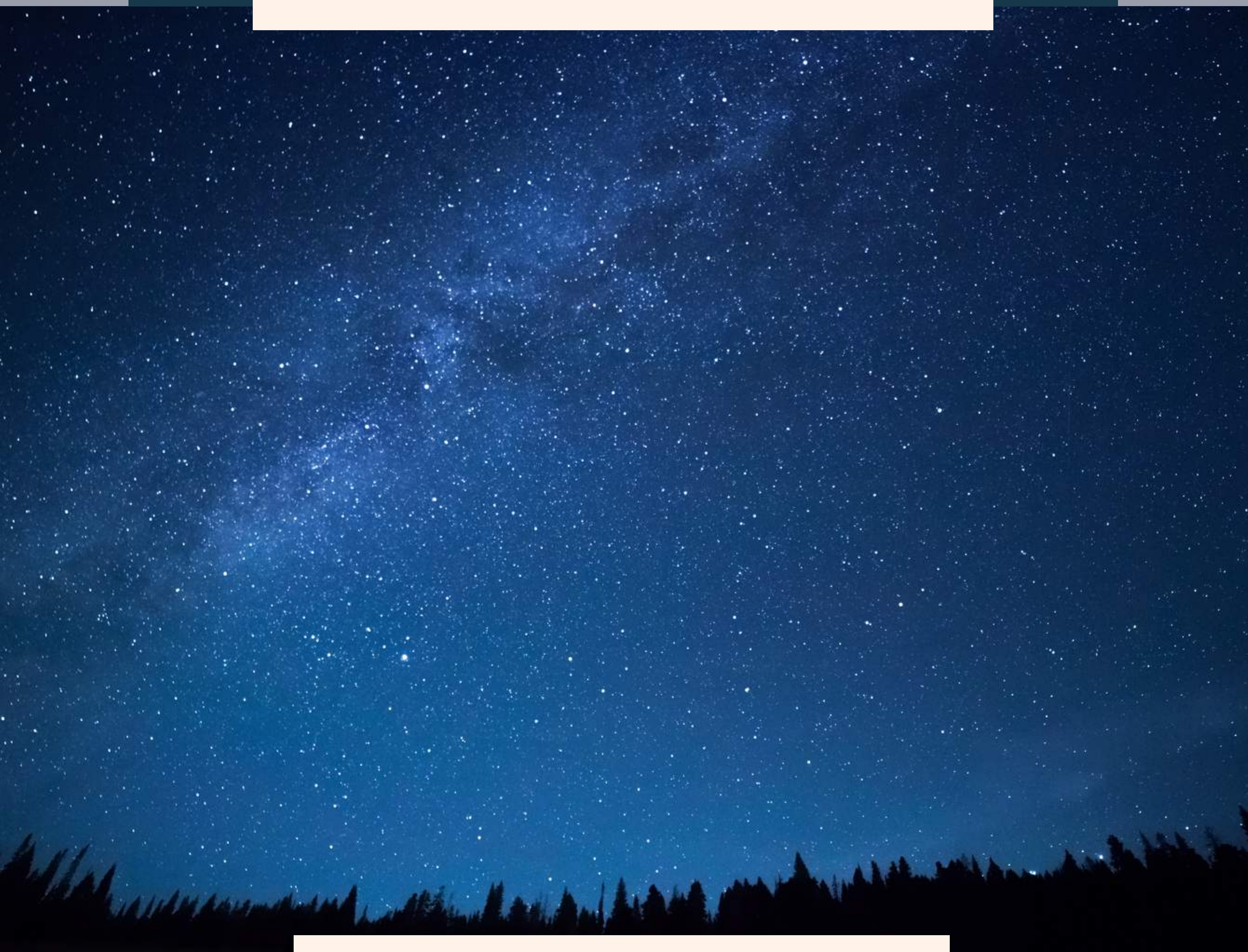
BLOSSOM & ROOT

ELEMENTARY SCIENCE // LEVEL 5

Wonders of Worlds Beyond

PART TWO: ASTRONOMY

PARENT GUIDE



LEVEL 5

Exploring Oceanography (Part One) and Astronomy (Part Two)

Blossom & Root

Nature-Based Home Education

www.blossomandroot.com

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Blossom & Root

Elementary Science,
Level 5:

Wonders of Worlds Beyond

Part Two: Astronomy

A Complete, Hands-On Secular Science Curriculum

Adaptable for Grades 1 - 6

Blossom & Root Elementary Science
Level 5: Wonders of Worlds Beyond
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Contents

Book List: Spines

Required Books:

There are no required books for this curriculum. Theoretically, you could complete this curriculum without using any books at all, simply by using our "big picture" messages listed in each unit and our suggested video links. However, we do have several books that are highly recommended (see below) to help truly bring each topic to life in a visual way for your child. Further in this guide, you will find many pages of optional supplemental books to consider as well.

Highly Recommended Books:

Wonder #	Book
Most 1 - 12	**Recommended Spine:** *DK Smithsonian Space*! | ISBN 978-1-4654-3806-5 This is the recommended primary spine for part two: astronomy.
All 1 - 12	(**Optional) Recommended Secondary Spine for Older, More Advanced, or Extra-Curious Learners:** *Astrophysics for Young People in a Hurry* by Neil deGrasse Tyson ISBN 978-1-324-00328-1 / 978-0-393-35650-2 This is a recommended (but optional) secondary spine for part two: astronomy. We recommend it be used <u>in addition to</u> *DK Smithsonian Space*!, not as an alternative to it. This spine is recommended for older, advanced, or extra-curious learners that wish to add astrophysics to their astronomy studies at this time. There is one chapter assigned to each wonder of this curriculum, but **please note that the content in those chapters does not necessarily align with the focus of each wonder**. This book is meant to be read and enjoyed alongside the content in this curriculum, and will lend an additional layer of exploration and understanding to the content, but it will not be neatly aligned with each lesson's content.
Most 1 - 12	**Alternative / Complimentary Spine Option:** *DK Smithsonian Super Space Encyclopedia* ISBN 978-1-4654-8171-9 | This is a good alternative or complimentary spine for the astronomy portion. It does feature quite a lot of information about space exploration, and specific stars and exoplanets.
Most 1 - 12	**Alternative Spine Option:** *Professor Astro Cat's Frontiers of Space* by Dr. Dominic Walliman and Ben Newman | ISBN 978-1909263079 If you're working with a younger learner, this would be a good alternative spine for the astronomy portion. It does <u>not</u> contain as much information as the DK books. Recommended for ages 5 - 8.
Most 1 - 12	**(Optional) Complimentary Spine Option:** *DK The Mysteries of the Universe* ISBN 978-1465499332 This would make a lovely (though optional) <u>complimentary</u> spine in addition to the recommended spine for the astronomy portion. There are stunning images and lots of interesting "small bite" tidbits.
Most 1 - 12	**(Optional) Complimentary Spine Option:** *Planetarium* curated by Chris Wormell and Raman Prinja | ISBN 978-1-5362-0623-4 This is a nice, optional, complimentary spine to use in addition to the primary recommended spine. Popular with fans of the "Welcome to the Museum" series, this spine features beautiful, large-scale illustrations and short, eloquent descriptions of various planets, stars, etc.
9	**Highly Recommended (ages 8+, screen first):** *A Black Hole is Not a Hole* by Carolyn Cinami DeCristofano

Wonder No. 2: A Solar Story

Welcome to Astronomy Wonder No. 2: A Solar Story.

