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.

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

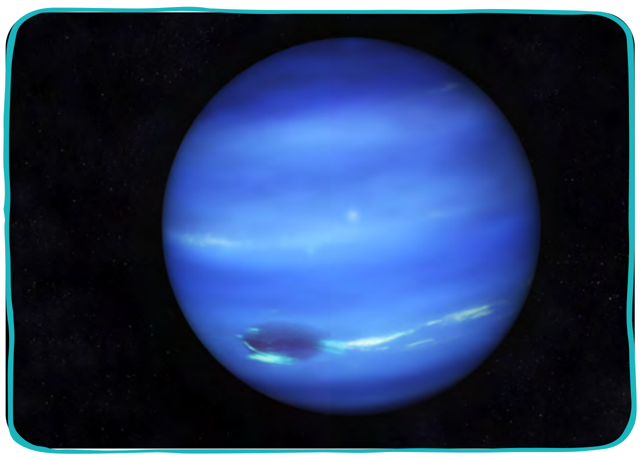
After leaving school, Bessel worked as an apprentice in a trading business. He started studying geography, Spanish, English, and navigation on his own in the evenings. His interest in navigation led him to study astronomy, and he wrote a paper about Halley's Comet that impressed Wilhelm Olbers, the leading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



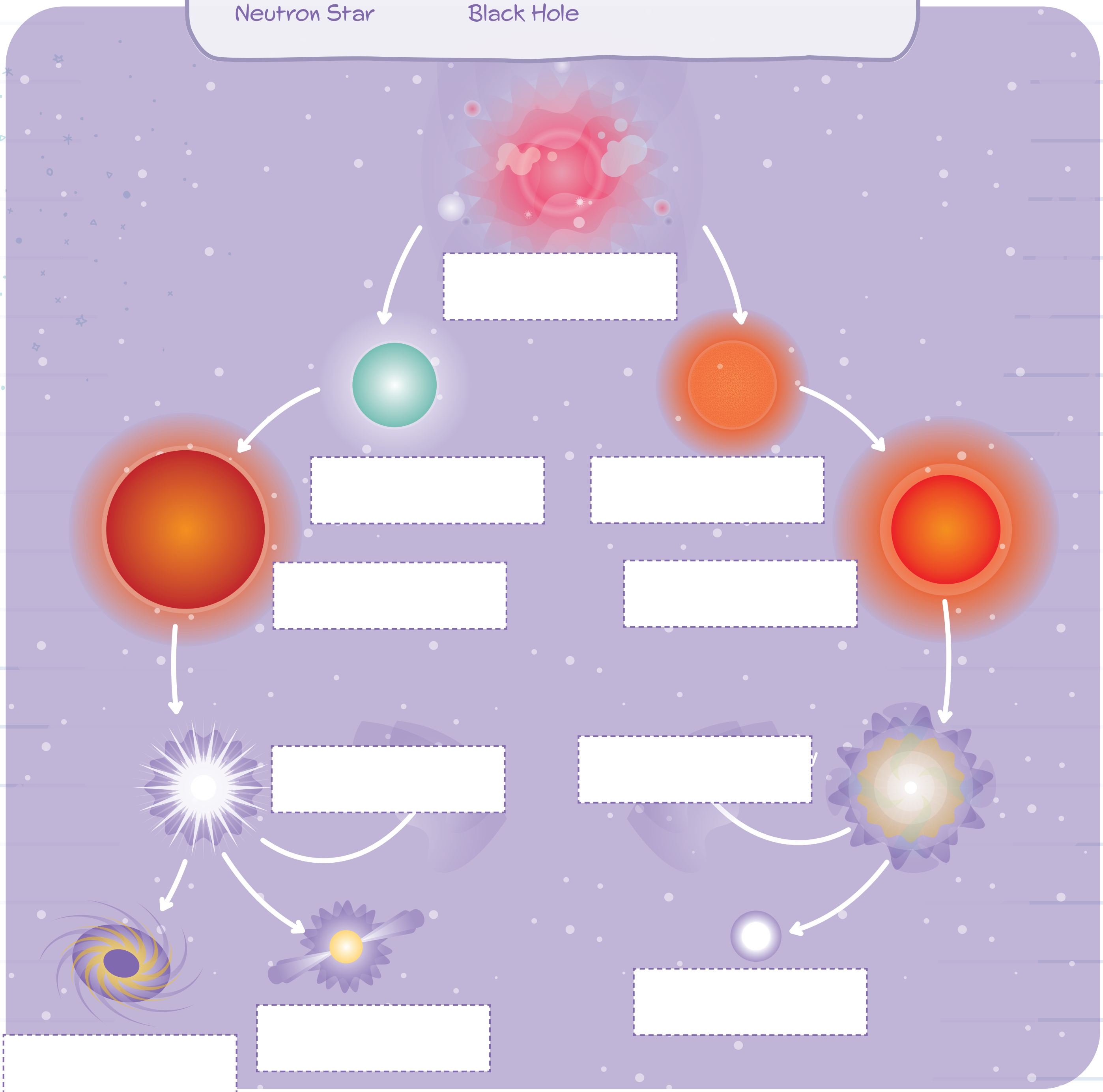
Additional Contributions

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

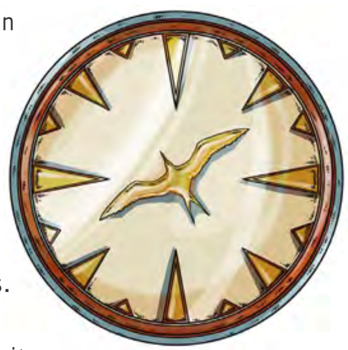
Instructions

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

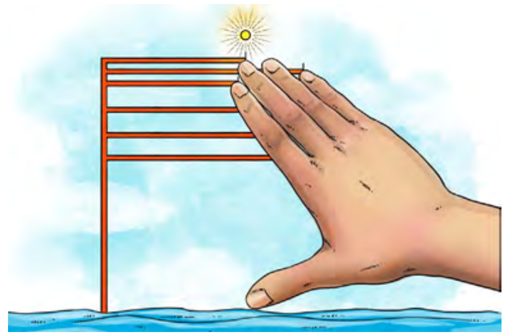
