Light and Matter:

Why do we sometimes see different things when looking at the same object?

Science Literacy

Teacher Guide

Transmission and Reflection

Mirage

GRADE 6 Core Knowledge Science®

Core Knowledge®

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Table of Contents

BEFORE YOU BEGIN

Before introducing the unit, please become fully acquainted with the program instructional model and classroom routines by reading the online resource **Teacher Handbook: Overview of the Core Knowledge Middle School Science Program**.

Online Resources	Use this link to download the **CKSci Online Resources Guide** for this unit, which includes specific links to: • the unit's comprehensive materials list • a full unit pacing snapshot • lesson guidance slides • all other recommended resources. **www.coreknowledge.org/cksci-online-resources**
Student Work Pages	All student handouts and exercise pages are included in the consumable Student Work Pages book so that there is no need to print copies of these resources.
Student Books	All student handouts and exercise pages are included in the consumable Student Work Pages book so that there is no need to print copies of these resources. Students also will use the Student Procedure Guide and the Science Literacy Student Reader throughout the unit.

UNIT OVERVIEW

Why do we sometimes see different things when looking at the same object?

This unit on light and matter begins with a perplexing phenomenon of one-way mirrors and how this material can act as both a mirror and a window at the same time. Students directly observe and investigate the one-way mirror phenomenon using a scaled box model built from two combined boxes with a flashlight in one box, darkness in the other box, and a one-way mirror in between the two. Through this initial investigation, students figure out that the one-way mirror acts like a mirror on the light side of the system and a window on the dark side of the system. This experience prompts students to wonder: Why do we sometimes see different things when looking at the same object?

Students articulate a set of classroom norms to promote a safe and equitable classroom culture that they will use as they investigate and explain phenomena. They learn how to ask different kinds of questions about the phenomenon and how to model what they figure out to explain the phenomenon. Through their investigations, students figure out that the one-way mirror transmits about half the light and reflects about half the light that shines on it due to its microscale structures. Students engage in productive dialogue with their peers to come to consensus about how to model the unseen light interactions with the people and one-way mirror. Students then convince themselves that on the light side of the system, the one-way mirror reflects light as the strongest input to the eye, which is why a person sees their own reflection on this side. On the dark side of the system, the transmitted light from the light side is the strongest input to the eye, therefore why a person can see through to the light side. Using these ideas, students explain how light on either side of a material changes the light input entering the eyes, which affects what we see. Students apply these science ideas to explain why window glass can act like a one-way mirror in certain light conditions.

Through these investigations, students will do the following:

- Develop a shared set of classroom norms to guide their work together.
- Ask questions about the one-way mirror phenomenon that they investigate in the classroom by (1) manipulating light in the scaled box model, (2) measuring transmitted and reflected light off different materials, and (3) obtaining information from readings and videos.
- Agree upon and develop models to explain how light interacts with the one-way mirror, glass, regular mirrors, the eye, and the brain.
- Use a model to explain how the one-way mirror acts like a mirror on the light side of the system and acts like a window on the dark side of the system.
- Apply to an everyday phenomenon the science ideas and models developed for explaining the one-way mirror.

Focal Disciplinary Core Ideas (DCIs): PS4.B; LS1.D

Focal Science and Engineering Practices (SEPs): Asking Questions and Defining Problems; Developing and Using Models

Focal Crosscutting Concepts (CCCs): Systems and System Models; Structure and Function

Building Toward NGSS Performance Expectations

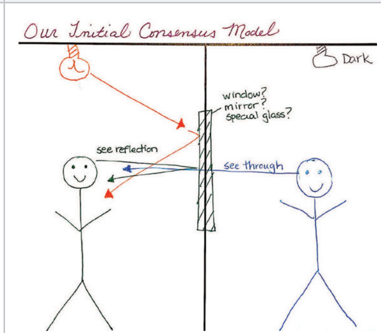
MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

MS-LS1-8: Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

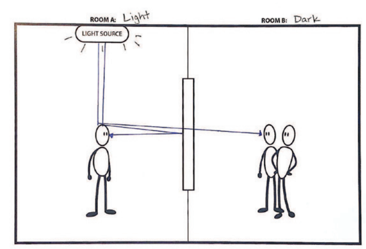
How students will engage with each of the phenomena

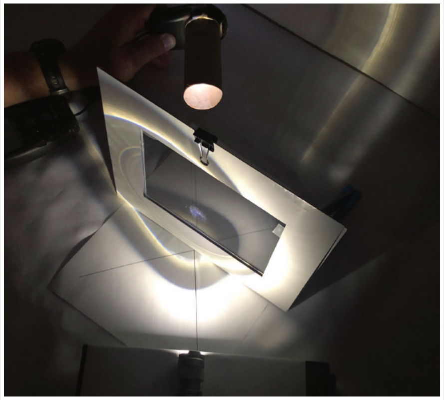
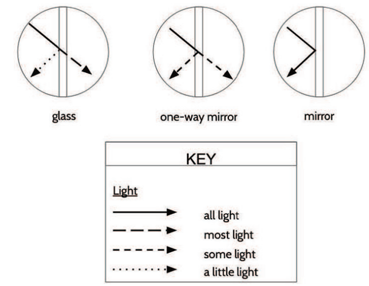
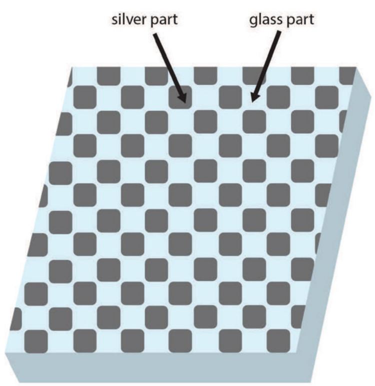
HANDS-ON/ LAB ACTIVITIES | VIDEOS OR IMAGES | DATA SETS | READINGS | COMPUTER INTERACTIVES

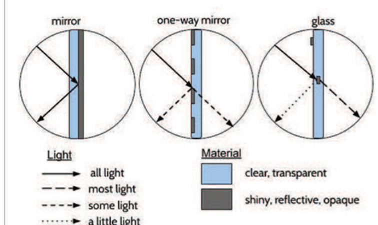
Why do we sometimes see different things when looking at the same object?

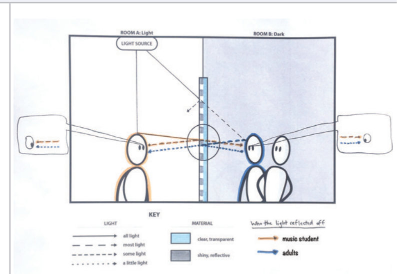
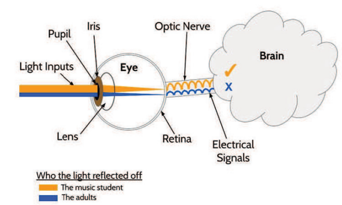
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 1 **4 days** **How can something act like a mirror and a window at the same time?** Anchoring Phenomenon	 *A piece of material looks like a mirror from one side and a window from the other side.*	We watch a puzzling video of a person who can see their reflection in what seems to be a mirror. The person doesn't see the people on the other side of the mirror, but those people can see through it like a window. We wonder how something can act like a mirror and window at the same time. We investigate the system using a box model that represents it. We develop an Initial Class Consensus Model, brainstorm related phenomena, and develop a Driving Question Board and an Ideas for Investigation chart. We figure out these things: • Some materials can be reflective and see-through at the same time. • Whether the material is reflective or see-through may be related to where there is a light.	

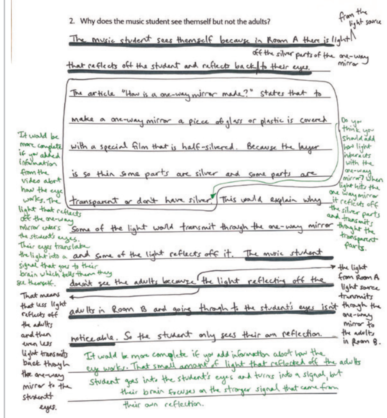
⇩ **Navigation to Next Lesson:** We figure out that the light on the other side of the mirror-window is likely important to whether it acts like a mirror or a window. We make predictions about how switching the light from Room A to Room B will affect what is seen.

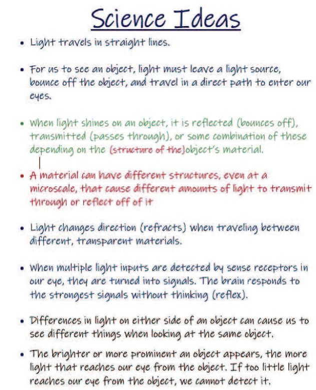
Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 2 **3 days** **What happens if we change the light?** Investigation	 *The one-way mirror phenomenon happens when there is a difference in light between the two sides of the material.*	In this lesson, we observe the one-way mirror in and out of the box model. We move the flashlight to Room B, make both rooms light, and make both rooms dark. We figure out these things: • When we change the location of light in the box system, the phenomenon reverses. • Reflection happens on the side that is lit, while the side that is dark is see-through. • The one-way mirror phenomenon is strongest when there is a difference in light between the rooms. • Light travels in straight lines. • For us to see an object, light must leave a light source, bounce off the object, and travel in a direct path to enter our eyes.	

