# Welcome to Science B!

In this program, your students will measure the sunlight in a day, explore the phases of the moon, develop ways to improve their hearing, build the best sail, and so much more.

The 36 experiments in this program will introduce your students to Light and Sound Waves, Biological Features, Space Systems, and Engineering Design. They are designed to teach your students to think like scientists and use real scientific skills and practices.

## What do Students Need to Know?

In the past, science instruction focused on teaching students what we already knew about science. However, as technological growth and development exploded in recent years, we realized that simply teaching students what we know now isn't sufficient—it doesn't adequately prepare them for the future. The technology and scientific developments our students will use when they are adults haven't been invented yet. So how do we prepare them for what they will need to know when it is still unknown to us?

Instead of teaching facts and knowledge, our instructional focus needs to shift. In addition to exposure to familiar science topics, such as Physical Science, Life Science, and Earth and Space Science, today's students also need skills, and scientific practices, that will help them find out what they need to know on their own. They need to become innovators and developers and not just passive consumers of scientific knowledge. By the time your students are ready for further education or to enter the workforce, they need to know how to investigate purposefully, build models, ask useful questions, and be able to report their findings so they can share what they learn with others. They should also be able to develop creative solutions to problems, and build and test their designs to determine how well they work. Once tested, they should be able to improve their designs so they can develop an even better solution. The lessons required to arrive at this destination will need to be hands-on, interactive, and student-driven. They may be a little noisy, and hopefully not too messy, but certainly an adventure like no other.

# Introduction

## How This Program Works

Through this program, your students will use the Scientific Method to explore their world, not just memorize the steps. Your students will brainstorm solutions to problems, and have space to come up with ways to test them with you. Together, we will begin to prepare them to think for themselves, weigh the claims they encounter around them, and innovate on their own. We will also incorporate key Scientific and Engineering Practices to explore ideas that connect across all subjects, like cause and effect, patterns, structure and function, systems, stability and change, cycles, and more.

In addition to practicing the Scientific Method, you will also begin to teach the process of Engineering Design, in which students investigate a problem they can solve through design. Some lessons will present a challenge or problem which will require your students to design (and build!) a solution, and then they will test their solution's effectiveness in solving the problem. From there, they may also apply what they learned from their tests toward designing an improved solution.

*Science B* will serve as your roadmap for this year's experiment instruction. We have chosen easy experiments that will fascinate your students and help them begin to develop key scientific skills through exploration. Before you start teaching, take a few minutes to familiarize yourself with this book and the structure of each experiment.

Each lesson begins with an overview of the **Key Concepts**, intended to give you, the instructor, a big-picture view of the goals of the lesson. By the end of the experiment and discussion, your students should have a solid understanding of the lesson's Takeaways (which mirror the Key Concepts), so you know they have mastered the important information. And since each lesson is truly an exploration, your students will often delve into elements of several different scientific disciplines in a single day.

## Let's Get Started

To help you teach with confidence, we recommend you read through each experiment the night before. You may also use this time to gather the supplies noted on the Materials List that you will need to provide. While you will find some experiment supplies around your home, we have collected a number of materials for your convenience in our **Science Supplies Kit**, listed with a **K** in the Materials List (at the beginning of each experiment). The data charts and templates, listed with a **P**, follow each experiment and are also included in the **Paper Packet**.

The **Appendix** of this book includes a complete list of the supplies you will need to provide yourself, a list of items in the Science Supplies Kit, and a list of charts and templates in the Paper Packet. You can start collecting the items you need to provide now so they will be ready when you need them.

A few of the experiments require some early preparation, which we'll warn you about in a **Before You Begin** note at the start of the experiment. Be sure to check the next experiment for this note when you wrap up an experiment so you will be fully prepared to teach the next lesson when you intend to.

When you have gathered the supplies and are ready to teach, head to the experiment's **Introduction** and simply start reading to your students. Our provided instruction helps you pique your students' curiosity about each day's topic, and will challenge them to **Make a Prediction** about what they will experience in the experiment. The **Investigate** section offers step-by-step procedures that walk you through the experiment itself, and includes discussion information to help you explain what's happening along the way. Use the questions under **Draw Conclusions** to bring the concepts and observations together, and close with the thoughts under **Takeaway**.