Long before the invention of the compass or ***sextant***, a tool used to measure the distance of a star from the horizon for navigation, ancient Polynesian cultures sailed the vast expanse of the Pacific Ocean, discovering and colonizing many of the ocean's small islands. Despite the immense distances 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.



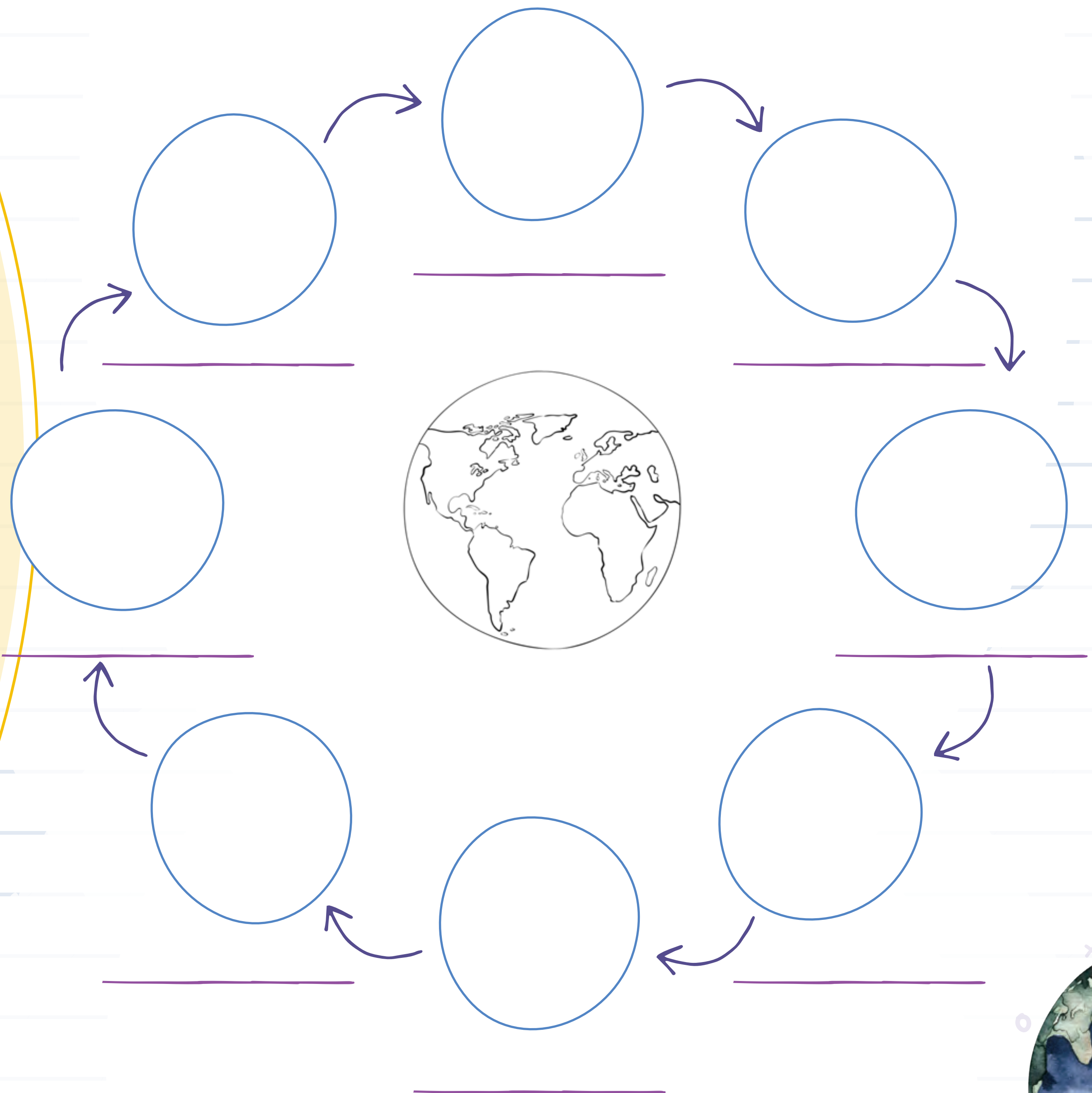
When Europeans first visited Polynesia, they had a hard time believing that the native Polynesians could have crossed such vast ocean distances without any of the tools that Europeans used, like compasses and sextants. After Europeans colonized the islands, the ancient art of wayfinding was in danger 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