As we begin our exploration of outer space, we'll start "close to home" by diving into our own solar system. In this unit, you will learn about our sun, and how our solar system formed.

There are 8 "big picture" messages to focus on during this unit:

1) Our sun is a star, and it is the closest star to us. It is only 93 million miles away from Earth, a relatively short distance when considering the vast distance between us and the next closest star. **However, it is not the biggest or the brightest star in the universe.** You will learn more about stars in Wonder 8. Its close proximity to us (compared to other stars) is why the sun appears to be so bright and so large compared to the other stars we can see from here on Earth.

2) Like other stars, our sun is a giant ball of burning gases, mostly hydrogen and helium. And like other stars, our sun has a "life cycle," even though it is not a living thing. Our sun is near the middle of its life cycle.

3) Our sun is in the center of our solar system. Our solar system includes the sun, and all of the planets and minor bodies that orbit around it. Our sun is massive compared to everything else in the solar system. In fact, it contains 99.8% of the entire mass of our solar system! (page 8, *DK Smithsonian Space*!) Eight planets orbit our sun in our solar system: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. You'll learn more about them in the next two wonders.

4) The sun's massive gravity is what holds our solar system together. Gravity is an invisible force that pulls objects toward each other. Everything that has mass also has gravity. The more mass an object has, the more gravity it has. The sun is more massive than anything else in our solar system, therefore its gravity controls a lot of what happens within it. There *are* objects outside our solar systems with far greater mass than the sun, but the strength of an object's gravity doesn't just depend on its mass--it also depends on distance. The closer an object is to another object, the stronger its gravitational pull on that other object will be.

A note to parents / educators: We explored gravity in *Level 4: Wonders of the Physical World*. If you haven't completed Level 4 or studied gravity just yet, you might want to pause and spend a little time exploring gravity with the recommended resources below before proceeding. Even if you have already completed Level 4 and / or learned about gravity, you might want to quickly refresh your child's memory, since a basic understanding of gravity is essential when studying astronomy.

- From CrashCourse Kids, "Gravity Compilation": https://youtu.be/EwY6p-r_hyU
- The Magic School Bus season 4, episode 8 "Gains Weight"
- From SciShow, "Is There Gravity in Space?": https://youtu.be/qnzquEOMLGU (addresses some common misconceptions about gravity in space--**screen first** as this was not made for kids)
- Recommended book: *The Ups and Downs of Gravity* by David A. Adler

5) Our solar system formed about 4.6 billion years ago from a cloud of gas and dust. Something--possibly a shock wave from a distant exploding star--upset this cloud, causing a pocket of gas within it to begin to shrink. As the clump of gas began to shrink, it also began to spin. Gradually as it spun, it formed a flat, spinning disk--what we call a protoplanetary disk--out of all of the substances in the cloud. The center of this cloud began to heat up, squeezed by its own gravity, until finally nuclear reactions began happening and our star--our sun--was born.

6) Around our new sun, the remaining materials fanned out at varying distances as they began to orbit it. The heavier materials closer to the sun began colliding and clumping together, and gradually the gravity of these clumps attracted more materials to them, forming rocks and planetesimals (tiny potential planets.) As these planetesimals grew, their gravity increased, and they attracted more planetesimals to them, accumulating more and more mass each time. Gradually, under their own increasing gravity, they became spherical in shape and they became the four inner planets: Mercury, Venus, Earth, and Mars.

7) Gas, dust, and ice further from the new sun also began clumping together in the same manner, increasing in mass and gravity with each accumulation until they, too, became spherical under the influence of their own gravity. Thus the four outer planets--Jupiter, Saturn, Uranus, and Neptune--were formed.

8) Not all planetesimals became planets. Some became moons, orbiting the planets. Others became part of the rings that circle the outer planets. Still others became asteroids, comets, and meteoroids, found throughout the solar system. We will explore the eight planets, their moons and rings, and the minor bodies of the solar system throughout the next several wonders.

7) Within the sun's super-hot core, a process called nuclear fusion occurs continuously during its life cycle. During this process, tremendous energy is released. This energy makes its way (very slowly) to the surface of the sun. As this energy leaves the surface of the sun, it radiates out into the solar system as light and other forms of radiation. (page 14, *DK Smithsonian Space*!) This energy can take up to 100,000 years to reach the surface of the sun from its core, but only eight minutes and 20 seconds to travel from the surface of the sun to us here on Earth. **The energy from the sun makes life on Earth possible.** (We'll explore this concept more in Wonder 6.)

8) The sun is made of several layers, including an ultra-hot core, the radiative zone around it, and the convective zone above the radiative zone. The sun also has an atmosphere, made of the the lowest layer, called the photosphere, then the chromosphere, and finally the upper-most layer, the corona. Learn more about each layer with the recommended videos below:
From Astronimate, "Less Than Five - Layers of the Sun Explained - Inner Layers": https://youtu.be/BGkqGb-KDK4 and "Less Than Five - Layers of the Sun Explained - Outer Layers": https://youtu.be/KFxJ_8ob6BM

Head's up: Because of the intensity of the sun's light, you should never look directly at the sun without specialized protective eyewear!