As you have time, enjoy the information under **See the Bigger Picture** which illustrates how the scientific principles discussed in the lesson apply to the world at large. Also, be sure to check out the **Make Connections** section as you work to add more depth and extend conversation about the experiment's topic. We also include **Tips** to help you know what to expect and complete the investigations with as few bumps as possible. If your students still want more, try out the suggestions under **Go Further** for related activities that will help you extend the exploration.

# Introduction

Plan for your students to take an active role in setting up the experiment and completing the steps (with your help, of course). Give them room to be curious and ask questions. If we don't address something that comes up as you work by the end of the experiment, make a note to help them find the answer later. The more you can support their curiosity and inquisitiveness, the better you will teach them to think like a scientist. And don't forget—they can help you clean up, too!

## You are Ready to Begin!

We can't wait for you to start this grand adventure with your students, helping them to explore their world while learning to think like scientists and design like engineers. Through this journey, you will prepare them to be an active part of a future that we can't even imagine today.

# Experiments

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# What Makes Day, Night, and the Seasons?

## Key Concepts

Patterns of the motion of the Sun in the sky can be observed, described, and predicted. Seasonal changes and day and night follow these predictable patterns.

The Sun seems to disappear at night. It is hidden because the Earth spins on its axis. When it is not visible to people in one location on Earth, it is visible to the people on the other side of the world.

The Earth rotates on its axis as it orbits the Sun.

The Earth's tilt on its axis points half the earth more directly at the Sun for approximately one half of the year. Then, the other half of the Earth is pointed more directly at the Sun. This causes seasons.

## Materials

- Styrofoam ball K
- wooden skewer K
- rubberband K
- thumbtack K
- sandwich-sized clear plastic bag
- twist tie
- flashlight
- lamp
- permanent marker
- Day, Night, and Seasons Test Data Sheet P

# Introduction

Every morning, the Sun rises over the **horizon**. When the Sun comes up, it is daytime. Every evening, the Sun sets on the opposite side of the Earth. When the Sun goes down, night falls and it gets dark. The Sun rises and sets every day. It has a pattern. It seems like the Sun moves. It looks like it moves from the eastern horizon to the western horizon. During the day, it seems to march across the sky. Ancient people once thought that the Sun traveled around Earth. While it certainly looks like that, it turns out that we travel around the Sun.

In many places, the weather changes as the year progresses. Some places have four distinct seasons. In spring, the weather gets warmer and plants start to grow. In summer, the weather is hot. Fruits and vegetables grow big and ripen. During the fall, the weather cools down. Farmers harvest their crops and plants die away or go dormant—which is somewhat like sleeping. In winter, it is cold and snowy. Other places have just two seasons: a rainy season and a dry season. But why? What causes the seasons?

Today we are going to make a model of the Earth and Sun. A **model** is a smaller version that can represent something real, but is easier to move around, study, or manipulate. We'll use light to serve as a model of the Sun and a ball for the Earth. We'll first look at day and night, and then we'll explore what causes the seasons.

## Make a Prediction

Why do we have light during the day and darkness at night? Why do we have seasons?

The **horizon** is the line where the land seems to meet the sky.

### Did you know?

When astronomers first began observing the planets, they still thought Earth was the center of the universe. However, the planets moved in strange loops, called **retrograde loops**, they couldn't explain, until a mathematician and astronomer named Nicolaus Copernicus tried putting the Sun at the center of the solar system. This fixed the problem and we could observe planets orbiting in circles.

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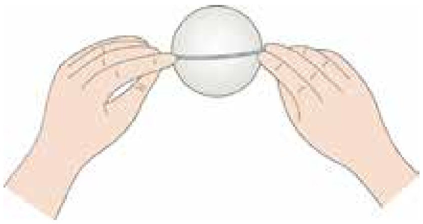
# Investigate

## Activity 1: Daytime and Nighttime on Earth

The **equator** is an invisible line that wraps around the Earth's middle like a belt.

