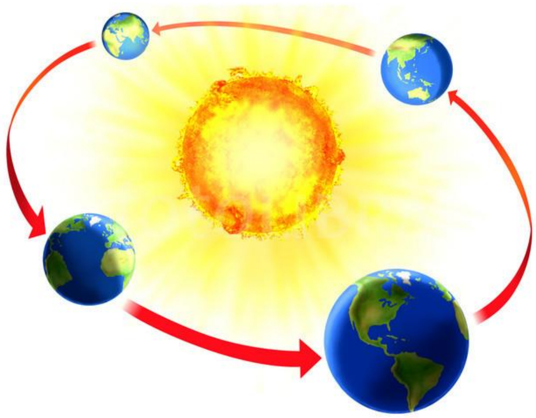


Astronomy Unit

Grade 5

Contents of this file:

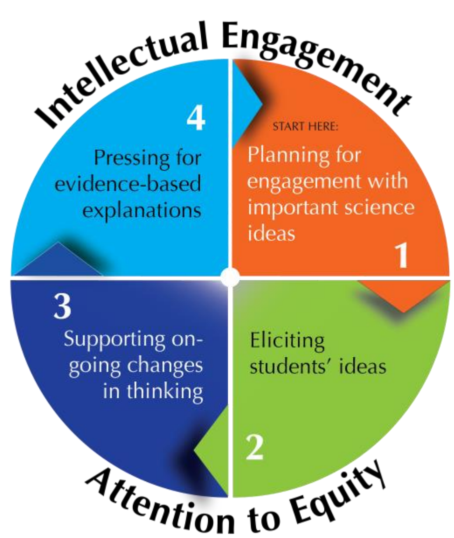
Unit Synopsis:

Students investigate a phenomenon of changing amounts of daylight per day over a year. In Seattle, there is a noticeable difference for students waiting for the school bus in December where they wait in darkness, compared with April or May where it's bright. Why does the amount of daylight change over a year? This phenomenon works for many other cities in the world as well.

Simulations, readings, and videos support students in making sense of the observations and data they collect during hands-on investigations. Throughout the unit, students have multiple opportunities to represent and interpret first and second-hand data. To explain this phenomenon, students will draw up on and make connections between what they learn from this unit about the Earth's rotation, tilt, and revolution along with how directly the Sun's rays strike the Earth at certain places.

Ultimately, the model and explanation students create is of the changing-daylight phenomenon; however, knowing the big science ideas behind this phenomenon allows students to understand or explain other related events, such as the causes of seasons or why patterns in the constellations we observe at night would appear to change over the year.

Ambitious Science Teaching Framework

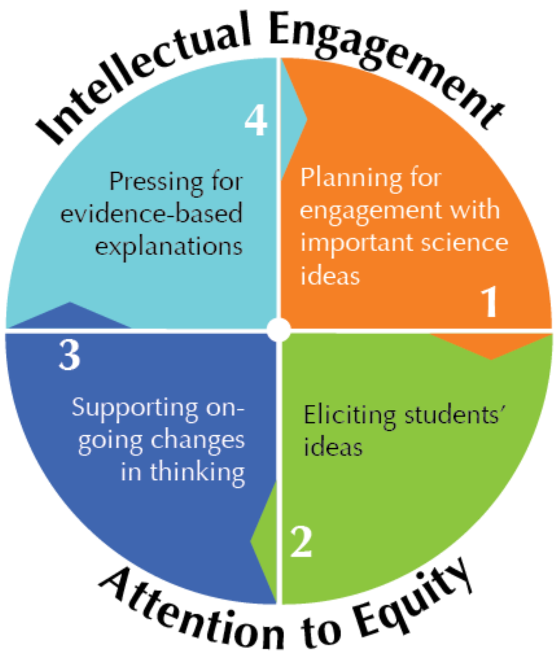


Guide Created by: Carolyn Colley cdawson1@uw.edu
University of Washington

This page intentionally left blank.

Ambitious Science Teaching

We provide here a vision of ambitious teaching—teaching that is effective, rigorous and equitable. But more than that, we provide a framework of research-based teaching practices that are consistent with this vision and a wide range of tools that can transform how students learn in your classroom. The vision, practice, and tools will furnish a common language about teaching for a group of science educators committed to the improvement of teaching. You will be able to identify "what we will get better at" and how to get started.



Ambitious teaching aims to support students of all racial, ethnic, and social class backgrounds in deeply understanding science ideas, participating in the talk of the discipline, and solving authentic problems. This teaching comes to life through four sets of teaching practices that are used together during units of instruction. These practices are powerful for several reasons. They have consistently been shown through research to support student engagement and learning. They can each be used regularly with any kind of science topic. And finally, because there are only four sets of practices, we can develop tools that help both teachers and students participate in them, anyone familiar with the practices can provide feedback to other educators working with the same basic repertoire, teachers can create productive variations of the practices, and everyone in the science education community can share a common language about the continual improvement of teaching.

The four Ambitious and Equitable Science Teaching Practices are summarized in the below.

Practices	What does it LOOK like?
Planning for engagement with important science ideas	• Planning a unit that connects a topic to a phenomena that it explains (Chemical Reactions – Bike Rusting, Photosynthesis – Seed Becoming a Tree) • Teaching a topic within a real-world context
Eliciting students' ideas	• Asking students to explain HOW and WHY they think a phenomena happens (How did the bike change? Why did it change? What is happening at the unobservable level?)
Supporting on-going changes in thinking	• Using ALL activities/lessons to explain the phenomena. • Giving students opportunities to revise their thinking based on what they're learning
Pressing for evidence-based explanations	• Allowing students to create a final model or explanation about the phenomena • Pressing students to connect evidence to their explanation

Many teachers want to know what their classrooms should look like and sound like—they want to understand how to interact with their students about science ideas and students' ideas. This is especially true now that the *Next Generation Science Standards* are being used in many states.
As a result of the last 30 years of classroom research, we know enough about effective instruction to describe in clear terms what kinds of teaching practices have been associated with student engagement and learning. This research tells us that there are many ways that teachers can design and implement effective instruction, but that there are common underlying characteristics to all these examples of teaching that can be analyzed, described, and learned by professionals. These practices embody a new form of "adaptive expertise" that EVERY science educator can work towards. Expert teaching can become the norm, not reserved for a select few. Ambitious teaching is framed in terms of practices that any teacher can learn and get better at over time. What would we see if we entered classroom of a science educator using ambitious teaching? To give you a sense of what ambitious teaching looks like, we have described below some features common to all science classrooms where ambitious teaching is being implemented (listed on right). These features address everyday problems with learning and engagement that teachers face (listed on left).

Common problems in supporting student engagement and learning	What you'd see in a science classroom where ambitious teaching is the aim
The problem: *Students don't see how science ideas fit together.* Each day is perceived by students to be the exploration of ideas that are unconnected with previous concepts and experiences.	At the beginning of the unit, students are focused on developing an evidence-based explanation for a complex event, or process. Students know that throughout unit, most of the activities, readings and conversations will contribute to this explanation.
The problem: *An oversimplified view of what it means "to know."* Science ideas perceived to be straightforward and learnable within a lesson—either you get it or you don't."	An idea is never taught once and for all, but revisited multiple times. Students' science explanations are treated as partial understandings that have to be revisited over time to become more refined and coherent.
The problem: *Lack of student engagement.* Students' experiences and interests not elicited or seen as relevant. Student ideas treated as "correct" or "incorrect."	Students' ideas and everyday experiences are elicited and treated as resources for reasoning; students' partial understandings are honored as a place to start. They are made public and built upon.
The problem: *Students reluctant to participate in science conversations.* Teachers dominate the talk, ask primarily for right answers, get brief responses from students.	Teachers use a varied repertoire of discourse moves to facilitate student talk. Guides and scaffolds for talk help students feel comfortable interacting with peers.
The problem: *Some students have little support for accomplishing tasks that would otherwise be within their grasp.* Little or no guidance for students' intellectual work. Giving "clear directions" is seen as enough to ensure participation in activities.	There is scaffolding that allows students to participate in science-specific forms of talk, in group work, and in science practices.
The problem: *Invisibility of student ideas and reasoning.* Teacher does not know what students think—their heads are a black box. Cannot then work on students' ideas. Students cannot take advantage of the ideas or ways of reasoning by their peers.	Students' thinking made visible through various public representations (tentative science models, lists of hypotheses, question they have, etc.). The teacher can see how students think and how that thinking could change over time. Students benefit from seeing and hearing the reasoning of others.
The problem: *Illusion of rigor.* Students reproduce textbook explanations, lean on vocabulary as a substitute for understanding. Talk of evidence and claims are rare.	The teacher presses for complete, gapless explanations for unique real-life events or processes, and press for the use of evidence to support claims.

As you will see, ambitious teaching is not a "method," and the teaching practices are not scripts. It is a set of principled practices that must be adapted to your classroom needs. Coaches and other teachers can work with you to do this ambitious work.

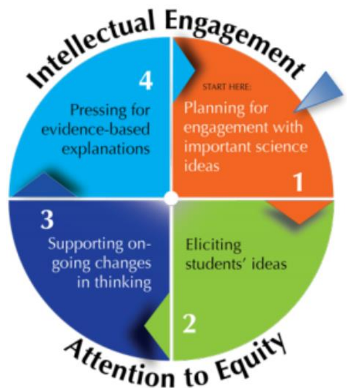
TEACHER BACKGROUND

Science Content Primer & Explanation of Phenomenon

Read through the explanation provided in the next few pages. Jot down questions or uncertainties. Consult internet resources to answer your questions, ask colleagues, and work together as a team to grow your own understandings of the science content and the phenomenon itself. This knowledge primes you to better listen and respond to student ideas in productive ways. Please feel free to revisit this explanation throughout the unit to revise and improve your own understanding of the science content.

Planning for Engagement with Important Ideas

In the Framework for Ambitious Science Teaching, the first phase in any unit of instruction is planning. Only when teachers understand where they are going in the unit can they begin to design instruction, and then take the journey with students through the other three sets of practices in the Framework.



One goal of this planning practice is to support teachers in moving from focusing on science topics towards bigger science ideas that can be used to explain multiple related phenomena in the real-world.

This section provides teachers with general science background knowledge around the content goals for this unit as well as an explanation for a specific phenomenon for this unit. It also suggests ways teachers can identify related phenomenon in their local contexts explained by the same science ideas to help students see this science in their lives, experiences, and/or communities.

Unit Phenomenon

In Seattle (or nearby city), why do we experience more hours of daylight per day in summer and fewer hours of daylight per day in winter? In June, the longest amount of daylight per day is nearly 16 hours and in December the least amount of daylight per day is about 8 ½ hours. Why does this extreme difference in daylight happen? Is this the same or different for other places in the world? Note: *The phenomenon can and should change to focus on a city (or comparison of cities) that are more relevant and meaningful to students. Ideally, this comparison would feature cities with a fairly large difference in latitudes such as a city near the equator compared with a city farther north or south. Or two cities roughly equidistant from the equator but one is north and the other south of the equator.*

Unit Goals

This earth science unit focuses on how the motion and position of the Earth in the Solar System causes daily and annual patterns that can be accurately predicted over time. Students will work with data sets (collecting, representing, interpreting, analyzing data) to gather evidence of and explain the following:

- The daily rotation of the Earth accounts for day-night cycles (daily pattern) on Earth.
- The tilt of the Earth can explain varying intensities of light (direct and indirect) at different places on Earth experiencing daytime (facing towards the Sun). For cities near the equator there is less fluctuation in intensity and amount daylight in a year, but for cities farther North or South, approaching the poles, get more and more extreme differences in the intensity of light.
- The position of the Earth in its orbital path (revolution) around the Sun in combination with the rotation of the Earth on its tilted axis all together account for the annual fluctuations in Seattle's daylight hours.

Addressing Next Generation Science Standards

*This page captures the NGSS for this unit. Each lesson guide also features information about the targeted peformance expectations (PE). The Ambitious Science Teaching Framework (AST) utilizes a model-based inquiry approach to science instruction and has students develop and use models and construct explanations more than what is called for in the bundled NGSS performance expectations below. Any additional SEP, DCI, or CC added to the NGSS to support student learning within AST framework are denoted with an ** in lesson guides and below.*

5th Grade Astronomy Unit

Performance Expectations

5-ESS1-1. Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from the Earth. [Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, stage).]

5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky. [Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [Assessment Boundary: Assessment does not include causes of seasons.]

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data - Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships. (5-ESS1-2) ***Engaging in Argument from Evidence*** - Support an argument with evidence, data, or a model. (5-ESS1-1) ** Added AST framework: ***Developing and Using Models*** - Use models to describe phenomena.	***ESS1.A: The Universe and its Stars*** - The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1) ***ESS1.B: Earth and the Solar System*** - The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)	***Patterns*** - Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2) ***Scale, Proportion, and Quantity*** - Natural objects exist from the very small to the immensely large. (5-ESS1-1)

** This SEP is not originally part of this PE bundle; however, it was added as part of this unit guide. Students will do this SEP in combination with the ones provided in NGSS in this bundle.

I. Teacher Background Knowledge

Key concepts:
The farther you live towards the north or south poles, the more extreme differences there are in the length of daylight in summer compared to winter seasons. How does this work? Here are some key concepts that must be combined to explain the phenomenon:

1. The rotation of the earth on its axis every 24 hours produces the night-and-day cycle.
2. The sun's gravitation pull hold the earth in orbit.
3. The sun provides light and heat to nearby planets.
4. Understanding the relative difference in size and distance between the Sun and Earth.
5. Rotating earth is tilted on its axis – this affects how much direct sunlight the poles receive.
6. Some things in nature have a repeating pattern, such as the day-night cycle and seasons.

1. The rotation of the earth on its axis every 24 hours produces the night-and-day cycle.
To people on earth, this turning of the planet makes it seem as though the sun, moon, planets, and stars are orbiting the earth once a day. But really the Earth is turning on its axis once every 24 hours – explaining the apparent motion of the sun, moon, and stars in a daily pattern. However nighttime and daylight are not equal times depending on where you live and at what position the Earth is in its revolution around the Sun. Note: The term "day" in science typically refers to the 24 hour period to make 1 rotation on an axis; however, everyday usage of the term "day" refers to "daylight" or "daytime". Worth clarifying if students are using the word interchangeably.

2. The sun's gravitation pull hold the earth in orbit.
The sun's gravitational pull holds the earth and other planets in their orbits, just as the planets' gravitational pull keeps their moons in orbit around them. One orbit around the sun equals one year for a planet, for the case of Earth, this happens approximately every 365 days. The orbital path is slightly elliptical but closer to a circle-shape than most diagrams and text books tend to portray.

3. The sun provides light and heat to "nearby" planets.
The sun is a medium-sized star located near the edge of a disc-shaped galaxy of stars, and at the center of our Solar System. The sun is thousands of times closer to the earth than any other star. Light from the sun takes a few minutes to reach the earth. The sun warms the land, air, and water. A warmer object can warm a cooler one by contact or at a distance. Light and heat energy can warm objects. How much an object's temperature increases depends on how intense the light striking its surface is, how long the light shines on the object, and how much of the light is absorbed. This idea combined with the fact the earth spins around a tiled axis (explained below) relates to the idea of the concentrated beam of light from the flash light and the oblique or "spread out" light. (Also, "nearby" is relative – remember space is REALLY big!) Also, light travels away from its source in straight lines.

4. The relative difference in size and distance between the Sun and Earth is HUGE.
The tilt isn't really making the Earthy "closer" to the sun. But the tilt does affect how directly the sun's rays hit the Earth. Students need to understand just how far away the Earth is from the Sun and how the Earth's orbit is approximately circular and not an oval (contrary to many textbook representations.) One idea that is not often reinforced by drawings is the *relative size and distance* difference between the sun and earth.

5. **The rotating earth is tilted on its axis – this affects how much direct sunlight the poles receive**.

This tilt directly influences how direct the light from the sun hits the earth. The sun's rays hit the equator fairly evenly as the earth orbits the sun, so there is not too much variation in temperature or daylight throughout the year. However, the closer you are to the poles, the more spread out the sun's rays are in hitting the earth. This can be demonstrated by shining a flashlight at a sheet of paper (the beam of light hits in a concentrated circle); then tilt the paper so that the light beam makes an oval shape (the beam of light hits obliquely and is less bright/concentrated). In the summer, the earth's axis tilts towards the sun as the earth rotates on its axis. This means that the closer cities are to the North Pole, the more direct light they receive from the sun (think concentrated beam from the flashlight experiment.) As the earth continues to orbit the sun, it is still tilted on its axis such that as it moves around the sun the north pole receives less and less direct light until the north pole of the earth is positioned tilting away from the sun. This means that the South Pole is receiving the more direct sun and the North Pole gets the oblique "spread out" light and heat. The number of hours of daylight and the intensity of the sunlight both vary in a predictable pattern that depends on how far north or south of the equator the place is. This variation explains why temperatures vary over the course of the year and at different locations.

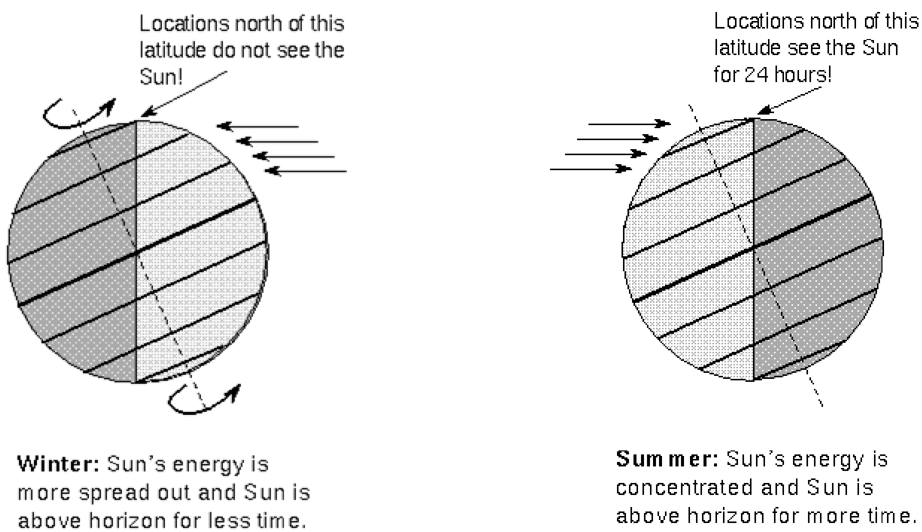
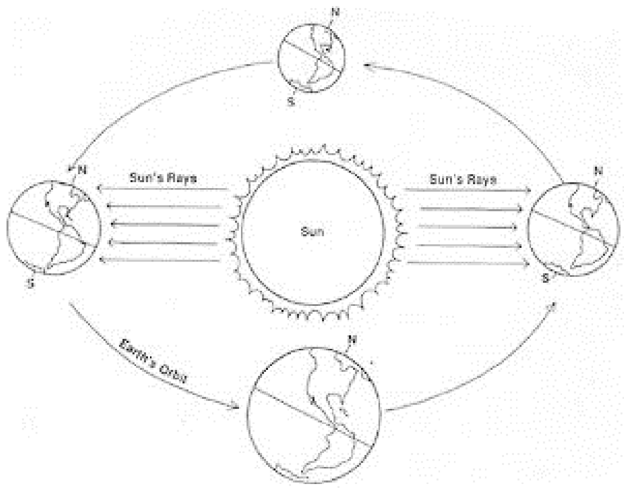


Image credit: http://sites.ehe.osu.edu/beyondweather/files/2011/02/seasons3.gif

6. **Things in nature have repeating patterns, such as the day-night cycle and seasons.**

Cycles, such as the seasons, can be described by what their cycle length or frequency is, what their highest and lowest values are, and when these values occur. Cycles can occur in different time scales. The day/night cycle is always completed in approximately 24 hours even though the amount of daylight (between sunrise and sunset) may vary based on geographic location. An alternative idea students may use to explain how Seattle may have a longer daylight during summer is that the earth slows down to face the sun longer, and then speeds up its rotation during the night to get through the night faster. Another consistent cycle is the rate of orbit of the Earth around the Sun (approximately every 365 days). Another alternative idea students may use to explain why we have longer daylight or warmer temperatures is the idea that the earth is actually closer to the sun during the summer and farther away during winter. This idea is often reinforced by the angled drawings of the orbit in textbooks.



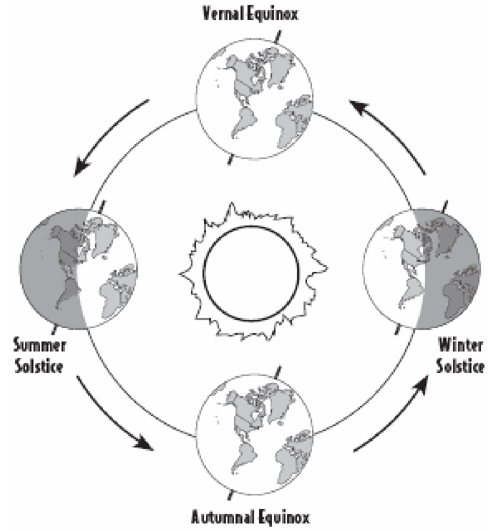


Image credits: http://pics-about-space.com/earth-orbit-and-seasons-worksheet?p=3

Videos to support teacher content knowledge:

Students do not need to explain how or why the seasons happen (NGSS assessment boundary); however, videos about how/why the seasons include key ideas for teacher background knowledge for this phenomenon including Earth's tilt, rotation, orbit, and direct and indirect light from the Sun.

- Khan Academy: Seasons Aren't Dictated by Closeness to the Sun http://bit.ly/1QNrYHb
- Khan Academy: How Earth's Tilt Causes Seasons http://bit.ly/24RVV2p

The videos below are student-friendly, but they deliver too much content at once and some have extra information. These are not included in the lesson guides but if you wish to play the "student-friendly" videos listed below as part of this unit, they would be most appropriate during or after lessons 6-8. View them before showing to students to see if they help students' answer their own questions or elaborate on their ideas. Also, decide when to pause to have students process what they hear through turn-and-talks or quick writes in their notebooks.

- Earth's Rotation & Revolution: CrashCourse Kids 8.1 (Student-friendly) http://bit.ly/1fjqojM
- Spaceship Earth –Documentary of how Earth works (Student-friendly) http://bit.ly/1phlrhb
- Seasons and the Sun: CrashCourse Kids 11.1 (Student-friendly) http://bit.ly/1RAS4gi
- Bill Nye explains seasons on Earth (Student-friendly) http://bit.ly/221dfD2
- Sun, Earth, Moon: The Science video (Student-friendly) http://bit.ly/1V5HrWd

II. Additional General Background

General earth science background for teachers corresponding to the Disciplinary Core Ideas taken directly from National Academies Press *A Framework for K-12 Science Education* available in its entirety for free: http://www.nap.edu/download.php?record_id=13165

ESS1.A: THE UNIVERSE AND ITS STARS

What is the universe, and what goes on in stars?
http://www.nap.edu/read/13165/chapter/11#174

The sun is but one of a vast number of stars in the Milky Way galaxy, which is one of a vast number of galaxies in the universe.

The universe began with a period of extreme and rapid expansion known as the Big Bang, which occurred about 13.7 billion years ago. This theory is supported by the fact that it provides explanation of observations of distant galaxies receding from our own, of the measured composition of stars and nonstellar gases, and of the maps and spectra of the primordial radiation (cosmic microwave background) that still fills the universe.

Nearly all observable matter in the universe is hydrogen or helium, which formed in the first minutes after the Big Bang. Elements other than these remnants of the Big Bang continue to form within the cores of stars. Nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases the energy seen as starlight. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.

Stars' radiation of visible light and other forms of energy can be measured and studied to develop explanations about the formation, age, and composition of the universe. Stars go through a sequence of developmental stages—they are formed; evolve in size, mass, and brightness; and eventually burn out. Material from earlier stars that exploded as supernovas is recycled to form younger stars and their planetary systems. The sun is a medium-sized star about halfway through its predicted life span of about 10 billion years.

Grade Band Endpoints for ESS1.A

By the end of grade 2. Patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted. At night one can see the light coming from many stars with the naked eye, but telescopes make it possible to see many more and to observe them and the moon and planets in greater detail.

By the end of grade 5. The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their size and distance from Earth.

By the end of grade 8. Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. The universe began with a period of extreme and rapid expansion known as the Big Bang. Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe..

ESS1.B: EARTH AND THE SOLAR SYSTEM

What are the predictable patterns caused by Earth's movement in the solar system?
http://www.nap.edu/read/13165/chapter/11#175

The solar system consists of the sun and a collection of objects of varying sizes and conditions—including planets and their moons—that are held in orbit around the sun by its gravitational pull on them. This system appears to have formed from a disk of dust and gas, drawn together by gravity.

Earth and the moon, sun, and planets have predictable patterns of movement. These patterns, which are explainable by gravitational forces and conservation laws, in turn explain many large-scale phenomena observed on Earth. Planetary motions around the sun can be predicted using Kepler's three empirical laws, which can be explained based on Newton's theory of gravity. These orbits may also change somewhat due to the gravitational effects from, or collisions with, other bodies. Gradual changes in the shape of Earth's orbit around the sun (over hundreds of thousands of years), together with the tilt of the planet's spin axis (or axis of rotation), have altered the intensity and distribution of sunlight falling on Earth. These phenomena cause cycles of climate change, including the relatively recent cycles of ice ages.

Gravity holds Earth in orbit around the sun, and it holds the moon in orbit around Earth. The pulls of gravity from the sun and the moon cause the patterns of ocean tides. The moon's and sun's positions relative to Earth cause lunar and solar eclipses to occur. The moon's monthly orbit around Earth, the relative positions of the sun, the moon, and the observer and the fact that it shines by reflected sunlight explain the observed phases of the moon.

Even though Earth's orbit is very nearly circular, the intensity of sunlight falling on a given location on the planet's surface changes as it orbits around the sun. Earth's spin axis is tilted relative to the plane of its orbit, and the seasons are a result of that tilt. The intensity of sunlight striking Earth's surface is greatest at the equator. Seasonal variations in that intensity are greatest at the poles.

Grade Band Endpoints for ESS1.B

By the end of grade 2. Seasonal patterns of sunrise and sunset can be observed, described, and predicted.

By the end of grade 5. The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily and seasonal changes in the length and direction of shadows; phases of the moon; and different positions of the sun, moon, and stars at different times of the day, month, and year.

Some objects in the solar system can be seen with the naked eye. Planets in the night sky change positions and are not always visible from Earth as they orbit the sun. Stars appear in patterns called constellations, which can be used for navigation and appear to move together across the sky because of Earth's rotation.

By the end of grade 8. The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. This model of the solar system can explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars. Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.

Unit At-a-Glance: 5th Astronomy

AST Practice	Activity Name & Suggested Time	Observations	Learning	Connections to Phenomenon	Next Generation Science Standards
Eliciting students' ideas	Lesson 1 Eliciting Students' Ideas about the Phenomenon Part I: 45 min Part II: 55 min	Students observe the amount of daylight (time between sunrise and sunset) on the winter solstice is way shorter than on the summer solstice. Students may have questions about the phenomenon which can be investigated during the unit. Students may wonder if this daylight change happens in other places in the world. Students develop and use a model with a partner to explain their initial ideas about why this phenomenon occurs every year.			**PE**: 5-ESS1-1, 5-ESS1-2. **SEP:** *Analyzing and Interpreting Data*; *Engaging in Argument from Evidence;* ** Added in AST: *Developing and Using Models* **DCI:** ESS1.A: ESS1.B: **CC**: Patterns; Scale, Proportion, and Quantity
Supporting on-going changes in thinking	Lesson 2 Day and Night Cycles Part I: 45 min Part II: 45 min	As the globe rotates, the side facing the lamp is lit up and the other side is in darkness. The lamp can't light up the globe at the same time, there is always a part in the dark.	The earth spins or rotates on its axis once every 24 hours = 1 day. When it is daytime in Seattle, it is night on the opposite side of the Earth (facing away from the Sun).	Daylight hours are measured between sunrise and sunset and this helps us understand that the Earth's 24 hour rotation causes day and night.	**PE**: 5-ESS1-2. **SEP:** *Analyzing and Interpreting Data* **DCI:** ESS1.B: Earth and the Solar System **CC**: Patterns
Supporting on-going changes in thinking	Lesson 3 Moving Shadows and the Apparent Motion of the Sun Part I: 60 min Part II: 50 min	The shadow moves in a circle. The length of shadow gets shorter from the morning to noon. The length of shadow gets longer from noon to the afternoon.	The shadow moves in a circle because the earth spins (the Sun does not move). The apparent motion of the sun means it appears to rise in the East and set in the West.	Shadow movement is evidence that Earth is rotating to create day/night. Shadows might look different around the year because sun appears lower in sky in winter and appears higher in the sky in summer (North. Hemis.)	**PE**: 5-ESS1-2. **SEP:** *Analyzing and Interpreting Data* **DCI:** ESS1.B: Earth and the Solar System **CC**: Patterns
Supporting on-going changes in thinking	Lesson 4 Sun Clocks & Earth's Rotation Approx. 45 mins	Shadows on the Pocket Sun Clock move one way if we spin to the right and go the other way in a circle if we spin to the left	Objects blocking light create shadows. Shadows made by the Sun change in length and direction over time because the Earth is rotating.	Direction of shadow is evidence that the Earth must be spinning counterclockwise when looking down at the north pole (or spinning to the left if we are acting like the earth) such that New York gets sunlight before Seattle.	**PE**: 5-ESS1-2. **SEP:** *Analyzing and Interpreting Data* **DCI:** ESS1.B: Earth and the Solar System **CC**: Patterns
Supporting on-going changes in thinking	Lesson 5 Annual Patterns in Daylight Hours Part I: 45 min *Optional: 45 mins* Part II: 45 min	Longest daylight in Seattle June 16-24th @ 15 hr 59 min Shortest daylight in Seattle December 19th-22nd @ 8 hr 25 min.	1 day = 24 hours 1 day = 1 rotation/spin 1 day = day + night 1 year = 1 revolution 1 year = 365 days Daylight ↑from Jan to June. Daylight ↓ from June to Dec.	2 key days (solstices) per year that signal increasing or decreasing amounts of daylight. The amount of daylight hours change in a predicable increasing or decreasing pattern around the solstices and equinoxes as the Earth orbits Sun.	**PE**: 5-ESS1-2. **SEP:** *Analyzing and Interpreting Data* **DCI:** ESS1.B: Earth and the Solar System **CC**: Patterns

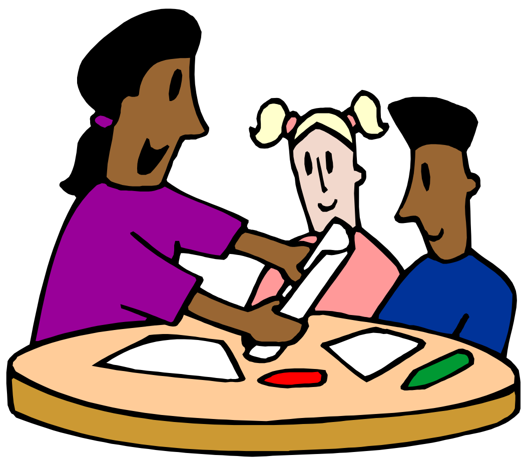
Supporting on-going changes in thinking	Lesson 6 Direct and Indirect Light Approx. 60 mins	Direct light: - Brightness 6-7 (scale 1-10) - Circle shape - Area of 56 squares Indirect light: - Brightness 3-4 (scale 1-10) - Spread out oval - Area of 78 squares	Direct sun hitting the earth is brighter and more concentrated than when light hits a tilted surface.	Because the earth is practically a sphere, it gets more and more tilted near the poles. This means the light is more spread out and not as direct. This helps explain why daylight near the poles is so extreme (extremely long in summer and short in winter)	**PE**: 5-ESS1-1. **SEP:** *Engaging in Argument from Evidence* **DCI:** ESS1.A **CC**: Scale, Proportion, and Quantity
Supporting on-going changes in thinking	Lesson 7 Daylight Hours: Determining City Location Using Length of Day Part I: 50 min Part 2: 50 min	Cities closer to the poles have more extreme daylight conditions. Daylight hours for cities near the equator don't vary that much during the year.	The amount of daylight hours change in a predicable increasing/decreasing pattern around the solstices and equinoxes as the Earth orbits the Sun for all places on Earth.	There are key dates during the year that correspond to places in Earth's orbit around the Sun that signal increasing or decreasing amounts of daylight. Locations closer to the poles, like Seattle (closer to North pole than equator) has more extreme daylight than Houston or Mexico City (for ex.)	**PE**: 5-ESS1-2. **SEP:** *Analyzing and Interpreting Data* **DCI:** ESS1.B: Earth and the Solar System **CC**: Patterns
Supporting on-going changes in thinking	Lesson 8 Size & Distance: Scale of the Sun and Earth Approx. 45 mins	The Earth is SUPER small compared to the Sun. It's also pretty far away.	The Earth orbits the Sun once every 365 days which equals one year. Light can travel across really far distances through Space.	The Earth receives heat and light from the Sun. The Sun provides the light we use in order to have daylight hours.	PE: 5-ESS1-1, MS-ESS1-3. **SEP:** *Analyzing and Interpreting Data* **DCI:** ESS1.B: Earth and the Solar System **CC**: Patterns
Pressing for Evidence-based Explanations	Lesson 9 Revising Models Part I: 45 min Part II: 45 min	It is important for students to revise their ideas over time in light of the new experiences, observations, and sense making talk that they have had throughout the unit activities. They have been revising their thinking through partner talk, class discussions, and through entries in their science notebooks but this lesson has students revisit and revise their initial models using evidence from activities 2-8 to pull the whole story together.			**PE**: 5-ESS1-1, 5-ESS1-2. **SEP:** *Analyzing and Interpreting Data*; *Engaging in Argument from Evidence;* ** Added in AST: *Developing and Using Models* **DCI:** ESS1.A: ESS1.B: **CC**: Patterns; Scale, Proportion, and Quantity
Pressing for Evidence-based Explanations	Lesson 10 Writing an Evidence-based Explanation Part I: 45 min Part II: 45 min	Now that students have updated their models, and had time to talk through the explanation, it is time to focus more explicitly on pairing evidence with their ideas in writing (multiple paragraphs) to tell the "Changing daylight" annual story using evidence from activities 2-8. Using a checklist and series of questioning prompts students will be able to use evidence to not only explain this phenomenon in Seattle but compare and explain it for another city of their choosing.			**PE**: 5-ESS1-1, 5-ESS1-2. **SEP:** *Analyzing and Interpreting Data*; *Engaging in Argument from Evidence;* ** Added in AST: *Constructing Explanations* **DCI:** ESS1.A: ESS1.B: **CC**: Patterns; Scale, Proportion, and Quantity

Materials List

Item (Qty)	Detail/Note
Lamp with bulb (1 ct.)	1 per class; house lamp with shade removed OR clip-on workshop/garage lamp
Globe (7 ct.)	1 per group of students; Classroom globes can be borrowed from multiple classrooms in the school OR inflatable globe balls would work; must have <u>at least</u> 1 globe with metal stand (able to show tilt)
Flashlights (15 ct.)	1 per pair of students
Styrofoam balls (15 ct.)	1 per pair of students
Sidewalk chalk (1 pkg)	1 piece of chalk per pair of students
Measuring tape (7 ct.)	1 per group of students
String (1 pkg)	1 pkg string for class (65 feet in length of string at minimum)
Sticker dots, large (3 pkg)	1 pkg sticker dots per 3 different colors
Pushpins (50 ct.)	Taller pushpins that stick up (not flathead thumbtacks)
Graph paper, 1 inch squares (25 sheets)	

NOTE: Materials such as scissors, tape, pencils, colored pencils, markers, chart or butcher paper, construction paper, etc. are not listed here (typical available classroom supplies) nor are any pictures or photocopies. Check the materials list at the beginning of each lesson guide for more details.