<table>
<tr><th>Lesson Question</th><th>Phenomena or Design Problem</th><th>What we do and figure out</th><th>How we represent it</th></tr>
<tr><td colspan="4">Navigation to Next Lesson: We figure out that the difference in light between the rooms is causing us to see different things from either side of the one-way mirror in the box model. We wonder how the phenomenon would change if the one-way mirror material was regular glass or a regular mirror.</td></tr>
<tr><td>LESSON 3
3 days
What happens when light shines on the one-way mirror?
Investigation</td><td>
Different materials reflect and transmit different amounts of light, as measured quantitatively by a light meter.</td><td>We know that the one-way mirror acts like a mirror in a brightly lit room and acts like a window in a dark room. To figure out why it behaves this way, we compare what happens when light shines on the one-way mirror, a pane of glass, and a regular mirror. We record initial observations and then use a light meter to measure the amount of light transmitted through and reflected off each of those materials. We use a tool to develop an experimental question and then plan the investigation. We document our observations and analyze data to figure out what happens when light shines on the one-way mirror. We figure out these things:
Light travels in straight lines. (reinforcing 4th grade)
When light shines on an object, it is reflected (bounces off), transmitted (passes through), or some combination of these, depending on the object's material.</td><td>
</td></tr>
<tr><td colspan="4">Navigation to Next Lesson: We think the one-way mirror acts like a regular mirror because the two materials have something in common. But, we know they are not exactly the same, since the one-way mirror lets some light transmit and the mirror doesn't. Our next step is to try to figure out what the one-way mirror and the regular mirror have in common.</td></tr>
<tr><td>LESSON 4
1 day
How do similar amounts of light transmit through and reflect off the one-way mirror?
Investigation</td><td>

A one-way mirror has a thin silver layer compared to a regular mirror that is fully silvered and glass that is not silvered.</td><td>We wonder how similar amounts of light transmit through and reflect off the one-way mirror. We think it has something to do with how the one-way mirror is made. We read more about regular mirrors and one-way mirrors and find out that regular mirrors have a thick layer of silver on the glass, and one-way mirrors have a thin layer of silver embedded in a plastic film on the glass. We modify a model to explain what happens when light shines on the different structures in each material. We figure out these things:
A material can have different structures, even at a microscale, that cause different amounts of light to transmit through or reflect off of it.</td><td>
</td></tr>
</table>

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
⇩ **Navigation to Next Lesson:** In this lesson, we figured out that the one-way mirror is structured to transmit and reflect about the same amount of light due to half-silvering. We are ready to explain how the structure of the one-way mirror interacts with light to cause the one-way mirror phenomenon.			
LESSON 5 **1 day** **How do light and the one-way mirror interact to cause the one-way mirror phenomenon?** Putting Pieces Together, Problematizing	 *The one-way mirror acts as a mirror on the lit side and as a window on the dark side.*	In this lesson, we revisit the anchoring phenomenon and model interactions between light, the people, and the one-way mirror to explain why the music student and the adults all see the music student. We realize that a little light reflects off the adults and enters the student's eyes, which makes us wonder why the student doesn't see the adults. We figure out these things: • When light reflects off the music student and travels to the one-way mirror, about half of the light reflects off the silver structures back to the student's eyes and the other half transmits through the transparent parts to the adult's eyes. • The light that transmits through the one-way mirror reflects off the adults and travels to the one-way mirror. About half of that light reflects off the silver structures back to the adult's eyes and the other half transmits through the transparent parts to the student's eyes.	
⇩ **Navigation to Next Lesson:** We figure out that there are two light inputs into the student's eyes: light that has reflected off the student and light that has reflected off the adults. We wonder why the student doesn't see the adults, and we share initial ideas.			
LESSON 6 **2 days** **Why does the music student not see the adults?** Investigation	 *What we see is determined by the interactions between the light that enters the eye, the structures that make up the eye, and the brain, which processes the signals it receives from the eye through the optic nerve.*	In this lesson, we know that light has reflected off the adults and enters the student's eyes. We wonder why the student can't see them. To figure this out, we obtain more information about what happens when light enters the eye. We model how light inputs transform into signals that the brain processes to tell us what we see. We think about experiences from our everyday lives to help us explain why we see some inputs of light better than other inputs. We figure out: • Light changes direction (refracts) when it travels between different transparent materials. • When a light input is detected by sense receptors in our eye, it is turned into a signal that travels along the optic nerve to the brain, which processes it into what we see. • When there are multiple inputs, the brain responds to the strongest signal.	

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
⇩ **Navigation to Next Lesson:** Now that we know how the eye and brain make sense of light inputs, we are ready to develop an explanation for the one-way mirror phenomenon.			
LESSON 7 **1 day** **Why do the music student and the adults see the music student but the music student can't see the adults?** Putting Pieces Together	 *The music student can see their reflection in the mirror on the lit side but cannot see the adults. The adults on the dark side can see the music student through the glass.*	In this lesson, we review the class models from Lessons 5 and 6, the class science ideas list, and our individual Progress Trackers. As a class, we develop a written explanation to answer the question: Why do the adults see the music student? We individually draft an explanation to answer the question: Why does the music student see themself but not the adults? We self-assess our explanations and give and receive peer feedback on them. We then revise a final explanation. We figure out these ideas: • The music student sees themself because light reflects off the music student to the one-way mirror and reflects back to their eye. This light input is the strongest signal that is processed by their brain. • The adults see the music student because light reflects off the music student to the one-way mirror and transmits through the mirror to their eyes. This light input is the strongest signal that is processed by their brains. • The music student can't see the adults and they can't see their reflection because the light input from those objects is weaker and the brain doesn't respond to them.	 2. Why does the music student see themself but not the adults? The music student sees themself because in Room A there is light from the light source that reflects off the student and reflects back off the silver parts of the one-way mirror to their eyes. The article "How is a one-way mirror made?" states that to make a one-way mirror a piece of glass or plastic is covered with a special film that is half-silvered. Because the layer is so thin some parts are silver and some parts are transparent or don't have silver. This would explain why some of the light would transmit through the one-way mirror and some of the light reflects off it. The music student doesn't see the adults because the light from Room A light source transmits through the one-way mirror to the adults in Room B. the light reflecting off the adults in Room B and going through to the student's eyes isn't noticeable. So the student only sees their own reflection. It would be more complete if you added information from the video about how the eye works. The light that reflects off the one-way mirror enters the student's eyes. Their eyes translate the light into a signal that goes to their brain which tells them they see themself. Do you think you should add how light interacts with the one-way mirror? When light hits the one way mirror it reflects off the silver parts and transmits through the transparent parts. That means that less light reflects off the adults and then even less light transmits back through the one-way mirror to the student's eyes. It would be more complete if you add information about how the eye works. That small amount of light that reflected off the adults student goes into the student's eyes and turns into a signal, but their brain focuses on the stronger signal that came from their own reflection.
⇩ **Navigation to Next Lesson:** We developed an explanation for the anchoring phenomenon and celebrated our accomplishments. In the next lesson, we will apply our model to related phenomena to see what else we can explain.			

Lesson Question	Phenomena or Design Problem	What we do and figure out	How we represent it
LESSON 8 **3 days** **Why do we sometimes see different things when looking at the same object?** **Investigation, Putting Pieces Together**	 *Materials like glass can act like one-way mirrors when there is a differential in light on both sides of the glass.*	We investigate the best light conditions for the one-way mirror phenomenon to occur and decide the effect is greatest when there is a large difference in light on both sides of the material. We use this idea to investigate related phenomena. We conclude that other materials, like glass, can act like one-way mirrors in situations in which there is a similar light differential on either side of the material. We use our model and science ideas to demonstrate what we have learned on an assessment. We revisit the DQB to document the questions we have answered in the unit and to reflect on our learning. We figure out these ideas: • Differences in light on either side of an object or material can cause us to see different things when looking at the same object or material. • The brighter or more prominent an object appears, the more light that reaches our eyes from the object.	
LESSONS 1–8 **18 days total**			

TEACHER BACKGROUND KNOWLEDGE

Lab Safety Requirements For Science Investigations

It is important to adopt and follow appropriate safety practices within the context of hands-on investigations and demonstration, whether this is in a traditional science laboratory or in the field. In this way, teachers need to be aware of any school or district safety policies, legal safety standards, and better professional practices that are applicable to hands-on science activities being undertaken.

Science safety practices in laboratories or classrooms require engineering controls and personal protective equipment (e.g. wearing safety goggles, non latex aprons and gloves, eyewash/shower station, fume hood, and fire extinguishers). Science investigations should always be directly supervised by qualified adults and safety procedures should be reviewed annually prior to initiating any hands-on activities or demonstration. Prior to each investigation, students should also be reminded specifically of the safety procedures that need to be followed. Each of the lessons within the units includes teacher guidelines for applicable safety procedures for setting up and running an investigation, as well as taking down, disposing, and storing materials.

Prior to the first science investigation of the year, a safety acknowledgement form for students and parents or guardians should be provided and signed. You can access a model safety acknowledgement form for middle school activities. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Disclaimer: The safety precautions of each activity are based in part on use of the specifically recommended materials and instructions, legal safety standards, and better professional safety practices. Be aware that the selection of alternative materials or procedures for these activities may jeopardize the level of safety and therefore is at the user's own risk.

Please follow these lab safety recommendations for any lesson with an investigation:

1. Wear safety goggles (specifically, indirectly vented chemical splash goggles), a non latex apron, and non latex gloves during the set-up, hands-on investigation, and take down segments of the activity.
2. Immediately wipe up any spilled water and/or granules on the floor, as this is a slip and fall hazard.
3. Follow your teacher guide for instructions on disposing of waste materials and/or storage of materials.
4. Secure loose clothing, remove loose jewelry, wear closed-toe shoes, and tie back long hair.
5. Wash your hands with soap and water immediately after completing this activity.
6. Never eat any food items used in a lab activity.
7. Never taste any substance or chemical in the lab.

Specific safety precautions are called out within the lesson using this icon and a call-out box.

What are the Disciplinary Core Ideas (DCIs) in the context of the phenomenon?

"Disciplinary Core Ideas" are reproduced verbatim from *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. National Research Council; Division of Behavioral and Social Sciences and Education; Board on Science Education; Committee on a Conceptual Framework for New K-12 Science Education Standards. National Academies Press, Washington, DC. This material may be reproduced and used by other parties with this attribution. If the original material is altered in any way, the attribution must state that the material is adapted from the original.

The anchoring phenomenon for this unit is a one-way mirror, which is a material commonly used in exterior building windows, interrogation rooms, research and medical offices, and exterior house windows. One-way mirrors are made by placing a layer of one-way mirror film onto transparent glass or plastic. While a regular mirror includes a thick layer of reflective material layered onto glass (which makes the mirror opaque), a one-way mirror has a very thin layer of reflective material, like silver, aluminum, nickel, or tin. This thin layer is added to the front of the glass or plastic film. Applying a thin layer creates a "half-silvered" material. Some parts of the glass or plastic film are covered with the reflective coating. However, because the coating is so thin, this leaves some parts of the glass or plastic film still exposed. The result is a material that has some transparent surfaces and some reflective surfaces.