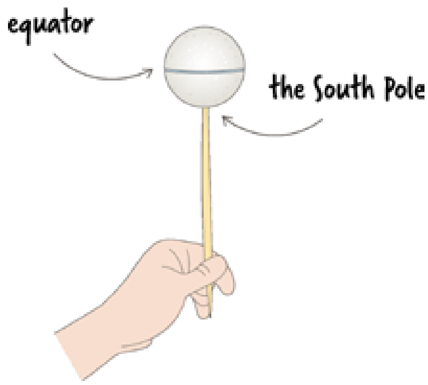
A **sphere** is a ball shape. The word **hemisphere** simply means "half of a ball" shape. The Earth is divided into the Northern Hemisphere and Southern Hemisphere at the equator.

1. Stretch a rubberband around the center of the Styrofoam ball to represent the **equator**.



2. Carefully poke the sharp end of the skewer into the Styrofoam ball so that the Styrofoam sits on the skewer without moving. The equator should be perpendicular to the skewer. The skewer is at the South Pole.

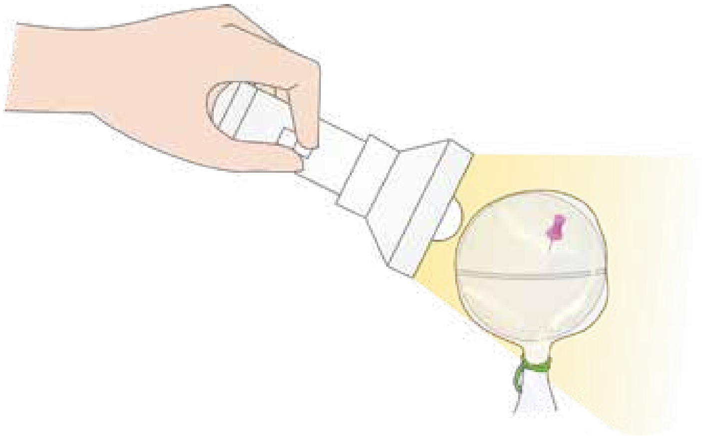
   **Caution:** Try not to poke toward your hand in case the skewer slips all the way through.




3. Slip the plastic sandwich bag over the Styrofoam ball, and secure it with a twist tie. The bag is only used so you draw on the model later on.

4. Place a thumbtack to represent where you live. If you live in the northern **hemisphere**, put one above the band. If you live in the southern hemisphere, place it below.

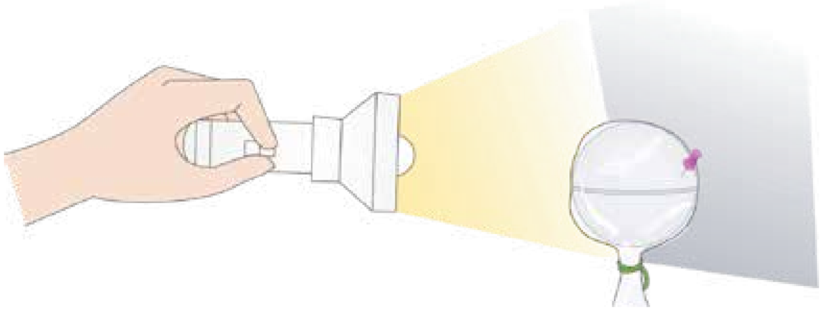
**5.** Shine the flashlight so that the light is hitting the thumbtack on the Styrofoam ball.



The flashlight represents the Sun and the Styrofoam ball represents the Earth. Right now, the Sun's light is shining on the tack.