Wonder No. 2: A Solar Story

1. For the Minimalists:

Talk about the "big picture messages" together and read the following pages from your spine(s) of choice:

- *DK Smithsonian Space*!: read pages 8 - 15
- *DK Smithsonian Super Space Encyclopedia*: read pages 8 - 9, 20 - 23, 32 - 35
- *Dk The Mysteries of the Universe*: read pages 30 - 39
- *Professor Astro Cat's Frontiers of Space*: read pages 10 - 13
- *Planetarium*: read pages 17 - 19, 45 - 51

Astrophysics for Young People in a Hurry: Read Chapter 2: How to Communicate with Aliens (remember--this won't necessarily line up with the specific content of this lesson)

2. For the Book Basket Folks:

Chapters 1 and 2 in *Our Solar System: An Exploration of Planets, Moons, Asteroids, and Other Mysteries of Space* by Lisa Reichley; *Solar System: Our Place in Space* (Science Comics) by Rosemary Moscco and Jon Chad (read anytime during wonders 2 - 6); Recommended for Younger Learners (ages 8 and under): *Sun*! *One in a Billion* by Stacy McAnulty

3. For the Visual Learners (always screen first):

From Crash Course Kids:

- "Here Comes the Sun": https://youtu.be/6FB0rDsR_rc
- "Seasons and the Sun": https://youtu.be/b25g4nZTHvM
- "Orbits are Odd": https://youtu.be/aGVXyCrpUn8

From Crash Course (better for more advanced learners):

- "Introduction to the Solar System: Crash Course Astronomy #9": https://youtu.be/TKM0P3XlMNA
- "The Sun: Crash Course Astronomy #10": https://youtu.be/b22HKFMIfWo

- From Professor Dave Explains, "The Formation of the Solar System and the Structure of the Sun": https://youtu.be/gxKCDjnWabk (stick to the first 3:35 of content for very young learners)
- From To Scale, "To Scale: The Solar System": https://youtu.be/zR3Igc3Rhfg (this is fascinating!)
- From TDC, "The Formation of the Solar System in 6 minutes!": https://youtu.be/x1QTc5YeO6w
- From National Geographic, "Sun 101": https://youtu.be/2HoTK_Gqi2Q
- From NASA Space Place, "The Solar System's Formation": https://youtu.be/RT4OO0TFLHw
- From Spark, "How Are Sunspots Formed?": https://youtu.be/j1Vs6dGGEvA
- From SciShow, "What Causes Auroras?": https://youtu.be/nXxwZVbDt1c (best for older learners)
- From TED-ed, "What is an Aurora?": https://youtu.be/czMh3BnHFHQ (best for older learners)
- From NASA Goddard, "NASA | Phoenix Prominence Eruption": https://youtu.be/WEd0kRjhi1Y and "NASA | The Difference Between CMEs and Solar Flares": https://youtu.be/TWjtYSRlOUI
- Check out NASA's pictures and videos of the sun: https://solarsystem.nasa.gov/solar-system/sun/galleries/

For Very Young Learners in Tow:

- From Free School, "Exploring Our Solar System: Planets and Space for Kids": https://youtu.be/Qd6nLM2QlWw
- From Peekaboo Kidz, "The Dr. Binocs Show | Best Learning Videos For Kids | Peekaboo Kidz": https://youtu.be/w36yxLgwUOc
- From SciShow Kids, "What is the Sun?": https://youtu.be/0b3GcLE4Vlg

Wonder No. 2: A Solar Story

From the Laboratory Guide:
4. For the Outdoor Learners:
Astronomy Wonder No. 2 "Recalling Personal Experiences Relating to Daylight at Different Times of the Year"
Astronomy Wonder No. 2 "Observing and Graphing Shadows During the Day"

5. For the Table-Lab Crowd:
Astronomy Wonder No. 2 "Solstices and Light Intensity"
Astronomy Wonder No. 2 "Graphing Daylight Hours plus Bonus Challenge: Guess the City"

6. For the Crafts-and-Projects Families:
Astronomy Wonder No. 2 "Dynamic Model of the Sun with Layers"
Astronomy Wonder No. 2 "Long-Term Project: Planning and Preparing Your Model Solar System" and "Long-Term Project: Create Your Model of the Sun"

Additional (External) Activities to Look Into:
- From NASA, an activity to compare a scale model of the sun to one of the Earth (and the distance between them): https://sunearthday.nasa.gov/2007/materials/solar_pizza.pdf
- From NASA, an activity exploring distances in the solar system: https://www.jpl.nasa.gov/edu/teach/activity/solar-system-scroll/

From the Student Notebook:
Complete Wonder No. 2 Entry. See next page for optional notebook prompts.

Optional **Student Notebook Prompts**

If your child is ready for more guided notebook entries, please feel free to offer one of the prompts below for them to use when completing their notebook entry. They can refer to the "big picture" messages, your chosen spines, any supplemental books or videos you added, or any additional resources (internet search, additional library books, etc.) to help them complete whichever prompt you've selected for them.

These prompts are completely optional, and if you would prefer to leave the notebook entry's content up to your child (as in previous levels), that is completely fine as well.

- Describe how our solar system formed.
- Name and describe the layers of the sun and its atmosphere. (Watch the recommended videos first.)
- **Challenge Prompt:** Describe how energy travels from the sun's core to its surface, and then to us here on Earth. You may need to do a little more research first, using the recommended resources on the previous pages.
- **Challenge Prompt:** Learn about the process of nuclear fusion within our sun's core and explain how it generates energy. (Here is one video to help you get started, from the Science Channel, "How Does Fusion Power the Sun?": https://youtu.be/W1ZQ4JBv3-Y)

Profile: Maria Mitchell, Ada Lovelace, and / or Margaret Hamilton

In this profile, you will use the recommended books, websites, and / or video links to learn about the life and contributions of Maria Mitchell, Ada Lovelace, and / or Margaret Hamilton.

Recommended Literature:
Maria Mitchell
- *What Miss Mitchell Saw* by Hayley Barrett
- page 5 in *Who Did It First?: 50 Scientists, Artists, and Mathematicians Who Revolutionized the World* by Julie Leung
- *Finding Wonders: Three Girls Who Changed Science* by Jeannine Atkins (some references to Mitchell's Quaker beliefs; trigger warning: child loss--briefly referenced)

Ada Lovelace
- page 17 in *Women in Science: 50 Fearless Pioneers Who Changed the World* by Rachel Ignotofsky
- page 20 in *Galaxy Girls: 50 Amazing Stories of Women in Space* by Libby Jackson
- page 156 in *Kid Scientists: True Tales of Childhood from Science Superstars* by David Stabler
- page 3 in *Who Did It First?: 50 Scientists, Artists, and Mathematicians Who Revolutionized the World* by Julie Leung
- pages 7 - 11 in *Bold Women in Science: 15 Women in History You Should Know* by Danni Washington
- *Ada Lovelace, Poet of Science: The First Computer Programmer* by Diane Stanley

Margaret Hamilton
- page 46 in *Galaxy Girls: 50 Amazing Stories of Women in Space* by Libby Jackson
- *Margaret and the Moon* by Dean Robbins

Recommended Video and Website Links:
Maria Mitchell
- From Studies Weekly, "Maria Mitchell": https://youtu.be/kQQWkiL1Mrg
- From Big Think, "Maria Mitchell: America's First Celebrity Scientist": https://youtu.be/l7VUQYTkLVY
- https://kidsdiscover.com/quick-reads/meet-maria-mitchell-americas-first-professional-female-astronomer/

Ada Lovelace
- From SciShow, "Ada Lovelace: Great Minds": https://youtu.be/uBbVbqRvqTM
- From Seeker, "Who Was Ada Lovelace, The World's First Computer Nerd?": https://youtu.be/lLOAuYv87uU
- https://kids.nationalgeographic.com/history/article/ada-lovelace

Margaret Hamilton
- From Rebel Girls, "Moon Landing 50th Anniversary: The Story of Margaret Hamilton": https://youtu.be/1Z8Ycd3a6i8
- From SciShow, "Great Minds: Margaret Hamilton": https://youtu.be/PPLDZMjgaf8
- https://kidscodecs.com/margaret-hamilton/

From the Student Notebook:
Complete a profile page (located at the end of the notebook.)