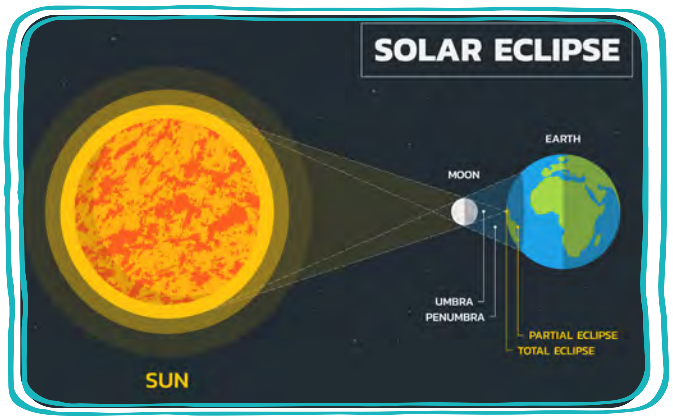
Instructions:

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

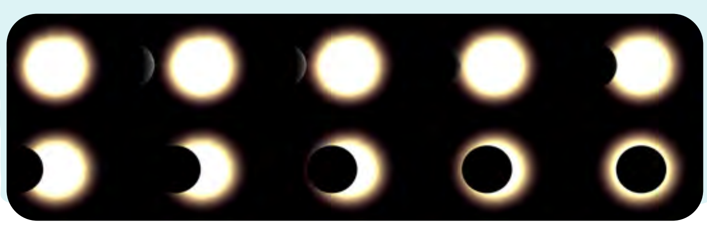
A solar eclipse is an exciting, dramatic event. In the middle of the day, the sky goes dark, temperatures drop, and winds slow down and change direction. Some stars might even be visible! At its height the sun's disk is completely blocked out, allowing you to see the glowing ***corona*** (Latin for "crown") 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.

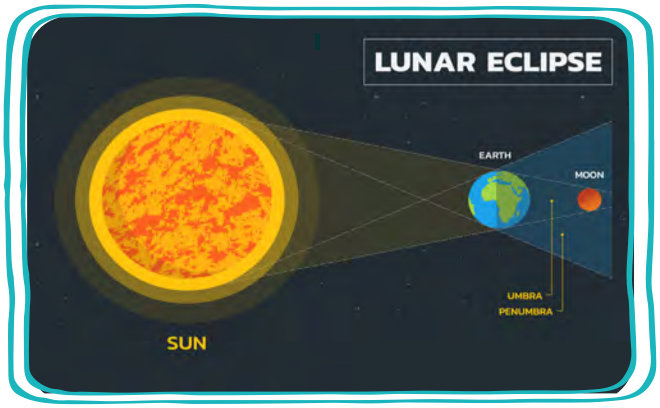
The moon's shadow has two components, the dark ***umbra*** and the lighter ***penumbra*** surrounding it. Within the umbra the eclipse is total; that is, the moon completely covers the sun. Within the penumbra the eclipse is partial, meaning that it never reaches totality. Did you ever notice that the 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

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			

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.