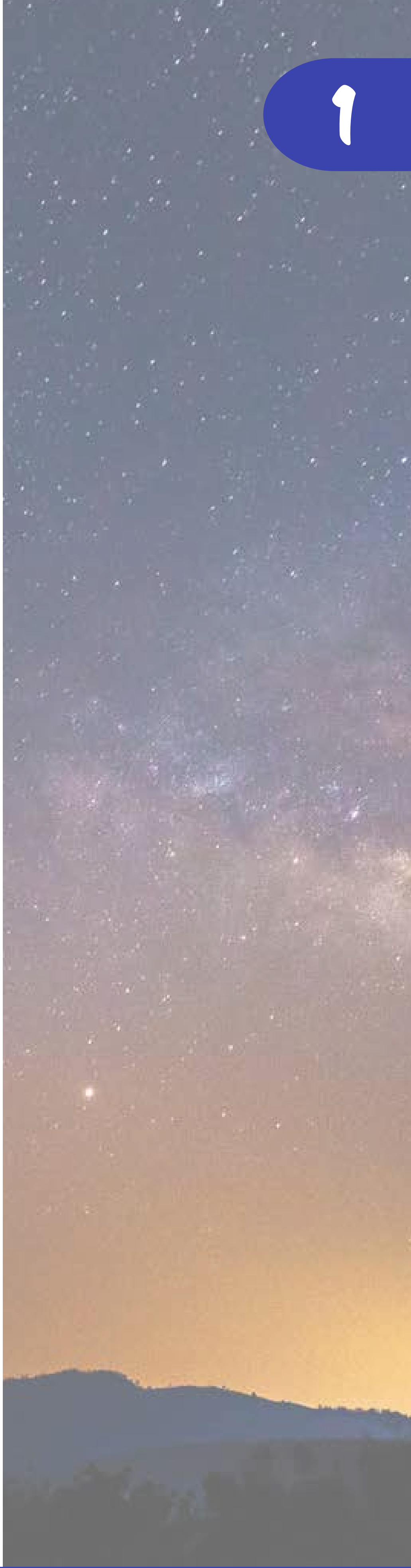
If you were standing on the thumbtack, would it be day or night? (It would be day because the thumbtack is in the light.)

**6.** Twist the skewer so that the thumbtack on the Styrofoam ball is facing away from the flashlight Sun.



The Earth rotates, or spins. You made the Earth rotate by twisting the skewer. Now the tack is away from the Sun.

If you were standing on the thumbtack, would it be day or night? (It would be night because the thumbtack is in the dark.)



Did you know?

The Earth rotates at roughly 1000 miles per hour. However, because it is so big (24,859.734 miles all the way around, to be exact), it takes 24 hours for it to turn all the way around once.

Is the flashlight Sun still shining? (Yes)

If you were standing on the thumbtack, would you be able to see the flashlight Sun shining? (No because the flashlight Sun is on the other side of the Earth.)

7. On the **Test Data Sheet**, draw a picture to show the position of the ball, thumbtack, and light when it is daytime for the thumbtack and another picture to show their positions when it is nighttime for the thumbtack.

Each day, the Earth spins around once. It takes 24 hours for the Earth to make one complete rotation. As it spins, different parts face the Sun. It is daytime for the parts of Earth that face the Sun. It is nighttime for the parts of Earth that face away from the Sun.

## Activity 2: The Reasons for Seasons

8. The Styrofoam ball from Activity 1 will continue to be the Earth. Find a lamp and remove the shade. Turn it on. This lamp will represent the Sun.

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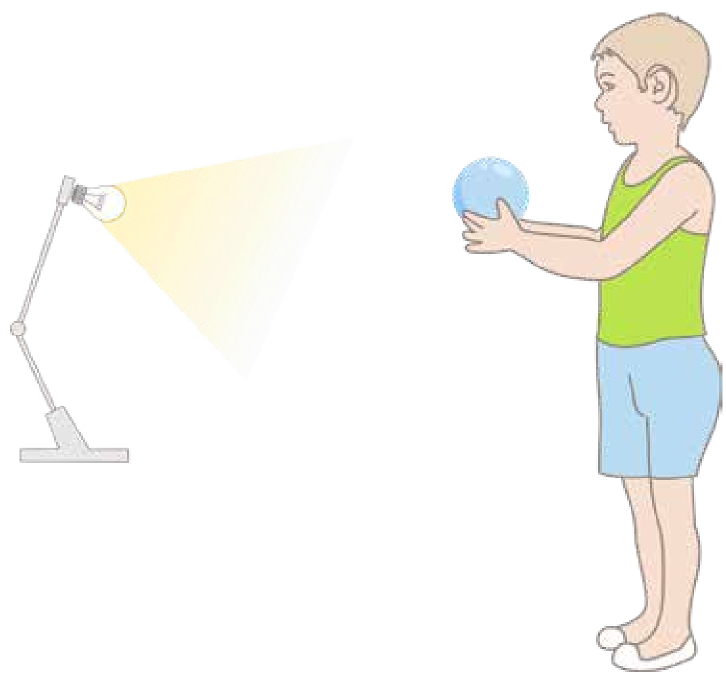
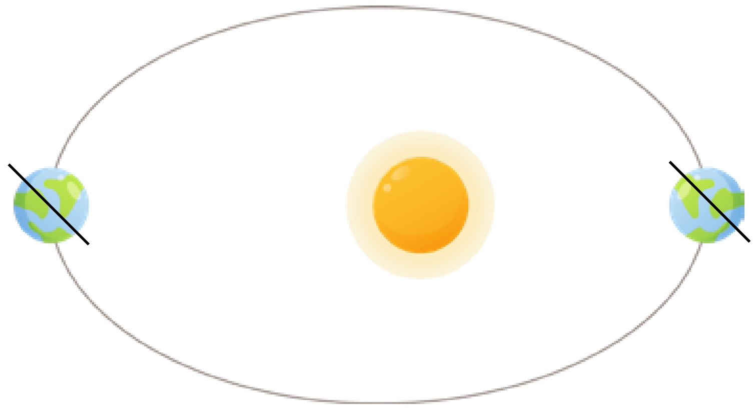