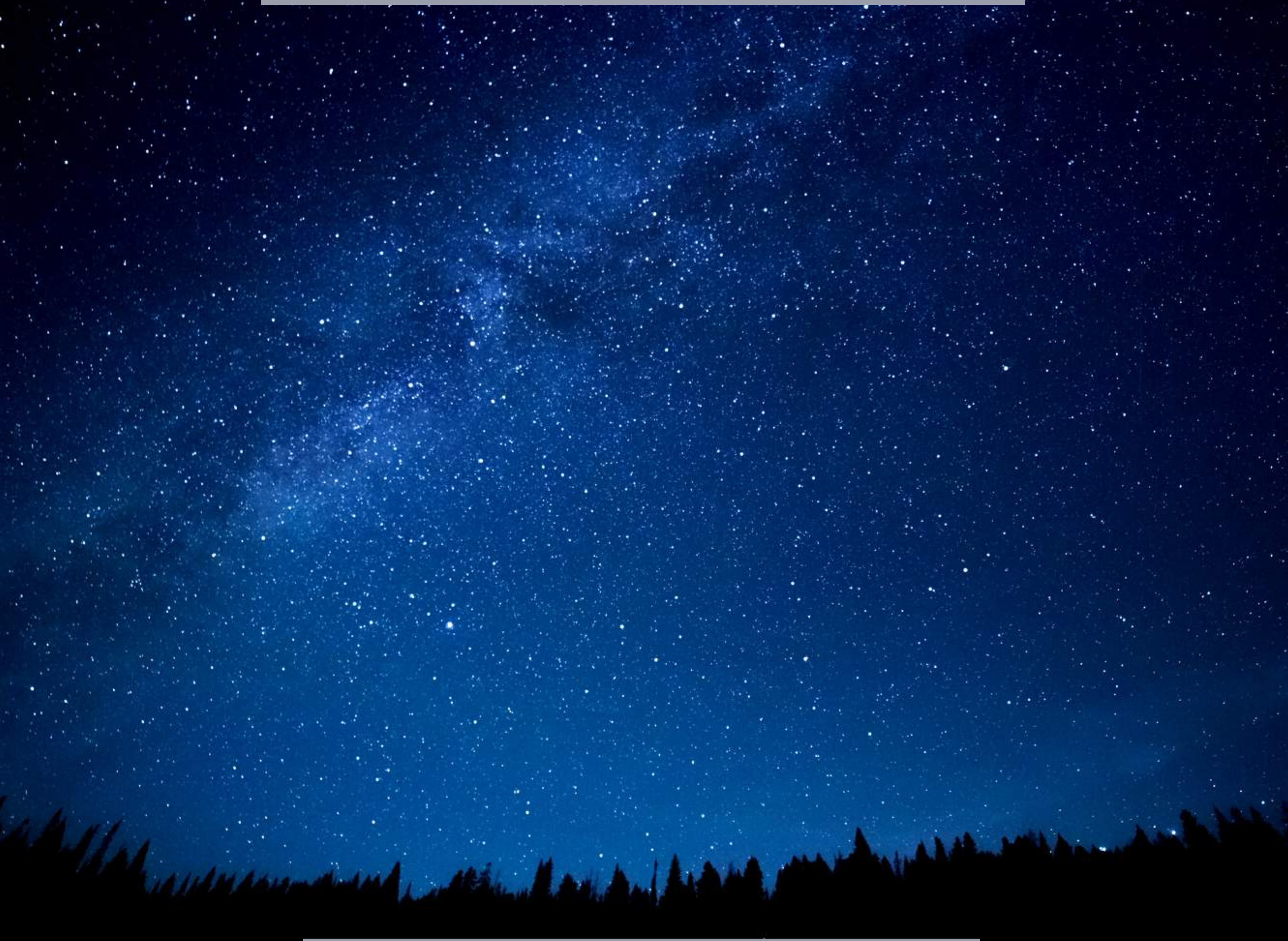
BLOSSOM & ROOT

ELEMENTARY SCIENCE // LEVEL 5

Wonders of Worlds Beyond

PART TWO: ASTRONOMY

LABORATORY GUIDE



LEVEL 5

Exploring Oceanography (Part One) and Astronomy (Part Two)

For the Outdoor Learners:

Recalling Personal Experiences Relating to Daylight at Different Times of the Year

What You'll Need:

- a sheet of paper
- a pencil
- a flashlight and a round rock or ball
- a sticker or marker

What to Do:
Sit down together in a comfortable spot outdoors. This can either be done orally, as a casual conversation, or you can write down your child's responses or have them write down their own responses.

Ask your child to think of times when they've noticed a difference in the amount of daylight during various times of the year. If they need a little bit of prompting, here are some ideas to trickle out:

- Have you noticed a difference in daylight at the time when we usually eat dinner? How is it different in the winter versus the summer?

- Have you ever noticed a difference in daylight in the late afternoon or early evening when playing with your friends outside?

- Have you ever noticed the sun traveling across a different path during the winter than it does in the summer?

- Have you ever noticed a difference in the daylight at the time when you usually get up and have breakfast?

Share your own experiences, too. If you weren't homeschooled yourself, you might recall waiting for the bus in darkness on winter mornings and in the bright sunshine in the early fall or late spring.

Next, ask your child if they think it's daytime for the people on the other side of the Earth right now. Why or why not?

Ask them why they think the amount of daylight changes during the year.

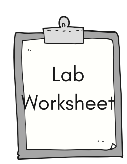
Finally, ask them why the sun appears to rise and set. Remind them that the Earth orbits the sun, if needed.