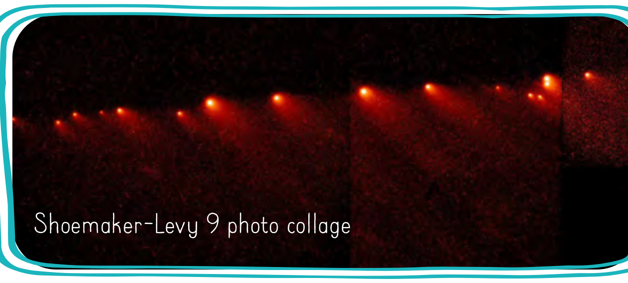
Famous Comets

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.

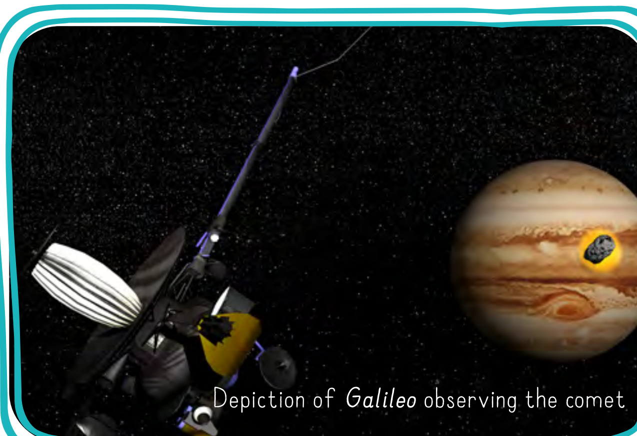
Chinese astronomers recorded sighting Halley's Comet in 239 BC! In 1066 the comet appeared shortly before William the Conqueror's invasion of England, and William believed it was a sign that he would be successful. The comet was woven into the Bayeux Tapestry, a 70-meter-long (230 feet) embroidered cloth 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***).

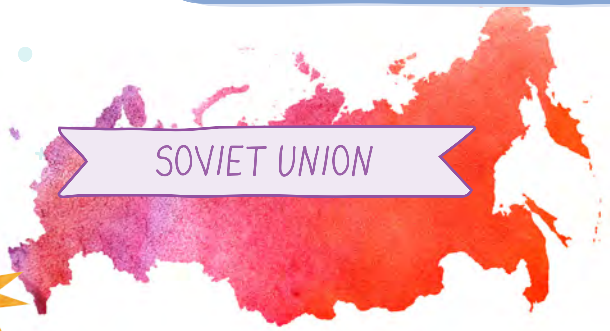
After carefully observing variable stars, she made her breakthrough discovery: the brightness of these stars was directly related to pulse rate! Brighter stars have longer pulse rates, while dimmer stars have shorter pulse rates. Why was this so important? It provided a standard for measuring distances 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.