Tracking Student Thinking Over Time



Science teachers work with and on students' ideas over time — helping students revise their thinking in light of new evidence. Tracking student thinking lesson-by-lesson can inform instructional adjustments to support student learning and revision of their ideas.

This section describes two tools that can support teachers in keeping track of student thinking. You can decide how often to use these tools. At a minimum, it is suggested to use one or both of these tools to describe student thinking at the beginning of the unit (after lesson 1), in the middle of the unit, and near the end of the unit (after lesson 7). To be able to more responsively tailor instructional adjustments, track after each lesson using evidence from student discussions and written work.

Working on Students' Ideas:

Using the Rapid Survey of Student Thinking – Teacher Tool

Analyzing student thinking is the primary way to make adaptations to your current unit plans and to make student-based instructional decisions. Below are steps to follow that will help you through this process.

1. **Decide on what big science ideas** relate to the lesson that you are currently teaching.
   a. Consider how you will elicit students' understanding of the relevant science ideas. These may be ideas that you've *just taught*— you may want to "take the students' temperature" before you feel you can move on. These may also be ideas that you are *going to teach*— and you want to understand what students already know.
   b. Make sure you get a written record of individual student thinking during class (e.g. answers to questions in index cards, drawings of models the students are thinking with, student notebook entries).

2. **Write down what you think the "ideal" student response would be** to the questions/tasks. If this student were perfectly knowledgeable for their age group, how might they respond? (You may wish, at this point, to do additional content knowledge research for yourself if this surfaces questions.)

3. **With this "ideal" in mind, now look at students' work**. Make notes about
   a. what they DO know (perhaps this is fragmented knowledge, but count it anyway) – partial understandings
   b. what alternative conceptions they may have
   c. what kind of vocabulary they use and
   d. what kind of everyday experiences they relate to the big ideas

4. After you record students' ideas in these three areas, **what trends emerge** in the student understanding, language, or experience? If you are collecting data *after* instruction, how were these patterns connected to instructional decisions that were made during the lesson?

5. **Decide on 2-3 future instructional changes** based on this data. It could be a small move during a lesson, revising or adding a lesson, change in lesson order, etc. How could you change instructional decisions for the future, given this data?
   a. What can I build on that they already know or already relate from their everyday experience?
   b. What ideas seem to need connecting or better integration (perhaps they seem only to have "vocabulary level" understanding of some ideas)?
   c. How can I make students dissatisfied with the alternative conceptions they bring to class?

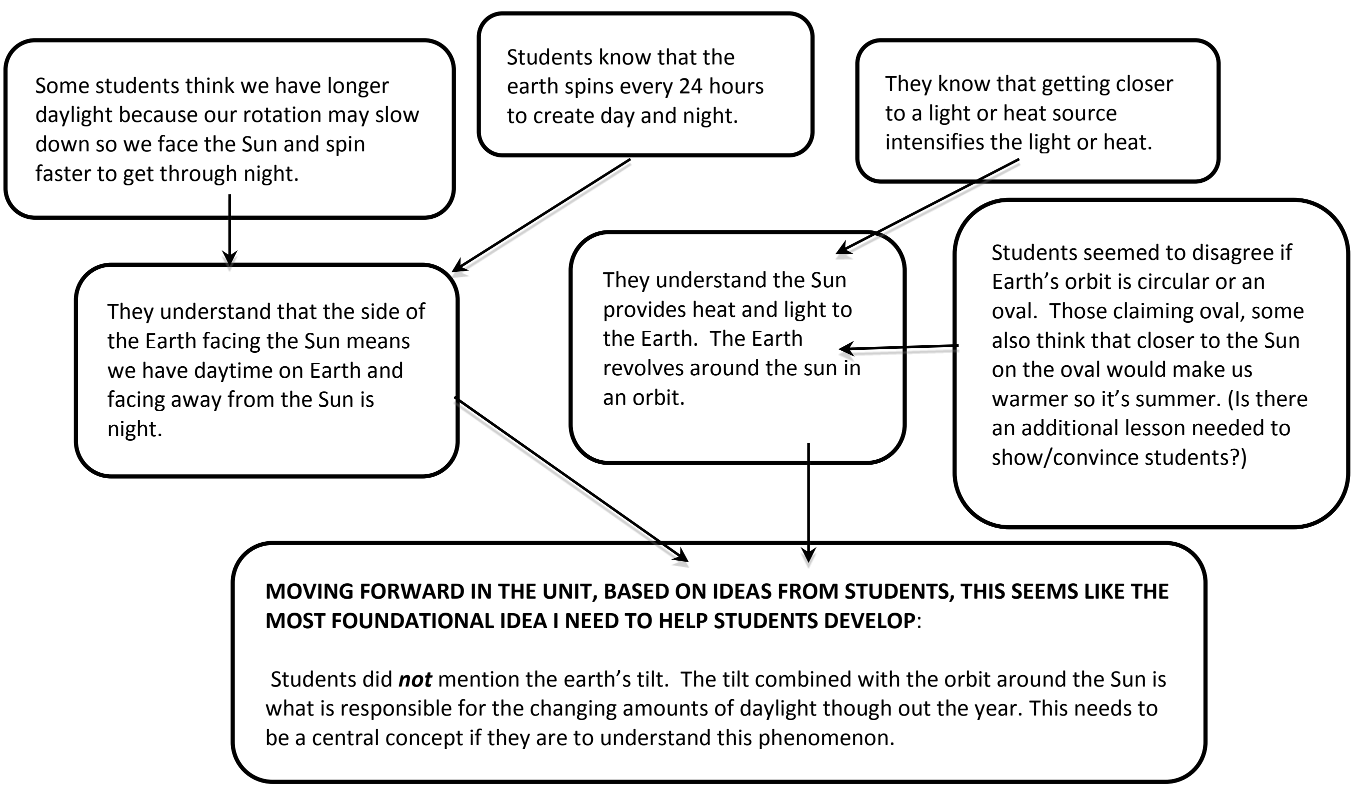
Why use the RSST?

Reflecting on and tracking student thinking after each lesson should inform instructional decisions that are responsive to students' current levels of understanding in order to advance their thinking and responsive to students' language and experiences which can make content more accessible and meaningful to the class as a whole.

After eliciting students' ideas you have a lot of information to work with. Your task now is to identify *which* ideas students are considering and what student language and experiences are the *most* important to help you plan your next moves. This requires a specific strategy—because at the same time you are selecting just a few student ideas to pay most attention to, you also likely need to expand your notions of what will "count" as valid student explanations.

The RSST helps capture and organize students' ideas, language, and experiences they share in each lesson. Use the kinds of talk you heard from students as well as ideas in their written work. As you fill in the table on the next page and read all the potential actions you might take (instructional decisions - right column) don't expect that there is a clear path to which actions are best. There are no "correct" teacher moves—it requires judgment as well as knowledge of your students and your curriculum to make principled choices about how to proceed.

As you distill all the students' contributions to the themes that are most consequential for your planning, it may help if you draw out the various partial understandings and alternative conceptions on a piece of paper and connect them in concept-map form. This representation of students' ideas can help you plan upcoming lessons. *Below is an example from the eliciting ideas lesson about the question "In Seattle, why do we have longer daylight in the summer and shorter daylight in winter?"*



Rapid Survey of Student Thinking (RSST)

	List evidence from student work and talk *What approximate % of your students have/use items you list in each category?*	**Instructional Decisions** (some examples provided)
Partial understanding What facets/fragments of understanding do students already have? Cite examples/quotes.		• Do further eliciting of initial hypotheses to clarify the extent of these partial understandings • Do 10-miwhole class review of 2-3 key points elicited • Write multiple hypotheses on board and/or develop an initial consensus model Other:
Alternative understandings What ideas do students have that are inconsistent with the scientific explanation? Cite examples/quotes.		• Pose "what if" scenario to create conceptual conflict about validity of alternative conception(s) • Challenge students to think further/giving them a piece of evidence to reason with • Target an activity designed around the supporting changes to student thinking teaching practice to address this alt. conception Other:
Everyday language … What terms did you hear students use that you can connect to academic language in upcoming lessons? Cite examples/quotes.		• Use this language to reframe your essential question in students' terms • Use as label in initial models that you make public (see next page). Work in academic versions of these words into public models and discussions later Other:
Experiences students have had that you can leverage… What familiar experiences did they note during the eliciting? Cite examples/quotes.		• Re-write essential question to be about experience • Make their prior experiences a central part of the next set of classroom activities • If students cannot connect science idea to familiar experiences they've had, provide a shared experience all students can relate to (through lab, video, etc.) Other:

WHAT-HOW-WHY
Levels of Explanation

Throughout the unit, students use evidence from their lived experiences and activities to explain the unit phenomenon and/or apply concepts to explain related phenomena. Over time, student understanding deepens. It is important to track student thinking in order to identify gaps or questions that will help shape future instruction.

What are what-how-why levels?

These levels indicate a depth of explanation. These can target a unit-long explanation of an entire phenomenon OR focus in on one core concept of the larger phenomenon.

- ***WHAT -*** *Student describes what happened. Describes, summarizes, restates a pattern or trend in data without making connection to any unobservable components.*

- ***HOW -*** *Student describes how or partial why something happened. Addresses unobservable components tangentially.*

- ***WHY -*** *Student explains why something happened and can trace a causal story for why a phenomenon occurred or ask questions at this level. Uses important science ideas that have unobservable components to explain observable events.*

  * Students may have a blend of what-how-why depending on which concepts they best understand. Ultimately, students are pressed to develop a 'why' level explanation. However, 'why' level is the most challenging to achieve because it requires wrestling with unobservable mechanisms.

Tracking the Development of Student Understanding

- *Planning* - When planning a unit or lesson, teachers outline what they expect to see or hear at each level of understanding (for a phenomenon). This could also be done for each component idea that makes up a full explanation.

- *Collecting data* - By listening to student talk and analyzing student work, teachers can identify and track the levels of understanding of their students about particular concepts or the phenomenon at large. There are many ways to keep track of student understanding. Choose 1 to use throughout the unit. There are templates for each in the next few pages.

  - **Individual students**: The most intensive is tracking individual students across a unit to see how and when they shift from a what, to how, to why levels of explanation.
  - **Focal students**: Another way is to select 4 focal students per class to follow. These students should be selected to represent the class or can target a particular population (i.e. English Learners, students of color, typically underserved, etc.). Focal students could change each week or unit.
  - **Class-level**: A class-level tracker employs tally marks on the tracker as you go through student work samples. At a class-level you can see generally where students are in their understanding. Some teachers opt to use student initials instead of tally marks in order to know which students may need additional support.

Define "What Counts" for each Level of Explanation: What-How-Why

Blank Template

This grid helps define "what counts" as each level of explanation which you can use throughout a unit. Below write the targeted DCIs for a unit. Then break down the DCI into observables (what-level), and causal (how/why). Propose some phrases of what ideas would sound like at a what-how-, or why level around each Disciplinary Core Idea targeted in this unit.**

DCIs	*WHAT*	*HOW*	*WHY*

*** NGSS Note: Although this chart targets students' developing understandings of a DCI, lesson tasks should ask students to demonstrate this understanding in a three-dimensional way through one (or more than one) science and engineering practices (SEP) and cross-cutting concept (CC).*

5th Grade Astronomy Unit Example What-How-Why

This grid helps define "what counts" as each level of explanation which you can use throughout the unit. Below are some suggestions of what deepening levels of understanding might sound like around each Disciplinary Core Idea targeted in this unit.** You may wish to add your own notes based on what you hear or see from your students in the blank spaces in each box.

DCI	*WHAT*	*HOW*	*WHY*
ESS1.A: The Universe and its Stars The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1)	The Sun is a bright star that gives off heat and light. The Sun is far away from Earth. Other stars are much farther away than our Sun.	Lights we see on Earth, like traffic lights or lamps, seem bigger and brighter than the same light when it is farther away.	The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their size and distance from Earth.
ESS1.B: Earth and the Solar System The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)	Patterns in the daytime sky can be observed, such as how the sun appears in low or high places. The sun appears in different places in the sky during the day. The Earth rotates on its axis every 24 hours. Shadows outside cast by an object in sunlight appear to move during the day and change size and shape. In summer, the sunlight is brighter and more direct. In winter, sunlight is weaker and more spread out. The number of hours of daylight on winter days is less than the number of hours of daylight on summer days.	Patterns in the daytime sky can be predicted and then observed based on prior observations. The Sun appears to move across the sky during the day causing day and night Shadows change length and shape because the angle of light changes (i.e. low angle, indirect light casts long spread out shadows). When sunlight directly hits Earth, it is brighter. When sunlight indirectly hits earth, it is not as bright and the light is more spread out. The extremes between daylight in winter and summer are more exaggerated for cities near the poles and fairly similar amounts of daylight by season nearer to the Equator. When it is winter in the Northern Hemisphere, it is summer in the Southern Hemisphere.	Patterns in the nighttime sky are more difficult to observe (light pollution) but can be predicted as similar to daytime patterns (i.e. stars seem to move across sky). The Sun appears to move across the sky but it doesn't. The Earth rotates causing day and night and making it seem like the Sun appears to move, but we do. If the Sun moved, we would always see the same constellations during the year but we do not. Shadows change in length and shape because the angle of light changes. This isn't because the Sun is moving but rather the Earth is rotating every 24 hours so changes in shadows can be predicted. Changes in the amount of daylight for cities near the poles compared to cities near the Equator is more extreme because of the tilt of the Earth and it's position in the orbital path around the Sun. The tilt of the Earth also accounts for why the Northern and Southern Hemispheres have opposite seasons because tilt causes differences in direct and indirect light as the Earth orbits the sun.

*** NGSS Note: Although this chart targets students' developing understandings of a DCI, in the lesson guides in this unit students are asked to demonstrate this understanding in a three-dimensional way through one (or more than one) science and engineering practices (SEP) and cross-cutting concept (CC).*

Grade: ________Unit: ________________ **Class-Level Tracking**

Tracking Levels of Explanation as a Class

Color	Date
☐	___/___/___
☐	___/___/___
☐	___/___/___
☐	___/___/___
☐	___/___/___

Use the level definitions on the previous page. Go through student work samples and what you observed from student discussions during class. For each student, place a tally mark to locate their understanding at a what, how, or why level. Jot a quote or short phase as evidence for your determination of what, how, or why. This provides a global view at a class-level of where, generally, students' understanding is at and how it is deepening over the course of a unit.

Add notes to this grid using different colored pens to track growth/change over time as students revisit key concepts (see key at left).

DCI	What Level	How Level	Why Level
Place tally marks or student initials to graphically represent where students' understanding is at in different points in time			
ESS1.A: The Universe and its Stars The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1)			
ESS1.B: Earth and the Solar System The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)			

Grade: _______Unit: _________________ **Focal Student Tracking**

Tracking Levels of Student Explanation

Color	Date
☐	___/___/___
☐	___/___/___
☐	___/___/___
☐	___/___/___
☐	___/___/___

Use the level definitions on the previous page. Select 4 focal students who are representative of particular student groups or learning needs. These focal students allow you do a deeper analysis of a representative sample of student thinking from the class. For each focal student, place a check mark to locate their understanding at a what, how, or why level. Jot a quote or short phase as evidence for your determination of what, how, or why.

Add notes to this grid using different colored pens to track growth/change over time as students revisit key concepts (see key at left).

Student Name	What Level	How Level	Why Level

Grade: _______Unit: ________________ **Individual Student Tracking**

Tracking Levels of Student Explanation

Color	Date
☐	___/___/___
☐	___/___/___
☐	___/___/___
☐	___/___/___
☐	___/___/___

Use the level definitions on the previous page. For each student, place a check mark to locate their understanding at a what, how, or why level. Jot a quote or short phase as evidence for your determination of what, how, or why.

Use different colored pens to track growth/change over time as students revisit key concepts (see key at left)

Student Name	What Level	How Level	Why Level

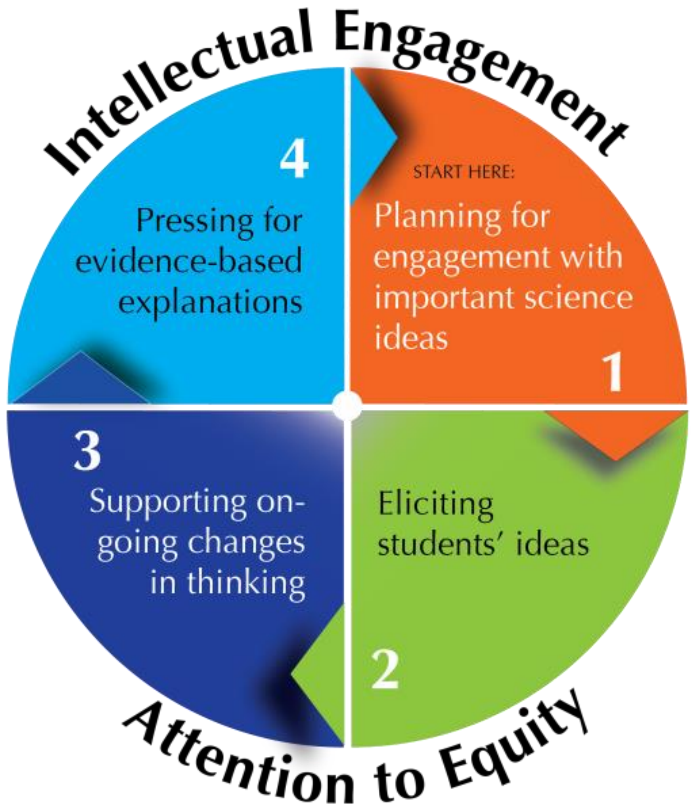
Student Name	What Level	How Level	Why Level

Student Name	What Level	How Level	Why Level

Curriculum Guide

Lessons & Activity Guides

Ambitious Science Teaching Framework



This curriculum guide follows the four core teaching practices of the Ambitious Science Teaching Framework. This model-based inquiry approach to science teaching leverages students' existing personal experiences and current understanding about causal mechanisms in their world to revise their own explanations of specific, contextualized scientific phenomena.

Lesson 1: Eliciting Ideas about the Phenomenon

OBJECTIVES & OVERVIEW

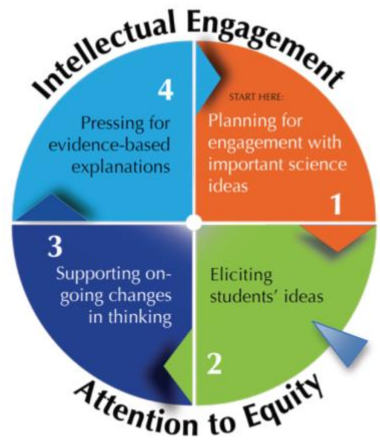
This lesson introduces students to the phenomenon that anchors this Astronomy unit. Students develop models using their current knowledge and related real-world experiences to explain why the amount of daylight varies during the year in Seattle (or nearby city).

By the end of this lesson, you will have a good sense of the partial ideas and alternative hypotheses students have about how the movements within the Sun-Earth system account for day-night cycles, patterns in changing shadows, and patterns in the sun's apparent movement.

Essential Question: In Seattle (or nearby city), why do we experience more hours of daylight in summer and fewer hours of daylight in winter?

- Students make observations and develop initial models to explain why daylight varies in Seattle.
- Students record and share their ideas and questions about day/night, Earth's rotation, Earth's orbit around the sun, and/or what's happening in the northern or southern hemispheres.

Ambitious Science Teaching Framework:
ELICITING STUDENTS' IDEAS



Your main objective as a science teacher is to change students' thinking over time. So you need to know what your students understand about the science before launching the unit. The goals of this practice set are to reveal a range of ideas, experiences, and language that students use to talk about the anchoring phenomenon, and to activate their prior knowledge about the phenomenon. For more information about this practice and the research behind it, visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Standards Note: Because this lesson is intended to elicit students' initial ideas and experiences, students will not entirely demonstrate the performance expectation (PE) listed here. Students will have additional opportunities in this unit to fully engage in the dimensions of the PE below. However, students will use their prior experiences and their casual observations of the daily changes in shadows and night and day as well as the seasonal appearance of the Sun (DCI) to develop models (SEP) that can explain patterns (CC) of night/day and how the amount of daylight changes over seasons . Students are engaged in a three-dimensional performance.

PE *5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.*
[Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [Assessment Boundary: Assessment does not include causes of seasons.]

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CC)
Analyzing and Interpreting Data - *Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.* **** Developing and using models -** *Develop and/or use models to describe and/or predict phenomena* *** This SEP is not part of the PE but was added to this lesson as part of the AST framework because students develop and use models to explain and describe the phenomenon using their initial hypotheses in this lesson.*	***ESS1.B: Earth and the Solar System*** *The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.*	***Patterns -*** *Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.*

MATERIALS

For Part I

For the class:

- Photos of dark bus stop and light bus stop
- Video: Summer Solstice compared to Winter Solstice http://safeshare.tv/v/z70P9CCD8PY
- 1 lamp/light
- 6-8 globes (borrowed from classrooms)
- chart/butcher paper & markers

For each pair of students:

- 1 ball (Styrofoam) with small sticker dots
- Extra flashlights (if available)
- Sticky notes
- Prompt card (optional, copy p.13)

For Part II

For the class:

- List of observations (made in Part I)
- Photos of dark bus stop and light bus stop
- 1 lamp/light
- 6-8 globes

For each pair of students:

- 1 model scaffold sheet
- 1 ball (Styrofoam) or globe with small sticker dots (these materials are in the kit)
- Extra flashlights (if available)
- pencils with erasers (colored pencils optional)
- Prompt card (optional, copy p. 13)

PROCEDURE

Part I. Introducing the phenomenon

Suggested time for Part I is about 45 minutes.

Present visuals

Show photos bus stop waiting areas to compare December vs April.

1. **ACTIVATE STUDENTS' EXPERIENCES –WHOLE CLASS** (10 mins)

   a. Show the full-sized, color versions of these photos from the revised guide materials. Ask students to think about how the daylight changes as they are coming to school at different times during the school year

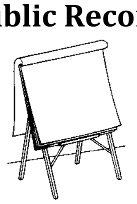
Turn-and-Talk

What are your experiences with light and dark when coming to school in the morning?

   b. Have students think then turn-and-talk about their personal experiences coming to school at different times of year.

   c. Students share whole-group to start a list of their personal experiences. Are they waiting in the dark for certain months? But observe it is light at other times? Which months have the longest daylight? Students may have lived or have family living in other cities/countries. Use stickers on a map (or globe) to mark where students have lived or have family. Ask about what they know about that place and its daylight and what time of day it is there. This can help future discussions about day/night and winter/summer. For now, get some personal experiences out. Add observations from students' experiences with time zones and day/night to the list.

Public Record



List observations from personal experiences

   d. Introduce the unit question: In Seattle (or nearby city), why do we experience more hours of daylight in summer and fewer hours of daylight in winter? (use p. 12)

Video Clip

Summer and Winter Solstice Time Lapse
00m55s
http://goo.gl/qY1mFM

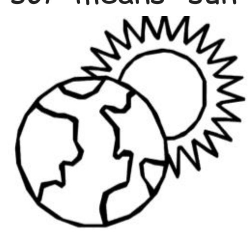
2. **MAKING OBSERVATIONS – WHOLE CLASS** (10 minutes)

a. Watch the time lapse video comparing summer solstice and winter solstice in a North American city (likely in northern California).

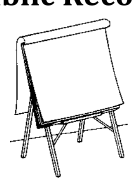
b. Ask students to make observations. Replay video as needed:
- Which day had sunrise first? (Summer or winter)
- Which day had sunset last? (Summer or winter)
- Which day had longer daylight? (Summer or winter)
- Which day had the most darkness? (Summer or winter)
- How is this similar to what we experience in/near Seattle?

Note how students are using the terms "day" and "daylight." If needed, clarify that each day has 24 hours. A 24-hour day is split between hours of daylight and night. There is more about this later in the unit but students may find it helpful to begin clarifying the terms day and daylight to clearly communicate..

If students want to know the definition of solstice, use the box below. It is not important that students learn or use the term unless it helps communicate or reason about the how/why daylight changes:

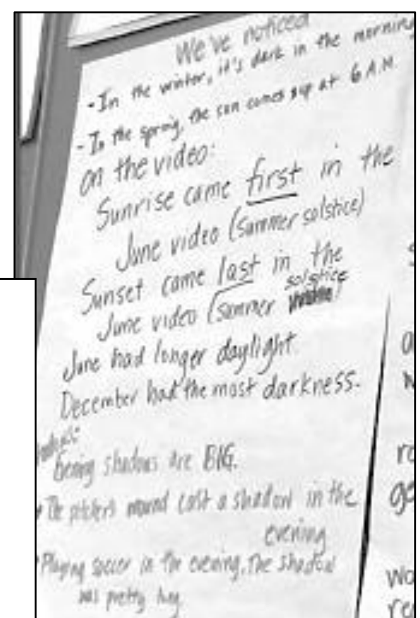
> **Solstices** happen at two times each year on the days with the longest and shortest amounts of daylight hours. The *summer solstice* is when the sun appears at the highest point in the sky at noon as has the longest daylight hours. The *winter solstice* is when the sun appears at lowest point in the sky at noon, marked by the shortest days.
>
> *sol-* means "sun"
>
> 

Public Record



Add to the observations list from photos/video

c. Generate a list of observations using the photo and video. You could also include students' personal experiences. The example shown at right and typed below is from a 5th grade classroom. Your chart will vary based on your students' observations and experiences.



We've noticed…
- In the winter, it's dark in the morning
- In the spring, the sun comes up at 6 A.M.

On the video…
- Sunrise came first in the June video
- Sunset came last in the June video
- June had a longer daylight
- December had the most darkness.

Experiences:
- Evening shadows are big
- Pitcher's mound casts a shadow in the evening
- Playing soccer in the evening, shadows are long

Safety Alert

Remind students not to stare at the lamp or shine flashlights into other students' eyes. Also, the lamp gets hot when left on so be careful not to touch it.

3. **ELICIT IDEAS & PRESS FOR EXPLANATIONS - PAIRS** (15 mins)

a. Read question: "Why do we experience more hours of daylight in summer and fewer hours of daylight in winter?" Tell students they will have some time with a partner to talk through some initial ideas. (Students could pick their partners or be partnered up strategically.)

b. Show the materials: flashlights/lamp represents the Sun; ball/globe represents Earth. Stickers are used to mark Seattle (or your city) on the ball/globe. This sticker serves as a point of reference in student discussions so make sure students use the sticker dots.

c. Provide the safety warning (at left) before dismissing students to partner up, gather materials, and get started on figuring out their ideas about the phenomenon.

d. As students work, circulate and listen. Jot notes about what you hear about their ideas, language, and experiences. If students seem stuck or you want more about their thinking, use back-pocket questions and/or provide the pair with the optional 'partner prompt' slip.

Back-Pocket Questions

How teachers can use back-pocket Q's:

1. Approach a pair and listen in.
2. Decide what question to ask based on what you see/hear.
3. Ask the question and make sure both students contribute.
4. Prompt students to continue with a particular task or question.
5. Leave and go visit another pair.

If students are stuck: **Help students get started**
Make sure students use a sticker dot to mark their city.
Have one student hold the earth and the other hold the flashlight.
Shine the sun on the earth globe at their city.

- *What cities are lit up? What cities are dark?* (Observation)
- *As you rotate or spin the globe, which cities are lit up as you turn the globe? In darkness?* (Observation)
- *What do you think this helps us understand about daytime and nighttime?* (Inference)
- *How could knowing about day and night help you figure out a possible answer to our key question?* (Connection)

If students are on-task, here are some possible prompts:

- *I heard you say __. Could you or your partner say more?*
- *I see you are <u>(insert action).</u> How do you know it works like that?* **OR** *How come you think it does that?*
- *To the partnership: Do you both agree or do you have different ideas? Can one of you summarize the ideas you've talked about so far and show me using the globe and light?*

Tasks to leave them with before visiting another pair.
Choose from this list of possible tasks or come up with your own:

- *So you have figured out ________. But why does the amount of daytime change for us during the year? Use the materials and talk to each other to try and figure it out.*
- *What additional information do you need to figure this out? What would you want to read about or watch videos about to help us figure this out? Write your needs on a sticky note.*
- *What are you two wondering now? What questions do you have? Write down your questions on sticky notes.*

Quick Write

Draw & write: Why do we experience more hours of daylight in summer and fewer hours of daylight in winter?

4. EXIT TASK – INDIVIDUAL (10 minutes)

a. If students wrote any questions on sticky notes earlier, collect these now and save them for Part II by placing them on a 'Questions' chart.

b. Have students take some independent quiet time to write and draw about their ideas and questions in their science notebooks to capture their thinking from today. Under document camera, project page 14 in this lesson guide.

Possible sentence starters:

- *I think we have more daylight in summer than winter because…*
- *One question I have is…*
- *I think we should experiment or read about_____ because…*

c. Tomorrow students will work with a partner on the model scaffold to more completely record their ideas and create a public list of their initial ideas and questions.

Part II. Developing Initial Models

Suggested time for Part II is about 50-55 minutes.

Turn-and-Talk

What did you see in the photos or video about the changing amount of daylight?

1. REORIENT TO THE PHENOMENON – WHOLE CLASS (5 minutes)

a. Use the list of observations created in Part I to reorient students to the essential question: Why do we experience more hours of daylight in summer and fewer hours of daylight in winter?

b. Turn and talk about what they observed in Part I. Have a few students read some observations off the list or describe what they saw in the photos/video.

2. INITIAL IDEAS & PRESSING FOR EXPLANATION – IN PAIRS (25 mins)

a. Show students the model scaffold sheet. Briefly walk through each part so they know what to draw and write about. Have the manipulatives available for students to use to explain their thinking to their partner as they work to figure out how to draw and write about their ideas. Tell students they can write/draw on the back of the model sheet if they want or need more space.

b. As students work on their models, listen in and look at what ideas students are inscribing in order to select 2 models you want to feature for particular reasons (i.e. how they represented changing sunlight or darkness; motion of Earth; hypotheses about length of day, etc.).

c. Pause partner work mid-way to have these pairs publicly share one part of their model. Then ask students to talk with their partner about how they could show that idea or a similar idea on their own model sheet.

Back-Pocket Questions
for Initial Models

- You have drawn some (arrows, lines, swirls, etc.). What does that show? How can you make that clear to someone looking at your model?
- I see you have _____ written (or drawn). Do you both agree about this? If so, why? If not, what does the other student think? How can you add that to your model to show both ideas?
- I hear you both saying _______. How might you represent your idea about ____ in pictures or words on your model?

d. As students continue working on expressing their ideas in drawing and writing, circulate and listen. Use the back-pocket questions (BPQs) suggested at left, the BPQ's listed in Part I, or come up with some of your own.

BPQs to elicit ideas are intended to:
1. Probe student thinking to find out how and why they think a phenomenon happens
2. Uncover students' language and experiences they use to make sense of the phenomenon
3. Support students in getting their ideas and questions down onto their models

Whole-class discussion

Eliciting multiple initial ideas

3. SUMMARIZE IDEAS PUBLICLY – WHOLE CLASS (15 minutes)

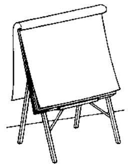
a. *Physically orient students towards each other:* Have students come to the gathering area so students can easily hear and see each other. Use document camera to project parts of students' models that they point to as they explain their initial thinking. Have manipulatives (lamp, globe, stickers) available so students act-out their ideas while narrating them so all students can better understand their peers' ideas or questions.

Talk Norms

Listen in order to comment or ask genuine questions

b. *Set the purpose for the discussion:* Tell students they will share out ideas and questions and that we will make a list which we can revise and change over time as we learn more. Explain that the purpose of today is to get out as many ideas, hypotheses, and questions as they can. Students may have similar or different ideas so talk moves to agree/disagree make sense. The purpose of this conversation is not to convince or argue but rather to generate a list of initial ideas and questions. Listening students are expected to offer comments or questions to the presenting students. (Students can and will argue, convince, and debate later in the unit once they have collected some common evidence and had shared experiences.)

Public Record



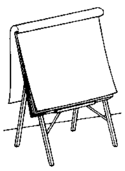
List of initial ideas

c. *Allow students to use talk norms and lead and manage the talk:*
1. Have one pair start off by sharing one idea from their model (also use manipulatives, if needed, to explain idea).
2. After they describe and show their idea, that pair calls on students who should offer comments or questions about the idea.
3. After taking a few comments/questions from their peers, a new pair can share one idea from their model. Then take a few questions or comments from their peers.

Here are two common issues that can arise during an eliciting ideas discussions and suggestions for how to manage them:

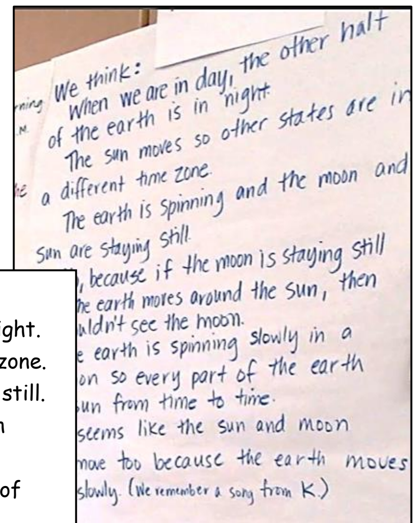
- If students try to argue from their background experiences → Instead of engaging in an argument now without any common evidence, redirect students and ask: *What experiment or research could/should we do together to help us figure this out?*
- If students are not be listening to each other to comment or ask questions → Have students turn-and-talk about their peers' idea(s) that the pair just shared to generate a question to ask the pair: *What question would you ask or what comment do you have for the student/pair?*

Public Record



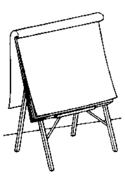
Continue the list of initial ideas

d. As students present/discuss (or right after), draft a list of students' initial ideas about why there are more daylight hours in the summer than the winter in/near Seattle. Your class' list will be different than the photo (at right) and typed below from a 5th grade class.



We think:
- When we are in day, the other half of the earth is in night.
- The sun moves so other states are in a different time zone.
- The earth is spinning and the moon and sun are staying still.
  -- No, because if the moon is staying still and the earth moves around the sun, then we wouldn't see the moon.
- The earth is spinning slowly in a rotation so every part of the earth gets sun from time to time.
- It seems like the sun and moon would move too because the earth moves really slowly (remembers a song from K.)

Public Record



Student Questions & Information Requests

4. EXIT TASK: ASK QUESTIONS & MAKE SUGGESTIONS – PAIRS (5 mins)

a. Students have already generated some questions and/or suggestions earlier in the lesson. Now, students can make sure these are shared by recording them on sticky notes and posting them on a public chart.

b. In the last 5 minutes, have students write any final questions they have on sticky notes. Then, have students make suggestions about the kind of learning and information they need to explain the phenomenon.