Demonstrate the rotation of the Earth, using a flashlight (as the sun) and a round rock or ball (as the Earth.) Ask your child to mark the rock / ball with a sticker or marker in one spot. Ask them to hold the flashlight while you slowly "rotate" the Earth, showing them how the spot they marked moves in and out of "daylight" as it rotates.

You can also demonstrate how the Earth orbits around the sun, tilted slightly on its axis. This causes one hemisphere to receive direct sunlight while the other receives indirect sunlight during one part of the year, and then they switch during another part of the year. This works better with an unshaded lamp at home standing in for the sun, in an otherwise darkened room.

For the Outdoor Learners:

Observing and Graphing Shadows During the Day



What You'll Need:

- pencil, markers
- graph paper
- tape
- a block, small figurine, or similar toy (one that is heavy enough to not fall over if the wind blows)
- a few rocks to weigh your paper down
- the lab worksheet in the student notebook

What to Do:
For this activity, you will follow the directions on the lab worksheet to observe the length of a shadow throughout a single day. Help your child to set up the activity, using the directions in the lab guide, and help them to fill out the lab worksheet as they go along.

Astronomy Wonder No. 2: A Solar Story

For the Table-Lab Crowd:

Solstices and Light Intensity

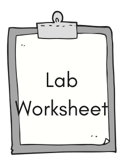
What You'll Need:

- lab worksheet in the student notebook
- pencil
- regular printer paper (6 sheets)
- a stapler, scissors
- a flashlight

What to Do:
For this activity, you will follow the directions on the lab worksheet to conduct a simple experiment exploring the intensity of light when the light source is direct versus when it is indirect. Help your child to set up the activity, using the directions in the lab guide, and help them to fill out the lab worksheet as they go along.

For the Table-Lab Crowd:

Graphing Daylight Hours plus Bonus Challenge: Guess the City



What You'll Need:

- lab worksheet in the student notebook
- pencils (colored pencils and regular pencil)
- internet access
- graph paper (2 sheets)
- ruler or straight edge

What to Do:
For this activity, you will follow the directions on the lab worksheet to graph daylight hours in two locations, using online data. Afterward, your child will try to guess the location of a "mystery city" out of several options, based on the city's given daylight hours. Help your child to set up the activity, using the directions in the lab guide, and help them to fill out the lab worksheet as they go along.

For the Crafts-and-Projects Families:

Dynamic Model of the Sun with Layers

What You'll Need:

- **clay version:** play-dough, Model Magic, or another modeling medium of your choosing in several colors (at least six colors); a piece of floss or string; toothpicks; paper; scissors; tape; a pen
- **paper version:** construction or craft paper in multiple colors (at least six), various round objects to trace OR a drawing compass, pencil, scissors, glue, crayon or marker

What to Do:
Clay Version: Create a model of the layers of the sun. You will begin by shaping a small bit of clay into a ball. This will be the core. You will roll a slightly larger bit of clay into a ball, then flatten it and use it to wrap a layer around the core. This will be the radiative zone. You will repeat this step with an even bigger piece of clay and create the convection zone. You can stop there, or you can make the three layers of the sun's atmosphere as well (the photosphere, chromosphere, and corona) by repeating this process again and again. Alternatively, you can use foil, tissue paper, or plastic wrap to create the layers of the sun's atmosphere. If you've used clay for all six layers, use a piece of string or floss to cut the completed ball of six layers in half, revealing all six layers. Your child may wish to make label flags by taping paper to toothpicks and sticking them into each layer. They may also wish to create features like sunspots and prominences out of clay to add to their model.

Paper Version: Layer circles cut from paper to create the three layers of the sun and the three layers of its atmosphere. Glue them to a sheet of paper, starting with the outermost atmosphere layer and ending with the core. Label each layer with a crayon or marker and add sunspots and prominences to your model.

Astronomy Wonder No. 2: A Solar Story

For the Crafts-and-Projects Families:

Long-Term Project: Planning and Preparing Your Model Solar System

What You'll Need:

- The materials you will use for this long-term project will depend on what your child chooses to use. There are many options, and you should encourage your child to really get creative and use items you have on-hand already as much as possible.

What to Do:

For Wonders 2 - 5, you will have the option of building a model of our solar system. There are so many possibilities to consider for this, and what you choose to use / how you choose to go about this should depend on the time and resources you have available and your child's interest. If you're short on time, you can absolutely use a kit from an educational or craft store, or purchased online. If you have more time, or your child is motivated to be really creative here, they can brainstorm how to use a variety of materials to create a custom-made model. It's truly up to you!

This week, spend a bit of time considering various options. This is a really easy activity to adjust up or down. Older or more advanced learners can concern themselves more with attempting scale, while younger learners can focus more on the appearance of the planets and less on scale.

Ask your child to help you come up with a list of supplies they'll need, and spend this week gathering them up together.

Be sure to share your ideas with other families in our Blossom and Root Families Facebook group!

For the Crafts-and-Projects Families:

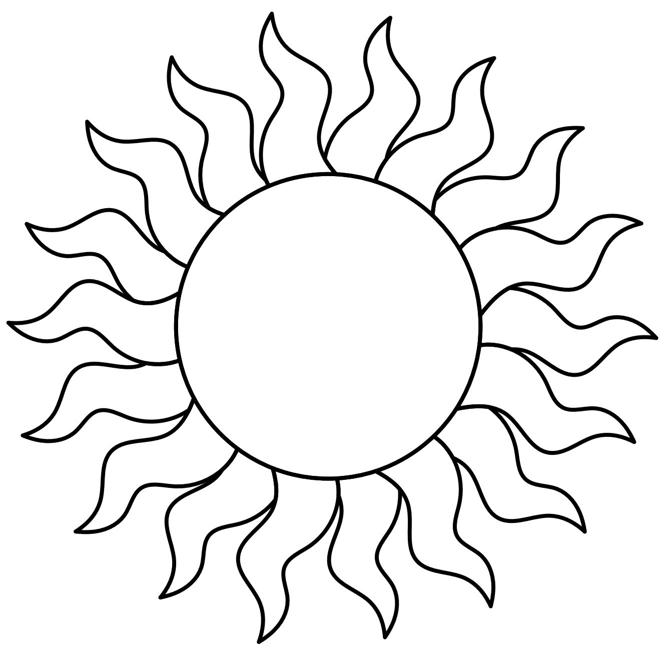
Long-Term Project: Create Your Model of the Sun

What You'll Need:

- The materials you will use for this long-term project will depend on what your child chooses to use. There are many options, and you should encourage your child to really get creative and use items you have on-hand already as much as possible.

What to Do:

During this wonder, you will create your model of the sun. Remember, you can use a kit, or create your model using any materials you like!