Due to its structure, a one-way mirror will reflect slightly more of the light that shines on it than it transmits. When the one-way mirror film is used in a situation where light is shining from *both* sides, the material looks a lot like a tinted film because light is reflecting and transmitting from both sides. When light shines from *only one side,* the material acts like a mirror from the light side and acts like a window from the dark side. This is the puzzling aspect of the phenomenon used to motivate students' learning in the unit.

Students figure out that the one-way mirror works the way it does because light entering our eyes from the light side of the system is mostly coming from light reflected off the silver structures in the one-way mirror. Thus, a person standing on this side of the material sees their own reflection. In order to fully understand this side of the system, students will learn to trace the light from the light source, reflecting on the person on this side of the system toward the one-way mirror, and reflecting back to the person's eyes. Alternatively, students trace the path of light transmitting through the one-way mirror. This light comes directly from the light source, but also from reflected light from objects on the light side of the system. The transmitted light enters the eyes of people on the dark side of the system. In order to fully explain why people see one thing and not the other, students need to account for how eyes detect light inputs and how the brain processes signals from the eyes. On the light side of the system, the light input from the reflected light is the strongest signal to the brain; thus, the brain tells the person that they see their reflection and do not see through the one-way mirror. On the dark side of the system, the stronger signal of light is the transmitted light from the light side of the system; thus, the brain tells the people that they see through the one-way mirror.

Because this unit is the first unit in the instructional material, it is designed to be used at the start of the school year in 6th grade. Given this placement, the unit intentionally reinforces a previous DCI element from grade 4:

- PS4.B: Electromagnetic Radiation: An object can be seen when light reflected from its surface enters the eyes.

You will see this DCI element reinforced during Lesson 2, with optional Building Prerequisite Understandings activities offered should students demonstrate they have not fully mastered this DCI.

In addition, the unit expands students' understanding of light to include grades 6-8 elements from PS4.B: Electromagnetic Radiation. The elements include the following:

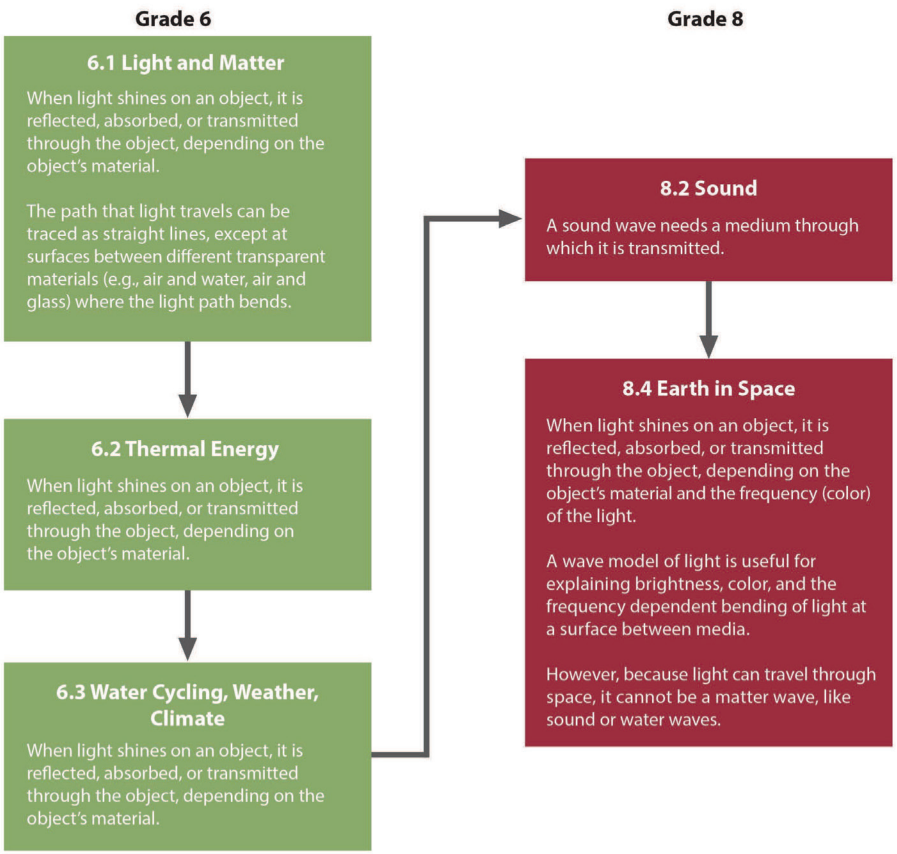
- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.

Below, we include important rationale about the PS4.B: Electromagnetic Radiation DCIs covered in this unit:

1. This unit does not address absorption of light, which is taken up in Lessons 7 and 8 of *Unit 6.2: How can containers keep stuff from warming up or cooling down? (Cup Design Unit)*. Should you teach *Cup Design Unit* following this unit, Lesson 8 offers a related phenomenon, focused on the use of one-way mirror film to make homes more energy efficient, that can help you transition from this unit to the *Cup Design Unit* unit.
2. The DCI elements associated with Performance Expectation MS-PS4-2 span five instructional units in the curriculum. This unit addresses only two of the elements, and the other elements are covered elsewhere in the materials, including the following:
    a. *Cup Design Unit* and *Unit 6.3: Why does a lot of hail, rain, or snow fall at some times and not others? (Storms Unit)* reinforce reflection and transmission of light, while adding absorption of light.
    b. *Unit 8.2: How can a sound make something move? (Sound Unit)* addresses PS4.A Wave Properties: A sound wave needs a medium through which it is transmitted.
    c. *Unit 8.4: Why do we see patterns in the sky, and what else is out there that we can't see? (Space Unit)* addresses the remainder of PS4.B: Electromagnetic Radiation: frequency (color) of the light; a wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media; and, however, because light can travel through space, it cannot be a matter wave, like sound or water waves.
3. The most notable omission from this unit with respect to DCI elements is the wave model of light. Until students understand waves, including frequency and amplitude, they are at a disadvantage for developing this kind of model for light. Students will engage deeply with wave models in the *Sound* unit. Thus, expanding the wave model from sound to light in the *Space* unit makes sense. The *Space* unit is also an ideal placement for these DCI elements as students will be ready to evaluate the limitations of a ray model of light for explaining phenomena in space and develop a wave model of light which has more explanatory power in the study of space-related phenomena.

In addition to the physical science DCIs, this unit also partly addresses a life science DCI, LS1.D: Information Processing. To fully explain why a person on one side of the one-way mirror primarily "sees" one thing, students must account for how the eyes detect light inputs and transform them into electrical signals sent to the brain. Therefore this unit includes the following:

Placement of DCI elements associated with MS-PS4-2



- Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.

The unit does not address cells, which will be introduced to students later in the 6th grade sequence. Instead, students learn about the "optic nerve" connecting eyes to the brain. Students also will not figure out how the brain responds in terms of reflex or memories. Students will revisit and expand on their understanding of this DCI in later units in the program, including returning to it in the *Unit 7.1: How can we make something new that was not there before? (Bath Bombs Unit)* in 7th grade and the *Sound Unit* in 8th grade.

How can I support my students in Asking Questions and Defining Problems?

In the units, students participate in asking questions about phenomena and defining problems. It is students' questions that play a critical role in driving their learning forward throughout the units. Students ask different kinds of questions for different purposes. Some questions arise from wonderment and curiosity about a phenomenon. Other questions beg to be answered empirically through investigations. Many questions are explanatory in nature (e.g., how or why) as students attempt to explain the phenomenon. These different kinds of questions will appear at the start of any unit as they encounter the phenomenon or problem for the first time. Over the course of the unit, students will answer some questions, refine others, and ask new ones as they come up.

Your students have already had a great deal of practice asking different kinds of questions during their elementary science experiences, though their background experiences may be uneven. It is expected that students will be able to identify testable questions from non testable ones and may have experience manipulating variables as they investigate experimental questions. At the elementary level, much of students' experiences will be closely tied to classroom investigations, or Planning and Carrying Out Investigations. A notable shift at the middle grades is that students will start to ask questions well beyond investigations. Students will be expected to ask questions to clarify a model, explanation, or premise(s) of an argument. Questions will guide their work as they seek additional information. They will further develop their understanding of testable questions, particularly experimental ones, and the kinds of evidence and how much evidence is necessary to answer those questions.

Given the placement of this unit at the start of middle school, much of the unit is used to (1) pre-assess students' experience with asking questions and (2) reinforce what they already know from elementary grades. However, you will engage your students in new elements of asking questions during the unit, which include the following:

- Ask questions that arise from careful observation of phenomena, models, or unexpected results to clarify and/or seek additional information (Lesson 1).

- Ask questions that can be investigated within the scope of the classroom, outdoor environment, and/or museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles (Lesson 2).
- Ask questions to determine relationships between independent and dependent variables and relationships in models (Lesson 3).
- Ask questions to clarify and/or refine a model, an explanation, or an engineering problem (Lesson 6).

Three Asking Questions Tools are provided to you, one that is used explicitly in Lesson 3. These tools are designed so that, as you pre-assess your students, you can better identify where your students need more or less support in subsequent units. These tools include the following:

- *Open and Closed Questions (Asking Questions Tool)*: Use this tool to support students in revising close-ended questions into open-ended ones. Avoid using it when students first offer questions for the DQB. Rather, use it later in a unit to transform close-ended questions into open-ended ones the class can investigate together.
- *Testable Questions (Asking Questions Tool)*: Use this tool to support students in asking testable questions that include enough specific information that one could gather evidence (e.g., measurements, observations) to answer the question. Note that this tool includes testable questions that are not specifically experimental ones, but ones that can be answered by gathering empirical evidence.
- *Experimental Questions (Asking Questions Tool)*: Use this tool to support students in asking experimental questions in which they will need to manipulate a variable in the system to observe its relationship to other variables. This is a tool designed to support students in crafting experimental testable questions.