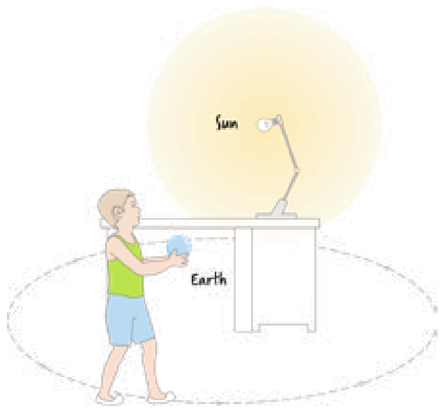
The Earth has an imaginary line from the north pole to the south pole, called it's **axis**. The skewer represents this line. In real life, Earth is tilted on its axis. Hold Earth at an angle to demonstrate its tilt.



**9.** Earth spins, or **rotates**, on its axis. Demonstrate Earth rotating by spinning the skewer between your fingers.

**10.** While Earth rotates on its axis, it also revolves, or **orbits**, around the Sun. Demonstrate rotation and orbiting at the same time. While spinning the Earth on its axis, also walk in a circular path around the lamp. The circular path is the Earth's orbit. As you walk, always face the same wall in the room, so sometimes the Sun will be in front of you, sometimes it will be on one side, sometimes it will be behind you, and sometimes it will be on your other side. Be sure to hold the skewer at the same angle as you walk.

**Parents:** If walking correctly and spinning is tricky, your students don't have to also spin the Earth. It's more important to walk and keep the Earth at the same angle on its axis..




To **orbit** means to travel in a circular path around something else.

**Tip:** If observing the Earth's tilt in relation to the Sun is difficult while walking, move the Earth around in a much smaller orbit with your hand and arm above the lamp. Be sure to keep the angle of the Earth steady and simply "draw" the circle with your arm.

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11. When the thumbtack is tilted (or "leaning") toward the Sun, say **"Freeze!"**
Since the thumbtack's part of the Earth pointed more directly at the Sun, that part of the world is experiencing warm temperatures.

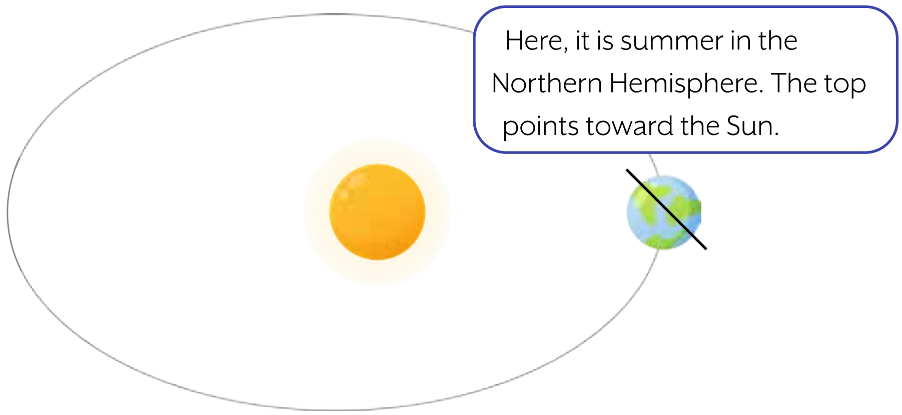
12. Continue moving the Earth on its orbit.