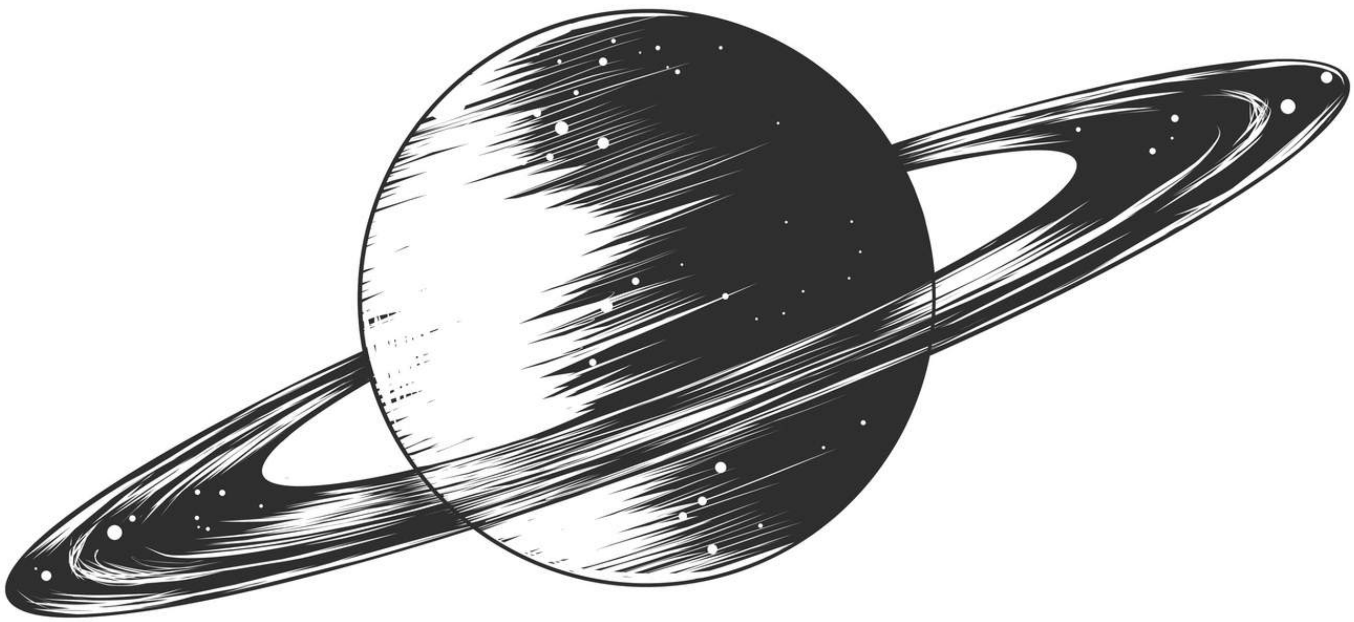
BLOSSOM & ROOT

ELEMENTARY SCIENCE // LEVEL 5

Wonders of Worlds Beyond

PART TWO: ASTRONOMY

STUDENT NOTEBOOK



This book belongs to:

LEVEL 5

Exploring Oceanography (Part One) and Astronomy (Part Two)

Lab Worksheet

2

Lab for Wonder No. 2: Observing and Graphing Shadows During the Day

Step One:

Begin by thinking about past observations of shadows and their lengths throughout different times of the day. Think about what you know about the Earth, and how it rotates on its axis, causing what we call daytime and nighttime, and the transitions between them.

Step Two:

After reading that information, think about this question: **If you track the shadow of one object from early morning until early evening, how will that shadow change during the course of the day?** Write down your guess below, and explain your reasons behind your guess.

Step Three:

Set up the experiment. In the very early morning, find a spot outdoors that will receive steady sunlight during the day, with no obstructions (or at least very few.) Tape four sheets of graph paper together to form one large sheet. Pin this down at all four corners with rocks, so the paper won't blow away in the wind. In the center of your giant sheet of graph paper, place an object upright on the paper (like a toy figurine or a heavy block.) It should be between 3 inches tall and 8 inches tall. You'll need the object to be heavy enough not to fall over in the wind. Use a marker to trace around the base of the object. That way, if it does move or fall over, you can put it back in the precise spot where it began the day.

Trace the object's current shadow with a marker, and lightly note the current time inside the shadow with a pencil. Repeat this step throughout the day. You should do this every two to three hours, but try to capture at least five shadows, with one at midday (noon.) At the end of the day, figure out the length of each shadow by counting the number of squares of graph paper that each shadow covered at its longest point and note this measurement next to the corresponding shadow. (For example: 12pm, approx. 12 1/2 squares long at its longest point / 3pm, approx. 7 squares long at its longest point.)

Lab for Wonder No. 2: Observing and Graphing Shadows During the Day, cont.

Step Four:

It's time to think about what happened. How did the **shape** of the shadows change during the day?

How did the **length** of the shadows change during the day?

What do you think happened here? How do the angle of the sun (in your current season) and the rotation of the Earth affect the length and shape of shadows cast by your selected object during the day?

Can you think of another way you could test your idea about what happened?

Lab Worksheet

2

Lab for Wonder No. 2: Solstices and Light Intensity

Step One:

Begin by thinking about the movement of the Earth around the sun, on its tilted axis. This causes the sun to shine directly on the northern hemisphere during part of the year while shining indirectly on the southern hemisphere. As the Earth orbits the sun, this gradually shifts so that the southern hemisphere receives the direct light while the northern hemisphere receives the indirect light. This creates the seasons we experience. We experience summer when the sun is shining on our hemisphere directly, and winter when it is shining on our hemisphere indirectly.

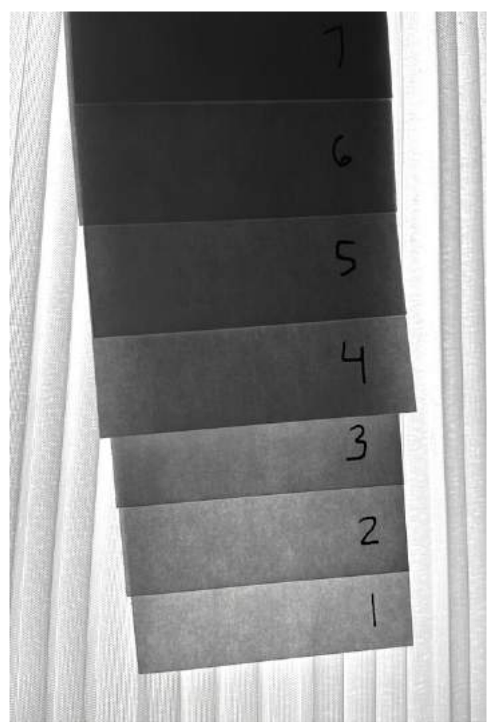
Step Two:

After reading that information, think about this question: **How does the perceived intensity of the sun's light change when it is direct versus when it is indirect? In other words, why does the sun seem more intense in the summer (when it is direct) than in the winter (when it is indirect)?** Write down your guess below, and explain your reasons behind your guess.