How can I support my students in Developing and Using Models?

When students engage in the modeling practice, they identify important components, relationships, and processes that work together to explain a range of related phenomena. Through the intentional use of their ideas for explaining not only the anchor phenomenon but a range of phenomena, we are helping students to generalize these important ideas beyond the specificity of the unit context and recognize through their use the explanatory power of the developed ideas.

Students' modeling work is scaffolded by starting with the explanation of the unit's anchor phenomenon, which prompts questions that will be investigated by students. Through the investigation of these questions, students figure out key parts of the underlying model. Through the putting-the-pieces-together routine, students consider how the individual pieces of the model that they've constructed can be synthesized together to explain the anchor phenomenon. Through this routine, we identify what aspects of the phenomenon we still need to figure out. Thus, the development of students' models is a central practice used to organize students' learning.

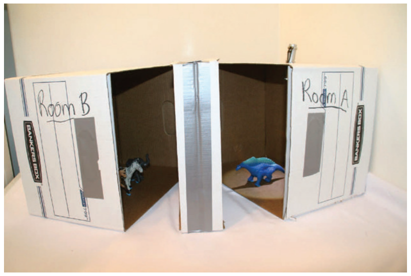
In units, students develop representations to help them make visible their ideas and mediate their work to explain the phenomenon. Thus, the goal is not to simply describe what is happening in the phenomenon, but to explain how and why a phenomenon occurs as it does. These representations can take various forms, including diagrams, where students depict both non visible and visible components of the phenomenon, or physical models. Regardless of how their models are represented, the focus of students' modeling work is the iterative development of students' underlying ideas. Thus, the move to make students' ideas visible allows them to consider how their ideas fit together to explain the phenomenon. In addition, it creates the space for students to consider hypothetical ideas that may be occurring that can be tested through investigation. Thus, students' models can facilitate argumentation as students use evidence to argue for particular ideas and reach consensus.

Below are some notable aspects of modeling important for this unit and the middle grades, more generally:

- Students use models not only to describe and represent, but also to do explanatory and predictive work. The latter becomes the focus in middle school as students engage more in the practice of modeling to predict and explain.
- Students move from physical models to conceptual or diagrammatic models and computer models.
- Students are not just identifying the limitations of models, but actually evaluating these limitations and thinking more about what the models do well and where they could be improved.

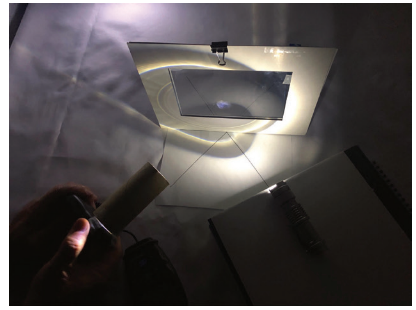
Using physical models to investigate and test aspects of phenomenon. Because they are not able to manipulate the real-world one-way mirror system, throughout the unit, students use physical box models to investigate and test aspects of the one-way mirror phenomenon to help them more fully understand the phenomenon itself. In Lesson 1, they use the box models to observe the phenomenon firsthand. These box models, like all models, have limitations. For example, students view the phenomenon through a peep hole at the back of the box rather than from where the music student or the adults are located within the system. In Lesson 2, they consider what would happen if parts of the real-world system changed by testing out different scenarios in the box models. They test swapping the light from Room A to Room B, putting lights in both rooms, and making both rooms dark. This helps them realize or reinforce their ideas that the light differential between rooms is key in causing the phenomenon. In Lesson 3, they zoom in to what happens when light interacts with the one-way mirror and measure the amount of light that reflects off and transmits through a one-way mirror, glass, and a regular mirror. By testing different materials, they figure out that one-way mirrors reflect and transmit about the same amount of light. Finally, in Lesson 8, students return to the box models and test ideas about manipulating the light brightness on both sides of the one-way mirror. They then test how another material—glass—can act like a one-way mirror in certain light conditions. The box models are not just representations of the system, rather, they are representations that students play with and manipulate that help them better understand the phenomenon and start to explain it.

Lesson 1



Lesson 2

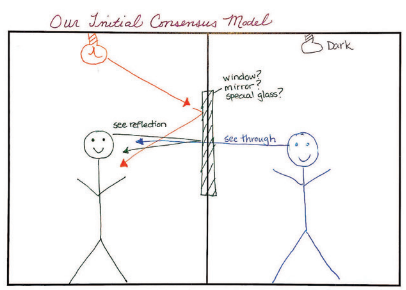
Lesson 3



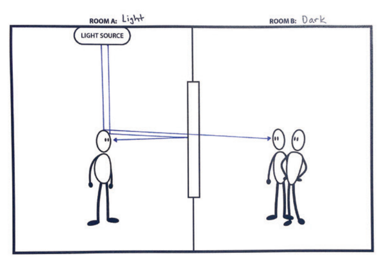
Lesson 8

Developing and revising diagrammatic models to explain the phenomenon. Students engage in developing and revising a conceptual or diagrammatic model that they use in Lesson 7 to develop a full explanation for the one-way mirror phenomenon. Unlike the box model that students manipulate to better understand the phenomenon itself, these diagrammatic models help students make sense of both the seen and unseen interactions between parts of the one-way mirror system. In Lesson 1, they develop an initial classroom consensus model, which is their first attempt to explain the phenomenon. This model may use arrows to represent the line of sight or to represent the path light travels, depending on what knowledge students bring from 4th grade. In Lesson 2, after manipulating the light in their box models, they revise their diagrammatic model and use arrows to represent the path that light travels from the Room A light source. In Lesson 5, students use what they figured out in Lessons 3 and 4 about how light interacts with the one-way mirror to again revise their diagrammatic models. This revision helps students make progress toward explaining what is happening when light from Room A shines on the music student and directly on the one-way mirror through to the adults. Finally, in Lesson 6, students zoom in on the eyes and model what happens when multiple light inputs enter the eyes. In Lesson 7 students use the revised Lessons 5 and 6 diagrammatic models to develop a full, written explanation for the one-way mirror phenomenon.

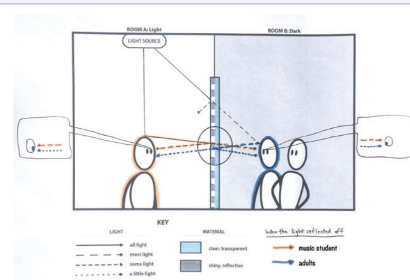
Lesson 1



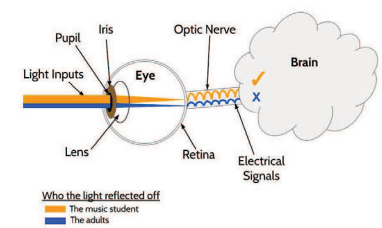
Lesson 2



Lesson 5



Lesson 6



How can I help my students to use Systems and Systems Models?

As students engage in modeling to explain the unit's anchor phenomenon, applying a systems lens is effective for helping students explain this complex phenomenon. The systems lens provides a way to systematically move or adjust the boundary of the system so that students can identify and focus on parts or *subsystems* of the phenomenon that can help them explain the anchor phenomenon and can think about outputs of one system being inputs to another system. For example, in this unit, we can analyze the unit phenomenon to consider the components, interactions, and processes that are important for explaining (1) how and why the music student could see themself, (2) why the music student could not see the adults, and (3) why the adults could see music student. We can then explain how light reflecting off objects in one system are outputs from the system and become inputs when they enter the eye and brain system. By examining interactions within and between systems, we can help students consider how the mechanisms work together to give rise to the more-complex one-way mirror phenomenon.

The unit scaffolds the use of a systems lens to first look at how light interacts with objects in the two rooms. Students then zoom into different parts of the whole system to investigate subsystems (e.g., the one-way mirror material with silver and transparent parts and light shining from one side). As students develop an understanding of the one-way mirror phenomenon, they are motivated to think about how we are able to see things in general, which prompts an investigation of how the eye takes in and changes inputs of light into electrical signals which the brain processes into what we "see." This introduces a new system for students to consider. The outputs of light off objects from one system are inputs of light to the eye and brain system. By the conclusion of the unit, students will have a better understanding of what constitutes a *system* and will have iteratively developed a *systems model* that describes how light interacts with all the objects in the two rooms and reflected light is an input into the eye.

How can I support my students to use Structure and Function?

Like Systems, the crosscutting concept of Structure and Function plays an important role in helping students make sense of phenomena in this unit. As students engage in identifying, modeling, and explaining the components and interactions that occur within and between the various subsystems that make up the two rooms, there are opportunities for students to consider how the shape and composition of key components of these subsystems help determine the function of those components as well as the function of the larger system as a whole. For example, as students investigate the one-way mirror phenomenon, they consider the structure of the one-way mirror, comparing it to a mirror and a window and looking for similarities that might help explain why the music student can see themself in the one-way mirror but cannot see the adults on the other side. Students investigate the microscale composition (structure) of the one-way mirror, learning that the one-way mirror is designed with a half-silvering approach different from a regular mirror that is fully silvered. However, unlike a regular mirror, the one-way mirror has a very thin layer of silvering. To determine the effect of this thin layer of silvering that can only be seen at the microscale (structure), students measure the amount of light that reflects off and transmits through the one-way system, which results in the one-way mirror functioning as a mirror and window in certain light conditions.

Students also determine that two light inputs are entering the student's eyes: the light that reflects off of him onto the one-way mirror and into his eyes and the light that passes through the one-way mirror and reflects off the adults back through the one-way mirror and into his eyes. To understand why the music student can't see the adults, students explore the shapes and components of the human eye to understand how light inputs are processed into what we see. Students learn that the lens of the eye, because of its structure (shape and composition), refracts light to a point on the retina, where light signals are changed into electrical signals that are sent to the brain along the optic nerve. This leads them to consider related phenomena that help explain how the brain "pays attention to" stronger signals rather than weaker signals.

What should my students know from earlier grades or units?