13. When the thumbtack is tilted (or "leaning") away from the Sun, say **"Freeze!"**
Since the thumbtack's part of the Earth is pointed away from the Sun, that part of the world is experiencing cooler temperatures.

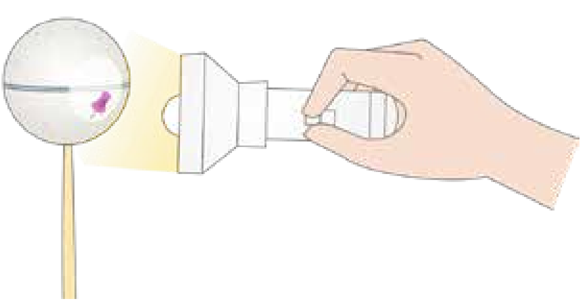
Next, let's see why this tilt in the Earth's axis makes summertime warmer and winter cooler.

14. Turn off the lamp and grab a flashlight.

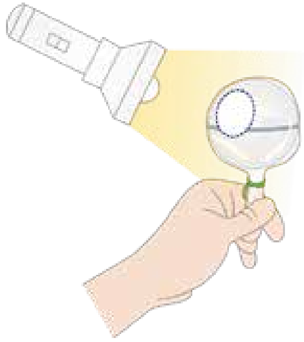
The amount of sunlight we experience on our part of the Earth changes with the seasons. In the summer, our part of the Earth tips toward the Sun.




If we tip our hemisphere on the Styrofoam ball toward the Sun, the circle of light from the flashlight on the ball is brighter, or more intense.