Questions about the phenomenon:
- *What are you still wondering about?*
- *What questions do you have?*

Suggestions for future learning experiences:
- *How could we test our hypotheses?*
- *What kind of information/experiences do we need to learn more?*

c. Have students stick questions and suggestions on a chart divided into two sections: "Our questions" and "Suggestions for learning." Over time, some questions may be answered, but others may be outside the scope of the unit. Some student suggestions may already be planned in the unit; others may be helpful and possible to add in.

EXAMINING STUDENT WORK

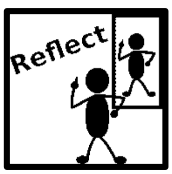
There are two tools that help teachers track student thinking over time. The two tools are:

- **Rapid Survey of Student Thinking (RSST)**
- **What-How-Why Explanation Tracker (WHY)**

Some teachers choose one and continue using it throughout the unit, others do both. Take about 20-30 minutes go through student work and fill out either the RSST or the WHY (or both) to help you identify which key ideas students are already thinking about and places they need to support ongoing changes in their thinking. (There is more information about each of these tools in the front matter of this unit guide).

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons.

Keep a record of these reflections for your professional portfolio.

1. TASK, TALK, & TOOLS.

Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

The task of hypothesizing about a phenomenon helped students to/with....
The task about _____ relates to students' and/or their families' lives because…

Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

The students talked to each other during <u>(name particular parts of lesson)</u> which allowed students to...
During turn-and-talks, I observed _____ which makes me wonder if/how…

Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students in communicating and capturing their ideas/thinking?

The model scaffold tool allowed students to...
Creating a list of initial ideas allowed students to…

Overall, reflecting on task, talk, and tools together:

Talk, task, and tools supported students to share their thinking because...
Overall, this combination of talk, task and tools, allowed most/all students to...

2. **EQUITY**.

   Name and describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue. Here are some categories to help you name a specific issue of equity:

   - Developing relationships & forming an inclusive, trusting community
   - Scaffolding for full participation in the culture and language of science
   - Recognizing our own and others' worldviews & developing critical consciousness about our own assumptions and beliefs
   - Addressing power dynamics (how a person is seen and responded to by others) to disrupt stereotypes and privilege

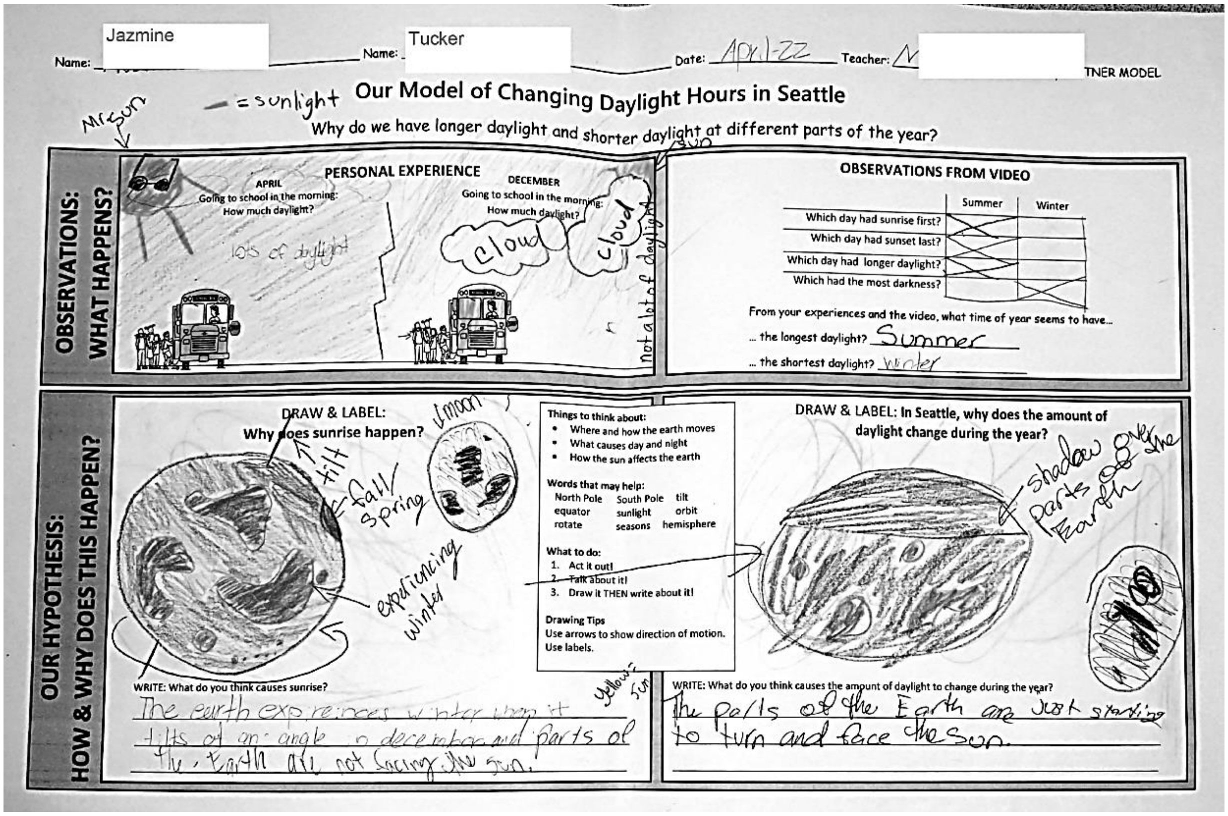
PLANNING NEXT STEPS

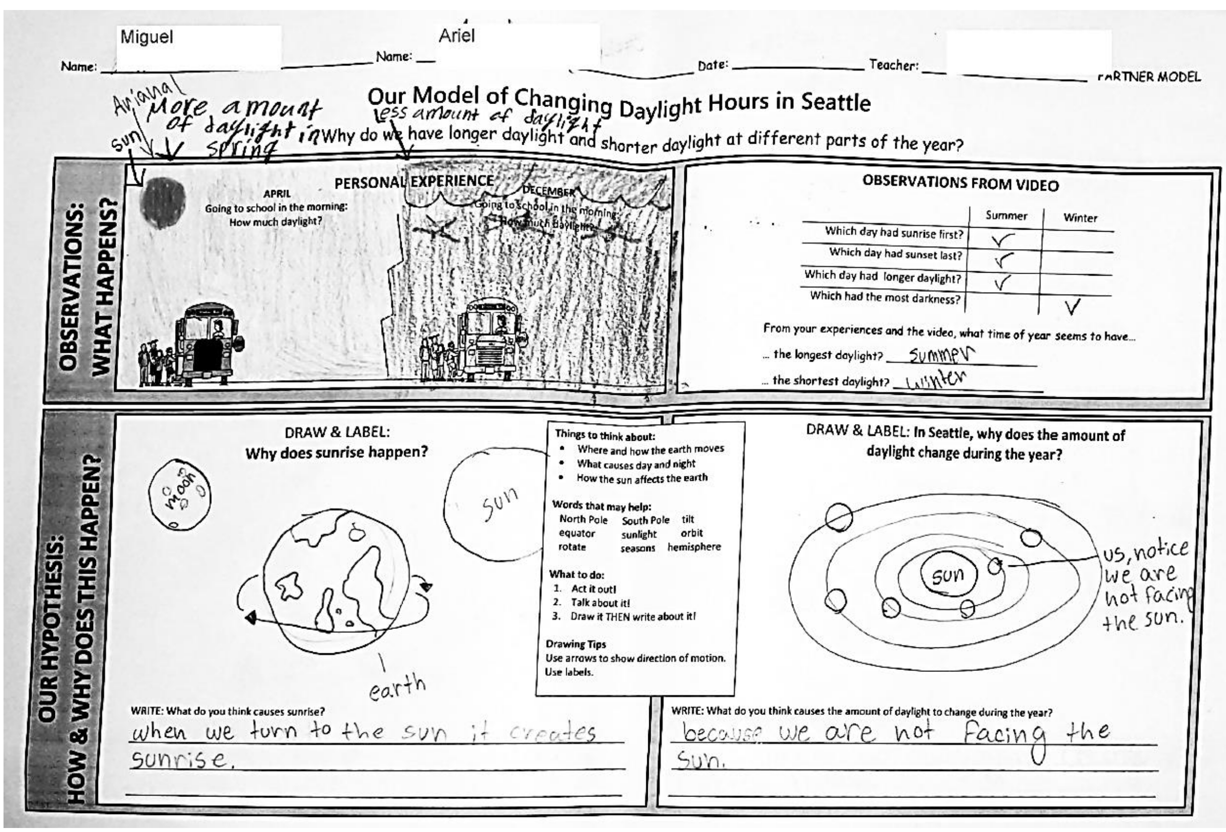
1. Use your analysis of student work (RSST or WHY) to decide what lesson should come next. Look at the unit overview as a whole and decide if the next lesson makes sense based on students' current thinking or if another lesson needs to be moved up or added in to better meet and move the current understanding of students forward.

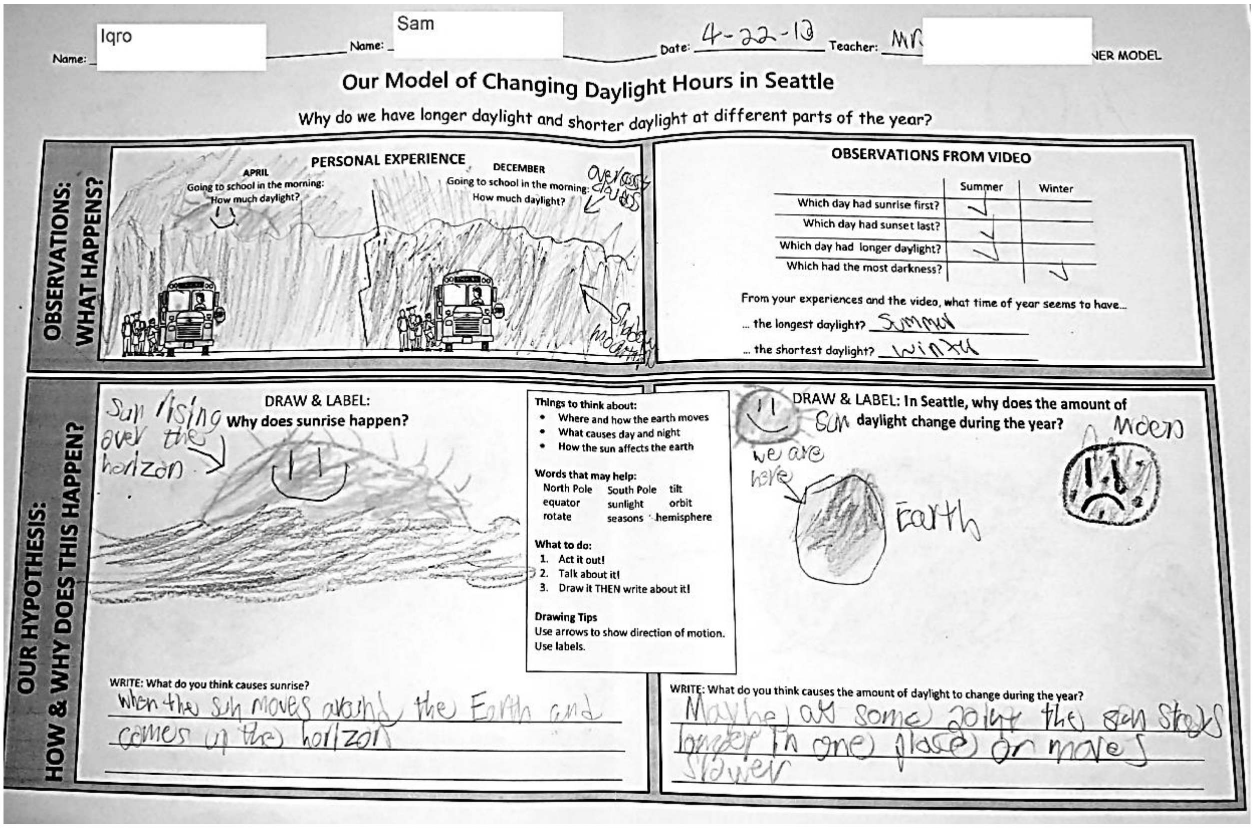
   Once you decide on the next lesson…

2. Apply your lesson reflection (3Ts and Equity) to make changes to the upcoming lesson's guide to address the issue of equity you identified as well as to better support your students to engage fully in the task, talk, and tools in the lesson guide.

Here are some examples of partner models from this eliciting students' ideas lesson. Notice the different ways they represented and explained shadows, the Earth-Sun relationship, and day/night,.







Name: Iqro Name: Sam Date: 4-22-13 Teacher: Mr [...]NER MODEL

Our Model of Changing Daylight Hours in Seattle

Why do we have longer daylight and shorter daylight at different parts of the year?

OBSERVATIONS: WHAT HAPPENS?

PERSONAL EXPERIENCE

APRIL
Going to school in the morning:
How much daylight?

DECEMBER
Going to school in the morning:
How much daylight?

OBSERVATIONS FROM VIDEO

	Summer	Winter
Which day had sunrise first?	✓	
Which day had sunset last?	✓	
Which day had longer daylight?	✓	
Which had the most darkness?		✓

From your experiences and the video, what time of year seems to have...
... the longest daylight? Summer
... the shortest daylight? winter

OUR HYPOTHESIS: HOW & WHY DOES THIS HAPPEN?

DRAW & LABEL:
Why does sunrise happen?

Things to think about:
- Where and how the earth moves
- What causes day and night
- How the sun affects the earth

Words that may help:
North Pole South Pole tilt
equator sunlight orbit
rotate seasons hemisphere

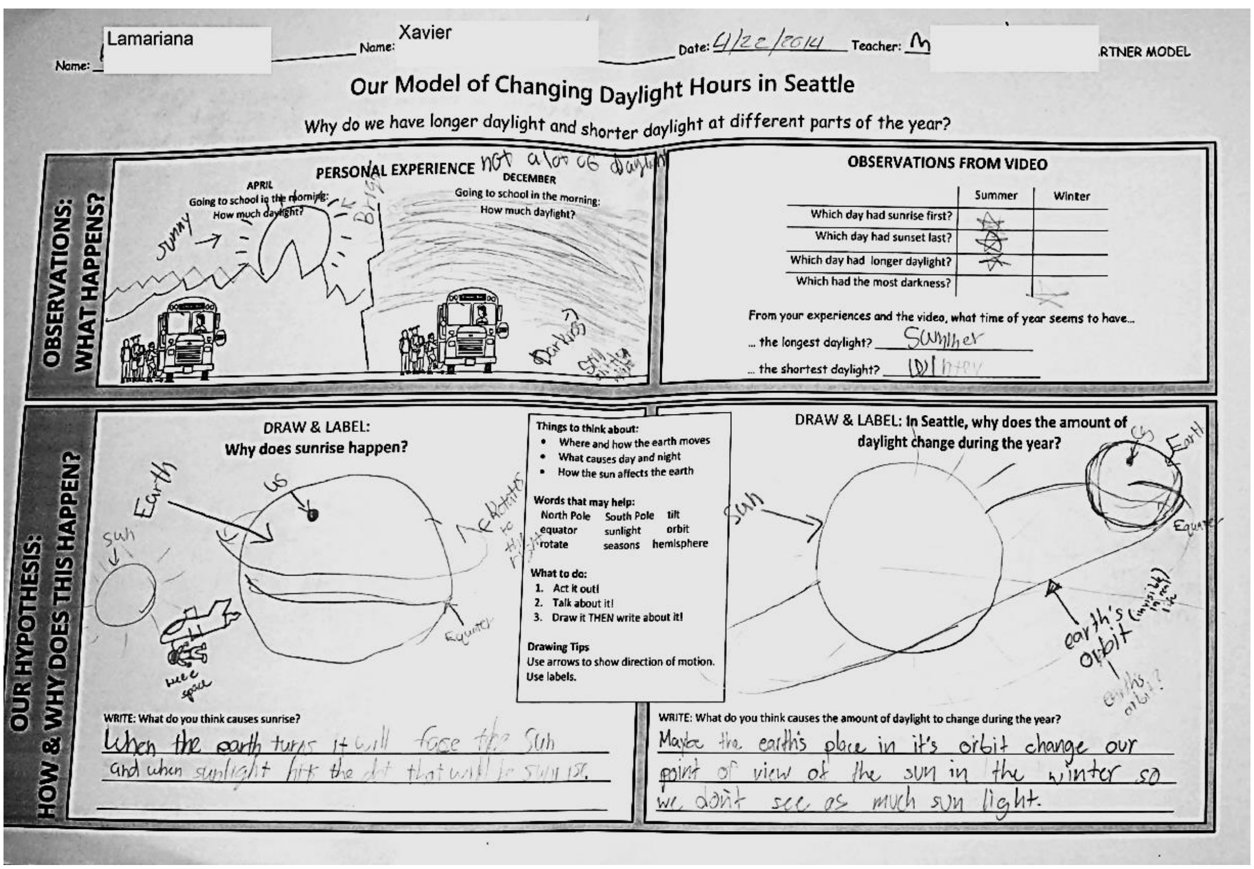
What to do:
1. Act it out!
2. Talk about it!
3. Draw it THEN write about it!

Drawing Tips
Use arrows to show direction of motion.
Use labels.

DRAW & LABEL: **In Seattle, why does the amount of daylight change during the year?**

WRITE: What do you think causes sunrise?
when the sun moves around the Earth and comes up the horizon

WRITE: What do you think causes the amount of daylight to change during the year?
Maybe at some point the sun stays longer in one place or moves slower



Name: Lamariana Name: Xavier Date: 4/22/2014 Teacher: M [...]RTNER MODEL

Our Model of Changing Daylight Hours in Seattle

Why do we have longer daylight and shorter daylight at different parts of the year?

OBSERVATIONS: WHAT HAPPENS?

PERSONAL EXPERIENCE not a lot of daylight

APRIL
Going to school in the morning:
How much daylight?

DECEMBER
Going to school in the morning:
How much daylight?

OBSERVATIONS FROM VIDEO

	Summer	Winter
Which day had sunrise first?	✗	
Which day had sunset last?	✗	
Which day had longer daylight?	✗	
Which had the most darkness?		✗

From your experiences and the video, what time of year seems to have...
... the longest daylight? Summer
... the shortest daylight? Winter

OUR HYPOTHESIS: HOW & WHY DOES THIS HAPPEN?

DRAW & LABEL:
Why does sunrise happen?

Things to think about:
- Where and how the earth moves
- What causes day and night
- How the sun affects the earth

Words that may help:
North Pole South Pole tilt
equator sunlight orbit
rotate seasons hemisphere

What to do:
1. Act it out!
2. Talk about it!
3. Draw it THEN write about it!

Drawing Tips
Use arrows to show direction of motion.
Use labels.

DRAW & LABEL: **In Seattle, why does the amount of daylight change during the year?**

WRITE: What do you think causes sunrise?
When the earth turns it will face the Sun and when sunlight hits the dot that will be sunrise.

WRITE: What do you think causes the amount of daylight to change during the year?
Maybe the earth's place in it's orbit change our point of view of the sun in the winter so we don't see as much sun light.

Waiting for the school bus at 7:15 AM in April

Waiting for the school bus at 7:15 AM in December

Why do we experience more hours of daylight in summer and fewer hours of daylight in winter?

Eliciting Initial Ideas:
Why do we experience more hours of daylight in summer and fewer hours of daylight in winter?

Partner Prompts

You need:
- ☐ 1 ball or globe
- ☐ 1 dot sticker
- ☐ 1 flashlight or lamp

1. Place a sticker on the ball or globe to show where your city is located.

2. Aim the flashlight at the ball or globe. Talk about:
- ☐ What parts of Earth are lit?
- ☐ What parts of Earth are dark?
- ☐ Show when your city has daytime (lit) and night (dark).

3. Use the flashlight and ball to discuss these questions with your partner:
- ☐ How/why do you think we have summer and winter on Earth?
- ☐ What are you puzzled by or wondering about?

Eliciting Initial Ideas:
Why do we experience more hours of daylight in summer and fewer hours of daylight in winter?

Partner Prompts

You need:
- ☐ 1 ball or globe
- ☐ 1 dot sticker
- ☐ 1 flashlight or lamp

1. Place a sticker on the ball or globe to show where your city is located.

2. Aim the flashlight at the ball or globe. Talk about:
- ☐ What parts of Earth are lit?
- ☐ What parts of Earth are dark?
- ☐ Show when your city has daytime (lit) and night (dark).

3. Use the flashlight and ball to discuss these questions with your partner:
- ☐ How/why do you think we have summer and winter on Earth?
- ☐ What are you puzzled by or wondering about?

Eliciting Initial Ideas:
Why do we experience more hours of daylight in summer and fewer hours of daylight in winter?

Partner Prompts

You need:
- ☐ 1 ball or globe
- ☐ 1 dot sticker
- ☐ 1 flashlight or lamp

1. Place a sticker on the ball or globe to show where your city is located.

2. Aim the flashlight at the ball or globe. Talk about:
- ☐ What parts of Earth are lit?
- ☐ What parts of Earth are dark?
- ☐ Show when your city has daytime (lit) and night (dark).

3. Use the flashlight and ball to discuss these questions with your partner:
- ☐ How/why do you think we have summer and winter on Earth?
- ☐ What are you puzzled by or wondering about?

End of Part I: Quick Write Directions

(project under document camera or write on board)

In your science notebook…

Quick Draw & Write

Why do you think we experience more hours of daylight in summer and fewer hours of daylight in winter?

I think we have more daylight in summer than winter because…

One question I have is…

To learn more, I think we should experiment or read about ______________ because…

Name: ________________________ Name: ________________________ Date: ______________ Teacher: ________________ PARTNER MODEL

Our Model of Changing Daylight Hours in Seattle

Why do we have longer daylight and shorter daylight at different parts of the year?

OBSERVATIONS: WHAT HAPPENS?

PERSONAL EXPERIENCE

APRIL

Going to school in the morning:
How much daylight?

DECEMBER

Going to school in the morning:
How much daylight?

OBSERVATIONS FROM VIDEO

	Summer	Winter
Which day had sunrise first?		
Which day had sunset last?		
Which day had longer daylight?		
Which had the most darkness?		

From your experiences and the video, what time of year seems to have…

… the longest daylight? ____________________

… the shortest daylight? ____________________

OUR HYPOTHESIS: HOW & WHY DOES THIS HAPPEN?

DRAW & LABEL:
Why does sunrise happen?

Things to think about:
- Where and how the earth moves
- What causes day and night
- How the sun affects the earth

Words that may help:

North Pole	South Pole	tilt
equator	sunlight	orbit
rotate	seasons	hemisphere

What to do:
1. Act it out!
2. Talk about it!
3. Draw it THEN write about it!

Drawing Tips
Use arrows to show direction of motion.
Use labels.

WRITE: What do you think causes sunrise?

____

____

____

DRAW & LABEL: **In Seattle, why does the amount of daylight change during the year?**

WRITE: What do you think causes the amount of daylight to change during the year?

____

____

____

Lesson 2: Day and Night Cycles

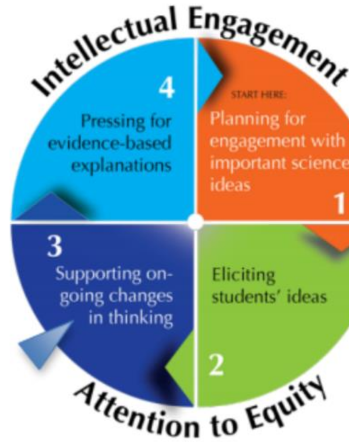
OBJECTIVES & OVERVIEW

This lesson allows students to explore the day-night cycle caused by the Earth's 24-hour rotation. This lesson asks students to develop and use models using their current levels of understanding to explain why we have day and night.

Focus Question: Is it daylight at the same time all over the world? Why or why not?

- Students make observations using physical models and interpret data to explain why we experience day and night.
- Students record and share their ideas and questions about the patterns of day/night cycles in their science notebooks.

Ambitious Science Teaching Framework:
SUPPORTING ON-GOING CHANGES IN STUDENT THINKING



This practice supports on-going changes in student thinking by (1) introducing ideas to reason with, (2) engaging with data or observations, and (3) using knowledge to revise models or explanations. For more visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Standards Note: This lesson is the first time students encounter data to discern patterns in the day-night cycle. Students have multiple opportunities across the unit to interpret and represent data about daily patterns in shadows, changing amount of daylight (annual pattern), and seasonal appearance of some stars (specifically the Sun) in the sky. In this lesson students are not representing daylight data, but interpreting data by comparing it to their personal experiences as well as the physical model they act-out to show daily day-and-night cycles using a lamp and their head representing the Earth.

PE *5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.*
[Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [Assessment Boundary: Assessment does not include causes of seasons.]

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CC)
Analyzing and Interpreting Data - *Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.*	***ESS1.B: Earth and the Solar System*** *The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.*	***Patterns*** - *Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.*

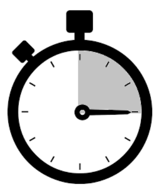
MATERIALS

Materials for the class
- 1 lamp, 1 globe, dot stickers
- Chart paper & markers
- 1-2 pages of a book about earth's rotation
- Video clip: Rotating day and night
  http://safeshare.tv/v/ss56dcbe2150545
- for Part II: Day and Night World Map
  http://www.timeanddate.com/worldclock/sunearth.html

Materials for each student:
- Science notebook & pencil
- *Optional for pair of students:*
  1 Styrofoam ball with 2 pushpins
  1 flashlight

PREPARATION

Approximately
15 minutes



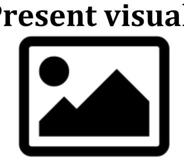
1. Find a library book that features 1-2 pages about the earth's rotation and day/night cycles focusing on the following:
   - The axis is an invisible line that runs north-south.
   - The equator is another invisible line that goes around the middle of the Earth running east-west.
   - Earth rotates or spins on its axis every 24 hours. Part of that time is facing the sun (lit/illuminated) and the other part of the Earth is dark (in shadow/dark).
2. Prepare a class demonstration globe. Mark cities on the globe using stickers including Seattle (or your city) and other cities your students have personal connections to (see Lesson 1, Part I) – If this is not known from lesson 1, do this at the beginning of the lesson (see step 1a).

OPTIONAL: Have 2-colors of pushpins and Styrofoam balls and flashlights ready in case some partners need materials to help communicate about day and night.

PROCEDURE

Part I. Observing and Modeling Day/Night Cycles
Suggested time for Part I is about 45 minutes

Present visuals



Show a map or globe.
If students marked cities in Lesson 1, Part I show those.

Turn-and-Talk

Is it daytime at the same time all over the world? Why or why not?

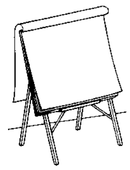
1. ORIENT STUDENTS TO THE CONCEPTS USING STUDENT IDEAS, EXPERIENCES, OR QUESTIONS (WHOLE GROUP) – (5 minutes)

a. Display a world map or globe where students identified cities they have lived or have family (from Lesson 1, Part I). If not yet marked, do so now by asking students to make a dot on the map for places they have lived, visited, or have family.

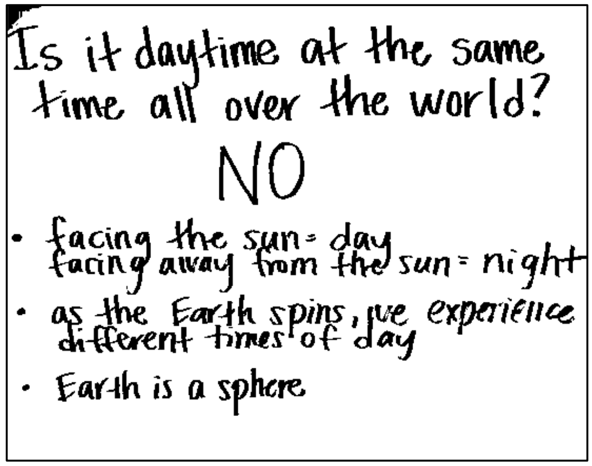
b. If they wanted to call their friend/family, could they do it right now? Why or why not? Turn-and-talk. (Expected responses*: "No, because it's night there now." "No, it's really early in the morning." For closer places, answers may be yes but some awareness that it's a different time of day there. Students may bring up daylight savings.)*

c. Title a chart paper "Day & Night: Is it daytime at the same time all over the world?" Tape up the map of Earth with dots from students

Public Record



on the chart paper below the question. Have students propose some ideas (2-3 bullets) – turn-and-talk if necessary.



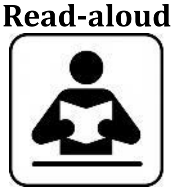
This is an example from a 5th grade class with their ideas about why it cannot be the same time all over the world. Your students' ideas may and should vary from those in this example.

Just-in-Time Instruction

2. Just-in-Time Instruction. (Whole Group) – (10 mins)
This just-in-time instruction about science concept(s) will help students better understand today's activity and more clearly communicate about their ideas. This is typically done using a short video clip, read aloud, or short lecture by the teacher to provide new information to students.

a. Use an idea or question students had from Lesson 1 about day/night or the rotation of the earth to introduce and set the purpose for today's lesson. And refer back to the question "Is it daylight at the same time all over the world? Why or why not?"

Read-aloud



Read 1-2 pages about Earth's rotation.

b. Read 1-2 pages from a book that features information about day/night on Earth and the rotation of the earth. After reading, students can share out facts they heard and these can be added to the chart under a heading of "What we learned from the reading:" These facts might include things like:

i. One full spin or rotation of the Earth = 1 day.
ii. 1 day or 1 rotation happens in 24 hours
iii. The spin or rotation happens around the axis of the Earth (invisible line running north-south)
iv. During 1 day, different parts of the Earth are lit up or illuminated at different times

Video Clip

Rotating Day and Night
0min 28 sec
http://goo.gl/O7WQM3

c. Play the short video clip showing an animation of the rotation of the Earth. This video does not have sound or narration. Have students watch it and then provide verbal descriptions of what is happening using the ideas and words they heard/learned in the read aloud.

3. GETTING STUDENTS STARTED – MAKING OBSERVATIONS (WHOLE GROUP) – (20 mins)

Part I: Acting like the Earth (10 mins)
Inspired by AstroAdventures: Lesson 3 Modeling the Earth/Sun Relationship, see p29-31.

SAFETY ALERT

Do not stare at the lamp light. Students can close their eyes and still sense light and dark.

Tell students that they are going to act out day and night on earth by using their heads as a model for the Earth. Seattle (or your city) is at your nose. *Say: Touch Seattle. Students touch their noses.* Tell them that their left ear is New York City. *Say: Touch New York City. Students touch their left ears.* Students can close their eyes during this activity if the light is too bright (see Safety Alert). Turn off classroom lights and turn on the lamp. Have students form semi-circle around the lamp so everyone can have access to the light and are not in the shadow of another student. Tell students to face the lamp and ask/prompt:

1. *If your left ear is New York, aim your left ear at the lamp. Is it daytime or night time? How do we know? (Possible responses: It's daytime because our ear or New York City is lit up. It's daytime because we're facing the Sun.)*

2. *Let's make Seattle have daylight so slowly rotate (turn) towards the lamp until our noses/Seattle faces the Sun.* (Students rotate to face their noses toward the lamp). *So it's daylight now in Seattle. What should we do to make it night time in Seattle?* (Students may respond and/or move to rotate or spin so their backs are to the lamp/sun).

3. Repeat and have students practice rotating in place to show day and night cycles (they observe light and darkness). They may find it helpful to say "noses-at-noon" to mean that when noses (our city) is directly facing the sun it is noon. Reinforce that one spin (rotation) happens in 24 hours.

Part II: Making observations using a globe (10 mins)

a. Have students sit so they can see the globe and lamp. Turn off classroom lights, turn on the lamp, and have the globe with stickers. The stickers represent Seattle (or your city) and other cities students have identified where they have lived or have family.

b. Ask some comparison questions locations and day/night to compare Seattle and other cities. Have students turn-and-talk. Then, share out by showing their thinking using the lamp, globe, and stickers paying attention to the part of the Earth that is lit up and the part that is dark.

Turn-and-Talk

(Comparing day/night in different cities – see next page for ideas)

Turn-and-Talk

(Comparing day/night in different cities – see ideas at right)

The prompts for turn-and-talks might sound like…

- *Here is Seattle (point/show on globe). Here is Nairobi, Kenya (point/show on globe) which is where Akeyo and his family are from. If it is daytime in Seattle, what time of day would it be in Nairobi? Turn-and-talk and explain how you know.*

- *Here is Seattle (point/show on globe). Here is Vancouver, British Columbia (point/show on globe) where Olivia's grandparents live. If it's noon in Seattle, what time would it be in Vancouver? Turn-and-talk and explain how you know.*

Quick Write

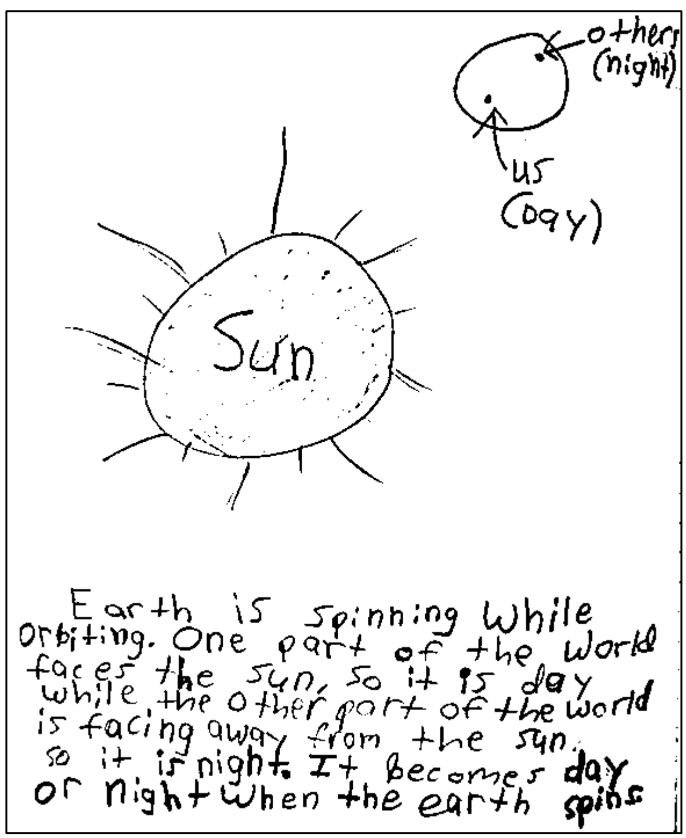
Draw and write about your observations and learning.

4. RECORD OBSERVATIONS & PRESS FOR EXPLANATION (10 mins)

Have students sketch and write about day/night, the rotation of the Earth and why it isn't daylight all over the Earth at the same time (returning to the focus question for this lesson).Suggested sentence stems:

It is daytime in Seattle when…
It is nighttime in Seattle when…
It can be day time and night time at different places on Earth at the same time because…

Here is one example of a 5th graders science notebook quick-write. She shows night/day in her drawing and explains that the Earth spins to face the sun (lit up/daytime) or faces away (dark/nighttime). She does not use the terms "rotate" or "rotation" but she clearly understands the concept of the day-night cycle.