In 4th grade, students develop a ray model of light that is useful for explaining how we see objects. This model should include light traveling in a straight line from a source (e.g., Sun, lightbulb) to an object and reflecting off the object to our eyes. In this unit, this model is called "path of light," or POL, as compared to a pre-4th grade model, "line of sight," or LOS. Students may have explored related phenomena using this POL model, such as shadows and the color we perceive from objects (but not frequency of light and color). Early pilots of this unit indicated very few students were using a POL model for explaining how we see objects, and they often retained their LOS model. More guidance is provided throughout Lessons 1 and 2 to help you identify whether your students are using a LOS or POL model at the start of this unit. Because it is likely that your students will not have a complete POL model at the start of the unit, we included Building Prerequisite Understandings activities in Lesson 2 so as to not repeat 4th grade content but also to offer support should students not have mastered this content. After Lesson 2 students progress into the 6-8 grade territory for DCI elements.

With respect to science practices, students should have some experiences from grades 3-5 with identifying scientific (testable) questions from nonscientific (non testable) questions. This unit will reinforce this element of practice and build upon it to have students practice articulating an experimental, testable question in Lesson 3 in which they name independent and dependent variables and generate questions to clarify and refine their models and explanations.

Students will work on their collaborative model building in this unit, reinforcing elements of practice from grades 3-5. They will engage in many consensus discussions around representations to use in models and work together to modify the representation as they see a need arise. For much of this work, the students will remain in the grades 3-5 territory, reinforcing (intentionally) this important element of practice. They build their modeling practice by also considering variables in the system that are not observable to the human eye but are observable at different scales, such as the microscale structures that allow the one-way mirror to function as it does. Students will advance their understanding of modeling beyond using models to describe systems, the system parts, and relationships between parts. Instead, they will learn to use models to consider what happens *if parts of the system change*. Thus, students will engage in modeling work that is less descriptive and more predictive and explanatory in nature.

Students will have had experiences in earlier grades related to structures and their function but will build on this crosscutting concept by investigating microscale structures that allow materials to function in predictable ways, such as the silvering of the one-way mirror. Students will also reinforce their understanding of systems as a group of related parts that interact and will advance their understanding of systems by identifying boundaries to the system, considering light inputs within and beyond those boundaries, and recognizing that systems can be chunked into subsystems that are part of the larger, more complex system.

What are some common ideas students might have?

Students may think of light as simply filling space as opposed to traveling through space. Because light moves so fast, we cannot observe its movement when we switch on a light. While this unit does not teach students about the speed at which light travels, it is important to emphasize to students that the arrow representations they use throughout the unit represent the path where the light once traveled and the direction in which it traveled.

Similarly, students may confuse how to use arrows to represent light. Many students will want to use arrows to represent the line of sight of what is seen. Lesson 2 will be your opportunity to discuss the difference between line of sight (LOS) and path of light (POL) and to settle on how to use arrows to represent the path of light as it travels between the source and different objects in the system.

Lastly, students may confuse our everyday use of the word *reflection* (as a noun) to describe what we see in a mirror versus the scientific use of the word to describe what light does when it bounces off the surface of an object. Use Lesson 3 to co-construct a scientific definition for the word *reflect* and discuss its meaning in comparison to the everyday use of the word.

What modifications will I need to make if this unit is taught out of sequence?

This is the first unit in the materials and intended to be used at the start of 6th grade. Given this placement, several modifications would need to be made if teaching this unit later in the curriculum. These modifications include the following:

- The unit spends time introducing the students to a Driving Question Board. This would not be necessary if taught after other units.
- The unit helps the class develop and practice a shared set of classroom norms. If this unit is taught later in a school year, the norm-building process would need to happen in an earlier unit and could be streamlined here.
- This unit focuses on reinforcing many grades 3-5 elements in all three dimensions. This reinforcement is intentional as preparation for students to begin building on those elements in the grades 6-8 space. If this unit is taught later in the sequence, modification to these elements would need to happen so that this unit is less about reinforcing grades 3-5 and more about building elements in grades 6-8.
- This unit is the first unit in an intentional sequence to build two Performance Expectations: MS-PS4-2 and MS-LS1-8. The DCIs associated with these Performance Expectations are fully covered across multiple units. The approach to these DCIs will need to change if this unit is taught after other units addressing the same, or closely related, DCIs.

What prerequisite math concepts are necessary for the unit?

In Lesson 3 students will collect light sensor data under very specific measurement conditions in which any deviation from the protocol could result in measurement error. Even given the detailed protocol students follow, the light sensor will not consistently report a single value, so students will need to determine a range that seems as accurate as possible given the measurement conditions. When they rank order the materials by transmissivity and reflectivity, they will use ranges that could overlap for some materials, and students may need to estimate the central tendency within the range of values to help them determine their rankings. This work is largely done as a whole group and can be more or less guided by you. However, the following math concept may be helpful:

- CCSS.Math.Content.6.SP.A.2: Understand that a set of data collected to answer a statistical question has a distribution which can be described by its center, spread, and overall shape.

Additionally, students collect these data using base tens (x10 lux). The following math concept will be useful in explaining why they are selecting this setting on the light sensors.

- CCSS.Math.Content.5.NBT.A.1: Recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and 1/10 of what it represents in the place to its left.

Consult with your students' math teacher(s) prior to Lesson 3 to coordinate your approach to the math concepts listed above with what your students will experience in their math classes.

PROVIDED SUPPLEMENTAL ACTIVITIES AND HOW TO USE THEM

This unit has optional supplements, or detours, that are not part of the main storyline. Building Prerequisite Understanding activities offered early in the unit are designed to support students who have not mastered the prerequisite conceptual understandings from elementary school. Extension Opportunity activities offered later in the unit are intended to be used for high-interest learners, learners who have already met the performance expectations, or teachers who want to more fully develop students' understanding of some science concepts. A summary of the supplemental activities is provided below with a short description and rationale for when a teacher would decide to spend additional time on these.

Lesson	Activity Type	Description
Lesson 2	Building Prerequisite Understandings	The additional activities that are offered are designed to reinforce 4th grade DCIs about the path light travels that enables us to see objects. These are prerequisite understandings that students need before advancing further in the unit. Formative assessment guidance in Lessons 1 and 2 will help you determine if your students need these activities before advancing to Lesson 3. Students will develop an understanding of the following ideas: • For us to see an object, light must leave a light source, bounce off the object, and travel in a direct path to enter our eyes. • If there is no light source, we don't see anything. • Light travels in straight lines. • Light cannot bend around a solid object. • A shadow is made when light cannot bend around an object or go through a solid object. • An arrow can show the direction light moved.
Lesson 6	Extension Opportunity	Additional activities deepen and extend students' understanding of refraction. The unit storyline briefly touches on refraction in connection to the eye lens focusing light inputs on the retina. Students use a physical model to figure out that some transparent material can change the direction light travels. This unit on Light and Matter is the only opportunity in the program to investigate refraction, and therefore, you may want to spend an additional class period or two investigating it further. If you choose to complete these supplemental activities, students will develop a deeper understanding of the following idea: • Light changes direction (refracts) when traveling between different, transparent materials.
Lesson 8	Extension Opportunity	Additional activities deepen and extend students' understanding of what happens when light reflects off objects with different microscale surfaces. These activities help students explain everyday phenomena like glare, smooth lake surfaces, and other mirror-image surfaces. Students will develop an understanding of the following ideas: • When light shines on surfaces that are rough at the micro scale, it scatters in all directions. • When light shines on surfaces that are smooth at the micro scale, it reflects in the same direction.

BUILDING NORMS TO SUPPORT A PRODUCTIVE CLASSROOM CULTURE

As the first unit of 6th grade, this unit has an emphasis on developing a classroom culture in which students feel like they belong and it is safe to participate, share their ideas, disagree, and productively struggle together. Refer to the *Teacher Handbook* for more information about the purpose of classroom norms, an example set of norms to use with your class, and strategies for developing and reinforcing norms. Below is an at-a-glance chart of how norms are introduced and reinforced in this unit, with the purpose of each activity to support modification to the norms to fit your class's needs.

Lesson	Activity	Purpose
Lesson 1	Day 2: Introduce Communicating in Scientific Ways.	These sentence starters are a way to help promote the use of scientific language. Starters around agreeing and disagreeing with ideas help the class make progress toward a culture that moves scientific thinking forward.
	Day 3: Develop a set of classroom norms by reviewing and revising *Science Classroom Norms* or co-constructing community norms with your class. Practice one norm during the Consensus Discussion.	An explicit set of norms will foster an equitable learning community that promotes trusting and caring relationships. Doing this at the start of the year and unit enables a place to return to and check how the class is doing. When developing norms, consider these questions: • What norms will you use? • When and how will you introduce norms? • How will you help students own and understand these norms?
	Days 3 and 4: Check in on the classroom norms.	Several optional slides are provided that you can use to reinforce and reflect on progress toward the norms. These can be used at any time during this lesson or in other lessons.
Lesson 2	Day 2: Facilitate a gallery walk and encourage idea pirating.	Discussing norms prior to a gallery walk gives students an opportunity to practice norms in the context of a specific activity where students see and are encouraged to take up the ideas of others. This reinforces norms in the category of "moving our science thinking forward", particularly these concepts: • *We use and build on each other's ideas.* • *We are open to changing our minds.* • *We challenge ourselves to think in new ways.*

Lesson	Activity	Purpose
Lesson 3	Day 1: Facilitate a Building Understandings Discussion.	Discussing norms prior to a Building Understandings Discussion gives students an opportunity to practice norms in the context of a specific activity where students are sharing their ideas and listening to others' ideas to build common understanding of the science ideas. This could help reinforce many different norms, such as these: • *We share our time to talk.* • *We critique the ideas we are working with, but not the people we are working with.* • *We encourage others' voices who we have not heard from yet.* • *We share our own thinking to help us all learn.* • *We listen carefully and ask questions to help us understand everyone's ideas.*
Lesson 4	Facilitate a Consensus Discussion.	Discussing norms prior to a Consensus Discussion gives students an opportunity to practice them in a specific activity where students are asked to come to agreement with one another. This could help reinforce many different norms, such as these: • *We use evidence to support our ideas, ask for evidence from others, and suggest ways to get additional evidence.* • *We are open to changing our minds.* • *We challenge ourselves to think in new ways.*
Lessons 5-7	No specific norms are highlighted in these lessons.	Consider how you can best reinforce and reflect on the class's progress toward the norms. Consider activities such as: • Discussion Map: Map who is talking during whole-group discussions to see if the conversation is equitable. The *Discussion Mapping Tool* is available in the Online Resources. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) • Have students choose an individual norm they want to practice and chart their progress on the norm throughout a lesson or across all three lessons.
Lesson 8	Navigate to pursue further exploration.	The use of norms here emphasizes *challenging ourselves to think in new ways* because students have just explained the anchoring phenomenon. They may feel they have finished the unit, but it is important to challenge their thinking to see if they can use their understandings in new contexts and to explain related phenomena.