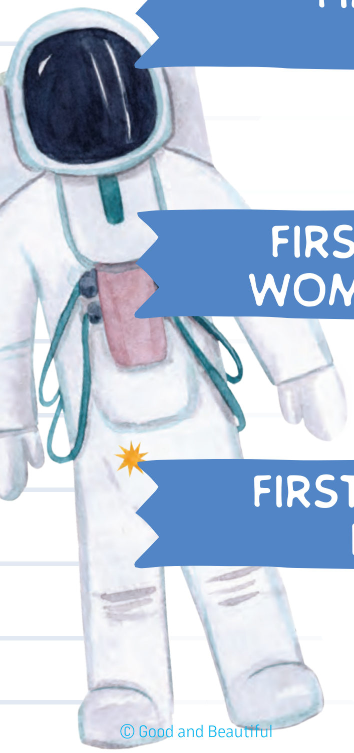
FIRST SATELLITE TO ORBIT THE EARTH

FIRST INTERNATIONAL DOCKING

FIRST ANIMAL IN ORBIT

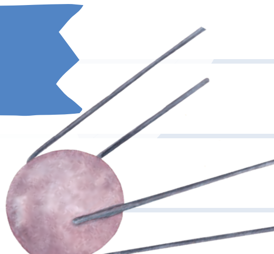
FIRST SPACE WALK

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

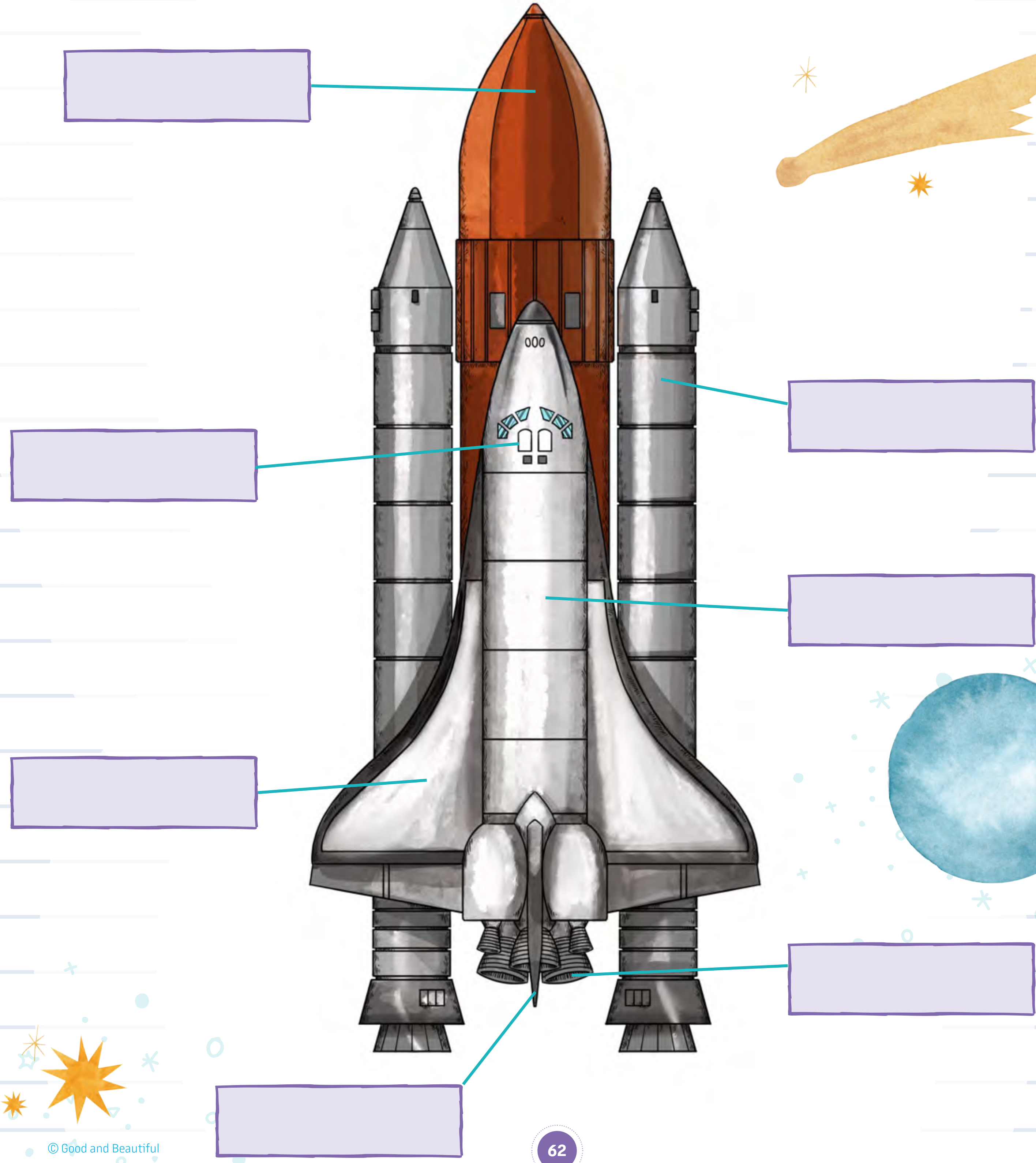
to developing the systems to run them, engineers were involved in almost every aspect of the Apollo missions. Judy Sullivan, one of the first female engineers to be hired by NASA, worked closely with the astronauts to help monitor their vital signs. She was the lead engineer for the Apollo 11 biomedical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

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?

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