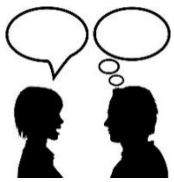


Part II. Using Data and Maps to Explain Day/Night

Suggested time for Part II is about 45 minutes

1. ORIENT STUDENTS TO THE CONCEPTS (5 mins)

Turn-and-Talk



What have we done or learned so far about day and night on Earth?

a. Give students silent time (about 30 seconds) to re-read what they wrote at the end of last class (Part I). Turn-and-talk with a partner using and pointing at your drawing and writing to remember what we are learning about day and night on Earth.

b. Tell students that today we will continue thinking about this question that we can't have daylight all over the Earth at the same time. Students will be using maps of Earth and globes/balls to reason about how to represent day and night on a map of the Earth.

2. INTERPRETING DATA TO MAKE SENSE OF OUR IDEAS – (WHOLE CLASS/PARTNERS) (25 mins)

a. Show students a 3-D globe (sphere) and a 2-D map (flat) of Earth. We know by looking at the globe that if there is a part lit up then it is experiencing daytime and if it is dark it is night time. But how can we show this on a flat map?

b. As a whole class, make observations about this website http://www.timeanddate.com/worldclock/sunearth.html. Locate Seattle (or their city) on the map. Use the back-pocket questions (below) to discuss this representation of day and night on a flat map. Use private think time, turn-and-talks, and whole class talk in various combinations to be responsive to students and make sense of the shading on the map.

Back-Pocket Questions

Making Observations

- What do you notice about the map?
- What do you think the shading means?
- How might the shading change if we click to make the time move forward 12 hours?

After students make predictions, click the link below the map that says "+ 12 hours."

- What do you notice now?
- What changed?
- Why did the map change?

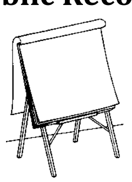
c. As students have discussed already, it is not daylight across the Earth all at once. Show partners the maps handouts with the data about times of day by city (bottom left) and the checklist of what-to-

Back-Pocket Questions

How teachers can use back-pocket Q's:

1. Approach a pair and listen in.
2. Decide what question to ask based on what you see/hear.
3. Ask the question and make sure both students contribute.
4. Prompt students to continue with a particular task or question.
5. Leave and go visit another pair.

Public Record



Summary Table

do (bottom right). Students can shade the map using the times of day to show what parts of Earth are in daylight and darkness. Then they discuss the questions in the bottom right.

d. Partner Work. Pass out the maps to students and have students get started by labeling the times next to each city on the map (using the data in the bottom left) and then working through the questions (bottom right). They can start with the "If it's 9:00AM in Seattle" map and then work on "if it's 2:00PM in Seattle" map.

As students work, use the following back-pocket questions:

If students are stuck and need help getting started…

- Tell students: *Start by taking the times of day and writing them next to each city on the map.*
- After they do this, ask:
  - *Which cities are having daylight?*
  - *Which cities are having night?*
- Leave students with this task: *Lightly shade your map, like the map we saw on the website so we can see which cities are having daylight and night.*

As students are working and talking in partners..

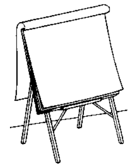
- *When it's (time) in Seattle, which cities have daylight and which have night time?* (Observation)
- *As we go from city to city, east to west, what is happening to the time of day?* (Observation)
- *Using the idea of Earth's rotation, how can we explain these observations?* (Inference/Connection)
- *Why do you think some of these times say 'next day' next to them? What does that mean? How could you show this using the flashlight, ball and stickers?*

3. **WHOLE CLASS COORDINATION OF IDEAS – SUMMARY TABLE** (15 mins)

   a. **OBSERVATIONS**: Reconvene as a whole class and summarize what students observed with the lamp/globe and from the map work today. This can be on a large piece of butcher paper in a row named "Day and Night Cycles" and fill in observation box together (see next page for example).

   b. **LEARNING**: Use the chart created in Part I to remind students what they learned from the read aloud about the earth's rotation. Record learnings about day/night and rotation in the learning column.

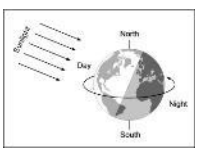
Public Record



Summary Table (continued)

c. **CONNECTION**: How can what we learned about this lesson help us explain a part of the phenomenon? Write some ideas in the summary table under "connection to phenomenon."

The summary table row below may be similar to what the summary table row looks like from the class discussion. Students may have additional questions. Have students write Q's on sticky notes and stick them on the 'Questions' chart. This lesson may have helped to answer students' original question(s). Check in with their questions to see if we have answers yet.

Activity	Observations & Patterns	What have we learned?	Connection to the phenomenon
Day and Night Cycles  	- As the globe rotates, the side facing the lamp is lit up and the other side is in darkness. - The lamp can't light up the globe at the same time, there is always a part in the dark.	- The earth spins or rotates on its axis once every 24 hours = 1 day - When it is daytime in Seattle, it is nighttime on the opposite side of the Earth (facing away from the Sun).	Daylight hours are measured between sunrise and sunset and this helps us understand that the Earth's 24 hour rotation causes day and night. (Possible student Q: But why isn't it just 12 hours day and 12 hours night? This question can be answered by subsequent activities particularly when students learn about the equinox and tilt.)

EXAMINING STUDENT WORK

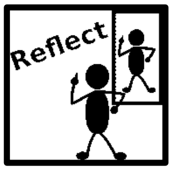
There are two tools that help teachers track student thinking over time. The two tools are:

- **Rapid Survey of Student Thinking (RSST)**
- **What-How-Why Explanation Tracker (WHY)**

Take about 15-20 minutes go through student notebook entries and what you heard from partner discussions and fill out either the RSST or the WHY (or both) to help you identify which key ideas students are already thinking about and places they need to support ongoing changes in their thinking. (There is more information about each of these tools in the front matter of this unit guide).

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons.

Keep a record of these reflections for your professional portfolio.

1. TASK, TALK, & TOOLS.

Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

The task of physically modeling day/night helped students to/with....
The task of mapping times of day across the world helped students to/with…
The task about ______ relates to students' and/or their families' lives because…

Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

The students talked to each other during (name particular parts of lesson) which allowed students to...
During turn-and-talks, I observed ______ which makes me wonder if/how…

Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students in communicating and capturing their ideas/thinking?

The summary table allowed students to...

Overall, reflecting on task, talk, and tools together:

Talk, task, and tools supported students to share their thinking because...
Overall, this combination of talk, task and tools, allowed most/all students to...

2. **EQUITY**.

Name and describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue. Here are some categories to help you name a specific issue of equity:

- Developing relationships & forming an inclusive, trusting community
- Scaffolding for full participation in the culture and language of science
- Recognizing our own and others' worldviews & developing critical consciousness about our own assumptions and beliefs
- Addressing power dynamics (how a person is seen and responded to by others) to disrupt stereotypes and privilege

PLANNING NEXT STEPS

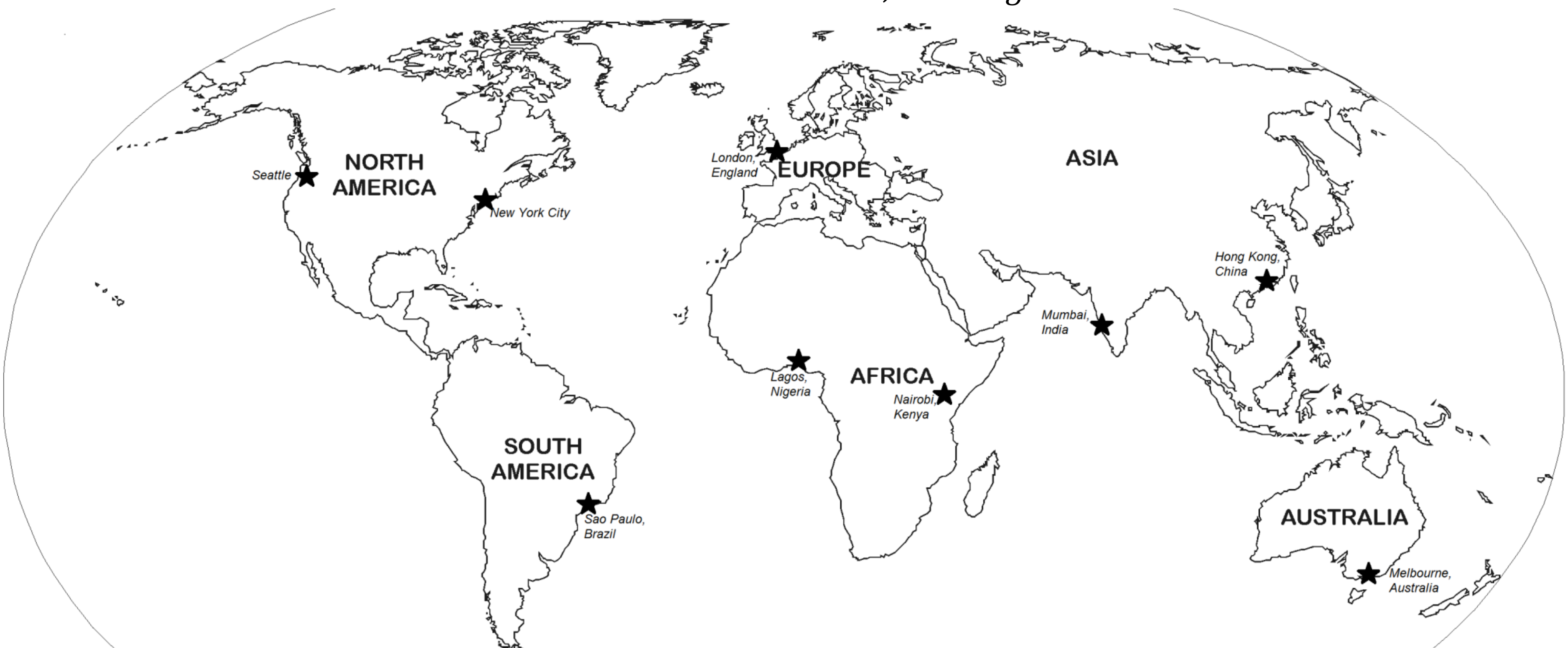
1. Use your analysis of student work (RSST or WHY) to decide what lesson should come next. Look at the unit overview as a whole and decide if the next lesson makes sense based on students' current thinking or if another lesson needs to be moved up or added in to better meet and move the current understanding of students forward.

   Once you decide on the next lesson…

2. Apply your lesson reflection (3Ts and Equity) to make changes to the upcoming lesson's guide to address the issue of equity you identified as well as to better support your students to engage fully in the task, talk, and tools in the lesson guide.

#1 Comparing Times of Day across the World

when it is 9:00AM in Seattle, Washington



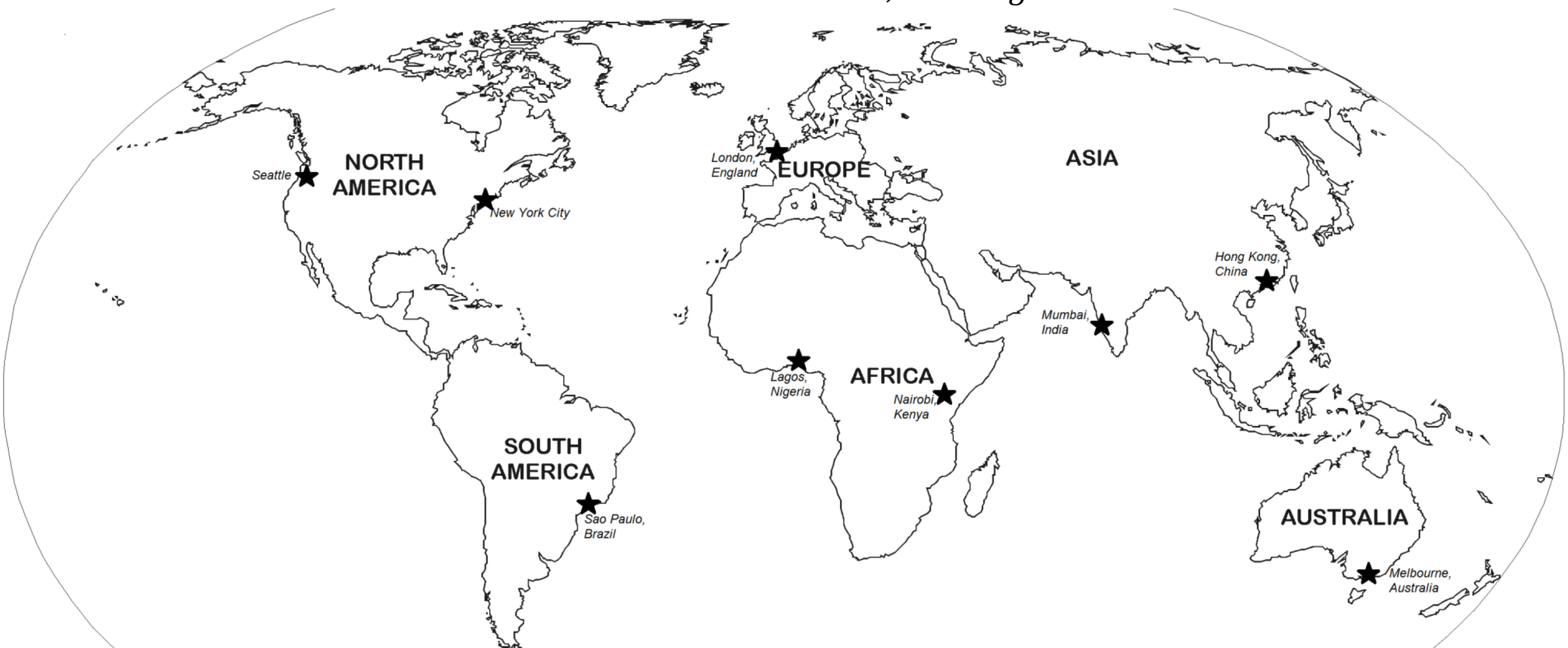
When it is **9:00AM** in Seattle….
It is …
12:00 PM (noon) in New York City
2:00 PM (afternoon) in Sao Paulo
5:00 PM (evening) in London
6:00 PM (evening) in Lagos
8:00 PM (night) in Nairobi
10:30 PM (night) in Mumbai
1:00 AM (night, next day) in Hong Kong
4:00 AM (night, next day) in Melbourne
Source: http://www.timebie.com/std/seattle.php?q=9

With a partner….

1. Look at the time data. Lightly shade the map to show who has daylight (unshaded) and who is having night (shaded)
2. Use 1 flashlight, 1 ball and sticker dots to understand this data and what you know about the rotation of the Earth to explain how there are different times across the Earth.
   - ☐ How can it be 9:00 AM in Seattle (day time) at the same time it is 10:30 PM in Mumbai (night time)?
   - ☐ How can it be 8:00 PM in Nairobi (night time) at the same time it is 12:00 PM (noon) in New York City (day time)?

#2 Comparing Times of Day across the World

when it is 2:00 PM in Seattle, Washington



When it is **2:00 PM** (afternoon) in Seattle….
It is …
5:00 PM (evening) in New York City
7:00 PM (evening) in Sao Paulo
10:00 PM (night) in London
11:00 PM (night) in Lagos
1:00 AM (night, next day) in Nairobi
3:30 AM (night, next day) in Mumbai
6:00 AM (morning, next day) in Hong Kong
9:00 AM (morning, next day) in Melbourne
Source: http://www.timebie.com/std/seattle.php?q=9

With a partner….

1. Look at the time data. Lightly shade the map to show who has daylight (unshaded) and who is having night (shaded)
2. Use 1 flashlight, 1 ball and sticker dots to understand this data and what you know about the rotation of the Earth to explain how there are different times across the Earth.
   - ☐ How can it be 2:00 PM in Seattle (day time) at the same time it is 11:00 PM in Lagos (night time)?
   - ☐ How can it be 10:00 PM in London (night time) at the same time it is 9:00 AM in Melbourne (day time)?

Lesson 3: Moving Shadows & Apparent Motion of the Sun

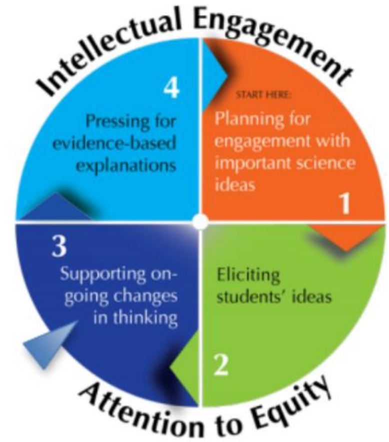
OBJECTIVES & OVERVIEW

Students will observe the apparent motion of the Sun as it moves across the sky over a school day and how this apparent motion changes shadows. The Sun seems to follow a path across the sky, rising in the East and setting in the West.

Focus Question: Why do we see the Sun in different places in the sky during the day?

- Students make observations of how a shadow changes over the course of a sunny school day and the apparent position of the Sun in the sky.
- Students record and share their ideas and questions about the role of the Sun and rotation of the Earth in how and why shadows change throughout the day.

Ambitious Science Teaching Framework:
SUPPORTING ON-GOING CHANGES IN STUDENT THINKING



This practice supports on-going changes in student thinking by (1) introducing ideas to reason with, (2) engaging with data or observations, and (3) using knowledge to revise models or explanations. For more visit *http://AmbitiousScienceTeaching.org*

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Standards Note: Students will collect data to discern patterns in daily changes of shadows. Students have multiple opportunities across the unit to interpret and represent data about daily patterns in shadows, changing amount of daylight (annual pattern), and seasonal appearance of some stars (specifically the Sun) in the sky. In this lesson students are focused on identifying patterns by analyzing and interpreting data about the daily changes in length and direction of shadows.

PE *5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.* *[Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [Assessment Boundary: Assessment does not include causes of seasons.]*

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CC)
Analyzing and Interpreting Data - *Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.*	***ESS1.B: Earth and the Solar System*** *The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.*	***Patterns -*** *Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.*

MATERIALS

Part I.

Materials for the class
- Sidewalk chalk (to trace shadow)
- Meter stick or tape measure
- Digital camera

Materials for each student:
- Data collection handout & pencil

Note: AstroAdventures curriculum (p 21-28) uses short plungers, black markers, and large paper for students to trace the shadow of the plunger stick over the course of the day. Easy to substitute a student and sidewalk chalk and trace the same students' shadow over the day.

Part II.

Materials for the class
- Chart paper & markers
- Summary table
- Optional: Online shadow simulator http://astro.unl.edu/naap/motion3/animations/sunmotions.swf

Materials for each pair:
- Flashlight
- Styrofoam ball with push pin (tall one, not a flat-head pushpin)

Materials for each student:
- Data collection handout & pencil

PREPARATION

Building on students' ideas or answering their questions. Find ideas from students' models or questions from their sticky notes that are about how the Sun seems to move or how it changes during the day or year. These will help introduce the lesson by showing students that we are doing investigations to help answer their questions and revise their ideas.

Scheduling logistics. Part I of this lesson involves collecting data over an entire school day. This requires a bit of extra planning around schedules:
- If you have your class for the whole day, you may be able to spread out the 50-60 minutes for science across 4-5 observation times throughout the day.
- If you teach multiple classes, students could collect share data (i.e. period 1 gathers data in the morning, period 2 mid-day, period 3, end of day and use the same height student and/or toilet plungers to standardized data collection). Also use digital camera throughout the day to make a photo log of the data. (These photos can be printed ad added to the summary table.)

Deciding if students will collect data in groups or as a class.
- If in groups: each group needs a plunger and tape measure or meter stick.
- If as a class: could use plunger or the same student can cast the shadow at each data collection time.

PROCEDURE — Part I. Collecting Data about Shadows and Apparent Motion of the Sun

Suggested time for Part I is about 60 minutes spread across a day

Turn-and-Talk

When have I seen the Sun in different places in the sky? When is it low? High?

1. **ORIENT STUDENTS TO THE CONCEPTS USING STUDENT IDEAS, EXPERIENCES, OR QUESTIONS (WHOLE GROUP) –** (5 minutes)

   a. Choose one of the options below to open the lesson (or do both):
      1. Ask students what observations have they made while coming to school or playing outside about where they see the Sun in the sky. When is it low? high? Have students turn-and-talk.
      2. Connect to one of your students' prior ideas or questions about why the sun appears in different places in the sky during the day. Have students say more about their ideas or questions.

b. Introduce the purpose of today's lesson: Today and during the next class students will figure out why it looks like the Sun is in different positions in the sky during the day and what affect that has on how shadows change. **Focus Question: Why do we see the Sun in different places in the sky during the day?**

SAFETY ALERT

Do not stare at the Sun! Even brief viewing of the Sun can damage eyes.

2. GETTING STUDENTS STARTED – MAKING OBSERVATIONS
(45-50 minutes across the day)

a. Tell students that today they will make observations about how Sun seems to move across in the sky during the day. They will do that by tracing the shadows that a student (or plunger) casts. They will also track the location of the Sun in the sky. Warn students not to stare at the Sun (see safety alert).

b. Show students the data sheet with the data table and Sun tracking side-view map. If using a student to cast the shadow, then this can be a whole-class data gathering process. If using the toilet plungers in the kit, it can be done whole-class, or there are enough to do in small groups or pairs.

c. Take students outside to the observation area to collect the first data point. This needs to be the same place students can go at multiple points during the day to trace the shadow, measure it, and do a quick sketch of the shadow and note the Sun's position in the sky. If choosing a student to stand and cast a shadow, use the same student all day (or a similarly sized student).

d. Repeat data collection 4-5 times over the day (before/after noon).

Prior to Part II, look over students' data to see if there are any major discrepancies. If data was collected as a whole-class, it will be less likely.

Part II. Analyzing Data and Drawing Conclusions
Suggested time for Part II is about 50 minutes

Turn-and-Talk

What did we observe about how the shadows changed? about the Sun?

1. **ORIENT STUDENTS TO THE CONCEPTS (WHOLE GROUP)** (5 mins)

   a. Give students silent time (about 30 seconds) to look over the data they collected about shadows and the motion of the Sun (Part I). Turn-and-talk with a partner using and pointing at your drawing and data table. Share out a few observations from the data.

   b. Tell students that today they will analyze their data and figure out how what we have learned before (in lesson 2) about the Earth's rotation can help us explain how shadows change during the day.

2. **JUST-IN-TIME INSTRUCTION (WHOLE GROUP)** (10 mins)

   This is not new instruction but rather time for students to connecting with prior instruction. Have students apply what they learned in lesson 2 about the Earth's rotation to model using the Styrofoam ball, pushpin and flashlight how the shadow of the pushpin changes as the Earth rotates on its axis.

   Discuss: How does this help us understand our observations of changing shadows on the playground?

3. **INTERPRETING DATA TO DRAW CONCLUSIONS – (INDIVIDUAL/PARTNERS)** (20 mins)

   a. Give students time to work on their data handout and answer the questions about their observations/patterns, make a graph, draw/write an explanation, and writing a conclusion. This time can be chunked if you feel your students need more guidance along the way – or check in with particular students who may need more support getting started

   b. Allow students to talk quietly with partners to work together but each student has their own paper. As students work to identify patterns/trends in their observations, explain how this happens, and draw a conclusion from the activity, circulate and ask back-pocket questions.

To help students identify trends/patterns in their data:
- What did you notice about how the shadow changed in the morning? The afternoon?
- What do you observe about where the Sun was in the sky in the morning? The afternoon?
- When the Sun appeared lower in the sky, how long was the shadow? When the Sun appeared higher in the sky how long was the shadow?

To help students think about causes of patterns:
- Why do you think the Sun looks higher in the sky around noon than it does in the morning or afternoon?
- How does knowing about the Earth's rotation help us think about this data? (Offer to students that they could use a globe and flashlight to think about this with a partner.)
- We've learned earlier that the Earth rotates on its axis to cause day and night. How might the Earth's rotation help us understand how the Sun appears to move across the sky? (Offer to students that they could use a globe and flashlight to think about this with a partner.)

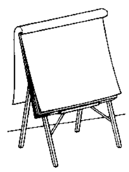
Back-Pocket Questions

How teachers can use back-pocket Q's:

1. Approach a pair and listen in.
2. Decide what question to ask based on what you see/hear.
3. Ask the question and make sure both students contribute.
4. Prompt students to continue with a particular task or question.
5. Leave and go visit another pair.

OPTIONAL: Before moving to the Summary Table, this online simulation could help students identify patterns in shadows. http://astro.unl.edu/naap/motion3/animations/sunmotions.swf
However, it does not show the rotation of the Earth. Look at the simulator and decide if you think it will be helpful to your students. To make the simulation easier for students observe do the following: Uncheck all boxes in the lower right except for "show stickfigure and its shadow." Click on the image and rotate so we have a birds-eye, top-down view of the stick figure. Click play and watch how the shadows change.

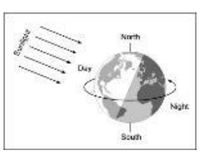
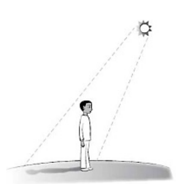
Public Record



Summary Table

4. WHOLE CLASS COORDINATION OF IDEAS – SUMMARY TABLE (15 mins)

a. **OBSERVATIONS**: Reconvene as a whole class and summarize what students observed tracing shadows throughout the day. The new row is named "Moving Shadows" and fill in observation box together (see next page for example of what might appear as possible observations).
b. **LEARNING**: Use what students learned about the earth's rotation and how the Sun does not move. Record learnings about day/night and rotation in the learning column.
c. **CONNECTION**: How can what we learned about this lesson help us explain a part of the phenomenon? Write some ideas in the summary table under "connection to phenomenon."

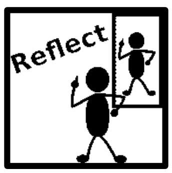
Activity	Observations & Patterns	What have we learned?	Connection to the phenomenon
Day and Night Cycles 	- As the globe rotates, the side facing the lamp is lit up and the other side is in darkness. - The lamp can't light up the globe at the same time, there is always a part in the dark.	- The earth spins or rotates on its axis once every 24 hours = 1 day - When it is daytime in Seattle, it is nighttime on the opposite side of the Earth (facing away from the Sun).	Daylight hours are measured between sunrise and sunset and this helps us understand that the Earth's 24 hour rotation causes day and night. (Possible student Q: But why isn't it just 12 hours day and 12 hours night? This question can be answered by subsequent activities particularly when students learn about the equinox and tilt.)
Moving Shadows 	The shadow moves in a circle. The length of shadow gets shorter from the morning to noon. The length of shadow gets longer from noon to the afternoon.	The shadow moves in a circle because the earth spins (the Sun does not move). The apparent motion of the sun means it appears to rise in the East and set in the West.	The movement of the shadows is some evidence that the earth is rotating to create day and night. The tracing of shadows might look different at different times of year because the sun is lower in the sky in winter and appears higher in the sky in summer (for northern hemisphere)

EXAMINING STUDENT WORK

Take about 15-20 minutes go through student work and what you heard from partner discussions and fill out either the RSST or the WHY (or both) to help you identify which key ideas students are already thinking about and places they need to support ongoing changes in their thinking.

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons.

Keep a record of these reflections for your professional portfolio.

1. TASK, TALK, & TOOLS.

Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

The task of tracking changes in shadows over a day helped students to/with....
The task about _____ relates to students' experiences or their families' lives because…

Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

The students talked to each other during (name particular parts of lesson) which allowed students to...
During turn-and-talks, I observed _____ which makes me wonder if/how…

Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students in communicating and capturing their ideas/thinking?

The data sheet with room to explain why shadows change allowed students to…
The summary table allowed students to...

Overall, reflecting on task, talk, and tools together:

Talk, task, and tools supported students to share their thinking because...
Overall, this combination of talk, task and tools, allowed most/all students to...

2. **EQUITY**.

   Name and describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue. Here are some categories to help you name a specific issue of equity:
   - Developing relationships & forming an inclusive, trusting community
   - Scaffolding for full participation in the culture and language of science
   - Recognizing our own and others' worldviews & developing critical consciousness about our own assumptions and beliefs
   - Addressing power dynamics (how a person is seen and responded to by others) to disrupt stereotypes and privilege

PLANNING NEXT STEPS

1. Use your analysis of student work (RSST or WHY) to decide what lesson should come next. Look at the unit overview as a whole and decide if the next lesson makes sense based on students' current thinking or if another lesson needs to be moved up or added in to better meet and move the current understanding of students forward.

   Once you decide on the next lesson…

2. Apply your lesson reflection (3Ts and Equity) to make changes to the upcoming lesson's guide to address the issue of equity you identified as well as to better support your students to engage fully in the task, talk, and tools in the lesson guide.

Student name: ______________________________ Date: _____________ Teacher: ________________

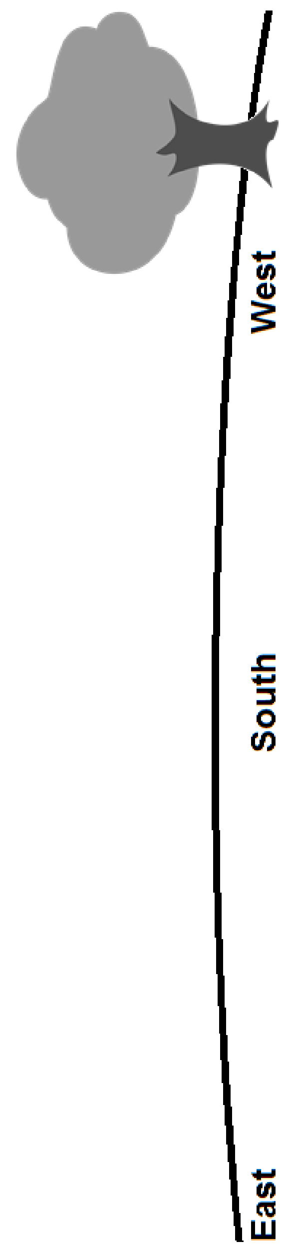
Moving Shadows

Collecting Data:

Changing Shadows and the Position of the Sun

Time of day	shadow Length *(cm)*	Small sketch of shadow *Sit in the same place each time.*

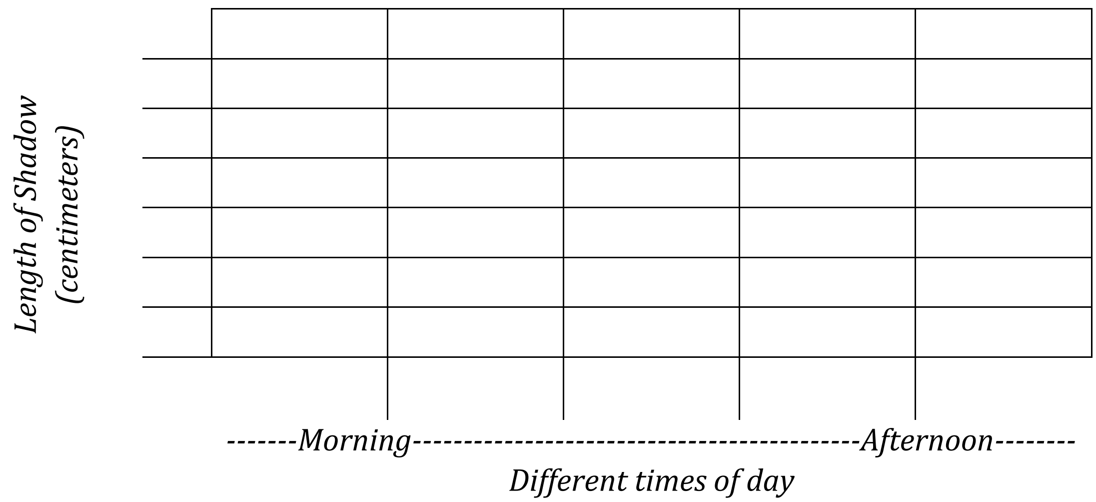
Observe by facing south. Sketch some points of reference such as trees or buildings. Never stare at the Sun. Track the position of the Sun in the sky at each time over the day.



Observations & Patterns

1. Graph the length of the shadow at different times over the school day.

Title: ______________________________



2. How did the shadow change during the day?

____

____

____

3. How does the apparent position of the Sun change during the day?

____

____

____

Explain the Data

4. What makes the shape of the shadow change during the day?
   Draw and write your explanation.

My Conclusion:

5. How does the rotation of the Earth affect the length of shadows over a school day?

Lesson 4: Sun Clocks & Earth's Rotation

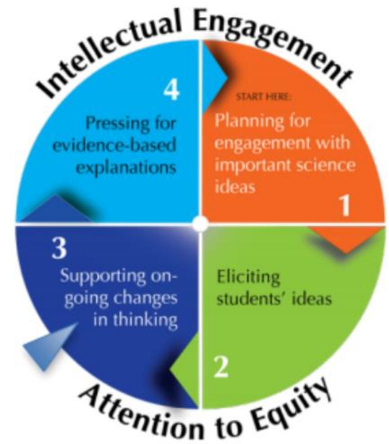
OBJECTIVES & OVERVIEW

This lesson continues to build on students' developing understanding about the Earth's rotation and how that causes the apparent motion of the Sun in the sky. This lesson has students build a Sun clock (see Pocket clock directions). Using the Sun clock in the classroom with the lamp representing the Sun and students acting as the Earth, rotating in place, reinforces the direction of the spin which supports explaining why the sun rises earlier in New York, for example, than Seattle.

Focus Questions: We know that the Earth rotates. But which way does it spin?
This helps students explain their shadow data and why it looks like the sun rises in the East and sets in the West.

- Students make observations of shadows that are cast by a pocket sun clock.
- Students record and share their ideas and questions about the patterns of day/night cycles in their science notebooks and the apparent motion of the Sun.

Ambitious Science Teaching Framework:
SUPPORTING ON-GOING CHANGES IN STUDENT THINKING



This practice supports on-going changes in student thinking by (1) introducing ideas to reason with, (2) engaging with data or observations, and (3) using knowledge to revise models or explanations. For more visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Standards Note: Students continue building their understanding by observing patterns in shadows to explain day and night cycles and the appearance of the Sun (a star) in the sky. This particular lesson does not have students analyzing and interpreting a formal set of data; however, they are interpreting their observations to identify patterns to deepen their understanding of the rotation of the Earth.

PE *5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.* *[Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [Assessment Boundary: Assessment does not include causes of seasons.]*

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CC)
Analyzing and Interpreting Data - *Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.*	***ESS1.B: Earth and the Solar System*** *The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.*	***Patterns -*** *Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.*

MATERIALS

Materials for the class:

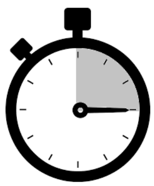
- Lamp
- Globe
- Summary table
- markers

Materials for each student:

- Pocket sun clock pattern on cardstock (from appropriate time zone – clock 3 for WA state)
- String about 7 inches (20 cm) long
- Science notebook & pencil
- Tape (for every few students)
- Scissors (for every few students)

PREPARATION

Approximately 15 minutes



Gather and prepare Sun clock materials:

- Copy template on cardstock and cut apart (see p37 in AstroAdventures)
- Cut 7 inch (20 cm) lengths of string for each student

Reading Integration (OPTIONAL): Find readings or books about sun dials and other ancient ways of telling time before clocks and watches. This could integrate into a reading lesson as a read aloud or reading comprehension practice that relates to what students are learning about in science.

PROCEDURE

1. **ORIENT STUDENTS TO THE CONCEPTS USING STUDENT IDEAS, EXPERIENCES, OR QUESTIONS (WHOLE GROUP) –** (10 minutes)

   a. Recap what students have been learning about so far: Earth's rotation, changing shadows during a day, and the apparent motion of the Sun in the sky. It is likely that students have begun talking about which way the Earth spins but may not have settled it yet.

   b. Show the globe in front of the lamp and spin the globe one way and then the other. Ask students: Which way does the Earth spin? How do we know? What's our evidence? After some private think time, have students turn-and-talk.

   c. Tell students that one way we can try to figure this out is by looking at the directions the shadows moved (from lesson 3). We are going to simulate that by making a pocket clock that will cast a shadow.