GUIDANCE FOR DEVELOPING YOUR WORD WALL

This unit refers to two categories of academic language (i.e., vocabulary). Most often in this unit, students will have experiences with and discussions about science ideas before they know the specific vocabulary word that names that idea. After students have developed a deep understanding of a science idea through these experiences, and sometimes because they are looking for a more efficient way to express that idea, they have "earned" that word and can add the specific term to the class Word Wall. These "words we earn" should be recorded on the Word Wall using the students' own definition whenever possible. On the other hand, "words we encounter" are "given" to students in the course of a reading, video, or other activity, often with a definition clearly stated in the text. Sometimes, words we encounter are helpful only in that particular lesson and need not be recorded on the Word Wall. However, if a word we encounter will be frequently referred to throughout the unit, it should be added to the Word Wall. As such, the Word Wall becomes an ongoing collection of words we will continue to use, including all the words we earn in the unit and possibly a few key words we encounter.

It is best for students if you wait and create cards for the Word Wall in the moment, using definitions and pictorial representations that the class develops together as they discuss their experiences in the lesson. When they co-create the posted meaning of the word, students "own" the word—it honors their use of language and connects their specific experiences to the vocabulary of science beyond their classroom. It is especially important for emergent multilingual students to have a reference for this important vocabulary which includes an accessible definition and visual support.

Sometimes creating Word Wall cards in the moment is a challenge. The teacher guide provides a suggested definition for each term to support you in helping your class develop a student-friendly definition that is also scientifically accurate. If you keep one Word Wall in your classroom for several sections of students, you might choose to record each class's definition separately and then propose at the next class meeting to post an "official" definition that captures the collected meaning.

The words we earn and words we encounter in this unit are listed in this document and in each lesson to help prepare and also to avoid introducing a word before students have earned it. They are not intended as a vocabulary list for students to study before a lesson, as that would undermine the authentic and lasting connection students can make with these words when they are allowed to experience them first as ideas they're trying to figure out.

Special note about supporting emergent multilingual learners with vocabulary development: In this unit, there are words we earn that could have different meanings depending on the suffix and the word's use in a sentence. For example the -ive in "reflect*ive*" indicates the word is an adjective, while the -ion in "reflec*tion*" indicates it's a noun. However, the use of -ing in "reflect*ing*" could indicate its use as an adjective or a verb. When we talk about light reflect*ing* off a surface, it's an action by the light. Because suffixes change the meaning of words in this way, it is especially important for you and your students not to use variations of this unit's high-frequency words interchangeably, particularly with your emerging multilingual learners. Talk with your school's language specialist for additional support.

Special note about systems and models: Students start to develop their understanding of "system" in Lesson 1 as they name parts, interactions, and the boundary of the one-way mirror system. They use the term throughout Lessons 2-7 but do not define it until Lesson 8 when they co-construct a definition to be placed on the Word Wall. Likewise, the term "model" is also introduced in Lesson 1. Students work with both physical models and conceptual, diagrammatic models throughout Lessons 1-4. They reflect on their modeling work in Lesson 5 and define the term when they place it on the Word Wall. For more information on the unit's approach to systems thinking and modeling, refer to the teacher background information.

Lesson	Words we earn	Words we encounter	Words we reinforce or apply from previous units
L1		one-way mirror, scale model, norm	
L2			light source
L3	reflect, transmit	independent variable, dependent variable, experimental question	
L4		silvering, transparent, opaque	
L5	model		
L6		retina, optic nerve, refract	
L7			
L8	system	scattering, specular reflection	

TEACHING SCIENCE LITERACY

How does the Core Knowledge Science Literacy routine integrate with the unit investigations?

The Core Knowledge Science Literacy Student Reader and the weekly Science Literacy routine layer varied reading opportunities into the science unit. In their lives after graduating from high school, most students will not become scientists. They will no longer routinely participate in guided investigations to figure out how phenomena work. They will, however, read text about science and scientific claims, day in and day out. The ability to learn and think about science through reading is a skill unto itself and is important in tandem with investigative learning. It is natural to primarily associate emerging literacy with reading and writing instruction at the elementary level, but middle school is an important time to hone literacy skills—specifically in science in the era of politicization of science topics, polarization among adults, and proliferation of misinformation on social media. Detection and construction of well-reasoned explanations are important not just in science, but throughout everyday life. Using claims and evidence in reasoning is the way that thoughtful people think about things, and writing is thinking in print. Students become voters as they emerge from high school, so it is important that they acquire skills for detection of faulty information and practice legitimate communication about scientific issues in the years leading up to that civic benchmark.

Throughout the course of the unit's investigative lessons, students write in their science notebooks in some fashion almost daily, and significant emphasis is placed on the speaking and listening communication threads of the CCSS. The instructional design of the investigations is deliberately light on having students access disciplinary core content through text. NGSS emphasis is on students investigating phenomena along the storyline, so students' interaction with text within lessons is minimal and in service to the unit's storyline. The Science Literacy routine is integrated to exercise students' ability to interact with text about science topics. The routine presents students with short reading selections in a variety of styles, all related to the unit in which students are engaged. Each reading selection is accompanied by a brief but thoughtful writing exercise. The subject matter of the reading selections ties back to the unit, but the timing for the assigned readings is such that students do not read about specific facets of the subject before they have completed the lessons to investigate that content. In other words, the reading enhances and reinforces the knowledge that students have built in previous lessons; the reading does not reveal beforehand the key takeaways that students are intended to learn through lesson interactions.

When is it done within a unit?

The Core Knowledge Science Literacy Student Reader includes one reading collection per week for every week of the unit. A week's reading collection relates to the lessons completed in the previous week. The reading is assigned at the beginning of the week with the accompanying writing exercise due at the end of the week. The reading and writing exercises are designed to be completed by students independently, with brief, supporting, teacher-facilitated discussions at the beginning, midpoint, and end of the week.

How do students typically represent their thinking as part of the routine?

Students generate a written product associated with each reading selection. The products are varied in form and include graphic organizers, concept maps, cartoons, memes, infographics, storyboards, outlines, and paragraphs. The complexity of the products increases from week to week, with the final product for the unit being a single, thoughtfully reasoned, and well-constructed paragraph.

Put Yourself in This Scene

Literacy Objectives

✓ Initiate thinking about the need to evaluate information in text and images.

Literacy Activities

- Read a brief scenario to pique interest, launch discussion, and begin to frame expectations.

Instructional Resources

Student Reader

Preface

Science Literacy Student Reader, Preface
"Put Yourself in This Scene"

No Prerequisite Investigations

The reading of the Preface is appropriate during the first week of unit instruction. The reading does not preemptively tell students facts about the topic that they are intended to learn throughout the course of their investigations.

Standards and Dimensions

NGSS

Disciplinary Core Idea LS1.D: Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.

Science and Engineering Practice: Asking Questions and Defining Problems

Crosscutting Concept: Cause and Effect

CCSS

English Language Arts
RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 6-8 texts and topics*.

RST.6-8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. No Core Vocabulary terms are highlighted in the Preface.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

LED light   **wavelength**

A Glossary at the end of the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction.

1. Plan ahead.

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the Science Literacy Student Reader.
- Friday: Set aside time at the end of the week to facilitate a brief discussion about the reading.

You'll proceed with the in-class lesson investigations during this week.

2. Preview the assignment and set expectations.

(MONDAY)

- Let students know that for the Science Literacy routine, they will read independently and then complete short writing assignments. The reading selections relate to topics they will be exploring in their Light and Matter unit science investigations.
- The reading and writing will typically be completed outside of class (unless you have available class time to allocate).
- The first week's reading is a short introductory segment in the book, and there is no accompanying writing exercise as the unit is getting started.
- The class will discuss the reading together at the end of the week.

SUPPORT—The Preface about blue light coming from screens scenario is written at approximately Lexile 1100–1200, which leans toward the high end of the expected text complexity band for middle school. You may wish to introduce a word identification and comprehension convention into your routine to support struggling readers. Hang an envelope near the door with the label, "When we talk about the next reading selection, I could use a little more help understanding the word(s). . ." Encourage students, as they are reading, to jot words, phrases, or sentences that they are unclear about onto small scraps of paper and tuck them into the envelope at any time preceding the discussion of the reading. Whenever you facilitate class discussion about a reading selection, check the envelope first, and layer in added examples and repeat definitions to help students build comprehension and fluency for terms or complex sentences about which they have revealed they are uncertain.

3. Facilitate discussion. (FRIDAY)

Facilitate a brief class discussion about the Science Literacy Student Reader Preface, entitled "Put Yourself in This Scene."