Step Three:

Make a light meter:

- Overlap 5 sheets of white printer paper. Spread them out approximately ¾ inch apart (see next page.)
- Fold the papers to make 10 layers.
- Staple at your fold line in 4 places.
- Use scissors to cut into 4 strips (one staple in each strip.) You will only need one strip, unless you're working with multiple children and they each want their own strip.
- Label each layer with numbers 1 - 10. (1 = 1 layer of paper; 2 = 2 layers of paper, etc., all the way to 10 = 10 layers of paper)
- To use the light meter, you will hold the strip up to a light source. Find the layer where you can still see a hint of light coming through (but the next layer blocks it completely.) This will be the "measurement" you use for that light source. For example, if you can barely see light through layer 6, and it's completely blocked in layer 7, then the measurement is "6."



There are visual instructions for this on the next page.

Lab Worksheet

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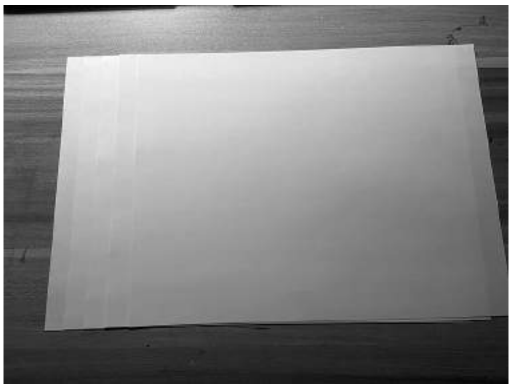
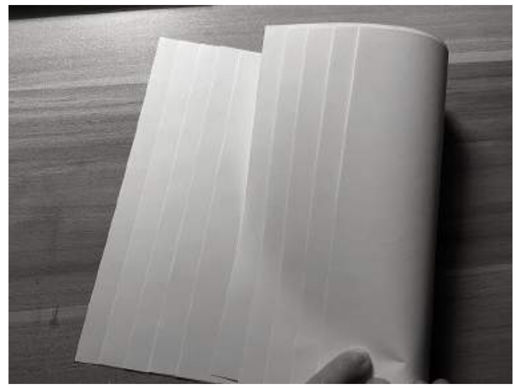
Lab for Wonder No. 2: Solstices and Light Intensity

Making a Light Meter:

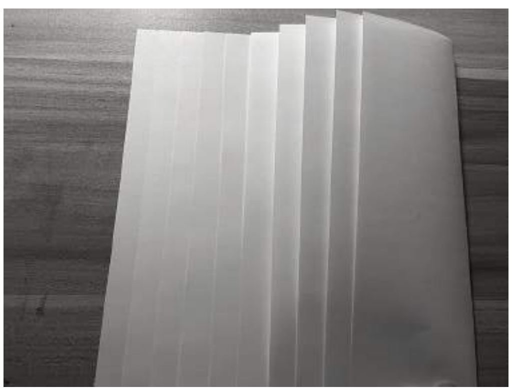
Step One: Layer Paper



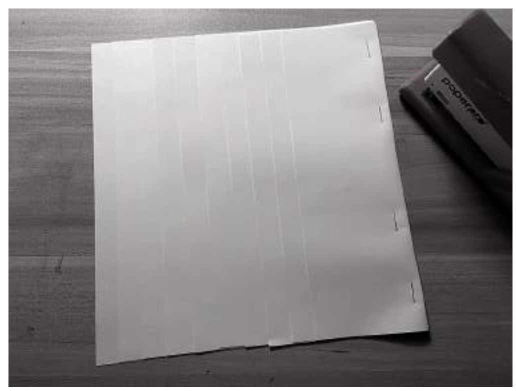
Step Two: Fold



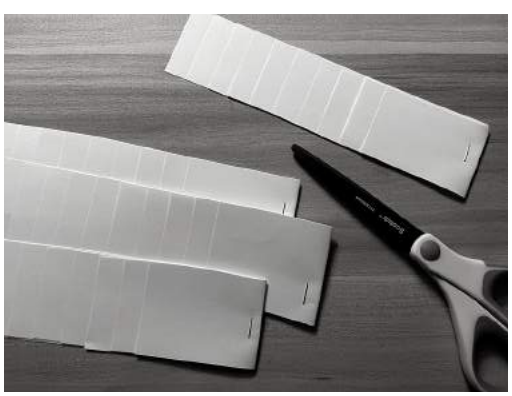
Step Three: Crease the Edge



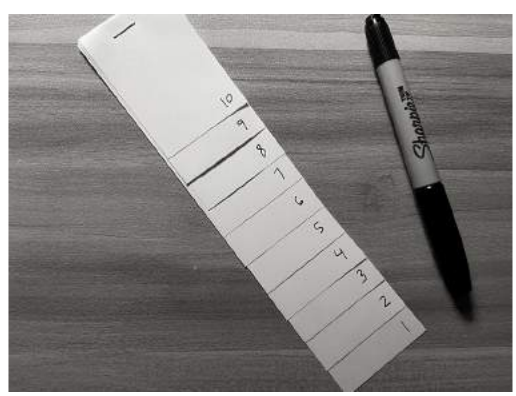
Step Four: Staple



Step Five: Cut Into Strips



Step Six: Label Strips 1 - 10



Lab Worksheet

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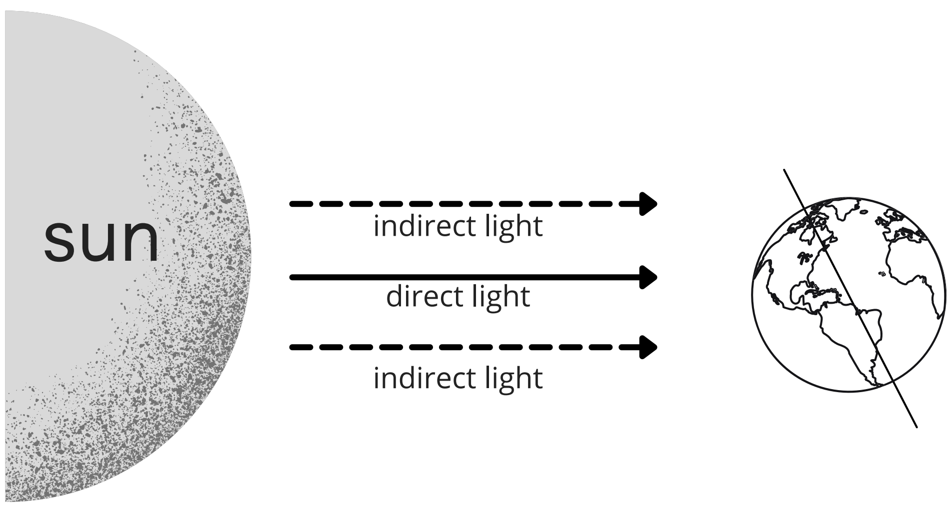
Lab for Wonder No. 2: Solstices and Light Intensity

Step Four:

This experiment may take more than two people, just to hold things in place.