Turn-and-Talk

Which way does the Earth spin? How do we know? What's our evidence?

2. **GETTING STUDENTS STARTED – MAKING OBSERVATIONS (WHOLE GROUP) –** (20 mins)

   a. Show students how to assemble their pocket sun clock.
      i. Cut the notches at either end of the rectangle.
      ii. Fold the rectangle with text facing on the inside of the fold.
      iii. Place the ends of the string through the notches and tape the string to the back of the clock to secure.

   Give students a few minutes to assemble their clocks.

b. When ready, have students gather in a semi-circle around the lamp so that no student is standing in another students' shadow. Have students hold their clocks facing the lamp. Turn off overhead lights and turn on the lamp to observe how the string on the pocket sun clock casts a shadow on the numbers.

c. Have students rotate one way or another to have the shadow move on the sun clock in the right direction (i.e. in the same way that the clock tells time from 7am, 8am, 9am, 10am and so forth).

Quick Write

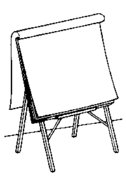
Draw & write about observations to answer: Which way does the Earth rotate? How do we know?

d. Talk about what students notice. Which way did they rotate to have the shadow tell the time in the right order?

e. Have students sketch what they did in their science notebooks and write about how the shadow changes as the student (the Earth) rotated. Which way does the Earth rotate? How do we know? What is evidence of this?

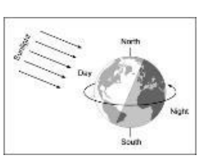
Possible sentence starters to support student writing:
When the pocket clock faced the sun, I observed that…
When I turned or rotated, I noticed that the shadow…
I think that the Earth rotates in the direction of ______ because…

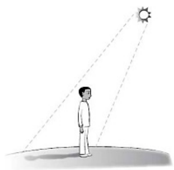
Public Record



Summary Table

3. **WHOLE CLASS COORDINATION OF IDEAS – SUMMARY TABLE** (15 mins) *Use quick write as a starting point for a summary table discussion.*
   a. **OBSERVATIONS**: Reconvene as a whole class and summarize what students observed.
   b. **LEARNING**: Use the chart created in Part I to remind students what they learned from the read aloud about the earth's rotation. Record learnings about day/night and rotation in the learning column.
   c. **CONNECTION**: How can what we learned about this lesson help us explain a part of the phenomenon? Write some ideas in the summary table under "connection to phenomenon.

Activity	Observations & Patterns	What have we learned?	Connection to the phenomenon
Day and Night Cycles 	- As the globe rotates, the side facing the lamp is lit up and the other side is in darkness. - The lamp can't light up the globe at the same time, there is always a part in the dark.	- The earth spins or rotates on its axis once every 24 hours = 1 day - When it is daytime in Seattle, it is nighttime on the opposite side of the Earth (facing away from the Sun).	Daylight hours are measured between sunrise and sunset and this helps us understand that the Earth's 24 hour rotation causes day and night. (Possible student Q: But why isn't it just 12 hours day and 12 hours night? This question can be answered by subsequent activities particularly when students learn about the equinox and tilt.)

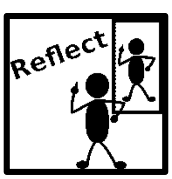
Moving Shadows 	The shadow moves in a circle. The length of shadow gets shorter from the morning to noon. The length of shadow gets longer from noon to the afternoon.	The shadow moves in a circle because the earth spins (the Sun does not move). The apparent motion of the sun means it appears to rise in the East and set in the West.	The movement of the shadows is some evidence that the earth is rotating to create day and night. The tracing of shadows might look different at different times of year because the sun is lower in the sky in winter and appears higher in the sky in summer (for northern hemisphere)
Sun Clocks & Earth's Rotation	Shadows on the Pocket Sun Clock move one way if we spin to the right and go the other way in a circle if we spin to the left	Objects blocking light create shadows. Shadows made by the Sun change in length and direction over time because the Earth is rotating.	The direction of shadow made by the Sun is evidence that the Earth must be spinning counterclockwise when looking down at the north pole (or spinning to the left if we are acting like the earth) such that New York gets sunlight before Seattle.

EXAMINING STUDENT WORK

Take about 10minutes go through students' notebook entries and what you heard from partner discussions and fill out either the RSST or the WHY (or both) to help you identify which key ideas students are already thinking about and places they need to support ongoing changes in their thinking.

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons.

Keep a record of these reflections for your professional portfolio.

1. **TASK, TALK, & TOOLS.**

Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

The task of making observations of a sun clock helped students to/with....
The task about _____ relates to students' interests, experiences, or lives because…

Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

The students talked to each other during (name particular parts of lesson) which allowed students to...
During turn-and-talks, I observed _____ which makes me wonder if/how…

Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students in communicating and capturing their ideas/thinking?

The summary table allowed students to...

Overall, reflecting on task, talk, and tools together:

Talk, task, and tools supported students to share their thinking because...
Overall, this combination of talk, task and tools, allowed most/all students to...

2. **EQUITY**.

   Name and describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue. Here are some categories to help you name a specific issue of equity:
   - Developing relationships & forming an inclusive, trusting community
   - Scaffolding for full participation in the culture and language of science
   - Recognizing our own and others' worldviews & developing critical consciousness about our own assumptions and beliefs
   - Addressing power dynamics (how a person is seen and responded to by others) to disrupt stereotypes and privilege

PLANNING NEXT STEPS

1. Use your analysis of student work (RSST or WHY) to decide what lesson should come next. Look at the unit overview as a whole and decide if the next lesson makes sense based on students' current thinking or if another lesson needs to be moved up or added in to better meet and move the current understanding of students forward.

   Once you decide on the next lesson…

2. Apply your lesson reflection (3Ts and Equity) to make changes to the upcoming lesson's guide to address the issue of equity you identified as well as to better support your students to engage fully in the task, talk, and tools in the lesson guide.

Lesson 5: Annual Patterns in Daylight Hours

OBJECTIVES & OVERVIEW

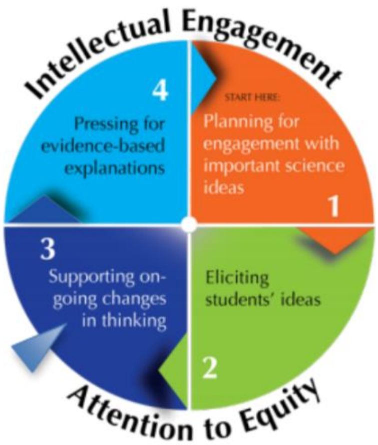
Prior lessons have focused on supporting students in understanding how the rotation of the Earth accounts for daily patterns in daytime (light) and nighttime (dark) and the apparent motion of the sun in the sky.

In this lesson students build on their understanding about daylight by examining annual patterns in the changing number daylight hours using data from Seattle (or their city).

Focus Question: When during the year does Seattle (or your city) have the most daylight? Least daylight? *Lessons 6, 7, 8 support students in how and why this pattern happens.*

- Students analyze and interpret a set of data to identify trends in the number of daylight hours, month by month, over a year.

Ambitious Science Teaching Framework:
SUPPORTING ON-GOING CHANGES IN STUDENT THINKING



This practice supports on-going changes in student thinking by (1) introducing ideas to reason with, (2) engaging with data or observations, and (3) using knowledge to revise models or explanations. For more visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Standards Note: Students use their understanding of the appearance of the Sun (a star) in the sky by and rotation of the Earth by analyzing and representing data about the number of hours of daylight across a year. Students will begin to explain how the tilt and rotation of the Earth as well as its revolution (orbit) around the Sun can explain changes in the amount of daylight throughout a year – this will be continued in lessons 6, 7, and 8.

PE *5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.* *[Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [Assessment Boundary: Assessment does not include causes of seasons.]*

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CC)
Analyzing and Interpreting Data - *Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.*	***ESS1.B: Earth and the Solar System*** *The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.*	***Patterns -*** *Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.*

MATERIALS

Materials for the class:

- 1 sheet large paper
- Tape & scissors
- Lamp & Globe
- Summary table & markers
- Video links:
  - ○ Rotation: http://goo.gl/ziY1TW
  - ○ Revolution: http://goo.gl/ObSdhy

Materials per pair:

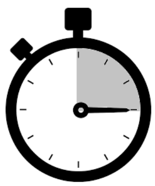
- 1 data table and 1 strip of 2-column graph *(see p. 7 this lesson guide for Seattle, WA 2016; see lesson preparation to customize data to city/year)*
- Highlighter/marker

Materials per student:

- student recording sheet (1 page, front/back)
- pencil

PREPARATION

Approximately 15 minutes



The annual daylight data for 2016 in Seattle, WA is provided in this lesson guide on p.7. If you need to find and prepare data tables with monthly data for a different city and/or year:

1. Go to http://aa.usno.navy.mil/data/docs/Dur_OneYear.php, select your state and type in your city. It will provide a year of data for the current year (or whatever year you specify).
2. Print off one data table for each pair. Highlight a different month on each copy so each pair knows which month of data to work with. (If you have more than 12 pairs, print data for the prior or next year).
3. Make copies of graph strips and pass out with the data table to students.

Optional: Print data tables of annual daylight data from other U.S. cities (enter state/province and name of city, Form A of website) and/or other cities world wide (enter latitude/longitude, Form B of website). Students can graph this data and compare it to Seattle (or their city).

PROCEDURE

Part I. Changing Daylight, Earth's Tilt and Orbit

Approximate time 45 minutes

Turn-and-Talk

Based on your personal experiences, when does Seattle have the most daylight? The least?

Video Clip

Rotation of Earth – Happy Learning
00m 43s
http://goo.gl/ziY1TW

1. **ORIENT STUDENTS TO THE CONCEPTS USING STUDENT IDEAS, EXPERIENCES, OR QUESTIONS (WHOLE GROUP) –** (5 minutes)

   a. Today students will use a data set of daylight hours each day for a year to answer the question ***When during the year does Seattle have the most and least daylight? How do we know?***

   b. Remind students of some key points about the length of a day that will help them reason with today's data.
      1 day = 24 hours
      1 day has day and night (daytime/nighttime, daylight/darkness)
      1 day = 1 full rotation of Earth about its axis
      For a video recap, watch http://safeshare.tv/v/ss56df9eeb6ffb6

   c. Tell students they will be working in partners and each group will get one month of daylight data to answer some questions to find out what day has the shortest daylight, the longest daylight, and what patterns we see across a year.

Investigating Data

Interpreting and representing data

2. GETTING STUDENTS STARTED – MAKING OBSERVATIONS (WHOLE GROUP/PAIRS) – (20 mins)

Introducing the data:

a. Show students the data table from for their city/year. In pairs, students use this data to make a bar graph of the least and most amount of daylight for each month across a year for a city. http://aa.usno.navy.mil/data/docs/Dur_OneYear.php

b. Have students look at the table. What do they notice? What they think it is about? Key parts to look at: city, year, months across the top as well as the hours/minutes of daylight. This data shows the number of daylight hours each day in a month for that city in a particular year. The amount of daylight is written in a number of hours and minutes. For example, in Seattle on January 1, 2016 there was 8 hours 30 minutes of daylight that day (meaning there was 15 hours 30 minutes of night, since one 24 hour day has both day and night time).

c. Partner task: Students will use the monthly data table to make a 2-bar bar graph of the longest daylight and shortest daylight for their *month*.
   i. Show students data table and graph strip.
   ii. Tell students each pair is responsible for graphing data from two points in their month: day with the longest daylight and day with shortest daylight from their month. *Note: It is a quick graph so a highlighter or marker makes it quick to fill in the bars. They are only graphing 2 bars for their month so this should go quickly.*
   iii. After they complete the graph strip for their month, they talk about and answer the "partner questions" on the front of the student recording sheet.

Back-Pocket Questions

Back pocket questions: As you check in with students, first, clarify any math/graphic questions students have and then ask students some of the following:

OBSERVATIONS

- Which date has the earliest sunrise?
- Which date has the latest sunset?

1. What happens to the amount of daylight from the beginning to the end of the month?
2. You have the month of ________. What do you think will happen with the amount of daylight in the next month? What do you think happened in the prior month? *Use data table.*

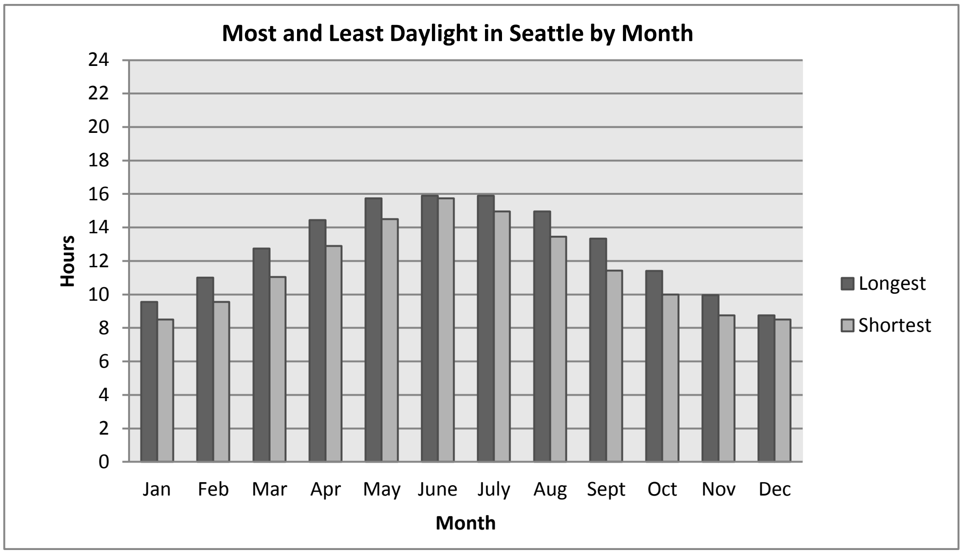
HYPOTHESES

3. Why do you think the amount of daylight is increasing/decreasing during the month?

Investigating Data

Observations & Patterns in Data Representations

d. Whole group: Create the whole-class graph of the year-long data by having pairs tape strips together in order from January-December on a large sheet of construction paper to create an annual graph. For Seattle, the graph might look something like this:



This graph display can be powerful for students to see changes in daylight across the year when each group tapes their graph strip up on the construction paper to make a class graph. Use the "whole-class questions" on the student recording sheet to facilitate students in making and recording observations about this data.

Back-Pocket Questions

Observations & Patterns

Back pocket questions: As the whole class interprets the class-created graph of annual daylight for Seattle (or another city), consider one or more of these questions to help students see relationship between the months/seasons, and how daylight varies. (This sets students up to learn more about what happens with the Earth during a year.)

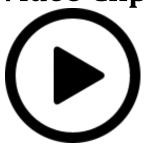
OBSERVATIONS & PATTERNS

4. What month has the most amount of daylight? The least?
5. For each season, what is the trend in the amount of daylight?
6. Across the year, describe trends in how daylight varies (use graph).
7. How does this data about daylight hours help us answer the question: When does Seattle have the most and least daylight?

The next piece of just-in-time instruction provides students with additional information about the tilt and revolution path of the Earth that are needed in order for students to begin reasoning about how/why the amount of daylight changes (going beyond their observations that it changes.)

Just-in-Time Instruction

Video Clip



Revolution of Earth – Happy Learning
01m 09s
http://goo.gl/ObSdhy

3. Just-in-Time Instruction: The Earth's tilt and path around the Sun & Identifying locations of solstices (15 minutes)

a. Remind students that the Earth rotates on a tilted axis, like the video clip they saw earlier had mentioned. The Earth does another motion while it spins or rotates. It moves in a large path around the Sun. This path is called a revolution and takes 1 year to complete. One year has 12 months (365 days). Watch video http://safeshare.tv/v/ss56dfa8ddad5eb. Turn-and-talk to process what they just saw/heard for a minute or so.

b. Review (or introduce) the term solstice. (This term may have been introduced in Lesson 1 as this term is used in the time-lapse video.)

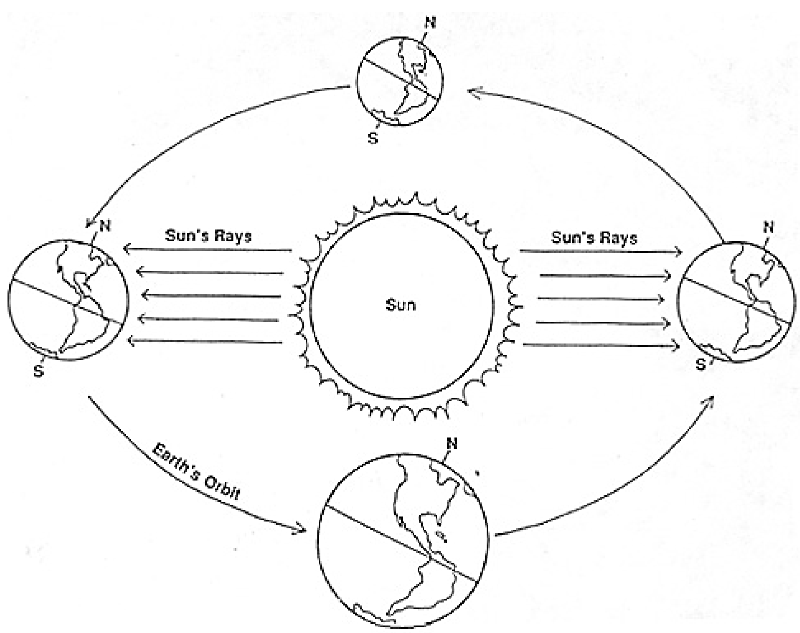
Solstices happen at two times each year on the days with the longest and shortest amounts of daylight hours. The *summer solstice* is when the sun appears at the highest point in the sky at noon as has the longest daylight hours. The *winter solstice* is when the sun appears at lowest point in the sky at noon, marked by the shortest days.

sol- means "sun"

c. Locate the points at which Seattle experiences a solstice in the Earth's path around the Sun. This diagram may help. In the next step, students will act out the pathway using the globe and lamp.

SUMMER SOLSTICE

In this position, cities in the Northern Hemisphere are experiencing the summer solstice, the longest amount of daylight in the year.



WINTER SOLSTICE

In this position, cities in the Northern Hemisphere are experiencing the winter solstice, the shortest amount of daylight in the year.

d. Use the globe and lamp and have student volunteers come up and act out the revolution of the Earth around the Sun, focusing on the tilt or Earth as it makes its revolution.
    i. Mark the location of Seattle on the globe using a sticker. Use the lamp to represent the Sun.
    ii. Have a student hold the globe at a tilt and spin globe to represent day/night. Then move in a circle around the lamp (revolution).
    iii. Pause at winter and summer solstice positions (see diagram on previous page). At those positions, rotate the globe to simulate day and night. Have students watch when Seattle stays in the light and then goes into darkness as the globe rotates. Then move the globe in an orbit around the lamp (maintaining angle and direction of tilt).

Questions to focus students' observations during the demonstration:

1. In winter solstice, watch the sticker. How long is it in shadow when the Earth rotates? How long is it lit up?
2. In summer solstice position, watch the sticker. How long is it in shadow when the Earth rotates? How long is it lit up?

    Students should observe that in winter solstice position the Northern Hemisphere is tilted away (tilted back) from the Sun and since Seattle is closer to the North pole it is in darkness longer than compared to when the globe is in the summer solstice position.

Quick Write

Turn-and-Talk

How does the video and demonstration help explain trends on our graph?

e. As students watch the video clip a second time and think about the act-out they just did with the globe, ***How can the video and demonstration helps us explain the trends on our graph about how daylight changes over a year in Seattle?*** This is a complex question because it requires students to connect multiple experiences to explain data on a graph. Students need some think time, turn-and-talk time, writing time, share out, discuss, etc. Help students express their ideas in pictures and words about what they have learned about daylight changes in Seattle and how/why it happens by giving time to think, rehearse, talk, and listen. Based on your students you may decide to do the quick write first and then turn-and-talk or vice versa. Based on where students are, a turn-and-talk or quick write might go well here (or both).

    How does knowing about the Earth's tilt and solstices in the Earth's year-long path explain our graphs of daylight in Seattle?

EXTENSION – OPTIONAL (approx. 45 mins)

If you would like your students to have an extended discussion opportunity using more data from the daylight hours website to continue to coordinate ideas bout Earth's tilt, Earth's revolution, and amount of daylight for a city. Choose one of the two similar scenarios below and pursue them as a class using additional daylight data from other cities.

1. We know 1 day is 24 hours. And we can see on the graph from earlier in the lesson that the most amount of daylight in Seattle happens in June and is about 15 ½ hours of daylight.
   - Do you think there could be places on earth that have 24 hours of daylight (no darkness)? Why or why not? How could we show that using a globe and lamp?
   - What additional information would be helpful to help us answer this question? *Offer to print off data charts for other cities at more northern and southern latitudes.*

2. How might this graph look different if we picked a different city like <u>(insert city relevant to students</u>)?
   - How do you know? OR Why do you think so? OR How could we find out?
   - *Print off data chart for that city and provide graph template if students want to make another graph to compare daylight changes in cities in different places on Earth.*

Part II. Public Coordination of Ideas
Approximate time 35-40 minutes

Turn-and-Talk

[Decide on a question based on Part I.]

1. REORIENTATION TO THE LESSON – (WHOLE CLASS) – (10 mins)

Have students recap what they have observed so far about the daylight data for their city. Have students turn-and-talk about a question that you want them to focus on today -- see the "on your own" questions on the data sheet from Part 1. This discussion with turn-and-talks may exceed 10 minutes if productive for students. Have globe and lamp on hand and make students show their ideas in addition to describing them verbally so all students can understand the ideas of their peers.

2. QUICK WRITE - (INDEPENDENT) (10 mins)

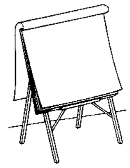
Quick Write

Now that students have talked a bit about some new ideas they need some time to process and to ask questions. Have students draw and write about how and why the amount of daylight changes in Seattle (or their city).

1. What did they observe from the graphs?
2. What did they learn from the video?

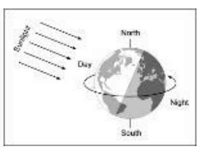
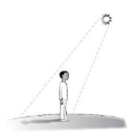
Resources students can use to help them: student recording sheet, class-created graph of daylight data from Seattle (or your city).

Public Record



Summary Table

3. **COORDINATION OF IDEAS – SUMMARY TABLE** (15 mins)
   a. **OBSERVATIONS**: Reconvene as a whole class and summarize what students observed from their month data and from the year data trends and patterns for Seattle (or their city).
   b. **LEARNING**: Use the information from the videos about the Earth's tilt, rotation, and revolution to possibly explain changes in daylight (Students may not be completely ready for this yet.) Record learnings in the learning column.
   c. **CONNECTION**: How can what we learned about this lesson help us explain a part of the phenomenon? Write some ideas in the summary table under "connection to phenomenon.

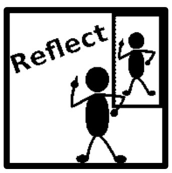
Activity	Observations & Patterns	What have we learned?	Connection to the phenomenon
Day and Night Cycles 	- As the globe rotates, the side facing the lamp is lit up and the other side is in darkness. - The lamp can't light up the globe at the same time, there is always a part in the dark.	- The earth spins or rotates on its axis once every 24 hours = 1 day - When it is daytime in Seattle, it is nighttime on the opposite side of the Earth (facing away from the Sun).	Daylight hours are measured between sunrise and sunset and this helps us understand that the Earth's 24 hour rotation causes day and night. (Possible student Q: But why isn't it just 12 hours day and 12 hours night? This question can be answered by subsequent activities particularly when students learn about the equinox and tilt.)
Moving Shadows 	The shadow moves in a circle. The length of shadow gets shorter from the morning to noon. The length of shadow gets longer from noon to the afternoon.	The shadow moves in a circle because the earth spins (the Sun does not move). The apparent motion of the sun means it appears to rise in the East and set in the West.	The movement of the shadows is some evidence that the earth is rotating to create day and night. The tracing of shadows might look different at different times of year because the sun is lower in the sky in winter and appears higher in the sky in summer (for northern hemisphere)
Sun Clocks & Earth's Rotation	Shadows on the Pocket Sun Clock move one way if we spin to the right and go the other way in a circle if we spin to the left	Objects blocking light create shadows. Shadows made by the Sun change in length and direction over time because the Earth is rotating.	The direction of shadow made by the Sun is evidence that the Earth must be spinning counterclockwise when looking down at the north pole (or spinning to the left if we are acting like the earth) such that New York gets sunlight before Seattle.
Annual Patterns in Daylight for Seattle	The longest days in Seattle in 2016 is June 16-24th with 15 hours 59 seconds of daylight. The shortest days in Seattle in 2016 will be December 19th-22nd with 8 hours 25 minutes of daylight. The month with the highest number of hours of daylight is June. The least is December.	1 day = 24 hours 1 day = 1 rotation/spin 1 day = day + night 1 year = 1 revolution around Sun 1 year = 365 days 1 year = 4 seasons Daylight increased from January to June Daylight decreased from June to December.	There are 2 key days (solstices) during the year that correspond to places in Earth's orbit around the Sun that signal increasing or decreasing amounts of daylight. The amount of daylight hours change in a predicable increasing or decreasing pattern around the solstices and equinoxes as the Earth orbits the Sun

EXAMINING STUDENT WORK

Take about 15 minutes go through students' notebook entries and what you heard from partner discussions and fill out either the RSST or the WHY (or both) to help you identify which key ideas students are already thinking about and places they need to support ongoing changes in their thinking.

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons.

Keep a record of these reflections for your professional portfolio.

1. **TASK, TALK, & TOOLS.**

Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

The task of creating graphs of daylight and analyzing data helped students to/with....
The task about _____ relates to students' interests, experiences, or lives because…

Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

The students talked to each other during (name particular parts of lesson) which allowed students to...
During turn-and-talks, I observed _____ which makes me wonder if/how…

Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students in communicating and capturing their ideas/thinking?

The summary table allowed students to...

Overall, reflecting on task, talk, and tools together:

Talk, task, and tools supported students to share their thinking because...
Overall, this combination of talk, task and tools, allowed most/all students to...

____

____

____

____

____

____

____

____

____

____

2. **EQUITY**.

   Name and describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue. Here are some categories to help you name a specific issue of equity:
   - Developing relationships & forming an inclusive, trusting community
   - Scaffolding for full participation in the culture and language of science
   - Recognizing our own and others' worldviews & developing critical consciousness about our own assumptions and beliefs
   - Addressing power dynamics (how a person is seen and responded to by others) to disrupt stereotypes and privilege

____

____

____

____

____

____

PLANNING NEXT STEPS

1. Use your analysis of student work (RSST or WHY) to decide what lesson should come next. Look at the unit overview as a whole and decide if the next lesson makes sense based on students' current thinking or if another lesson needs to be moved up or added in to better meet and move the current understanding of students forward.

   Once you decide on the next lesson…

2. Apply your lesson reflection (3Ts and Equity) to make changes to the upcoming lesson's guide to address the issue of equity you identified as well as to better support your students to engage fully in the task, talk, and tools in the lesson guide.

Duration of Daylight for One Year - Seattle, WA 2016

Retrieved from http://aa.usno.navy.mil/data/docs/Dur_OneYear.php

Directions:

1. For your month, find the day of the month with the least amount of daylight for that month.
2. Graph that amount on the graph strip on the left bar named “Most Daylight.”
3. For your month, find the day of the month with the most amount of daylight for that month.
4. Graph that amount on the graph strip on the right bar named “Least Daylight.”
5. Cut along the dotted line. As a class, tape these strips together to make a year-long graph of the daylight in your city.

```
              o  ,    o  ,
Location: W122 20, N47 38
```

SEATTLE, WASHINGTON
Pacific Standard Time

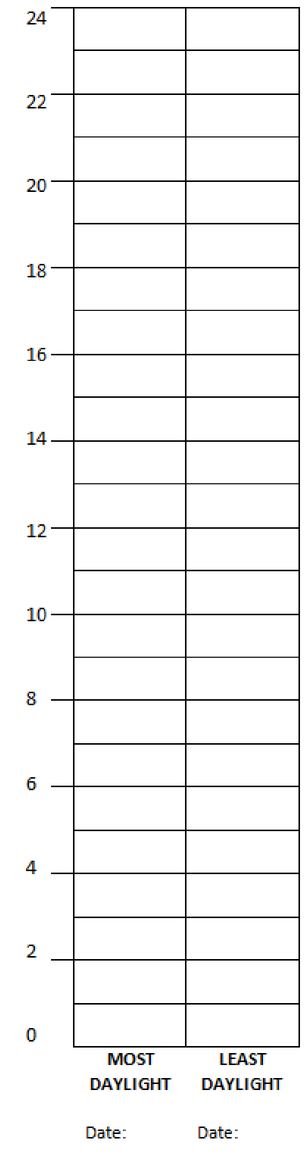
Astronomical Applications Dept.
U. S. Naval Observatory
Washington, DC 20392-5420

Duration of Daylight for 2016

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
01	08:30	09:34	11:06	12:53	14:31	15:45	15:54	14:55	13:20	11:38	09:56	08:42
02	08:31	09:36	11:10	12:57	14:34	15:46	15:54	14:53	13:17	11:35	09:53	08:41
03	08:33	09:39	11:13	13:00	14:37	15:47	15:52	14:50	13:13	11:31	09:50	08:39
04	08:34	09:42	11:17	13:04	14:40	15:49	15:51	14:47	13:10	11:28	09:47	08:38
05	08:35	09:45	11:20	13:07	14:43	15:50	15:50	14:44	13:06	11:25	09:44	08:36
06	08:36	09:48	11:24	13:10	14:46	15:51	15:49	14:41	13:03	11:21	09:41	08:35
07	08:38	09:51	11:27	13:14	14:49	15:52	15:48	14:38	13:00	11:18	09:39	08:34
08	08:39	09:54	11:30	13:17	14:51	15:53	15:46	14:36	12:56	11:14	09:36	08:32
09	08:41	09:57	11:34	13:21	14:54	15:54	15:45	14:33	12:53	11:11	09:33	08:31
10	08:42	10:01	11:37	13:24	14:57	15:55	15:43	14:30	12:50	11:08	09:30	08:30
11	08:44	10:04	11:41	13:27	15:00	15:56	15:42	14:27	12:46	11:04	09:27	08:29
12	08:46	10:07	11:44	13:31	15:02	15:57	15:40	14:24	12:43	11:01	09:25	08:29
13	08:48	10:10	11:48	13:34	15:05	15:57	15:38	14:21	12:39	10:58	09:22	08:28
14	08:50	10:13	11:51	13:37	15:07	15:58	15:37	14:18	12:36	10:54	09:19	08:27
15	08:52	10:16	11:55	13:41	15:10	15:58	15:35	14:15	12:33	10:51	09:17	08:27
16	08:54	10:20	11:58	13:44	15:12	15:59	15:33	14:11	12:29	10:48	09:14	08:26
17	08:56	10:23	12:02	13:47	15:15	15:59	15:31	14:08	12:26	10:44	09:12	08:26
18	08:58	10:26	12:05	13:50	15:17	15:59	15:29	14:05	12:22	10:41	09:09	08:26
19	09:00	10:30	12:09	13:54	15:20	15:59	15:27	14:02	12:19	10:38	09:07	08:25
20	09:02	10:33	12:12	13:57	15:22	15:59	15:25	13:59	12:16	10:34	09:04	08:25
21	09:05	10:36	12:15	14:00	15:24	15:59	15:22	13:56	12:12	10:31	09:02	08:25
22	09:07	10:39	12:19	14:03	15:26	15:59	15:20	13:53	12:09	10:28	09:00	08:25
23	09:09	10:43	12:22	14:06	15:28	15:59	15:18	13:49	12:05	10:25	08:58	08:26
24	09:12	10:46	12:26	14:10	15:30	15:59	15:16	13:46	12:02	10:21	08:55	08:26
25	09:15	10:50	12:29	14:13	15:32	15:58	15:13	13:43	11:59	10:18	08:53	08:26
26	09:17	10:53	12:33	14:16	15:34	15:58	15:11	13:40	11:55	10:15	08:51	08:27
27	09:20	10:56	12:36	14:19	15:36	15:57	15:08	13:36	11:52	10:12	08:49	08:27
28	09:22	11:00	12:40	14:22	15:38	15:57	15:06	13:33	11:48	10:09	08:47	08:28
29	09:25	11:03	12:43	14:25	15:40	15:56	15:03	13:30	11:45	10:06	08:46	08:29
30	09:28		12:47	14:28	15:41	15:55	15:01	13:26	11:42	10:03	08:44	08:29
31	09:31		12:50		15:43		14:58	13:23		09:59		08:30

Graph of Most & Least Daylight
In Seattle for the month of:

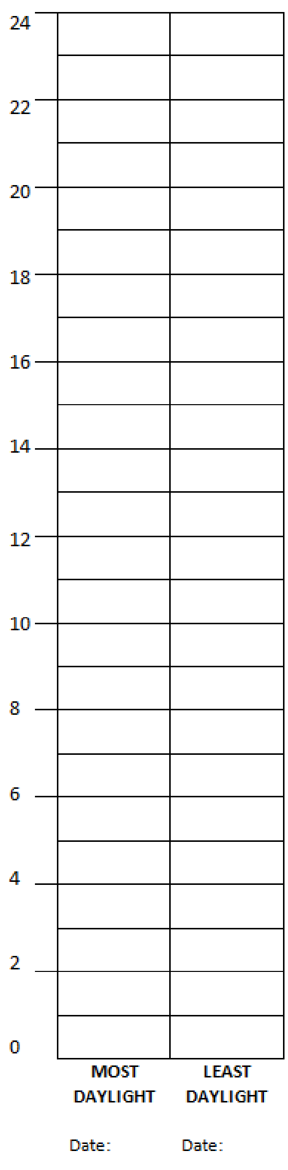
____



Use the website http://aa.usno.navy.mil/data/docs/Dur_OneYear.php to download data tables that match your city and year (or a city or year of interest. Then copy the graph strips below, cut apart, and hand each partnership the data sheet from a city with one month highlighted and one graph strip (below). Students will graph the day with the least and most daylight hours on their graph strip and then build a year-long graph as a class.

