wing, Orbiter, Main Engines, and Vertical Stabilizer. Color or decorate your space shuttle if desired.



Getting to Know the Planets Cards

MERCURY

Illustration of Planet

FACTS

Circle the best answer:

What ordinal position is it from the sun?

SUN 1 2 3 4 5 6 7 8

Is it **BIGGER** or **SMALLER** than Earth?

Is it **HOTTER** or **COLDER** than Earth?

VENUS

Illustration of Planet

FACTS

Circle the best answer:

What ordinal position is it from the sun?

SUN 1 2 3 4 5 6 7 8

Is it **BIGGER** or **SMALLER** than Earth?

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