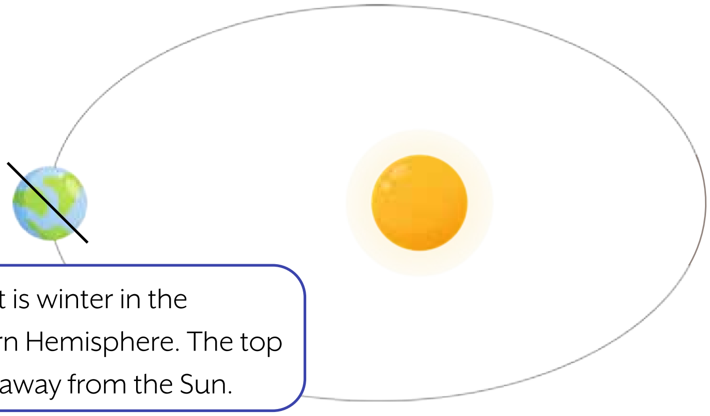


**15.** Use a permanent marker to trace the circle of light on the bag.

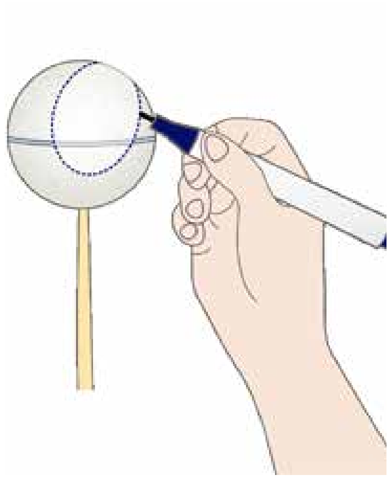


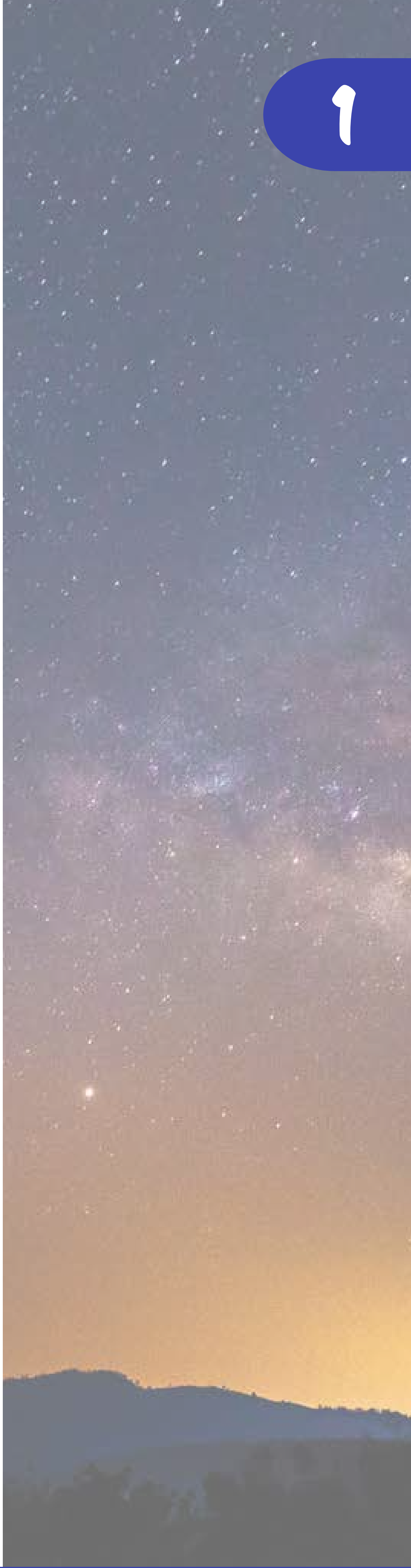
When the Sun's energy is focused in this small space, this part of the Earth gets very warm. The Sun shining directly here makes summer warmer.

During the winter, our hemisphere tips away from the Sun.

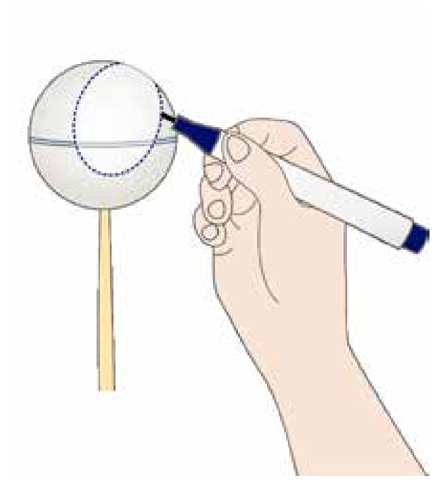



The circle of light from the flash-light Sun turns oval-shaped and looks less bright. The sunlight is less intense, which is why winter is cooler.





**16.** Tip the Earth so your hemisphere points away from the Sun and the beam of light from the flashlight is more oval shaped. Use a permanent marker to trace the oval of light on the bag.



**17.** Record your findings. On the **Test Data Sheet**, draw how the Earth looks on its tilt when the tack experienced warmer temperatures. Then draw how the Earth looked on its tilt when the tack experienced cooler temperatures. Be sure to include the tack in your drawings.

Remember, the Earth spins all the way around once each day. As it spins, the Earth also orbits around the Sun. The path that Earth takes around the Sun is called its **orbit**. It takes a little over 365 days for Earth to make one trip around its orbit. Because of the Earth's tilt, sometimes one hemisphere is pointed more directly at the Sun than the other. The hemisphere with more direct sunlight experiences warmer temperatures than the hemisphere that is tilted away. This is why we have seasons that last for many days.

### Important

Please save the Styrofoam ball, thumbtack, and skewer model of the Earth you made today. You will use it again later this year. You may remove the plastic bag.

## Draw Conclusions

What causes us to experience day and night? (The Earth rotating, or spinning.)

Where does the Sun go at nighttime? (It disappears over the horizon as the Earth spins. The Sun is only visible on the side of the Earth facing the Sun. When it is nighttime here, it is daytime on the other side of the Earth.)

Remember, when the tack leaned (or tilted) toward the Sun, temperatures for the tack were warmer. When it leaned away from the Sun, temperatures were cooler.