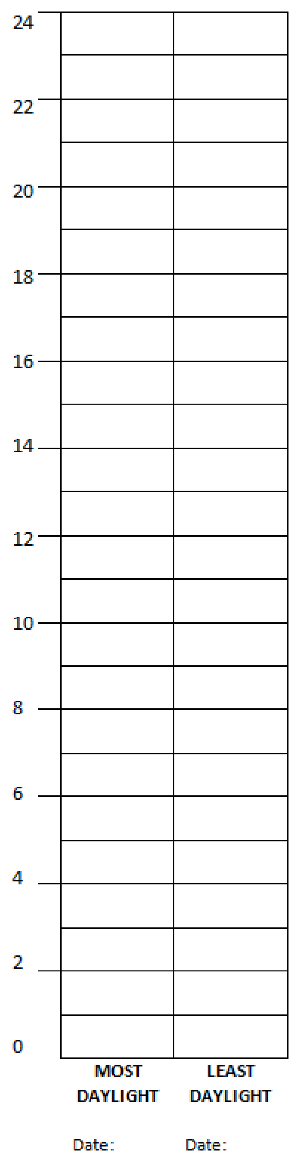
Graph of Most & Least Daylight
In Seattle for the month of:

____



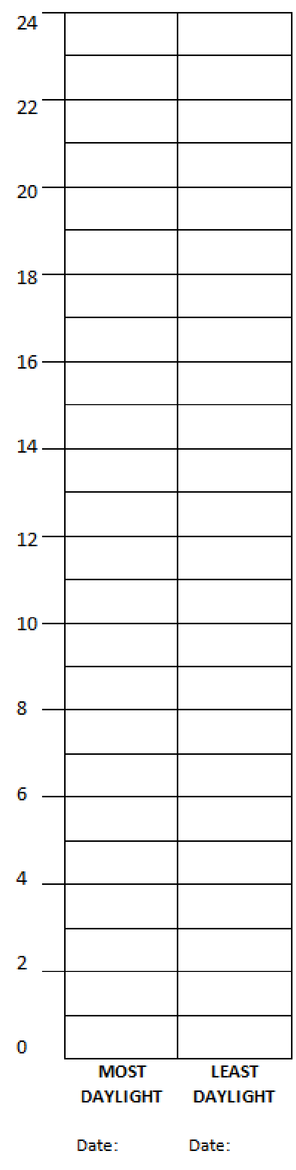
Graph of Most & Least Daylight
In Seattle for the month of:

____



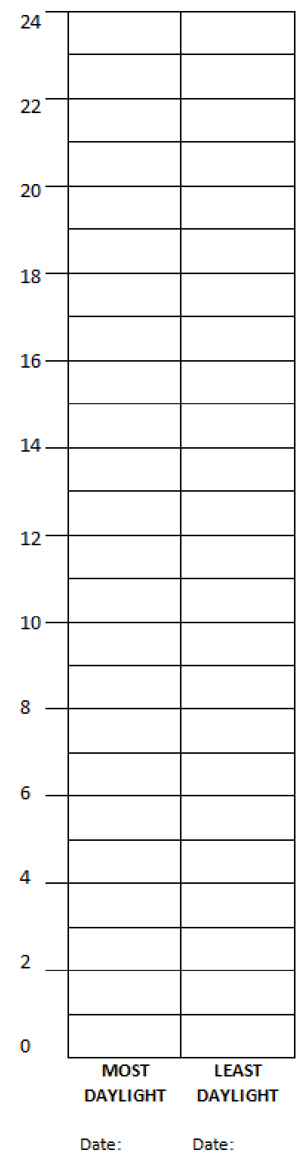
Graph of Most & Least Daylight
In Seattle for the month of:

____



Graph of Most & Least Daylight
In Seattle for the month of:

____



Name: ____________________________________ Date: _______________

Question: When does Seattle have the most and least daylight?

Partner Questions: *Use the data table to answer these questions for your month of data.*

1.) What month did you analyze? Name of month: ___________________

2.) Which date in the month had the shortest daylight? _______________

3.) From the first day of the month to the last day of the month, was the amount of daylight **increasing**, **decreasing**, or **staying the same**? _______________________

BONUS: What is the **average** amount of daylight per day in the month?___ hr ___min

Whole Class Questions: *Use the graphs and knowledge of each month (from partners) to answer these questions.*

4.) Which date has the **longest** hours of daylight?

Month: ________ Day: _____ How much daylight? ____ hours ____ min

5.) Which date has the **shortest** hours of daylight?

Month: ________ Day: _____ How much daylight? ____ hours ____ min

6.) What is the length of daylight time on the following dates?

June 21, 2013 ______ hours _____ mins Sept 22, 2013 ______ hours _____ mins

Dec 21, 2013 ______ hours _____ mins March 20, 2014 ______ hours _____ mins

7.) For each season, what is the trend in the amount of daylight? (Circle one.)

Winter (Dec 21 – Mar 19)	increasing	decreasing	same
Spring (Mar 20 – June 20)	increasing	decreasing	same
Summer (June 21 – Sept 21)	increasing	decreasing	same
Fall (Sept 22 – Dec 20)	increasing	decreasing	same

<u>On your own:</u>

8.) How does this data about daylight hours help us answer the question:

When does Seattle have the most and least daylight?

____

____

____

9.) What is the connection between this data and our unit question about waiting for the bus in the morning in December or April?

____

____

____

Lesson 6: Direct and Indirect Light

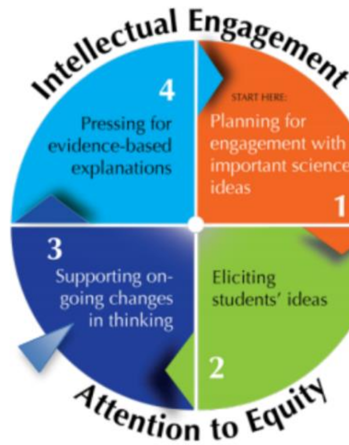
OBJECTIVES & OVERVIEW

In this lesson students build on their understanding about daylight by applying their knowledge about the Earth's tilt and what they observe in the data they collect in this lesson to support an argument that the Sun appears brighter in summer in Seattle (Northern Hemisphere) than in winter because of how the Earth's tilt and orbit around the Sun accounts for direct and indirect sunlight hitting Earth.

Focus Question: In Seattle, why does the Sun seem brighter in the summer that the winter?

- Students will observe the difference in intensity and surface area of a direct light and an indirect light source on a surface by doing a simulation.
- Students will support an argument about the apparent brightness of our star, the Sun.

Ambitious Science Teaching Framework:
SUPPORTING ON-GOING CHANGES IN STUDENT THINKING



This practice supports on-going changes in student thinking by (1) introducing ideas to reason with, (2) engaging with data or observations, and (3) using knowledge to revise models or explanations. For more visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Standards Note: Lesson 6 and lesson 8 of this unit target this performance expectation. In this lesson, lesson 6, students are more focused on identifying a pattern or relationship between the Earth's tilt and the directness and apparent brightness of the sun (CC: Patterns) than strictly on the scale of the distance/size between the Sun and Earth (CC: Scale, Proportion, and Quantity). Lesson 8 focuses more on scale.

5-ESS1-1. Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from the Earth. [Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, stage).]

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CC)
Engaging in Argument from Evidence - *Support an argument with evidence, data, or a model. (5-ESS1-1)* *Engaging in argument from evidence in 3–5 builds on K–2 experiences and progresses to critiquing the scientific explanations or solutions proposed by peers by citing relevant evidence about the natural and designed world(s).*	***ESS1.A: The Universe and its Stars-*** *The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1)* *** **ESS1.B: Earth and the Solar System*** *The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)* *** This DCI ESS1.B, though not part of the PE as written in NGSS, has been added to this lesson because students will be utilizing this knowledge to construct their argument about scale and quantity.*	***Scale, Proportion, and Quantity-*** *Natural objects exist from the very small to the immensely large. (5-ESS1-1)*

MATERIALS

Materials for the class:

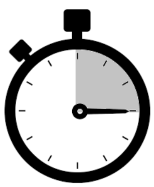
- Lamp & Globe
- Summary table & markers
- Video links –
  Earth's rotation: http://goo.gl/ziY1TW
  Earth's revolution: http://goo.gl/ObSdhy
- Optional: Read aloud book from lesson 2 featuring the Earth's rotation and axis.

Materials per group:

- 2 sheets graph paper
- 1 marker
- Flashlight
- Hard surface (like whiteboard or clipboard)
- Light meter (strips of folded paper)
- Group directions
- Group role cards handout

PREPARATION

Approximately 15 minutes

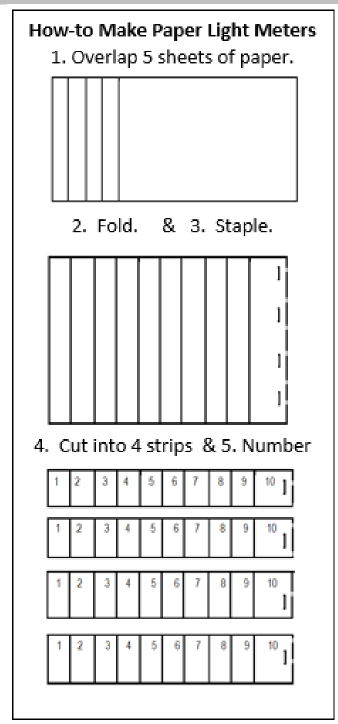


Make one light meter for each group by using folded copy paper as shown here:

1.) Overlap 5 sheets of white paper and spread them out with about ¾ inch.
2.) Fold the papers to make 10 areas.
3.) Staple near fold in 4 places.
4.) Use a paper cutter to cut into 4 strips.
5.) Number each layer (1 = 1 layer of paper; 2 = 2 layers of paper, etc.)

How to use the light meter:

1.) Hold meter in front of a light source.
2.) Look to see which layer the light can still be seen through such at that the next layer completely blocks the light (i.e. if there is light shining barely through 5 but no light at 6, then the rating is a "5")
3.) This provides a quantified rating of the intensity of light which is helpful in this activity when comparing intensity of direct beams of light and indirect light.



PROCEDURE

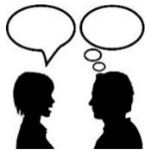
Earth's Tilt Affects Intensity of Light

Approximate time 60 minutes

1. **ORIENT STUDENTS TO THE CONCEPTS USING STUDENT IDEAS, EXPERIENCES, OR QUESTIONS (WHOLE GROUP) –** (5 minutes)

   a. Connect with students' ideas', questions, or prior observations. One possible option: *Review relevant observations about the phenomenon* (students' observations from Lesson 1) that focus on the descriptions of the light in each solstice. They may have observed that in the summer (Northern Hemisphere) the sun appears to be brighter, warmer (more direct), and higher in the sky. In the winter, the sun seems dimmer or less bright, not as warm (as direct), and lower in the sky.

Turn-and-Talk



Why do you think the Sun seems brighter in the summer than winter? Does the Sun change? Does the Earth change?

b. Turn-and-talk: Do you think the Sun changes? Do you think the Earth changes? ***Why does the Sun seem brighter in the summer that the winter?*** Share out a few hypotheses and listen for how students use ideas about tilt, rotation, and revolution. (Students may also mention weather and clouds, which is a pattern that typically occurs in winter – this may be worth pursuing a bit to see if clouds actually change how bright the sun is or just how bright it looks to us because it's partially blocked.)

c. Introduce today's question: **Why does the Sun seem brighter in the summer than the winter?** How does the intensity (brightness) of the sunlight vary by location on the globe? Today students will be measuring the brightness of direct and indirect light as well as the surface area of the light.

d. Remind students of some key points about the Earth's position and motion that they have learned so far:
   - Earth is tilted on its axis.
   - Earth rotates once every 24 hours to give us day and night
   - Earth revolves or orbits around the sun once a year as we go through the seasons.

   Use the read aloud pages from lesson 2 and/or the video clips from lesson 5 to review this information:

   Earth's rotation: http://goo.gl/ziY1TW

   Earth's revolution: http://goo.gl/ObSdhy

Just-in-Time Instruction

2. JUST-IN-TIME-INSTRUCTION: The intensity of light (10 minutes)

a. Tell students that the Sun, the star of our Solar System, does not actually change in brightness, it stays the same brightness. But what we perceive or observe changes. Today we will try to figure out why sometimes the Sun seems to be weaker or dimmer (less intense) and why other times it appears brighter and more direct (more intense).

b. Introduce some helpful terms for communicating about light.

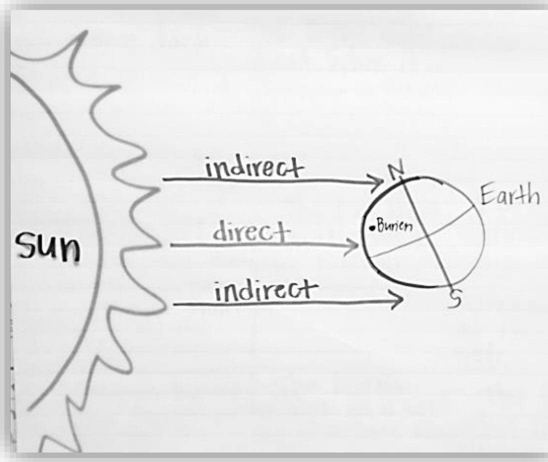
   i. **Direct light** – Light that hits an object directly, head on.

   ii. **Indirect light** – Light that hits an object at an angle. Indirect light happens on Earth at sunrise and sunset when the angled light casts long shadows and is more direct at noon. This is a daily pattern (comparing sunrise, noon, and sunset). There is also an annual pattern which we will learn more about today.

   iii. **Brightness or intensity** – A super bright light could be described as being more intense than a dimmer, softer light.

c. Describe the terms direct and indirect by using the globe and the lamp. Show that lamp light hits the area around the equator more directly than it does near the poles. Tell students that they will now make some observations about direct and indirect light.

A chart like this one reminds students about the terms direct and indirect light and what this looks like in our Sun-Earth model (terms in context).

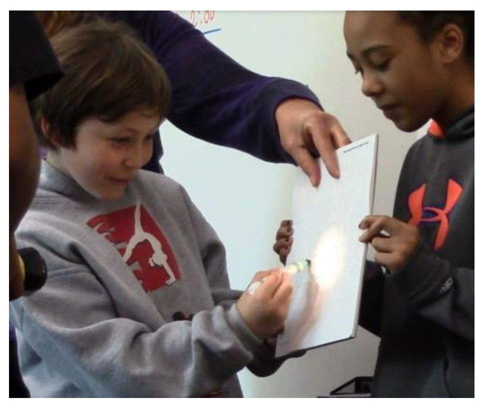


3. GETTING STUDENTS STARTED – MAKING OBSERVATIONS (SMALL GROUPS) (20 mins)

NOTE: This is written for small groups; however, it can be done as a whole class demonstration if needed.

a. Demonstrate the investigation set up and explain group roles before sending groups to work. Follow directions on group directions card.

b. Collecting data (group task): Students each have a role (see role cards) to collect data about direct and indirect light. They will be tracking the shape of the circle of the beam of light and how many squares on the graph paper (area) that light covers. Pass out materials and students sheets and have students get started.



Each group needs a copy of the directions (see Group Directions). Student 4 in the group reads each step before the group does it (go step by step). Also, each student in the group of 4 has a different job and a data table on a ½ sheet. Student 1’s looks like (see top of next page):

Student 1 – Light beam tracer

Job: You trace around the beam of light where it hits the paper. You need a marker.

Your question: How did the shape of the beam of light change comparing direct and indirect light?

____

____

____

____

____

Data Table: Observing Direct and Indirect Light

	Direct Light	**Indirect Light**
Name the shape of the traced area (i.e. circle, oval, square, etc.)		
Area (# of squares)		
Brightness (light meter) 1-2 = really dim 3-4= dim 5-6= bright 7-8 = really bright 9-10 = super bright		

Back-Pocket Questions

Back pocket questions: Check in first to clarify any procedure questions students have and then circulate ask students some of the following:

OBSERVATIONS

- What do you notice about the shape of each beam, comparing direct and indirect light? *Possible response: The shape of the direct light is a circle and the indirect light is an oval. Indirect light takes up more area but isn't as bright.*

- Using the light meter, what was the intensity or brightness of each observation? *Possible response: the direct light is brighter, like a 6-8 on the meter but the indirect light is weaker/dimmer, like a 3-4.*

HYPOTHESES

- Why do you think the beams of light hitting the graph paper look different even though the flashlight itself did not move?

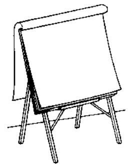
- Why do you think the indirect light has a more spread out shape?

Quick Write

4. QUICK WRITE - (INDEPENDENT) (5 mins)

Give students time to answer the question on their ½ sheet under their job. Each student in the group has a slightly different question. These questions can help facilitate the summary table discussion. End with turn-and-talk about their question in partners or with their table group

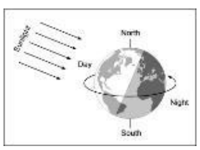
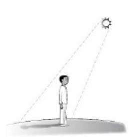
Public Record



Summary Table

5. WHOLE CLASS COORDINATION OF IDEAS – SUMMARY TABLE
(15-20 mins) *Use quick write and students' data tables as a starting point for a summary table discussion.*

a. **OBSERVATIONS**: Reconvene as a whole class and summarize what students observed from direct and indirect data collection (students cite data from data tables). If there are any major discrepancies in the data. Quickly redo as a whole class to troubleshoot and figure out why results varied.
b. **LEARNING**: Use the information about Earth's tilt to think about how or why light would sometimes be direct and sometimes indirect for a given city. Record learnings in the learning column.
c. **CONNECTION**: How can what we learned about this lesson help us explain a part of the phenomenon? Write some ideas in the summary table under "connection to phenomenon.

Activity	Observations & Patterns	What have we learned?	Connection to the phenomenon
Day and Night Cycles 	- As the globe rotates, the side facing the lamp is lit up and the other side is in darkness. - The lamp can't light up the globe at the same time, there is always a part in the dark.	- The earth spins or rotates on its axis once every 24 hours = 1 day - When it is daytime in Seattle, it is nighttime on the opposite side of the Earth (facing away from the Sun).	Daylight hours are measured between sunrise and sunset and this helps us understand that the Earth's 24 hour rotation causes day and night. (Possible student Q: But why isn't it just 12 hours day and 12 hours night? This question can be answered by subsequent activities particularly when students learn about the equinox and tilt.)
Moving Shadows 	The shadow moves in a circle. The length of shadow gets shorter from the morning to noon. The length of shadow gets longer from noon to the afternoon.	The shadow moves in a circle because the earth spins (the Sun does not move). The apparent motion of the sun means it appears to rise in the East and set in the West.	The movement of the shadows is some evidence that the earth is rotating to create day and night. The tracing of shadows might look different at different times of year because the sun is lower in the sky in winter and appears higher in the sky in summer (for northern hemisphere)
Sun Clocks & Earth's Rotation	Shadows on the Pocket Sun Clock move one way if we spin to the right and go the other way in a circle if we spin to the left	Objects blocking light create shadows. Shadows made by the Sun change in length and direction over time because the Earth is rotating.	The direction of shadow made by the Sun is evidence that the Earth must be spinning counterclockwise when looking down at the north pole (or spinning to the left if we are acting like the earth) such that New York gets sunlight before Seattle.
Annual Patterns in Daylight for Seattle	The amount of daylight increased from January to June The amount of daylight decreased from June to December. The month with the highest number of hours of daylight is June. The least is December.	1 day = 24 hours 1 day = 1 rotation or spin on the Earth's axis 1 day = day + night 1 year = 1 revolution around the sun 1 year = 365 days 1 year = 4 seasons The amount of daylight hours change in a predicable increasing/decreasing pattern around the solstices and equinoxes as the Earth orbits the Sun	There are key dates during the year that correspond to places in Earth's orbit around the Sun that signal increasing or decreasing amounts of daylight.

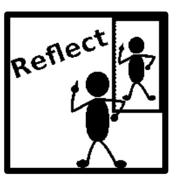
Direct and Indirect Light	Direct light: - Brightness 6-7 - Circle shape - Area of 56 squares Indirect light: - Brightness 3-4 - Spread out oval - Area of 78 squares	Direct sun hitting the earth is brighter and more concentrated than when light hits a tilted surface.	Because the earth is practically a sphere, it gets more and more tilted near the poles. This means the light is more spread out and not as direct. This helps explain why daylight near the poles is so extreme (extremely long in summer and short in winter)

EXAMINING STUDENT WORK

Take about 15 minutes go through students' ½ sheet taped in their notebook and what you heard from partner and whole-class discussions and fill out either the RSST or the WHY (or both) to help you identify which key ideas students are already thinking about and places they need to support ongoing changes in their thinking.

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons.

Keep a record of these reflections for your professional portfolio.

1. **TASK, TALK, & TOOLS.**

Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

The task of observing direct and indirect light (using the globe-lamp and/or flashlight-graph paper) helped students to/with....
The task about _____ relates to students' interests, experiences, or lives because…

Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

The students talked to each other during (name particular parts of lesson) which allowed students to...
During turn-and-talks, I observed _____ which makes me wonder if/how…

Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students in communicating and capturing their ideas/thinking?

The summary table allowed students to...

Overall, reflecting on task, talk, and tools together:

Talk, task, and tools supported students to share their thinking because...
Overall, this combination of talk, task and tools, allowed most/all students to...

2. **EQUITY**.

   Name and describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue. Here are some categories to help you name a specific issue of equity:
   - Developing relationships & forming an inclusive, trusting community
   - Scaffolding for full participation in the culture and language of science
   - Recognizing our own and others' worldviews & developing critical consciousness about our own assumptions and beliefs
   - Addressing power dynamics (how a person is seen and responded to by others) to disrupt stereotypes and privilege

PLANNING NEXT STEPS

1. Use your analysis of student work (RSST or WHY) to decide what lesson should come next. Look at the unit overview as a whole and decide if the next lesson makes sense based on students' current thinking or if another lesson needs to be changed or added in to better meet and move the current understanding of students forward.

   Once you decide on the next lesson…

2. Apply your lesson reflection (3Ts and Equity) to make changes to the upcoming lesson's guide to address the issue of equity you identified as well as to better support your students to engage fully in the task, talk, and tools in the lesson guide.

GROUP DIRECTIONS

Gathering data on direct and indirect light

Collect data about direct light:

1. **Student 3:** Hold graph paper to a hard surface perpendicular to the table.
2. **Student 2**: Aim flashlight directly at the whiteboard. Turn on light. Don't move!
3. **Student 1**: Trace the light on the paper.
4. **Student 3**: Count the area (squares) for the direct beam of light. Write the area on the graph paper.
5. **Student 3**: Hold graph paper still as student 4 removes the hard surface. Keep graph paper steady so beam of light lines up with traced area.
6. **Student 4**: Look through the light meter at the back of the graph paper to measure the intensity of the beam of direct light.

Collect data about indirect light:

7. **Student 3**: Recline the whiteboard, so the graph paper is tilted back at an angle.
8. **Student 2**: The flashlight should still be in the same position as it was originally. Don't move!
9. **Student 1**: Trace the light on the paper.
10. **Student 3**: Count the area (squares) for the indirect beam of light. Write the area on the graph paper.
11. **Student 3**: Hold graph paper still as student 4 removes the hard surface. Keep graph paper steady so beam of light lines up with traced area.
12. **Student 4**: Look through the light meter at the back of the graph paper to measure the intensity of the beam of direct light.
13. **Student 2**: Turn off flashlight.

All students: Work on answering the question on your ½ page.

Student 1 – Light beam tracer

Job: You trace around the beam of light where it hits the paper. You need a marker.

Your question: How did the shape of the beam of light change comparing direct and indirect light?

____

____

____

____

____

Data Table: Observing Direct and Indirect Light

	Direct Light	**Indirect Light**
Name the shape of the traced area (i.e. circle, oval, square, etc.)		
Area (# of squares)		
Brightness (light meter) 1-2 = really dim 3-4= dim 5-6= bright 7-8 = really bright 9-10 = super bright		

Student 2 – Light holder

Job: You hold the flashlight steady. Do not move! Please turn off the flashlight when you are finished.

Your question: The flashlight didn't move. Why did the shape of the light hitting the paper change?

____

____

____

____

____

Data Table: Observing Direct and Indirect Light

	Direct Light	**Indirect Light**
Name the shape of the traced area (i.e. circle, oval, square, etc.)		
Area (# of squares)		
Brightness (light meter) 1-2 = really dim 3-4= dim 5-6= bright 7-8 = really bright 9-10 = super bright		

Student 3 – Hold board &
Count squares

Job: Hold the graph paper on the hard surface. After the light is traced, count the area (squares) inside the shape. Write area on paper.

Your question: Which beam of light has a larger area? Why?

____

____

____

____

____

Data Table: Observing Direct and Indirect Light

	Direct Light	**Indirect Light**
Name the shape of the traced area (i.e. circle, oval, square, etc.)		
Area (# of squares)		
Brightness (light meter) 1-2 = really dim 3-4= dim 5-6= bright 7-8 = really bright 9-10 = super bright		

Student 4 – Directions Reader &
Light meter reader

Job: Read directions out loud before each step. Measure brightness using the light meter. Record brightness on graph paper.

Your Question: Which beam of light, direct or indirect, appeared brighter? Why?

____

____

____

____

____

Data Table: Observing Direct and Indirect Light

	Direct Light	**Indirect Light**
Name the shape of the traced area (i.e. circle, oval, square, etc.)		
Area (# of squares)		
Brightness (light meter) 1-2 = really dim 3-4= dim 5-6= bright 7-8 = really bright 9-10 = super bright		

Lesson 7: Daylight Hour Data & Mystery City Locations

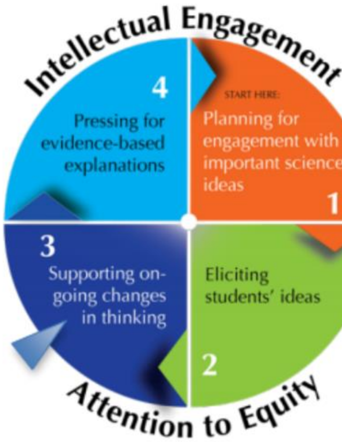
OBJECTIVES & OVERVIEW

This lesson provides an opportunity for students to apply their knowledge of the Earth's tilt, rotation and revolution to construct an argument for the location of a mystery city using that city's annual daylight data.

Focus Question: How can we use patterns in annual daylight data to figure out the location of cities on the Earth?

- Students use data to create graphs and identify patterns and trends in these graphs of daylight hour data from around the world.
- Students construct an argument about the location of mystery cities using patterns in data and their knowledge of the Earth's tilt, rotation, and revolution.

Ambitious Science Teaching Framework:
SUPPORTING ON-GOING CHANGES IN STUDENT THINKING



This practice supports on-going changes in student thinking by (1) introducing ideas to reason with, (2) engaging with data or observations, and (3) using knowledge to revise models or explanations. For more visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Standards note: This lesson has students represent data in graphical displays to reveal pattern of annual changes and seasonal patterns in the amount of daylight for cities all over the world. Then students construct an argument to defend their claim about the location of that city based on their knowledge of Earth's tilt, rotation, and revolution.

PE *5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.* *[Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [Assessment Boundary: Assessment does not include causes of seasons.]*

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CC)
Analyzing and Interpreting Data - *Represent data in graphical displays (bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.* *** Additional SEP for this lesson, used in combination with above:* ***Engaging in Argument from Evidence*** *- Support an argument with evidence, data, or a model. (5-ESS1-1)*	***ESS1.B: Earth and the Solar System*** *The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.*	***Patterns -*** *Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.*

MATERIALS

Part I

For the class:
- Sticky notes
- Large world map with identified cities
- Video clip: Seasons http://bit.ly/1U64AKE

Per 3 students:
- 3 graph templates
- 3 markers
- 3 mystery city data tables (for the same city)

Part II

For the class:
- Copies of Hemispheres and Seasons reading
- Chart paper
- Globe & lamp, dot stickers

Per 3 students:
- Styrofoam ball & flashlight
- Graph per student from Part I
- 1 whiteboard & 1 dry erase marker
- Group discussion checklist
- Discussion prompts (optional)

Part III

For the class:
- Large world map with identified cities
- Globe & lamp
- Student-created graphs from Part I
- Seasons diagram with video notes from Part II

PREPARATION

Approximately 30 minutes

Name/Label these places using sticky notes on your large world map prior to class:
- Miami, Florida
- Brisbane, Australia
- Nairobi, Kenya
- Punta Arenas, Chile
- Nome, Alaska
- Singapore
- Cape Town, South Africa
- Seattle, Washington
- Vostok, Antarctica

Copy the data table sheet and cut apart mystery city data tables so each student gets a data table.

Highlight a different city on each data table. You need 3-4 copies of each city's data table, except for H. Save H as teacher demonstration city.

Also copy temperature data tables for use in Part II.

TEACHER DECISION POINT

Strategic Student Groupings & Scaffolds

Identifying mystery cities from daylight data is no easy task. Students must pull together multiple experiences and learnings from prior lessons to make decisions and construct their arguments. Use what you know about your students strengths, needs, and goals to create pairs. Then consider which mystery cities to assign each pair (Note: Save city Has a demonstration city, not students are working on H.)

For example, cities E and I are easy-to-medium difficulty because these are most extreme changes in daylight (these cities are closest to the poles). These cities may be good to assign to students who had questions or have talked about how some cities could have 24 hours of night or 24 hours of day in prior lessons. If assigning particular cities, jot student names on the data tables before passing them out so specific students get particular cities.

Also, read over parts I, II, and III before starting the lesson. There are some scaffolds built into the lesson that you may want to have all students use or make them optional. You may also wish to make changes to the lesson that you think will better support your students in reasoning through this task.

PROCEDURE — **Part I. Representing and Interpreting Daylight Data**
Approximate time 45 minutes

Investigating Data

Observations & Patterns in Data Representations

1.) **ORIENT STUDENTS TO THE CONCEPTS USING STUDENT IDEAS, EXPERIENCES, OR QUESTIONS (WHOLE GROUP) –** (10 minutes)

a. Explain to students that today we will be applying what we've learned so far about intensity of light from the sun and what we know about the Earth's movement to figure the location of a mystery city is based on annual daylight data. Let's first review what we know about annual daylight patterns in Seattle.

b. Show students the graph from lesson 5 for monthly daylight in Seattle, Washington. Ask students to turn and talk about: *How does the amount of daylight change over the year in Seattle?*

Turn-and-Talk

How does the amount of daylight change over the year in Seattle?

c. Identify where Seattle is on the large, labeled world map:

What are the general patterns/trends in daylight by months?
Is it in the northern or southern hemisphere? (use globe)
Is it near one of the poles or closer to the equator? (use globe)

Summarize notes on the board, it could look like this:

Seattle, WA
Daylight increases ↑from January to June
Daylight decreases ↓ from June to December
Northern hemisphere
Closer to the north pole than the equator

2. GET STUDENTS STARTED - MAKE OBSERVATIONS (10 mins)

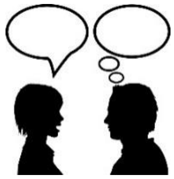
Tell students that they will be graphing daylight by month, like we did as a class for Seattle but for another city, a mystery city! Individually, students create bar graphs of the daylight in the mystery city highlighted on their data table.

Investigating Data

Representing and Interpreting Data

a. Pass out highlighted data tables, markers, and graph templates to all students. Have students use a marker to shade in bars using data for the highlighted city on the data table to make their graphs. *If students need a demonstration, use data from city H, and a blank graph to quickly shade bars for the first 2 or 3 months for city H under the document camera.*

Turn-and-Talk



What patterns to you notice in your mystery city's daylight graph?

b. Once students make graphs, students answer "Observations & Patterns" questions to the right of the graph. This prepares them for the turn-and-talk in the next step.

c. Students turn and talk with a partner to describe the observation and patterns they see, using their responses to the questions to the right of their graph. Students may or may not be sitting next to their mystery city partner. They can compare similarities and differences in the trends if they are sitting next to a student with a different city.

3. MAKING SENSE OF TRENDS ON THEIR GRAPHS – (15 mins)

a. Say something like: *To figure out where our mystery cities are located, we need to know about the daylight in different parts of the world. Let's review what we know about the Earth's tilt, rotation, and revolution and what that has to do with daylight by watching a video.*

b. Have students come to the carpet area to watch the video. On their way to the carpet area, quickly collect a sample of each city's (A-I) graph to display on the whiteboard ledge. This way students can see there are different daylight patterns.

c. Sketch the Sun and the orbit path of Earth on chart paper. Draw a tilted earth in 4 places at the solstices and equinox. You will take notes on this diagram as students share what they heard video say.

Video Clip

Four Seasons
2 min 51 sec
http://bit.ly/1U64AKE

d. Set the purpose for watching. Tell students: *You can see (point to graphs) that we have lots of different patterns in daylight data. We are trying to figure out where each of these cities are on Earth, So as you watch, listen for what it says about daylight in certain times of the year. We will pause a few times to take some notes together. Let's see if we can figure out if your mystery city is in the northern hemisphere or the southern hemisphere.* Play video http://safeshare.tv/v/M4sLcm9vapA

   a. Watch 0:47 to 1:12. Pause. Ask:
      What did the video say about the daylight in December?

   b. Watch from 1:12 to 1:43. Pause. Ask:
      What did the video say about daylight in March?

   c. Watch 1:44 to 2:12. Pause. Ask:
      What did the video say about daylight in June?

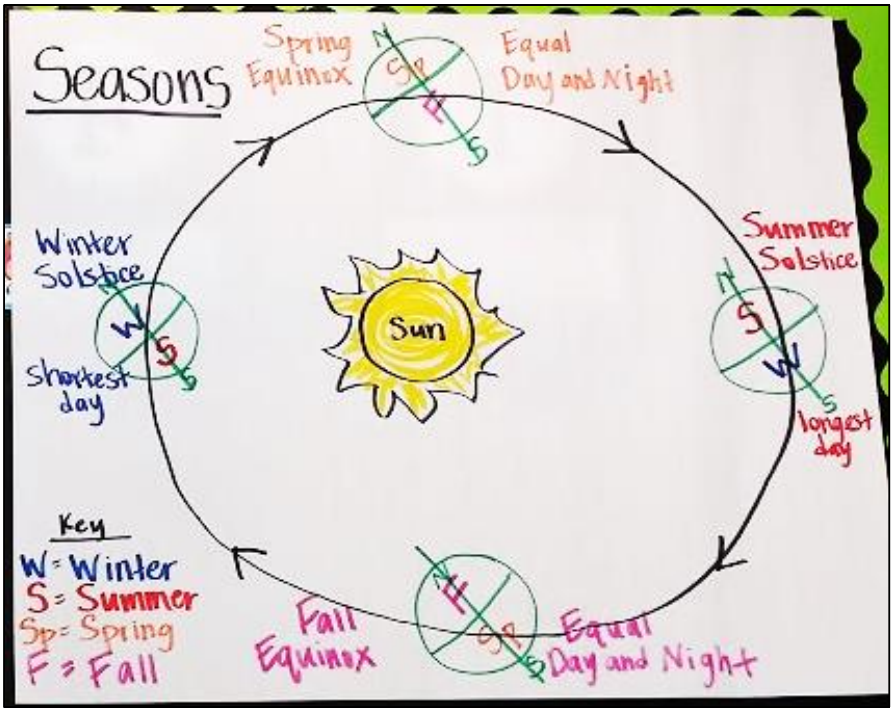
   d. Watch from 2:13 to 2:34. Pause. Ask:
      What did the video say about daylight in September?

   e. Turn-and-talk: *For a city in the southern hemisphere (point at chart drawing), what month or season of the year do you think would have the most daylight?*

Turn-and-Talk

For a city in the southern hemisphere, what month of the year do you think would have the most daylight?

Notes could look something like this maybe with a few more details from the video



Quick Write

Draw & write: In which hemisphere, northern or southern, do I think my mystery city located?

4. QUICK WRITE (INDEPENDENT) – (5 mins)

Send students back to their desks to look at their graphs. Ask: *Do you think your mystery city could be in the northern hemisphere or the southern hemisphere? Why do you think so? Use the sentence stems to help you get started.*

Have students do a quick write on the back of their graph sheet. They can draw a diagram to help explain their reasoning.