Begin by reminding your child of the tilt of the Earth's axis, and how this creates areas of direct and indirect sunlight throughout the year. You can demonstrate this with a round object (the Earth) and an unshaded lamp (the sun), or you can show them the image below.



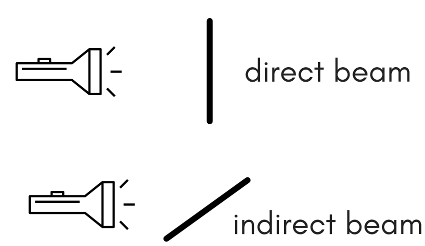
Hold a sheet of paper up. You'll need this to be still and taut, so you may need to ask another family member to step in and hold the paper for you. You will be holding the flashlight on the front side of the paper, and your child will be holding (and reading) the light meter on the back side of the paper.

Shine the flashlight directly at the front side paper, holding it a few inches away from the paper. Ask your child to hold their light meter against the back of the paper, in the area where the light is shining. Ask them to record the measurement of the light's intensity below (1 - 10.) Ask them to mentally note the shape of the light on the paper.

Next, ask the paper-holder to tilt the paper so that the flashlight's beam spreads across it indirectly (see below.) Ask your child to hold their light meter against the back of the paper again, and record the measurement of the light's intensity below. Ask them to mentally note the shape of the light on the paper.

Intensity of the light, direct (1 - 10):

Intensity of the light, indirect (1 - 10):



Lab Worksheet

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Lab for Wonder No. 2: Solstices and Light Intensity

Step Five:

If needed, review what the summer and winter solstices are, using the recommended resources below:

- From The Register-Guard, "What is the winter solstice?": https://youtu.be/BzBw0ZlMwkU
- From SciShow Kids, "The Longest Day of the Year": https://youtu.be/SVzkVsWQBR8
- From National Geographic, "What is a Solstice?": https://youtu.be/btcTfor-j-c

Step Six:

It's time to think about what happened. What was the shape of the direct beam on the paper? What was the intensity of the direct beam?

What was the shape of the indirect beam on the paper? What was the intensity of the indirect beam?

Which beam represents sunlight around the summer solstice?

Which beam represents sunlight around the winter solstice?

Finally, why does the sunlight seem more intense during the summer and less intense during the winter? Does the intensity of the light that the sun is emitting actually change? If not, why does it seem more or less intense here on Earth in different seasons?

Can you think of another way you could test your idea about what happened?

Lab Worksheet 2

Lab for Wonder No. 2: Graphing Daylight Hours (Plus Bonus Challenge: Guess the City)

Step One:

Begin by thinking about how the length of a day changes throughout the year. Think about your own personal observations of this. Perhaps you've noticed that you often eat dinner when it's still light outside during the summer, and when it's dark during the winter.

Watch the following video on why day length changes during the year:

- From NGSS Nerd, "What Causes Day Length to Change from Summer to Winter?": https://youtu.be/Em3TlqNOUsk

Step Two:

After reading that information and watching the video, think about these questions: **Which month has the longest days where you live? Which month has the shortest days where you live? Would these answers be different if you lived in a place on the other hemisphere? How and why would they be different?** Write down your guess below, and explain your reasons behind your guess.

Step Three:

Set up a graph on a piece of graph paper. You should write months of the year along the x-axis, and length of days (in half hour increments) along the y-axis. (An adult should assist as needed, to accommodate different skill levels.) Repeat this step, so that you have two graphs ready to go. On one graph, you will mark the longest day of the month for each month of a full year where you live. On the other graph, you will do the same thing for a location of your choosing in the opposite hemisphere.

You will need to use the internet to look up records of day lengths for a full year in your location and your selected secondary location. There are many websites where you can do this, but a good one is https://sunrise-sunset.org/. An adult should assist if needed, based on age and skill level of the student.

Fill in your graphs, using the information you find online. Remember to look for the longest day length for each month, and use that number for your graph. To make this more challenging for older or advanced learners, you might find the average day length for each month instead, using addition and division.

Lab Worksheet

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Lab for Wonder No. 2: Graphing Daylight Hours (Plus Bonus Challenge: Guess the City), cont.

Step Four:

It's time to think about what happened. Take a look at your guesses in step two, then take a look at the data you collected. Were your initial guess correct? Which month has the longest days where you live? Which month has the shortest days where you live? Are these answers different for a location in the opposite hemisphere? How and why are they different? Write down your observations and thoughts below.

Does this raise any new questions for you? How could you find the answers to those questions?

Bonus Challenge: Guess the City

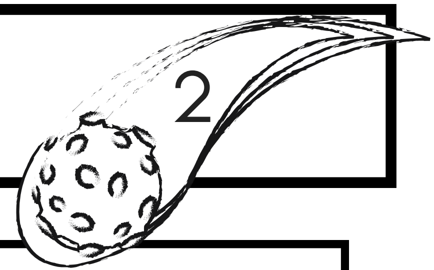
Below are the longest day lengths for a full year in a mystery city.

- January: 12 hours, 13 minutes
- February: 12 hours, 12 minutes
- March: 12 hours, 10 minutes
- April: 12 hours, 8 minutes
- May: 12 hours, 6 minutes
- June: 12 hours, 5 minutes
- July: 12 hours, 5 minutes
- August: 12 hours, 7 minutes
- September: 12 hours, 9 minutes
- October: 12 hours, 11 minutes
- November: 12 hours, 13 minutes
- December: 12 hours, 14 minutes

Based on what you learned from this exercise, can you guess the location of the mystery city from the options below? You may need to use an atlas (online or physical) to help you. The answer is at the bottom of the next page.

A) Buenos Aires, Argentina   B) Nairobi, Kenya   C) Paris, France   D) Brisbane, Australia   E) Oslo, Norway

A Solar Story



Answer to Mystery City Challenge: Nairobi, Kenya