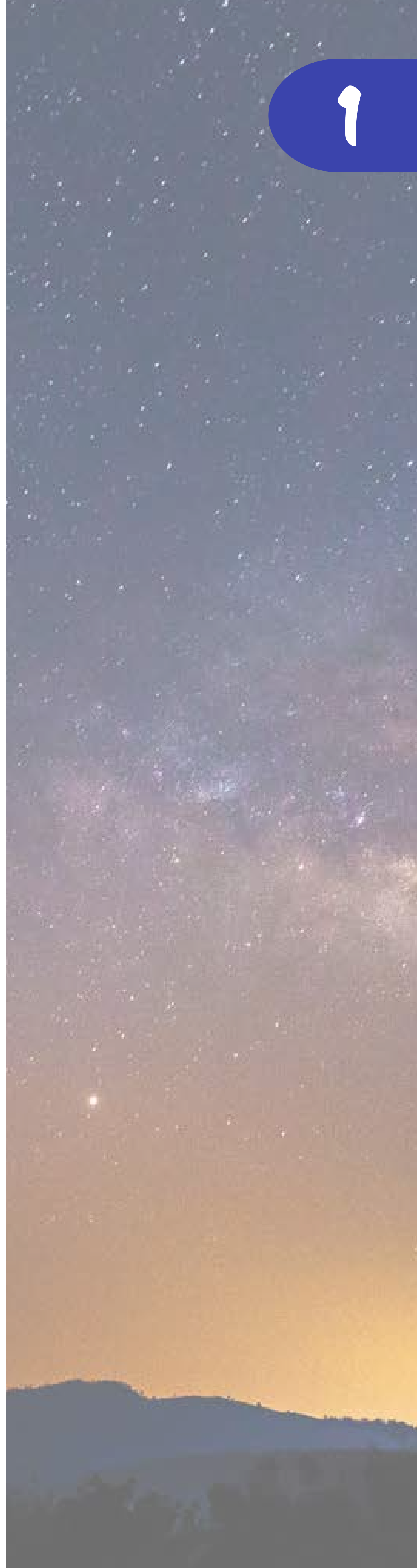
Why do we have seasons? (Possible: Because the Earth is tilted on its axis. During half of the year, the top half of Earth receives more direct sunlight. During the other half of the year, the bottom half of the Earth receives more direct sunlight.)

How is the Earth tilted when we are having summer? (Possible: Our hemisphere is tilted toward the Sun.)

# Takeaway

In this activity, you demonstrated two patterns we experience on Earth. The first pattern was day and night. The Sun gives off its own light, which we see during the day, when our side of the Earth faces the Sun. The Earth rotates, causing us to face away from the Sun. When we do, we cannot see the light from the Sun, which is why nighttime is dark.

The second pattern you demonstrated explains why seasons occur. Earth is tilted on its axis as it orbits the Sun. The tilt causes either the Northern Hemisphere or the Southern Hemisphere to receive more direct sunlight at different times of the year. When our half receives more direct sunlight, we experience seasons with warmer temperatures. When it is tilted away, we have seasons with cooler temperatures.



### See the Bigger Picture

Different planets in the solar system spin at different speeds and orbit in bigger and smaller circles around the Sun. This means that a "day" on Earth is not the same amount of time as a "day" on another planet. On Jupiter, for example, a "day" lasts a little less than 10 hours, which means it spins around twice (or has two days) in the time it takes for Earth to spin around once. Since Jupiter is farther from the Sun, its orbit is much bigger than Earth's, too. In fact, it takes 12 Earth years for Jupiter to go around the Sun once.

### Go Further

Try acting as the Earth. Ask a grown up to point the flashlight at your stomach so you can see the light on your shirt.

**Caution:** Do not look directly into the light.

Are you experiencing day or night?
(It is day because you can see the light on your shirt.)

Turn around and face away from the Sun, but continue to have the flashlight shining on you.

Are you experiencing day or night?
(It is night because you can't see any light on your shirt.)

The light from the flashlight never stopped giving off light, just like the Sun never stops giving off light. We just can't always see the light the Sun is giving off because sometimes we are facing away from the Sun.

# What Makes Day, Night and the Seasons?

## Test Data Sheet

### Activity 1: Daytime and Nighttime on Earth

Draw a picture to show the **light**, the **ball**, and the **tack** when it is daytime for the tack.

Draw a picture to show the **light**, the **ball**, and the **tack** when it is nighttime for the tack.

### Activity 2: The Reasons for Seasons

Draw how the **Sun**, the **Earth** on its **axis**, and the **tack** look when the tack experiences a warmer season.

Draw how the **Sun**, the **Earth** on its **axis**, and the **tack** look when the tack experi-ences a cooler season.