Pages 2–3 **Suggested prompts**	**Sample student responses**
How would you summarize the "scene" referred to in the title?	*A dad tells his teen he is no longer allowing screen time after eight because he heard that the blue light screens give off is bad for developing eyes and prevents people from falling asleep.*
What do you already know about these two possible effects of using screens?	*I've heard about the blue light making it hard to fall asleep, but I haven't heard that blue light damages kids' eyes.* *I haven't heard about either of these effects, but I know my eyes sometimes feel dry when I use screens for a long time.*
What does "wavelength" describe?	*It the distance from the crest or trough of one wave to the crest or trough of the next wave.*
What have you observed about the color of lights given off by different sources, such as LEDs versus incandescent light bulbs?	*Incandescent light is yellowish, but LED lights can be different colors.*
What are two questions that you think the teen should research to find out more?	*Does screen time cause damage to kids' eyes?* *And does blue light from screens affect people's sleep patterns?*
What does it mean to be "scientifically literate"?	*It means you can think critically about what you read from all sources but especially on social media and other websites.* *It means you can understand the science you read or listen to in the news.* *It means you are skeptical about what you read and watch.*

Student Reader

Preface

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

Pages 2–3 **Suggested prompts**	**Sample student responses**
What kinds of reliable sources would a school librarian or reference librarian point you to if you wanted to check out the accuracy of what the dad said?	*Librarians show you to sources written, edited, or reviewed by scientists for accuracy, especially those approved by librarian groups.* *They would point you to subscription encyclopedias, articles in science magazines, or websites from science organizations such as museums and universities.*
Why do people have to be careful about reading only the websites at the top of the search results of some search engines?	*These are websites that are very popular, but that doesn't mean the science is accurate.* *Some of those websites pay an advertising fee to get to the top of the list.*

KEY IDEA—Point out that something "heard on the news" might or might not be accurate. Or it might be a partially accurate explanation of a phenomenon. For these reasons, online or library research is often needed when trying to interpret science-related statements. Students should rely on trusted sources for science information that can include science teachers, government science agency websites (NASA, for example), and science museum websites. Regarding the blue-light phenomenon, students should check the dates of websites they use, because the research is evolving. Both the investigations and the reading selections in the unit ahead will help students advance to a place where they have more knowledge to apply to the scenario, and they will circle back to the topic of wavelengths of light at the end of the unit.

EXTEND—LEDs (light-emitting diodes) are commonplace, but the invention of blue-light LEDs was a big deal when it finally happened. Adding blue light to red- and green-light LEDs already in use, means the three sources of light could be mixed to finally produce white light. Students interested in electronics or inventors may wish to read online about the 1993 invention of the first bright blue LEDs, which led to a Nobel Prize in Physics in 2014 for three scientists from Japan. Have students search online for news stories about the winners and their invention.

LESSON 1

How can something act like a mirror and a window at the same time?

Previous Lesson

There is no previous lesson.

This Lesson

Anchoring Phenomenon

4 DAYS

We watch a puzzling video of a music student who can see their reflection in what seems to be a mirror. The student can't see the adults on the other side of the mirror, but the adults can see the student. We wonder how something can act like a mirror and a window at the same time. We investigate the scenario using a box model that maps to the system in the video. We develop an Initial Class Consensus Model to explain the one-way mirror phenomenon, and we identify related phenomena that could help us explain it. We share questions about the one-way mirror, which helps us form our Driving Question Board. We brainstorm investigations and data we need to answer our questions.

Next Lesson

We will take the one-way mirror out of the box model and observe that it looks the same from both sides: partially reflective and partially see-through. We will change the amount of light on either side of the box model to further investigate the role that light plays.

Building Toward NGSS

MS-PS4-2, MS-LS1-8

What Students Will Do

1.A Develop a model to identify the important parts of the system and how those parts interact that could cause an object to look different in different light conditions.

1.B Ask questions that arise from observations of a phenomenon in which an object appears different depending on the light conditions within the defined system.

What Students Will Figure Out

- Some materials can be reflective and see-through at the same time.
- Whether the material is reflective or see-through may be related to where there is a light.

Lesson 1 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	10 min	**INTRODUCE A PUZZLING PHENOMENON** Play the Music Lesson video, showing a student who can see only their reflection in a one-way mirror while adults on the other side can see through the one-way mirror. Have students record noticings and wonderings.	A	computer and projector, Music Lesson video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources)**
2	10 min	**SHARE NOTICINGS AND WONDERINGS FROM THE VIDEO** Share noticings and wonderings from the video with a partner. Lead a class discussion to record these observations and questions on a class chart.	B	Notice and Wonder chart (prepared in advance), markers
3	15 min	**IDENTIFY PARTS AND INTERACTIONS TO DIAGRAM OUR THINKING** Through partner talk and class discussion, co-construct a list of the important parts in the video phenomenon and a diagram of the parts' interactions that should be included in initial explanations.	C-E	*Initial diagram to explain the phenomenon* (optional), Parts chart (prepared in advance), markers
4	5 min	**COMPARE DIAGRAMS WITH A PARTNER** Arrange students into partners to share their diagrams and note similarities and differences.	F	*Initial diagram to explain the phenomenon* (optional)
5	5 min	**NAVIGATION** Brainstorm ideas for making a scale model that represents the system in the video to investigate the phenomenon in the classroom.	G	
				End of day 1
6	5 min	**NAVIGATION** Introduce the box model and elicit students' prior experiences with scale models.	H	1 box model setup, 1 picture mat set with one-way mirror film, 1 flashlight, toys
7	10 min	**MAP THE BOX MODEL TO THE VIDEO** Guide students in mapping the parts of the box model to the important parts in the video. Use this mapping to highlight the benefits and limitations of using the box model.	I	Mapping the Model to the ________ chart (prepared in advance), Parts chart (prepared in advance), markers
8	15 min	**CARRY OUT THE BOX MODEL INVESTIGATION** Give students time to explore the box model and to add noticings and wonderings to their chart.	J	1 box model setup, 1 picture mat set with one-way mirror film, 1 flashlight, toys

Part	Duration	Summary	Slide	Materials
9	12 min	**SHARE OBSERVATIONS FROM THE BOX MODEL INVESTIGATION** Facilitate a class discussion to connect what students noticed and wondered in the *Box Model Investigation* to what they saw in the video. Evaluate the box model.	K-L	Communicating in Scientific Ways handout, Notice and Wonder chart (prepared in advance), markers
10	3 min	**NAVIGATION** Ask students to complete an exit ticket in preparation for a Consensus Discussion.	M	index card
				End of day 2
11	15 min	**FORM A SCIENTISTS CIRCLE AND DISCUSS CLASSROOM NORMS** Arrange the classroom and students in a Scientists Circle. Before developing a classroom consensus model, develop explicit, shared norms for the learning community.	N	*Science Classroom Norms*
12	18 min	**DEVELOP AN INITIAL CLASS CONSENSUS MODEL** Stay in a Scientists Circle while students share their diagrams. Facilitate a Consensus Discussion to develop the Initial Class Consensus Model.	O-Q	Initial Class Consensus Model (prepared in advance), markers
13	12 min	**BRAINSTORM RELATED PHENOMENA AND ASSIGN SELF-DOCUMENTATION** Generate a class list of possible related phenomena and experiences. Assign home learning for students to document related phenomena in their lives over the next few days.	R-S	Related Phenomena list (prepared in advance), markers
				End of day 3
14	6 min	**WRITE QUESTIONS FOR THE DRIVING QUESTION BOARD** Students individually generate questions about the phenomenon in preparation for building the DQB.	T-U	2 sticky notes, marker
15	24 min	**DEVELOP A DRIVING QUESTION BOARD** Share questions to build the DQB about what is causing the phenomenon observed in this lesson.	V-W	Driving Question Board (overlaid on the Initial Class Consensus Model)
16	12 min	**DEVELOP IDEAS FOR FUTURE INVESTIGATION** Students use the DQB to develop a list of investigations we could conduct to answer our questions and explain the one-way mirror phenomenon.	X	Ideas for Investigations chart (prepared in advance), markers

Part	Duration	Summary	Slide	Materials
17	3 min	**DECIDE WHERE TO GO NEXT** Students predict what would happen if we switch the light to the other room in the box model.	Y-Z	

End of day 4

Lesson 1 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide** **Student Work Pages**	• science notebook • *Initial diagram to explain the phenomenon* (optional) • Communicating in Scientific Ways handout • index card • *Science Classroom Norms* • 2 sticky notes • marker	• 1 box model setup • 1 picture mat set with one-way mirror film • 1 flashlight • toys	• computer and projector • Music Lesson video • Notice and Wonder chart (prepared in advance) • markers • Parts chart (prepared in advance) • Mapping the Model to the ________ chart (prepared in advance) • Initial Class Consensus Model (prepared in advance) • Related Phenomena list (prepared in advance) • Driving Question Board (overlaid on the Initial Class Consensus Model) • Ideas for Investigations chart (prepared in advance)

Materials preparation (160 minutes)

Online Resources

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Check the *Music Lesson* video clip to ensure that it plays on your device and can be viewed by the whole class. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Use *Box Model Assembly Instructions* to build 6 box models. If you have a larger class, you may want to build more to ensure smaller group sizes. Each box model takes approximately 20 minutes to assemble, though the first one may take longer as you learn the procedures. Once built, these models can be used in the future.

Edit *Science Classroom Norms* and **slide N** as necessary to include the norms you want to adopt in your classroom. You will also introduce the *Communicating in Scientific Ways* sentence starters. Provide this as a handout for students to tape in their science notebook or post it as a classroom reference chart.

Prepare the following spaces and charts that will be used throughout the unit:

- Day 1: Notice and Wonder chart, Parts chart
- Day 2: Mapping the Model to the _____ chart (on chart paper or whiteboard or project slide over whiteboard)
- Day 3: Initial Class Consensus Model (on chart paper), Related Phenomena list
- Day 4: Ideas for Investigations chart. Also, prior to day 4, determine where to set up the DQB so students can gather around it and use the Initial Class Consensus Model as the backdrop for the DQB.

Day 2: Box Model Investigation

- **Group size:** This will depend on class size and the number of models you build.
- **Setup:** See *Box Model Assembly Instructions* for building instructions. Once the models are assembled, store them in a location where students cannot see them until day 2. When you are ready for students to work with the models, arrange them around your classroom to facilitate small-group work. Have the box model setup completely assembled for today's investigation with one-way mirror film already inserted into each box. Check batteries in the flashlights and replace if needed.
- **Notes for during the lab:** The viewing holes may allow light into the box and diminish the desired effect. Dim your classroom lights to minimize this problem.
- **Storage:** These box models will be used again in Lesson 2.