During the month of June, my city has ____ hours of daylight.
During the month of December, my city has ____ hours of daylight.

I think maybe my mystery city letter ____ could be in the ___________ hemisphere because…
OR
I'm not sure if my mystery city is in the northern or southern hemisphere because…

Part II. Reviewing Possible Evidence of City Locations
Approximate time 45 minutes

Independent Reading

Short article with diagram

1. **PATTERNS & CONNECTIONS (INDIVIDUALS) –** 10 mins

   a. Individually, students silently read the short reading titled "Seasons & Hemispheres." This reviews information they saw in the video in Part I. (This information is not new, so the majority of students can do this independently. Consider possible strategies to support those students who may need support.)

   b. Individually, students read over their quick write from Part I. Do they still agree with their own response? Give a few minutes to change and/or add more about whether or not their mystery city could be in the Northern or Southern Hemisphere.

   c. Whole class, have a 2 students share their thinking about their city and which hemisphere they think it could be in (Northern or Southern) and why they think so. They can put their work (quick write from Part I) under the doc cam to refer to it as they explain their thinking. *Note: If a debate starts now, ask students to hold that because they will have time for that conversation in just a minute with a group. But you can remind students of norms about how to do this respectfully.*

2. **CONNECTIONS, & CONCLUSIONS (SMALL GROUPS)** – 30 mins

   a. Tell students that they will now discuss their idea with other students who have the same mystery city to figure out where they think the city is. Refer to the world map labeled with the 9 cities from Part I to show that these are our choices for the mystery cities.

Talk Norms

Listen respectfully in order to respond and/or ask genuine questions

      i. Show students the group checklist so they know what they will be doing in their groups.

      ii. Remind students of talk norms to listen to each other and ask hard, genuine questions in a respectful way. Tell students that their thinking might change and that together they can make new conclusions so be open to changing your idea.

      iii. Remind students of the resources and evidence they can draw on (i.e. notes diagram on chart paper from the video in Part I, the reading from the opening of Part II, the summary table from the unit).

b. Have students collect their graphs, data table, reading, a pencil, and be ready to move. Say: "I need students with city A to bring your graph, data table, reading, and a pencil and sit together over here." Repeat for each city so students are in groups in their own space.

Small group discussion

Coming to a consensus: *Where is our mystery city located?*

c. As a group, students begin by sharing their quick write responses about whether they think their city is in the southern or northern hemispheres (all students in this pair or group are now looking at the same mystery city). Check in with each group and hand out the task checklist.

d. Circulate as students work in groups to see if most students agree with their group or disagree. On a group-by-group basis decide on what prompt or scaffold each group needs may to move forward in their reasoning about the mystery city. This can be done through questions (back-pocket questions) or additional scaffolding. Listen in on group conversation to decide on what you think would help support all students in that group to make progress on this task.

Possible Scaffolds (Provide, as needed, to each group.)

If students in the group are unsure how to get started or keep going:

- Redirect students to the checklist. Assign one student as group manager who is responsible for reading items on the checklist and checking them off as students do them.

To help reason about daylight, temperature, and seasons in northern and southern hemisphere:

- Provide a copy of the temperature data table for the mystery cities (provided in this lesson guide). Students can compare their personal experiences with temperature and seasons, what we know about Seattle and the temperature trend in this chart can help students figure out where their city might be.

To coordinate with evidence, remind students to use:

- Video notes on chart from Part I
- Reading from earlier this lesson
- Summary table from the unit

For language support:

- Provide sentence stem book marks (in this lesson guide) to groups who need additional language support and to keep the conversation going in productive directions.

Back-Pocket Questions

How teachers can use back-pocket Q's:

1. Approach group and listen in.
2. Decide what question to ask based on what you see/hear.
3. Ask the question and make sure all students contribute.
4. Prompt students to continue with a particular task or question.
5. Leave and go visit another group.

OBSERVATIONS/PATTERNS

- What patterns do you observe in the daylight for your mystery city over a year?
- How are the patterns of daylight for your mystery city similar or different than Seattle's daylight patterns? (Refer students to graph from lesson 5, used in Part I)

INFERENCES

- We have the most daylight in the summer around June (see Seattle graph). When do you think your city has summer?
- We have the least daylight in the winter around December (see Seattle graph). When do you think your city has winter?
- Do you think your mystery city is in the Northern or Southern Hemisphere? What makes you think that?

  If students start talking about warmer/colder when reasoning about seasons, it may be helpful to introduce them to the temperature data table.

- Direct students to the questions on the graph sheet. Do you think your city is closer to the equator or the poles? What makes you think that?

3. MAKE A DECISION – CLAIM YOUR CITY - (5 minutes)

a. In the last 5 minutes of class, have students in their group decide where they think their mystery city is. They may not be completely certain so they could claim 1 or 2 cities (i.e. they may have narrowed it down to 2 options but aren't sure which one). Tell students we will all worth together as a class to work through this as a class.

b. On the large, labeled world map, have students place 1 or 2 sticky notes with the letter of the city (or cities) they believe could fit their mystery city data. Some groups with different mystery city letters may claim the same city! This will be productive for the debate in Part III.

Part III. Arguing from Evidence

Approximate time 45 minutes

Preparing for this part of the lesson: Use what you observed from Part II to decide on which group you would like to present their claims first. You may start with what students seemed to think was the easiest city to figure out. Or perhaps start with a city that many groups claimed at the end of Part II.

1. SETTING THE PURPOSE FOR THE DISCUSSION – (5 mins)

a. *Physically orient students towards each other*: Bring students to the gathering area to sit on the carpet, or, if students would be more comfortable, safely bring their chairs up to the front to make a large oval so students can see and hear each other easily.

b. *Set the purpose of today's discussion:* Say something like: *Last class, you worked in groups to try to figure out which city on the map is your mystery city. Today we will come together as a class to see if we can figure this out together using evidence from activities, readings, and videos from this unit so far. This is really hard thinking and reasoning so remember our talk norms and to keep an open, flexible mind because our thinking can grow and change by talking with others.*

c. *Allow students to use talk norms and lead and manage the talk:* Remind students of talk norms and encourage them to call on each other and not look to the teacher. Pass out the discussion prompt handout (½ sheet) from Part II so students have some language supports to participate.

Whole-class discussion

Coming to consensus by engaging in argument from evidence

2. ENGAGING IN ARGUMENTS (WHOLE GROUP) – (35 mins)

NOTE: If the whole-class discussion is structured by having each group stand up and present their claims and evidence, this will likely result in students going into "presentation" mode — meaning very little back-and-forth questioning between students. Instead, have students stay seated (unless they want to get up to demonstrate using the globe and lamp or point to a graph or map) to share their thinking and question each other.

a. Have one group start off the discussion by stating their claim about which city they think is their mystery city and why they think so using data from the daylight graph and evidence from other sources. They can stand up to demonstrate using the globe and lamp or to point to maps or charts if needed.
   - *We picked __(insert city name here)__ for our mystery city because our daylight graph showed ….*
   - *The reading/video said that ___________ which made us think that this is our city because…*

Talk Norms

Remind students about talk norms as needed to make sure all students feel heard and respected.

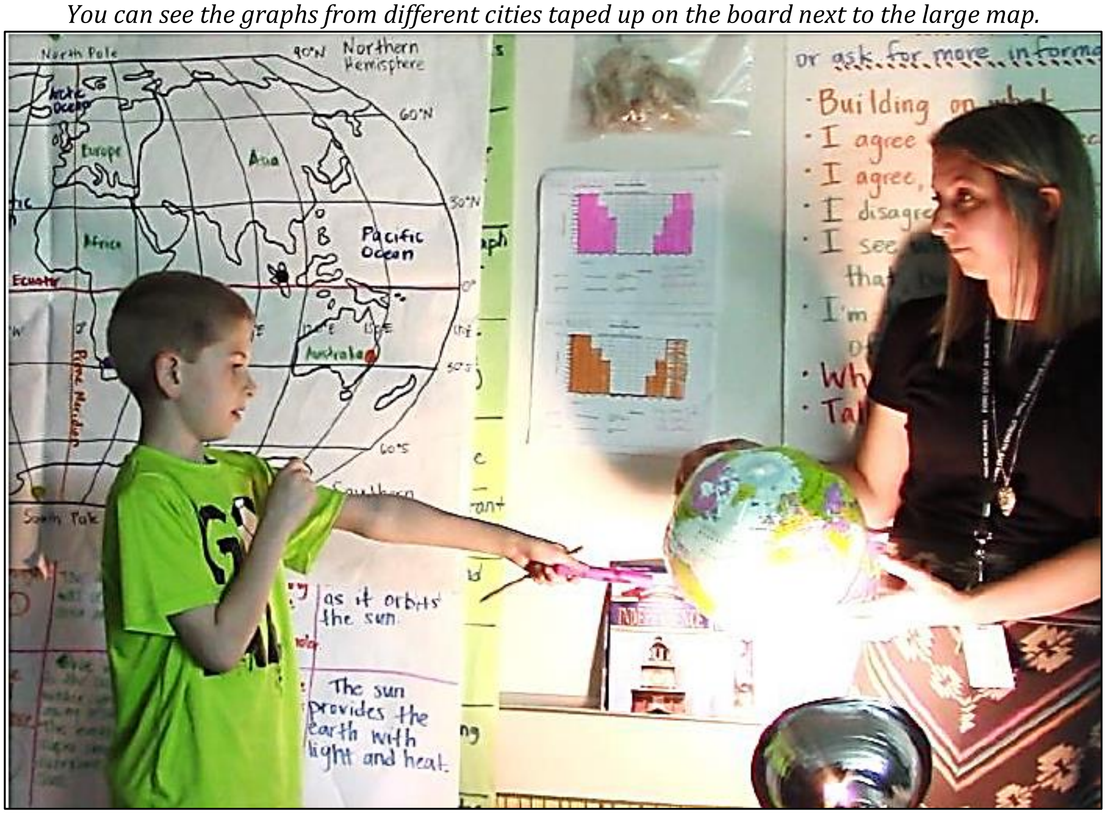
b. Let other groups enter the conversation and go back-and-forth using the discussion sentence stems on the ½ sheets. Manage the conversation as needed, but encourage students to call on each other.

c. Allow students to make changes in where the letters are on the map if they decide during the discussion that a letter should move to another city.

d. If students do not do so, prompt students to use the globe and lamp, evidence from readings/videos, or other charts around the room to help support their thinking.
   - *What makes you think that?*
   - *How do you know it works like that?*
   - *What have we done or learned about that makes you think…?*

In this discussion, help students distinguish between facts or information and their reasoned judgements by asking student to identify a source of information that helped them figure out their ideas. Students may prompt each other if they use the discussion sentence stems. (For more about the SEP of engaging in argument from evidence see Appendix F of NGSS pp 13-14.)

Here a student used the globe and lamp to demonstrate his ideas about his city's location on a physical model. You can see the graphs from different cities taped up on the board next to the large map.



Quick Write

How did we do as a class on our talk norms?

3. REFLECTING ON TALK (INDIVIDUAL) – 5 mins

Have students take a few silent minutes to reflect on how they think the discussion went. Be honest because this can help the class get better at talking as a whole group to figure out ideas together. This could be in their science notebook or on an exit slip. Some sentence prompts:

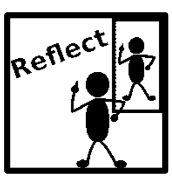
I felt like my ideas were/were not heard today because…
I think that most students did/did not participate because…
We could get better at talking to each other if we worked on…

EXAMINING STUDENT WORK

Reflect on the intellectual work and reasoning students have done through parts I, II, and III. What ideas and thinking did you hear initially? How did their ideas or thinking change over the lesson? Did they use evidence in different ways? The student work from this lesson is mostly verbal from the small group discussions and the whole-group discussions. Use the What-How-Why or RSST to track where students are in their understanding based on what you observed. Compare where students are with the requirements specified by the NGSS. Are students meeting these performance expectations?

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons.

Keep a record of these reflections for your professional portfolio.

1. TASK, TALK, & TOOLS.

Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

The task of figuring out the location of a mystery city helped students to/with....
The task about _____ relates to students' interests, experiences, or lives because…

Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

The students talked to each other during (name particular parts of lesson) which allowed students to...
During turn-and-talks, I observed _____ which makes me wonder if/how…
The discussion sentence stems allowed students to...

Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students in communicating and capturing their ideas/thinking?

Students used (charts of notes/ideas, summary table) which helped them to…

Overall, reflecting on task, talk, and tools together:

Talk, task, and tools supported students to share their thinking because...
Overall, this combination of talk, task and tools, allowed most/all students to...

2. **EQUITY**.

   Name and describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue. Here are some categories to help you name a specific issue of equity:
   - Developing relationships & forming an inclusive, trusting community
   - Scaffolding for full participation in the culture and language of science
   - Recognizing our own and others' worldviews & developing critical consciousness about our own assumptions and beliefs
   - Addressing power dynamics (how a person is seen and responded to by others) to disrupt stereotypes and privilege

PLANNING NEXT STEPS

1. Use your analysis of student work (RSST or WHY) to decide what lesson should come next. Does another lesson needs to be added in before moving to the next lesson to further students' understanding of Earth's tilt, rotation, and revolution.

   Once you decide on the next lesson…

2. Apply your lesson reflection (3Ts and Equity) to make changes to the upcoming lesson's guide to address the issue of equity you identified as well as to better support your students to engage fully in the task, talk, and tools in the lesson guide.

Daylight Hours Across the Globe

Time is indicated as number of hours (h) and number of minutes (m)

City	1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun	1-Jul	1-Aug	1-Sep	1-Oct	1-Nov	1-Dec
A	10h 34m	11h 00m	12h 18m	12h 25m	13h 07m	14h 18m	14h 24m	14h 00m	12h 40m	12h 35m	11h 11m	11h 20m
B	14h 31m	13h 22m	13h 20m	12h 29m	11h 04m	11h 11m	11h 05m	11h 29m	11h 32m	12h 20m	13h 49m	14h 24m
C	12h 12m	12h 10m	12h 08m	12h 06m	12h 04m	12h 03m	12h 03m	12h 04m	12h 05m	12h 07m	12h 09m	12h 09m
D	17h 32m	15h 27m	13h 33m	11h 22m	10h 03m	8h 32m	8h 17m	9h 27m	11h 22m	12h 46m	14h 53m	16h 33m
E	4h 53m	7h 02m	10h 03m	13h 35m	17h 36m	21h 17m	22h 09m	18h 04m	15h 16m	11h 19m	8h 36m	5h 31m
F	12h 04m	12h 04m	12h 05m	12h 07m	12h 50m	12h 51m	12h 11m	12h 10m	12h 08m	12h 06m	12h 04m	12h 03m
G	15h 03m	13h 45m	13h 20m	12h 24m	11h 26m	10h 03m	10h 36m	11h 07m	11h 23m	12h 24m	14h 08m	14h 14m
H	9h 12m	10h 15m	11h 04m	13h 31m	15h 18m	15h 42m	16h 34m	15h 36m	13h 22m	11h 41m	10h 39m	9h 24m
I	24h 00m	24h 00m	19h 01m	14h 40m	0h 00m	0h 00m	0h 00m	0h 00m	7h 14m	15h 14m	24h 00m	24h 00m

Daylight Hours Across the Globe

Time is indicated as number of hours (h) and number of minutes (m)

City	1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun	1-Jul	1-Aug	1-Sep	1-Oct	1-Nov	1-Dec
A	10h 34m	11h 00m	12h 18m	12h 25m	13h 07m	14h 18m	14h 24m	14h 00m	12h 40m	12h 35m	11h 11m	11h 20m
B	14h 31m	13h 22m	13h 20m	12h 29m	11h 04m	11h 11m	11h 05m	11h 29m	11h 32m	12h 20m	13h 49m	14h 24m
C	12h 12m	12h 10m	12h 08m	12h 06m	12h 04m	12h 03m	12h 03m	12h 04m	12h 05m	12h 07m	12h 09m	12h 09m
D	17h 32m	15h 27m	13h 33m	11h 22m	10h 03m	8h 32m	8h 17m	9h 27m	11h 22m	12h 46m	14h 53m	16h 33m
E	4h 53m	7h 02m	10h 03m	13h 35m	17h 36m	21h 17m	22h 09m	18h 04m	15h 16m	11h 19m	8h 36m	5h 31m
F	12h 04m	12h 04m	12h 05m	12h 07m	12h 50m	12h 51m	12h 11m	12h 10m	12h 08m	12h 06m	12h 04m	12h 03m
G	15h 03m	13h 45m	13h 20m	12h 24m	11h 26m	10h 03m	10h 36m	11h 07m	11h 23m	12h 24m	14h 08m	14h 14m
H	9h 12m	10h 15m	11h 04m	13h 31m	15h 18m	15h 42m	16h 34m	15h 36m	13h 22m	11h 41m	10h 39m	9h 24m
I	24h 00m	24h 00m	19h 01m	14h 40m	0h 00m	0h 00m	0h 00m	0h 00m	7h 14m	15h 14m	24h 00m	24h 00m

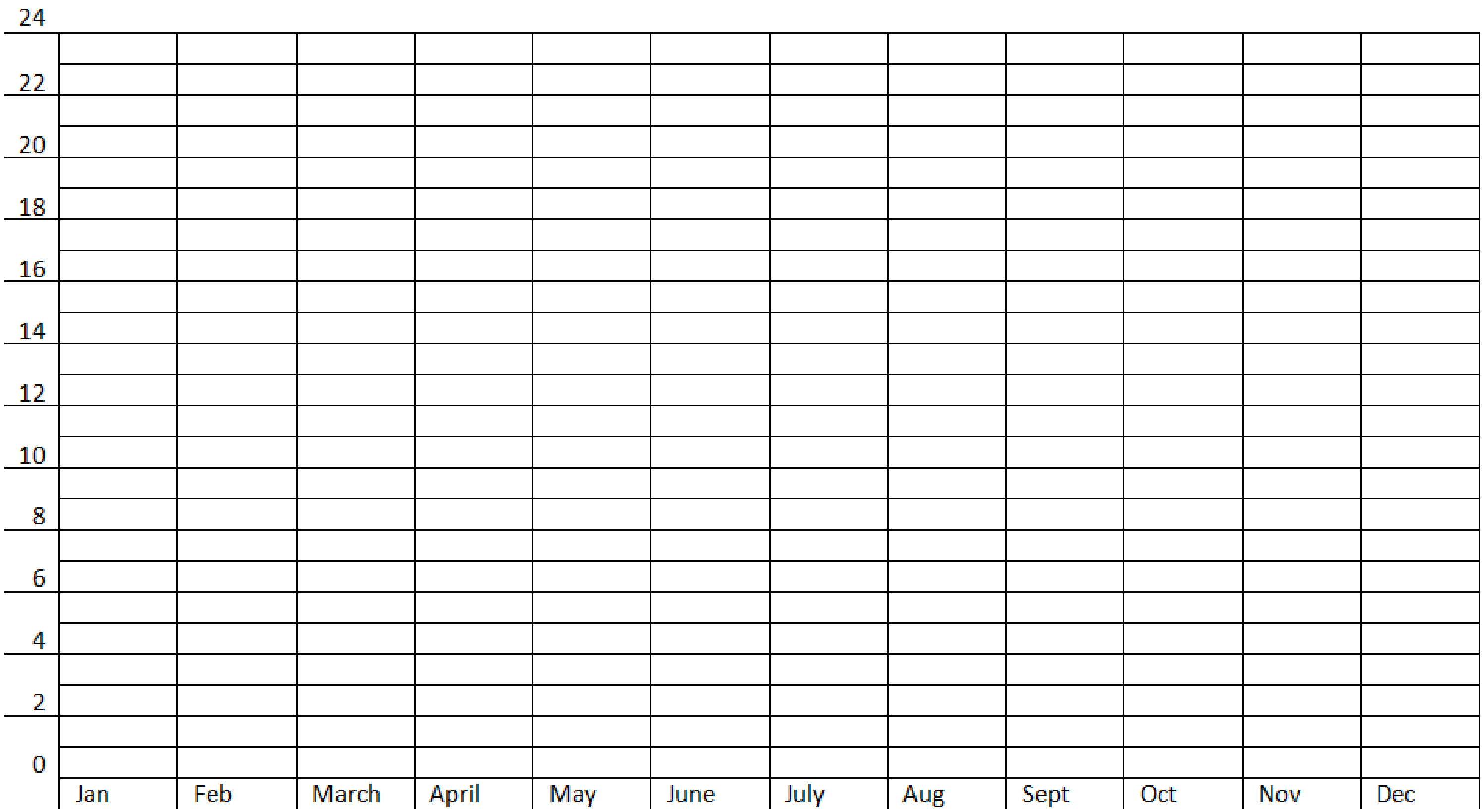
Daylight Hours Across the Globe

Time is indicated as number of hours (h) and number of minutes (m)

City	1-Jan	1-Feb	1-Mar	1-Apr	1-May	1-Jun	1-Jul	1-Aug	1-Sep	1-Oct	1-Nov	1-Dec
A	10h 34m	11h 00m	12h 18m	12h 25m	13h 07m	14h 18m	14h 24m	14h 00m	12h 40m	12h 35m	11h 11m	11h 20m
B	14h 31m	13h 22m	13h 20m	12h 29m	11h 04m	11h 11m	11h 05m	11h 29m	11h 32m	12h 20m	13h 49m	14h 24m
C	12h 12m	12h 10m	12h 08m	12h 06m	12h 04m	12h 03m	12h 03m	12h 04m	12h 05m	12h 07m	12h 09m	12h 09m
D	17h 32m	15h 27m	13h 33m	11h 22m	10h 03m	8h 32m	8h 17m	9h 27m	11h 22m	12h 46m	14h 53m	16h 33m
E	4h 53m	7h 02m	10h 03m	13h 35m	17h 36m	21h 17m	22h 09m	18h 04m	15h 16m	11h 19m	8h 36m	5h 31m
F	12h 04m	12h 04m	12h 05m	12h 07m	12h 50m	12h 51m	12h 11m	12h 10m	12h 08m	12h 06m	12h 04m	12h 03m
G	15h 03m	13h 45m	13h 20m	12h 24m	11h 26m	10h 03m	10h 36m	11h 07m	11h 23m	12h 24m	14h 08m	14h 14m
H	9h 12m	10h 15m	11h 04m	13h 31m	15h 18m	15h 42m	16h 34m	15h 36m	13h 22m	11h 41m	10h 39m	9h 24m
I	24h 00m	24h 00m	19h 01m	14h 40m	0h 00m	0h 00m	0h 00m	0h 00m	7h 14m	15h 14m	24h 00m	24h 00m

Daylight Hours for Our Mystery City *(Letter ______)*

Names: ________________________



OBSERVATIONS

The month(s) with the **most** daylight hours:

____

The month(s) with the **least** daylight hours:

____

From **January to June**, the amount of daylight is:

increasing /decreasing

From **June to December**, the amount of daylight is:

increasing /decreasing

1.) We think our city is ... (choose one below).

- ☐ At or near the North Pole
- ☐ Way north of the Equator
- ☐ Just barely north of the Equator
- ☐ Just barely south of the Equator
- ☐ Way south of the Equator
- ☐ At or near the South Pole

2.) We think the city must be there because

____

____

____

________________________________.

3.) Therefore, we think our city is likely... (choose one).

- ☐ Vostok, Antarctica
- ☐ Miami, Florida
- ☐ Brisbane, Australia
- ☐ Nairobi, Kenya
- ☐ Seattle, Washington
- ☐ Cape Town, South Africa
- ☐ Singapore
- ☐ Nome, Alaska
- ☐ Punta Arenas, Chile

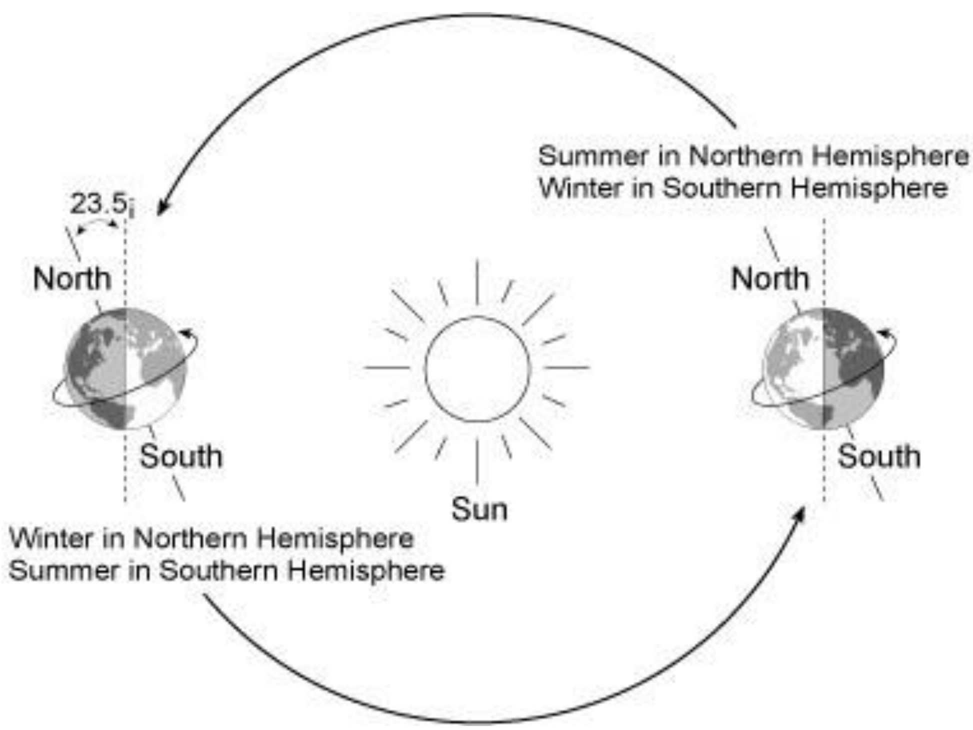
Seasons & Hemispheres

The four seasons of our year—spring, summer, fall, and winter—follow a repeated pattern annually. Each season has its own light, temperature, and weather patterns.

In the **Northern Hemisphere**, winter generally begins on December 21 or 22. This is the **winter solstice**, the day of the year with the shortest period of daylight. Summer begins on June 20 or 21, the **summer solstice**, which has the most daylight of any day in the year. Spring and fall, or autumn, begin on **equinoxes**, days that have equal amounts of daylight and darkness. The vernal, or spring, equinox falls on March 20 or 21, and the autumnal equinox is on September 22 or 23.

The seasons in the Northern Hemisphere are the opposite of those in the Southern Hemisphere. This means that in Argentina and Australia, winter begins in June. The winter solstice in the Southern Hemisphere is June 20 or 21, while the summer solstice, the longest day of the year, is December 21 or 22.

In June, when the Northern Hemisphere is tilted toward the sun, the sun's rays hit it for a greater part of the day than in winter. This means it gets more hours of daylight. In December, when the Northern Hemisphere is tilted away from the sun, with fewer hours of daylight.



Reading modified from: http://education.nationalgeographic.com/education/encyclopedia/season/?ar_a=1

Copy and cut apart temperature data tables. Distribute this table of average monthly temperatures to students as needed to help them reason about what seasons happen in their city in given months. This is a necessary step to help them decide on the location of their city. Many students find it helpful to reason about warm/cool months of the year to use the seasons and also to locate how far north or south a city is since they know that cities near the equator are warmest. (Note: Although degrees Celsius are a more traditionally scientific norm, most students in the U.S. are more familiar with degrees Farenheit and this is information is meant to help students reason so it should be in the friendliest, most familiar form.)

Mystery City – Average Monthly Temperatures in degrees Fahrenheit (°F)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
A	68	70	72	75	79	81	84	84	82	80	75	70
B	75	74	70	70	65	57	59	60	68	70	71	73
C	68	70	67	65	65	64	63	63	65	68	68	68
D	51	50	48	43	37	34	36	38	40	44	47	50
E	5	7	10	20	37	48	52	50	43	29	17	8
F	75	76	77	78	80	83	82	80	79	78	78	77
G	72	71	68	63	58	54	55	56	57	59	66	68
H	41	42	45	50	55	60	73	64	60	53	46	43
I	-3	-10	-18	-20	-22	-23	-26	-26	-24	-19	-10	-3

Mystery City – Average Monthly Temperatures in degrees Fahrenheit (°F)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
A	68	70	72	75	79	81	84	84	82	80	75	70
B	75	74	70	70	65	57	59	60	68	70	71	73
C	68	70	67	65	65	64	63	63	65	68	68	68
D	51	50	48	43	37	34	36	38	40	44	47	50
E	5	7	10	20	37	48	52	50	43	29	17	8
F	75	76	77	78	80	83	82	80	79	78	78	77
G	72	71	68	63	58	54	55	56	57	59	66	68
H	41	42	45	50	55	60	73	64	60	53	46	43
I	-3	-10	-18	-20	-22	-23	-26	-26	-24	-19	-10	-3

Mystery City – Average Monthly Temperatures in degrees Fahrenheit (°F)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
A	68	70	72	75	79	81	84	84	82	80	75	70
B	75	74	70	70	65	57	59	60	68	70	71	73
C	68	70	67	65	65	64	63	63	65	68	68	68
D	51	50	48	43	37	34	36	38	40	44	47	50
E	5	7	10	20	37	48	52	50	43	29	17	8
F	75	76	77	78	80	83	82	80	79	78	78	77
G	72	71	68	63	58	54	55	56	57	59	66	68
H	41	42	45	50	55	60	73	64	60	53	46	43
I	-3	-10	-18	-20	-22	-23	-26	-26	-24	-19	-10	-3

Discussion Stem Bookmark

Respond as a respectful listener:

What do you mean by _____?

Tell me/us more about ______.

I want to better understand what you mean. Can you say it again a different way?

Say more about why you think_______.

Clearly share your thinking:

I think that_____ because…

In the video or reading, it said that..

In the activity about ____, we learned that….

I'm not sure about…

I'm wondering if/why…

Respectfully agreeing or disagreeing:

I agree with the idea about __________ because…

I respectfully disagree with the idea that ______ because…

I'm not sure I agree. Would you say more why you think that?

What other information do we need to work out our thinking together?

Discussion Stem Bookmark

Respond as a respectful listener:

What do you mean by _____?

Tell me/us more about ______.

I want to better understand what you mean. Can you say it again a different way?

Say more about why you think_______.

Clearly share your thinking:

I think that_____ because…

In the video or reading, it said that..

In the activity about ____, we learned that….

I'm not sure about…

I'm wondering if/why…

Respectfully agreeing or disagreeing:

I agree with the idea about __________ because…

I respectfully disagree with the idea that ______ because…

I'm not sure I agree. Would you say more why you think that?

What other information do we need to work out our thinking together?

Where is our mystery city located?

Group Discussion Checklist

If you need these to help you communicate, one student from the group may get:

- 1 whiteboard
- 2 dry erase markers
- 1 globe or ball
- 1 flashlight

1. **Each student shares the response from the question.**
   Use what you wrote on the back of your graph paper. Do you think your mystery city could be in the northern hemisphere or the southern hemisphere? Why do you think so?

2. **Talk about your ideas**.
   Do we all agree? Disagree? Take turns listening and responding.

3. **Answer questions 1, 2, and 3 on the graph sheet.**
   Talk first. Decide on an answer. Then each student writes on their own paper. Every student needs to participate.

4. **Decide which city is your mystery city.**
   Look at the large world map with the 9 cities labeled. Which city do you think matches your data? What makes you think so?

Where is our mystery city located?

Group Discussion Checklist

If you need these to help you communicate, one student from the group may get:

- 1 whiteboard
- 2 dry erase markers
- 1 globe or ball
- 1 flashlight

1. **Each student shares the response from the question.**
   Use what you wrote on the back of your graph paper. Do you think your mystery city could be in the northern hemisphere or the southern hemisphere? Why do you think so?

2. **Talk about your ideas**.
   Do we all agree? Disagree? Take turns listening and responding.

3. **Answer questions 1, 2, and 3 on the graph sheet.**
   Talk first. Decide on an answer. Then each student writes on their own paper. Every student needs to participate.

4. **Decide which city is your mystery city.**
   Look at the large world map with the 9 cities labeled. Which city do you think matches your data? What makes you think so?

Lesson 8: Scale of the Sun and Earth

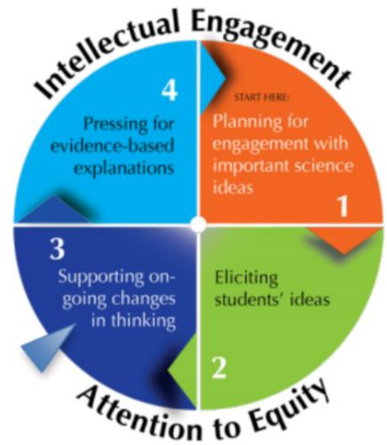
OBJECTIVES & OVERVIEW

The relative difference in size and distance between the Sun and Earth is much more dramatic that is often portrayed in textbook diagrams or video animations. To help students understand that the tilt isn't really making the Earthy "closer" to the sun, students need to understand just how far away the Earth is from the Sun and how the Earth's orbit is slightly eliptical and not an exaggerated oval (contrary to textbook representations). Students may also be thinking about temperatures, being closer to the Sun in summer and farther in winter; this lesson helps students revise their thinking about size and distance..

Focus Questions: How can accurately representing the size of the Earth and Sun and the distance between them help us think more about changing daylight hours or the seasons?

- Students create a scale model of the Earth and Sun and identify limitations a variety of models of the Earth's orbit around the Sun.

Ambitious Science Teaching Framework:
SUPPORTING ON-GOING CHANGES IN STUDENT THINKING



This practice supports on-going changes in student thinking by (1) introducing ideas to reason with, (2) engaging with data or observations, and (3) using knowledge to revise models or explanations. For more visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Standards Note: Lesson 8 focuses on the idea of relative distance from Earth and the brightness of the Sun, our Star. It does not look at other stars that we see at night and why they look dimmer than our Sun. This would be a possible extension and could lead into additional lessons about patterns of stars in the night sky. These lessons are not included in this unit guide but could fit nicely after this lesson.

5-ESS1-1. Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from the Earth. [Assessment Boundary: Assessment is limited to relative distances, not sizes, of stars. Assessment does not include other factors that affect apparent brightness (such as stellar masses, age, stage).]

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CC)
Engaging in Argument from Evidence - *Support an argument with evidence, data, or a model. (5-ESS1-1)* *** Added to this lesson* ***SEP: Developing and Using Models*** *- Identify limitations of models.*	***ESS1.A: The Universe and its Stars-*** *The sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their distance from Earth. (5-ESS1-1)* **** ***ESS1.B: Earth and the Solar System*** *The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year. (5-ESS1-2)* *** This DCI ESS1.B, though not part of the PE as written in NGSS, has been added to this lesson because students will be utilizing this knowledge to construct their argument about scale and quantity.*	***Scale, Proportion, and Quantity-*** *Natural objects exist from the very small to the immensely large. (5-ESS1-1)*

MATERIALS

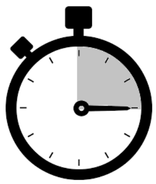
This lesson uses NASA's Sun-Earth Day lesson using scale drawings of the Sun and Earth http://sunearthday.nasa.gov/2007/materials/solar_pizza.pdf

For the class:

- 1 Sun on cardstock (1 sheet of cardstock)1 Earth card per student on cardstock (1 sheet has class set of Earth cards)
- 65 feet of string
- Large field area

PREPARATION

Approximately 15 minutes



- Make copies of Sun and Earth cards on cardstock.
- Cut out Earth cards per student.
- Measure and cut 65 feet of string.
- Find a large area outside the building.

PROCEDURE

Turn-and-Talk

How do these representations show the size of and distance between the Sun and Earth?

1. **ORIENT STUDENTS TO THE CONCEPTS USING STUDENT IDEAS, EXPERIENCES, OR QUESTIONS (WHOLE GROUP) –** (10 minutes)

   a. Look at different diagrams of the Earth's orbit around the Sun (see page near the end of this lesson guide for some options or show drawings from books from the library or science text books). Compare these representations. What's similar? What's different? Turn-and-Talk. What do you notice about how they show the size of the Sun and Earth and the distance between them?

   b. Share out some ideas, particularly from students who notice it looks like the Earth gets super close to the Sun at some parts of the year and/or that the Sun and Earth look similar in size.

   c. Tell students that today they will act-out the Earth's orbit outside on the playground field to make a scale model of the revolution.

2. **GET STUDENTS STARTED – MAKE OBSERVATIONS (WHOLE GROUP) –** (15 mins)

   a. Tell students that they will observe a scale model of the Earth's orbit around the Sun. A scale model means that we are shrink down the system to be able to make observations when we can't really observe the real thing because it is too big and too far away.

   b. Show students the Sun card and explain that if we shrunk the sun down to be this size, then Earth (show card) would be this tiny – the small circle on the Earth card. Tell students that the string is 65 feet long. If the

Earth and Sun were the sizes shown on the cards, then they would be 65 feet apart.

c. Take students outside to the field and give each student an Earth card. Have one student be the Sun and stand in the middle of the field holding one end of the string. Have one student with an Earth card hold the other end of the string. The rest of the class with their Earth cards can orbit the sun using the 65 foot string to keep students the right distance away from the sun. As the class is orbiting you could ask these questions:

Back-Pocket Questions

i. *What do you notice about the Sun from here?*
ii. *What are some other observations you have?*
iii. *What is this making you think about?*
iv. *How can we show tilt in our human model?*
v. *How is this different than the representations we just looked at in class?*

Quick Write

Sketch what we did. How does this representation compare to the ones we looked at earlier?

3. QUICK WRITE (INDIVIDUAL) – (5 mins)

When students return to class, have them quick write in their science notebooks about their scale model. Sketch what they did and observed and write about how this is similar and different than other representation we have seen so far. What is this making you wonder about now?

Our model on the field outside showed…
Model A on the board shows…
These are similar because…
They are different because…
I think the best model of the Earth's orbit around the Sun would be/would show_________ because...

4. WHOLE CLASS DISCUSSION (WHOLE CLASS) – (10 mins)

Whole-class discussion

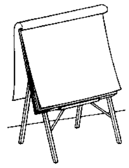
Evaluating limitations of models

a. Revisit representations from the beginning of class and compare them to what students drew during the quick write.

b. Discuss similarities and differences. Which ones do students think are the most accurate? Why? What are the challenges of trying to draw how the Earth and Sun actually are? What do some models do more clearly than others?

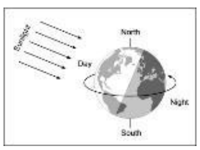
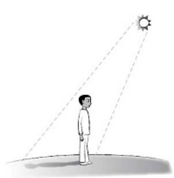
c. Note: This human model is not perfect. It implied the orbit of the Earth is circular. Compared the extreme ellipses drawn in textbooks, the orbit is closer to looking circular than oval-shaped. Just another example of how any model or representation has limits and cannot completely reflect the actual system completely accurately.

Public Record



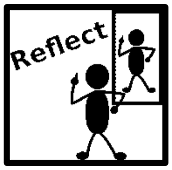
Summary Table

5. **WHOLE CLASS COORDINATION OF IDEAS – SUMMARY TABLE** (15 mins) *Use quick write as a starting point for a summary table discussion.*
   a. **OBSERVATIONS**: Reconvene as a whole class and summarize what students observed.
   b. **LEARNING**: What did students learn today about different representations? What questions do they have? (This learnings could be added to after doing some read aloud or independent research to answer students' questions about scale and distance.) Record learnings about day/night and rotation in the learning column.
   c. **CONNECTION**: How can what we learned about this lesson help us explain a part of the phenomenon? Write some ideas in the summary table under "connection to phenomenon.

Activity	Observations & Patterns	What have we learned?	Connection to the phenomenon
Day and Night Cycles 	- As the globe rotates, the side facing the lamp is lit up and the other side is in darkness. - The lamp can't light up the globe at the same time, there is always a part in the dark.	- The earth spins or rotates on its axis once every 24 hours = 1 day - When it is daytime in Seattle, it is nighttime on the opposite side of the Earth (facing away from the Sun).	Daylight hours are measured between sunrise and sunset and this helps us understand that the Earth's 24 hour rotation causes day and night. (Possible student Q: But why isn't it just 12 hours day and 12 hours night? This question can be answered by subsequent activities particularly when students learn about the equinox and tilt.)
Moving Shadows 	The shadow moves in a circle. The length of shadow gets shorter from the morning to noon. The length of shadow gets longer from noon to the afternoon.	The shadow moves in a circle because the earth spins (the Sun does not move). The apparent motion of the sun means it appears to rise in the East and set in the West.	The movement of the shadows is some evidence that the earth is rotating to create day and night. The tracing of shadows might look different at different times of year because the sun is lower in the sky in winter and appears higher in the sky in summer (for northern hemisphere)
Sun Clocks & Earth's Rotation	Shadows on the Pocket Sun Clock move one way if we spin to the right and go the other way in a circle if we spin to the left	Objects blocking light create shadows. Shadows made by the Sun change in length and direction over time because the Earth is rotating.	The direction of shadow made by the Sun is evidence that the Earth must be spinning counterclockwise when looking down at the north pole (or spinning to the left if we are acting like the earth) such that New York gets sunlight before Seattle.
Size & Distance: Scale of the Sun and Earth	The Earth is SUPER small compared to the Sun. It's also pretty far away.	The Earth orbits the Sun once every 365 days which equals one year. Light can travel across really far distances through Space.	The Earth receives heat and light from the Sun. The Sun provides the light we use in order to have daylight hours. We don't seem to be closer to the Sun in the summer, which is how some drawings show our orbit.

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons.

Keep a record of these reflections for your professional portfolio.

1. **TASK, TALK, & TOOLS.**

   Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

   The task of acting out the orbit of the Earth with to-scale sized cards helped students to/with....
   The task about _____ relates to students' interests, experiences, or lives because…

   Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

   The students talked to each other during (name particular parts of lesson) which allowed students to...
   During turn-and-talks, I observed _____ which makes me wonder if/how…
   Doing the quick-write before talking about the activity seemed beneficial for some students because…

   Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students in communicating and capturing their ideas/thinking?

   The summary table allowed students to...

   Overall, reflecting on task, talk, and tools together:

   Talk, task, and tools supported students to share their thinking because...
   Overall, this combination of talk, task and tools, allowed most/all students to...

2. **EQUITY**. Describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue.

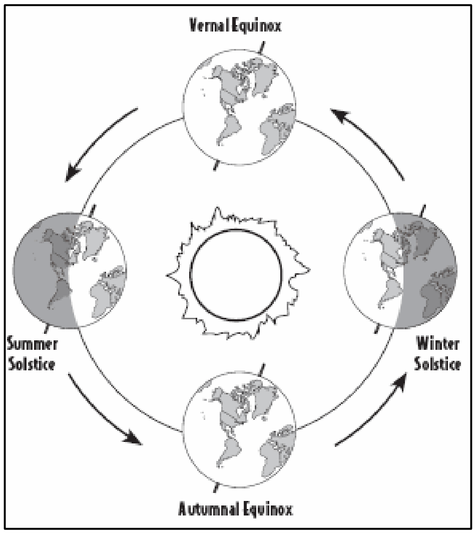
PLANNING NEXT STEPS

This is the last lesson in this guide before students go and revise their models. You may decide to add additional lesson(s) here to help answer students' questions or continue to support changes in student thinking around some of their hypotheses about what causes changing amounts of daylight throughout the year.

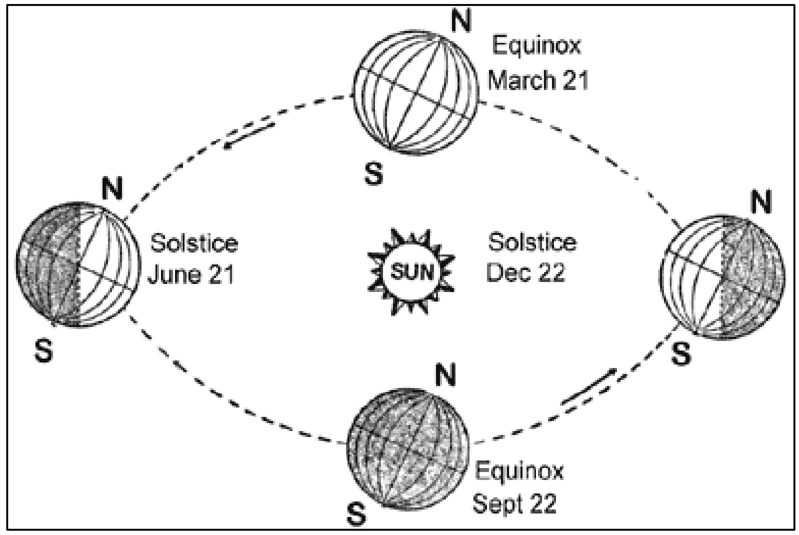
Comparing Representations of the Earth's Orbit around the Sun

What is similar? What is different?
Which representation do you like the best? Why?

#1



#2



#3

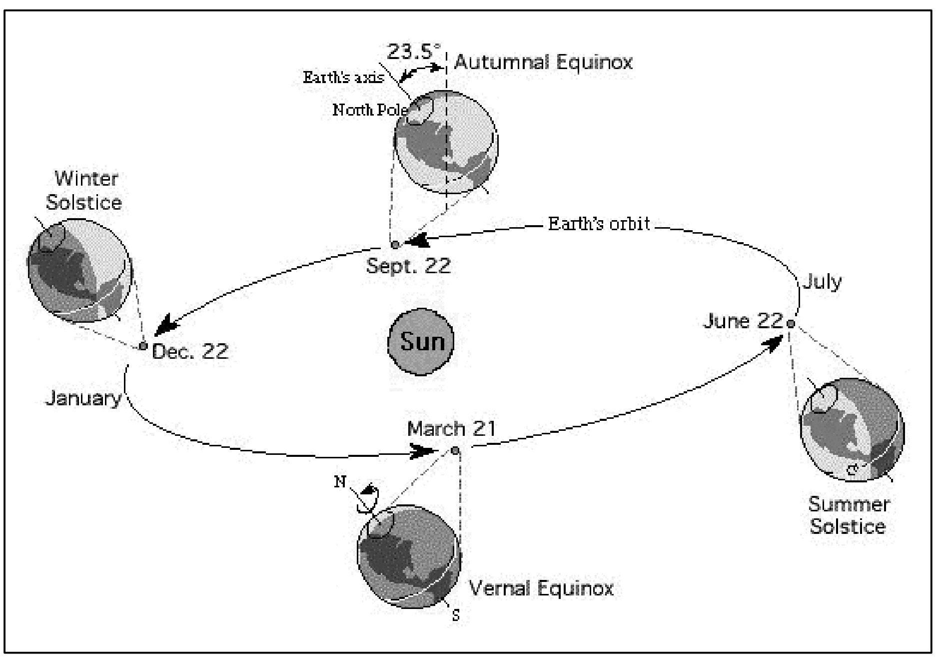


Image credits:
1 - http://www.uen.org/Lessonplan/preview.cgi?LPid=21558
2 - http://www.msnucleus.org/membership/html/k-6/uc/earth/6/images/uc6e05 .gif
3 - http://www.zo.utexas.edu/courses/bio301/chapters/Chapters2-7/Orbit.gif

From http://sunearthday.nasa.gov/2007/materials/solar_pizza.pdf

NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION

http://sunearthday.nasa.gov

Public Outreach
- Make and Take Activities

What You'll Need

- copies of the Sun and Earth handout sheet (see next page)
- measuring tape
- a large room or a long hallway where you will be able to walk 65 feet in a straight line without many obstacles
- (optional) scissors
- (optional) 65 feet length of string

Note: Copies of our readymade cardstock version of this Sun-Earth scale model are available for free by request. If you need copies for a specific event or education program, email us at outreach@cse.ssl.berkeley.edu

Both English and Spanish versions available.

Scale Model of Sun and Earth

About this Activity

This activity explores the relative size of Sun and Earth as well as the distance between them.

Below right: Looking toward the model Sun from the model Earth. A pre-measured piece of string was used to mark the appropriate distance for the scale model.

Preparation

Measure 65 feet (the distance between Sun and Earth in the scale of our model) from where you will be doing this activity and mark the distance for later reference. If you do not have a fixed location, we find it helpful to have a piece of string cut to exactly 65 feet in length for you to use as a reference during the activity.

If you want your participants to guess the size of the Earth, you might want to keep the image of Earth out of sight by cutting off the top of the hand-out page along the dash line.

To Do and Notice

1) Show participants the image of the Sun. (This is a good opportunity to notice what the Sun's surface look like and to point out that the Sun is not as featureless and uniformly bright as it might look to our eyes.) Ask participants to guess how big the Earth would be if the Sun is the size of this image.

2) Reveal the answer by showing the image of Earth. (Optional: you might want to let the participants cut out the Earth and the disc of the Sun instead of using the 2 sections of the handout sheet.) Ask participants to guess how far the model Earth should be from the model Sun. We suggest allowing participants to walk to where they think the distance should be. We find it helpful to tape the model Sun to a spot around eye-level at the starting point and have the facilitator walk with the participants. The model Earth should be 65 feet away from the model Sun. Use the marker you placed earlier (or the cut piece of string) to guide you.

3) (Optional) At 65 feet away, look back towards the model Sun. Notice how big it looks to you at this distance. At this scale, the model Sun should be about the same size as the actual Sun would appear to us here on Earth. (It is always a good idea to remind participants not to look directly at the Sun.) Since this part requires a basic understanding of ratio and scale model, it might not be appropriate for all participants.

Activity Notes

"Why does the Sun I see in the sky look different from this picture?" is a common question. The Sun image here was taken by a telescope that is mounted on a satellite in space (the TRACE mission to be exact). Besides being able to see farther than we can and without the clouds and Earth's atmosphere in the way, this telescope also looks at a different kind of light. The Sun gives off different kinds of energy, only part of that is in the form of visible light which we can see. The telescope that took this picture looks at the extreme ultraviolet (EUV) light coming from the Sun.

Related Websites

TRACE Education Resources: the Sun, its structure, and the satellite mission.
http://trace.lmsal.com/Public/eduprodu.htm

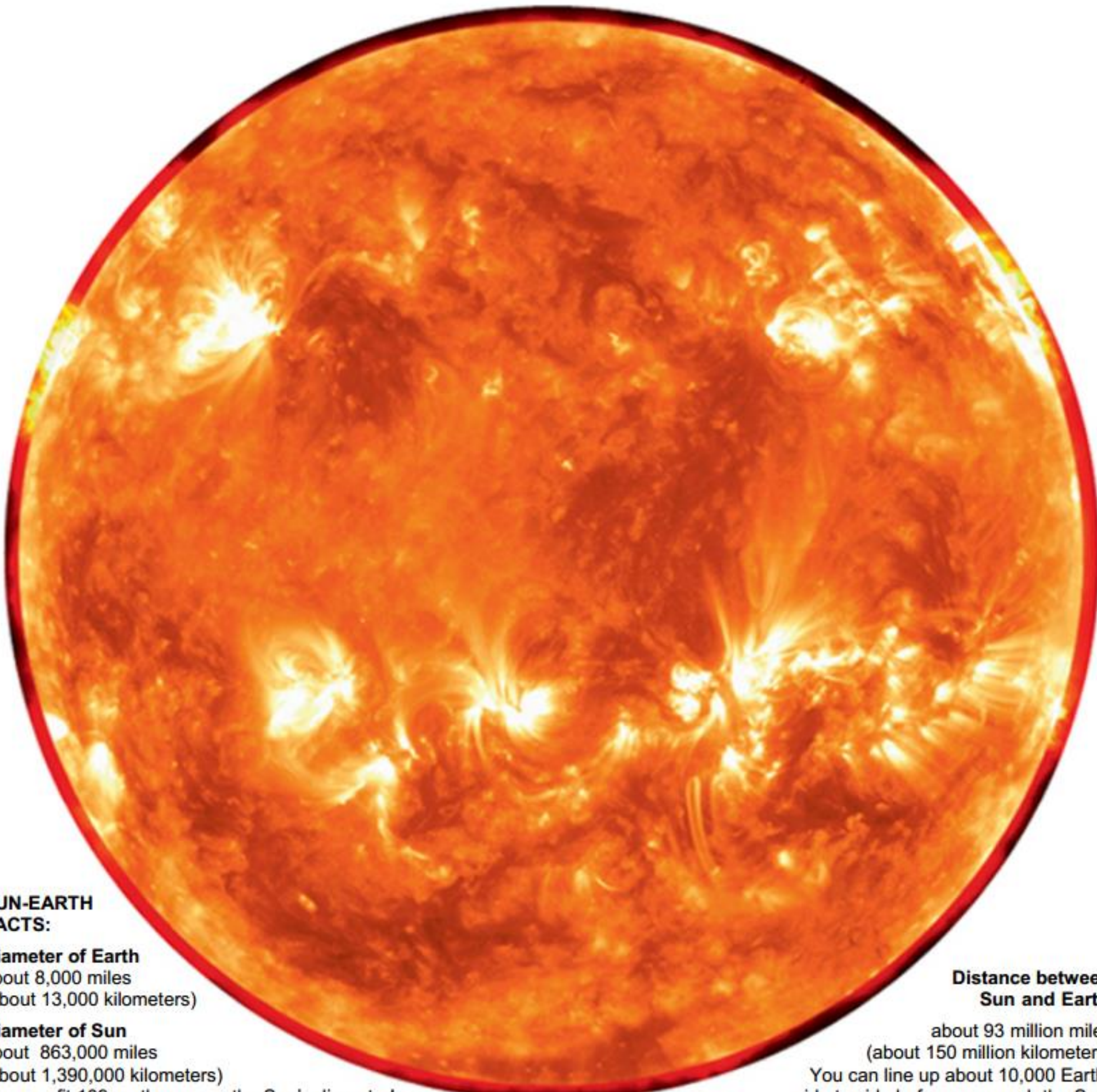
Stanford Solar Center: About the Sun
http://solar-center.stanford.edu/about/

Earth	Earth	Earth	Earth	Earth	Earth	Earth	Earth
Earth	Earth	Earth	Earth	Earth	Earth	Earth	Earth
Earth	Earth	Earth	Earth	Earth	Earth	Earth	Earth

1. Cut out the images of the Sun and the Earth.
2. To demonstrate the distance between Sun and Earth at this scale, separate the images 65 feet (about 20 meters) apart. This distance represents approximately 93 million miles (150 million kilometers).

This image of Earth is scaled to the proper size in relation to the image of the Sun below.

Earth



SUN-EARTH FACTS:

Diameter of Earth
about 8,000 miles
(about 13,000 kilometers)

Diameter of Sun
about 863,000 miles
(about 1,390,000 kilometers)
You can fit 109 earths across the Sun's diameter!

Distance between Sun and Earth:
about 93 million miles
(about 150 million kilometers)
You can line up about 10,000 Earths side to side before you reach the Sun.

Lesson 9: Revising Models

OBJECTIVES & OVERVIEW

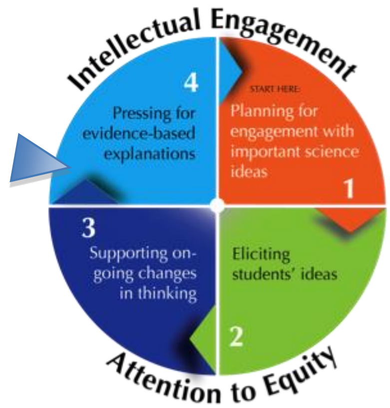
Students have been revising their thinking about the unit phenomenon over time in light of the new experiences, observations, and sense making talk that they have had throughout the unit activities. In this lesson, students will pull together what they have learned in this unit and identify how their thinking has changed by revising their models and supporting changes with evidence.

Focus Question: In Seattle (or nearby city), why do we experience more hours of daylight in summer and fewer hours of daylight in winter?

- Students revise their models in light of evidence from unit activities to explain the phenomenon.

Ambitious Science Teaching Framework:

PRESSING FOR EVIDENCE-BASED EXPLANATIONS



This practice happens near the end of a unit, but parts can be introduced at other times when students talk about evidence. This requires that several tools be available to students: 1) their current models, 2) an explanation checklist, 3) the summary table, and 4) a scaffolded guide to help students create, in writing and drawing, their final model. For more visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Standards Note: Because this lesson is intended to help students revise their models using evidence, students will not entirely demonstrate the performance expectation (PE) listed here. Students have had prior opportunities in this unit to fully engage in the dimensions of the specific PE below. Students in this lesson are engaged in a three-dimensional performance, relying more on the SEP of Developing and Using models and Constructing Explanations than on Analyzing and Interpreting Data.

PE *5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.*
[Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [Assessment Boundary: Assessment does not include causes of seasons.]

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CC)
Analyzing and Interpreting Data - *Represent data in graphical displays to reveal patterns that indicate relationships.* **** Developing and using models -** *Develop and/or use models to describe and/or predict phenomena* *** **Constructing Explanations** - Identify the evidence that supports particular points in an explanation* *** These SEP is not part of the PE but were added to this lesson as part of the AST framework because students revise models based on evidence as one form of constructing explanations of a naturally occurring phenomenon.*	***ESS1.B: Earth and the Solar System*** *The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.*	***Patterns -*** *Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.*

MATERIALS

For the class:
- Summary table
- Chart paper
- Markers

For each pair of student:
- sticky notes
- 1 blank model scaffold * (see preparation)
- their original model (completed in pairs in Lesson 1)
- colored pencils or pens
- science notebooks (for reference)

PREPARATION

Approximate time
30 minutes

* One possible option for a revised model scaffold is suggested in this guide, you may use the one provided or create your own version. Copy on 11x17" paper
Create a different model scaffold than the one students used in Lesson 1. Use clear prompts so students know what you want them to focus on and do in each part of the model. Give space to draw and write. You could even do a model comparing Seattle and another city that students' have studied.

PROCEDURE — PART I. Revising Models

Present visuals

Show photos bus stop waiting areas to compare December vs April.

Turn-and-Talk

What ideas do we need to include in an explanation of the phenomenon?

1. GENERATE EXPLANATION CHECKLIST (WHOLE GROUP) – 10 mins

a. Remind students of the unit phenomenon using the photos of students waiting at the bus stop in December and April (from Lesson 1). *In Seattle (or nearby city), why do we experience more hours of daylight in summer and fewer hours of daylight in winter?*

b. Ask students to think about what they have learned in this unit (refer them to look at the summary table) and identify: What are the key pieces that we have to know about in order to explain changing amounts of daylight in Seattle? Give private think time. Have students turn-and-talk.

c. Share out some ideas and generate an explanation checklist on chart paper with markers. The list might have items on it such as:

EXPLANATION CHECKLIST:
We should …
- Use data from our graph to include numbers about hours of daylight in December compared to April.
- describe how the Earth moves (rotation and revolution) and how that explains how we have daylight
- explain why some places have more daylight than others
- show our ideas in pictures and words

2. STUDENTS UPDATE EXPLANATORY MODELS (PAIRS) – 35 mins

a. Leave the explanation checklist on the board for student reference. Tell students that they will have a chance to create a new model about the phenomenon working in pairs to show all the new ideas they have now that they have had so many experiences in this unit (point to summary table).

b. Show students the model scaffold and explain what you expect to see in each part of it. Also, remind students that both students in the pair should be talking, drawing, and writing on the sheet.

c. Give students time to work in pairs to develop a new model. Redirect students as needed to the explanation checklist, the summary table, or their notebooks to help them make progress on their models.

Back-Pocket Questions

Prompt reasoning about gaps and contradictions

As students work in pairs, prompt reasoning about gaps and contradictions in their models. These prompts or questions could help you do this:

- *"Can you tell me what role [insert idea or concept] has in your explanation?"*
- *"How does this part about ______ fit with the rest of your model?"*
- *"How have you included this idea about ______ from the explanation checklist?"*
- *"I see you have drawn and labeled _______. How do you know it works like that? Have we done something in class on the summary table?"*

PART II. IDENTIFYING EVIDENCE

1. PREPARE STUDENTS TO USE EVIDENCE – (15 mins)

a. Have a pair share one claim they have made on their model so far. It should be a claim that we have evidence for from an activity, video, or reading from the unit.

b. Ask the class: What evidence do we have of this idea? Where can we look to remember what evidence we have?

c. Demonstrate how to write evidence on a sticky note and put it on the model next to the claim. The sticky note could look like the box at right.

> In the "Day and Night" activity, our heads were the earth. When we turned to face the lamp it was daylight and night when we faced away. The Sun doesn't move, we do.

d. Give students 10 minutes to identify 2 claims on their model and write sticky notes about evidence. Each student in the pair should write one sticky note and share their evidence with their partner.

e. As students work, circulate and look at how students are selecting evidence. If they are stuck, refer them to the summary table or their science notebook. If students only name the activity, put some sentence stems on the board to help get more about why this activity provided us with evidence for a certain idea or claim.

2. PUBLIC COMPARISON OF MODELS (WHOLE GROUP) – 15 mins

Talk Norms

Remind students about talk norms.

a. *Physically orient students towards each other*: Have students bring their model sheets to the gathering area and sit so students can see and hear each other easily and see the screen when students share work under the document camera.

b. *Set the purpose of today's discussion:* Say something like: *We are coming together to see ways to represent ideas in models and how we use evidence to support our ideas. Give each other feedback by agreeing or disagreeing and saying why you think the evidence they picked supports their idea or if you think another piece of evidence from our summary table would be stronger. After the discussion you will have time to add more evidence or clarify your ideas on your models.*

Whole-class discussion

Collaboratively revise a model based on evidence

c. *Allow students to use talk norms and lead and manage the talk:* Remind students of talk norms and encourage them to call on each other and not look to the teacher. Pass out the discussion prompt handout (½ sheet) from Part II of Lesson 8.

d. Choose one pair to start the conversation and have them share their idea and the evidence they selected to support it. Encourage students to agree or disagree, in either case saying what evidence they used or would use and how it supports their idea. Students should be sharing work under the document cameras as they have a discussion. Peers could suggest changes to either their ideas or the evidence they selected.

NGSS Note: In Appendix F: Science and Engineering Practices, one performance of developing and using models for grades 3-5 students is to Collaboratively develop and/or revise a model based on evidence that shows the relationships among variables for frequent and regular occurring events. Students are mostly doing this in pairs this lesson but this whole group discussion is another way to collaboratively revise their partner models.

3. MAKE ADAPTATIONS TO MODELS (PAIRS) – 10 mins

a. Have students go back to working in their pair and make changes to their models to clarify their ideas, add new ideas they heard during the discussion they agreed with, and to add or change the evidence they selected to support some of their claims.

b. By the end of the lesson students should have drawn and written about their ideas to explain the phenomenon and have at least two sticky notes with evidence to support two of their claims.

Quick Write

How has my thinking changed?

4. HOW HAS MY THINKING CHANGED? – 5 mins

Pass back initial models and let students look over them. As an exit ticket, have students write how their thinking has changed in this unit.

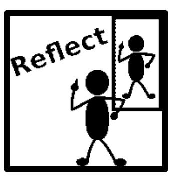
At first I thought…. Now, I think…
I used to think…. Now, I know…
Before I didn't know how… But, now, I learned that…

EXAMINING STUDENT WORK

Examine students' model revisions and see how their thinking has changed over the unit. Track changes in thinking on the What-How-Why rubric. Look at how students are using evidence and if, in Lesson 10, there would be a need for some prompting or scaffolding to help students use evidence.

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons.

Keep a record of these reflections for your professional portfolio.

1. TASK, TALK, & TOOLS.

Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students to communicate their ideas?

2. **EQUITY**. Describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue.

____

____

____

____

____

PLANNING NEXT STEPS

This lesson sets students up for the last lesson in this unit where they create a written explanation using evidence. Consider what you've observed from student talk and seen in student models and on sticky notes to determine what support students might need in writing their explanations.

Name: ______________________ Name: ______________________ Date: __________________ Teacher: ______________________

Our Model of Changing Daylight in Seattle

Draw a model to explain the changing amounts of daylight that Seattle has over a year. Compare summer and winter.
Include ideas about day-night cycles, Earth's tilt, rotation and revolution.

- How much does daylight vary in Seattle over a year?
- Why do we even daylight at all? How do we have day and night?
- Why does the number of daylight hours increase or decrease over a year?

In Seattle, why do you think it is light outside at 7:15 AM in April, but it's dark at 7:15 AM in December?

____

____

____

____

____

____

Lesson 10: Writing an Evidence-based Explanation

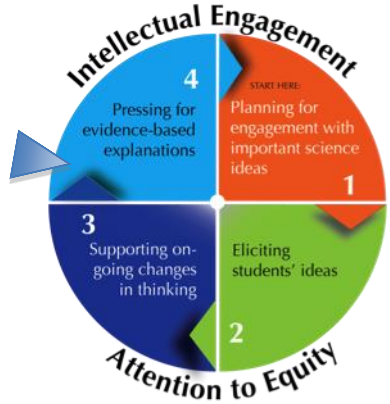
OBJECTIVES & OVERVIEW

In lesson 9, students worked in pairs to develop new models to explain the patterns of daylight in Seattle using evidence from unit activities. In this lesson, students will use that work to compose an evidence-based explanation (or "science story") about the phenomenon.

Focus Question: In Seattle (or nearby city), why do we experience more hours of daylight in summer and fewer hours of daylight in winter?

- Students use their updated models and evidence from the unit to compose a written explanation (a "science story").

Ambitious Science Teaching Framework:
PRESSING FOR EVIDENCE-BASED EXPLANATIONS



This practice happens near the end of a unit, but parts can be introduced at other times when students talk about evidence. Students need: 1) their current models, 2) an explanation checklist, 3) the summary table, and 4) a scaffolded guide to help students create, in writing and drawing, their final model. For more visit http://AmbitiousScienceTeaching.org

NEXT GENERATION SCIENCE STANDARDS (NGSS)

Standards Note: Because this lesson is intended to help students construct evidence-based explanations, students will not entirely demonstrate the performance expectation (PE) listed here. Students have had prior opportunities in this unit to fully engage in the dimensions of the specific PE below. Students in this lesson are engaged in a three-dimensional performance, relying more on the SEP of Constructing Explanations than on Analyzing and Interpreting Data.

PE *5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.*
[Clarification Statement: Examples of patterns could include the position and motion of Earth with respect to the sun and selected stars that are visible only in particular months.] [Assessment Boundary: Assessment does not include causes of seasons.]

Science & Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Cross-Cutting Concepts (CC)
Analyzing and Interpreting Data - *Represent data in graphical displays to reveal patterns that indicate relationships.* **** Developing and using models -** *Develop and/or use models to describe and/or predict phenomena* ***** Constructing Explanations*** *- Identify the evidence that supports particular points in an explanation* *** These SEP is not part of the PE but were added to this lesson as part of the AST framework because students revise models based on evidence as one form of constructing explanations of a naturally occurring phenomenon.*	***ESS1.B: Earth and the Solar System*** *The orbits of Earth around the sun and of the moon around Earth, together with the rotation of Earth about an axis between its North and South poles, cause observable patterns. These include day and night; daily changes in the length and direction of shadows; and different positions of the sun, moon, and stars at different times of the day, month, and year.*	***Patterns -*** *Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena.*

MATERIALS

For the class:

- Summary table
- Explanation checklist (created in Lesson 9)

For each pair of students:

- Large construction paper or butcher paper.
- Zipper baggie of claims and evidence sentence starters (see lesson preparation)**
- Glue stick or tape
- Markers
- Revised model with sticky notes (from Lesson 9)

PREPARATION

Approximate time
15 minutes

** If you do not think your students need sentence starters as a scaffold, skip this step. If you think these would be helpful, there are sentence starters at the end of this lesson guide. Copy claims sentence starters on one color paper. Copy evidence sentence starters on a different color. Cut apart and place in a zipper baggie. Make one baggie for each pair of students or each table group.

PROCEDURE

COMPOSING A WRITTEN EXPLANATION (PAIRS) – 45-90 mins

1. Tell students that today they will be working in partners to write their explanation on large construction paper and using some sentence stems to help them. Show students how to pick a claim sentence starter, complete the sentence. Then pick an evidence sentence starter (different color) and complete that sentence to support the claim. Glue the starters to the construction paper or butcher paper.

2. Give time for pairs to get started drafting their written explanation using their model and evidence sticky notes from Lesson 9 and the baggie of sentence starters. Once they layout the sentence starters, students write their explanation on large construction paper or butcher paper.

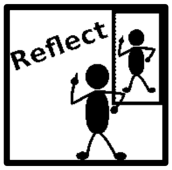
OPTION: After students have completed a few sentences with at least one claim and one piece of evidence, have students pair up as group of four and share their work so far. Peers can give and receive feedback about how their peers' explanation is going so far and what they could improve about how they explain their idea or describe their evidence.

EXAMINING STUDENT WORK

Track student understanding on the What-How-Why tracker. What patterns do you see on the tracker? Have most students shifted into deeper levels of reasoning (from what to how or how to why)? For students who have not displayed deeper levels of explanation were there other barriers in today's task limited that students' performance? For students who went beyond expectations, what about today's task helped students do so?

LESSON REFLECTION

Teacher Reflection



Task, Talk, Tools & Equity

Use the prompts to reflect on the lesson in order to track student thinking and make changes to improve future lessons.

Keep a record of these reflections for your professional portfolio.

1. **TASK, TALK, & TOOLS.**

   Task. What was the nature of the task in this lesson? Overall, what was the cognitive load? How does the task relate to students' lived experiences or funds of knowledge?

   Talk. What was the nature of talk in this lesson? What structures and routines supported student participation in talk?

   Tools. Tools scaffold student thinking and can house student ideas. Tools in this lesson included the model scaffold and public records/charts. How did tools support students to communicate their ideas?

2. **EQUITY.** Describe one issue around equity that arose during this lesson. Consider change(s) to the next lesson to help address this issue.

PLANNING NEXT STEPS

In moving into future units or lessons where students need to use evidence to support their ideas, what strengths did students show in this writing task? What areas can they improve? Consider how to plan to support students in improving how to select relevant evidence and clearly write about their ideas in a future lesson based on student performance in this lesson.

CLAIM SENTENCE STARTERS

Day and night happens because…

The tilt of the Earth causes…

The Earth orbits…

In Seattle, we have __________ daylight hours in winter because…

In Seattle, we have ___________ daylight hours in summer because…

In summer, Seattle has almost 16 hours of daylight per day because…

In winter, Seattle has about 8 ½ hours of daylight per day because…

EVIDENCE SENTENCE STARTERS

We know this because…

We learned that…

The _____________ activity showed us that…

The video about _________ said that…

The reading about _________ said that…

The _____________ activity showed us that…

The video about _________ said that…

The reading about _________ said that…