Lesson 1 • Where We Are Going and NOT Going

Where We Are Going

This first lesson elicits students' initial ideas about what causes us to see different things with the same material. The lesson is sequenced to elicit initial ideas about the conditions for sight (i.e., what we need in order to see) and the different ways light interacts with materials. Many students will be curious about how a material can act as both a mirror and a window at the same time. They will deepen their understanding of the anchoring phenomenon using a scale model to help them explain what's happening in the real world. Their curiosities will seed initial questions and future investigations into (1) the positioning of the light in the two rooms, (2) the light's interactions with the one-way mirror compared to a regular mirror and a regular piece of glass, and (3) the structure of the one-way mirror compared to a regular mirror and a piece of glass. Students will also (4) delve into how we see objects and how our eye processes light inputs of different intensities, or brightness.

Day 1 refers to the material as a "mirror-window," but starting on day 2, refer to it as a "one-way mirror" or the name you've adopted for it as a class (e.g., "mirdow," "mirrindow," or "two-way mirror").

This lesson builds on a 4th-grade DCI: *PS4.B: Electromagnetic Radiation: An object can be seen when light reflected from its surface enters the eyes.* (4-PS4-2). That DCI is focused on moving students toward a "path of light" (POL) model, which traces the path of light from its source to an object and then reflecting off the object into our eyes. When this is drawn, students may use arrows that point away from the source, point away from objects that reflect the light, and point toward the eyes. In contrast, it is common for students to use a "line of sight" (LOS) model focusing on what is seen by the person, so they may use arrows pointing away from the eyes and toward the object that is seen. Some students' models may reflect ideas that are a hybrid of the two models, such as arrows pointing away from the light source and also away from the eyes. In Lessons 1 and 2, look at students' models and ask probing questions to ascertain whether your students have a 4th-grade understanding (POL) or not (LOS). Additional guidance is provided throughout these two lessons to assess their understanding and to modify instruction as needed.

Below are suggested verbs to use and others to avoid when describing how light interacts with a surface:

- OK to use: shines on, reaches, travels, bounces off, goes through
- Avoid: hits (because it implies a force)

Students will refine their understanding of "bounces off" and "goes through" in Lesson 3, and you will add "reflect" and "transmit" as words we earn to your Word Wall. The word "reflection" will be used by students early in their discussions of the anchoring phenomenon, likely to describe the image seen in a mirror. Because reflection is part of the 4th-grade DCI, some students may also use the term to refer to how light interacts with an object. Over the course of Lesson 1, leverage what students already know about reflection even if their ideas are incomplete. Through Lesson 3, they will refine their understanding of "reflect" and add it to the Word Wall (see *Guidance for Developing your Word Wall* in Teacher Edition).

This lesson also builds on a CCC element from 3rd-5th grade for Systems and System Models: *A system can be described in terms of its components and their interactions*. The lesson extends students' understanding of systems to a level consistent with 6th-8th grades on day 4, when they articulate the boundary of the system and carve out what is important to study to make sense of the phenomenon. You will add "system" to the Word Wall in Lesson 8, when it becomes a word your students have earned.

Likewise, students will develop their understanding of modeling in this unit. The class will talk about physical models as scaled representations of a system in the real world that we can use to develop and test ideas for explaining a phenomenon. They will also name diagrammatic models on day 3 as a way to document ideas about how and why a phenomenon occurs. Through the course of the unit, students will deepen their understanding of modeling. You will add "model" to the Word Wall in Lesson 5, when it becomes a word your students have earned.

See the *Teacher Background Knowledge* and *Guidance for Developing your Word Wall* in the Teacher Edition for guidance on how to support students' understanding of "system" and "model" during the unit.

Where We Are NOT Going

The phenomenon that anchors this unit can be sufficiently explained using a ray model of light (straight lines and arrows). Students will develop a robust understanding of reflection and transmission using this model over the course of studying light. They will deepen their understanding of light absorption in subsequent units (*Unit 6.2: How can containers keep stuff from warming up or cooling down? (Cup Design Unit)* and *Unit 6.3: Why does a lot of hail, rain, or snow fall at some times and not others? (Storms Unit)*). It is not until 8th grade that students will transition to a wave model of light in *Unit 8.4: Why do we see patterns in the sky, and what else is out there that we can't see? (Space Unit)* after having developed knowledge about waves in *Unit 8.2: How can a sound make something move? (Sound Unit)*.

If students do not use the words *transmit* or *transmission* in this first lesson, do not introduce them. They will be explicitly introduced in Lesson 3 and added to the Word Wall at that time.

LEARNING PLAN FOR LESSON 1

1. Introduce a puzzling phenomenon.

10 MIN

Materials: science notebook, computer and projector, Music Lesson video (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

Introduce the anchoring phenomenon. Frame the introduction to the phenomenon by saying, *I have a video with an interesting phenomenon in it that may make you wonder what's happening and how it works. Let's watch this video together to figure out what's going on.* *

Additional Guidance

If this is the students' first Notice and Wonder chart, model a "notice" or observation and a "wonder" or question before playing the video. Modeling examples will focus their noticings and wonderings on the phenomenon rather than distracting details in the video.

Prepare science notebooks to record noticings and wonderings.* Present **slide A**. Have students find a new left-side page in their science notebook and draw a two-column chart to record noticings and wonderings. Tell students, *As you watch the video, observe it carefully and record things you notice and wonder that could help us explain how this phenomenon works.*

Watch the mirror-window video. Play the *Music Lesson* video. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**) Pause the video for students to record their ideas. Play it again if time permits. When the video concludes, give students a few minutes to add to their Notice and Wonder chart.

Science Notebook

If this is the first unit of your 6th-grade course and students have not yet set up and organized their science notebook, include additional time to do so now. Have students organize their notebook using a format that will be easy to maintain across the year. Here are some helpful tips:

- Number pages so students can quickly locate their work (models, data sets, and so forth) during collaborative discussions.
- Maintain and update a table of contents. Reserve at least 2 pages (1 page front and back) for the table of contents for each unit. The table of contents can be located at the front of the notebook and encompass all the units within the notebook, or it can occur at the beginning of each new unit.
- Give each page a recognizable title that can be listed in the table of contents.
- After the table of contents, reserve the next 6 pages (3 pages front and back) for this unit's Progress Tracker. This is where students will individually reflect on their progress and also add key consensus modeling work completed by the class.
- Be prepared to tape the classroom norms and the *Communicating in Scientific Ways* sentence starters in a useful location in the notebook.

Online Resources

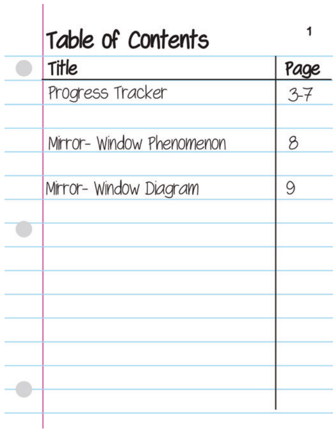
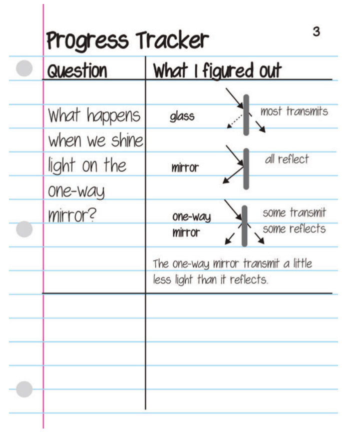
***Attending to Equity**

Supporting Universal Design for Learning: Community building is emphasized throughout this unit. In this lesson, it is important to encourage students to draw from their own ideas and not worry about whether their ideas or questions are right or wrong. All ideas and questions are welcome. This provides students access by supporting student *engagement*.

***Attending to Equity**

Supporting Emerging Multilingual Learners: Keeping a science notebook gives students a space in which to communicate their developing understandings. Students should be encouraged to record their ideas using linguistic (e.g., written words) and non-linguistic modes (e.g., photographs, drawings, tables, graphs, mathematical equations, and measurements). This is especially important for emerging multilingual students because making connections between

For more information on science notebook management, refer to this section of the *Teacher Handbook*.

Example table of contents	Example progress tracker entry
	

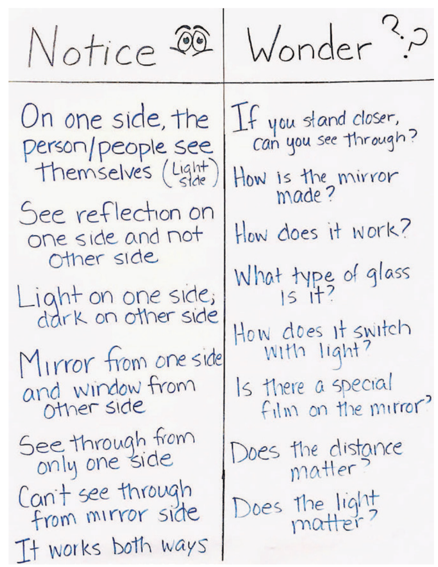
written words and non-linguistic representations helps them generate richer explanations of scientific phenomena.

2. Share noticings and wonderings from the video.

10 MIN

Materials: science notebook, Notice and Wonder chart (prepared in advance), markers

Share noticings in whole-class discussion. Display **slide B**. Prompt students to share their noticings from the video. As they share, probe deeper into a few observations to build a sense of mystery or to clarify (e.g., *OK, so you noticed that there was light. Tell me where you saw the light.*). Record students' observations on the "What we notice" or "Notice" side of the class Notice and Wonder chart.



Point out that many of the noticings identified the material as glass or a mirror. Say, *It's really strange that this thing in the video can act like a mirror on one side and a window on the other side.*

Repeat the sharing process for wonderings. Take a moment to draw attention to the role that asking questions will play in your classroom. Emphasize that, as a learning community, we are asking questions about why certain things are happening in the video, and by investigating our questions, we will be able to figure it out.*

Pose the question we need to figure out. Say, *There are a lot of observations here about this thing being like a mirror or a piece of glass, kind of like a window. And questions about what it's made of and how it works. How can something act like a mirror and a window at the same time? We need to figure this out.*

Remind students to title the page with their Notice and Wonder chart something like "Mirror-Window Phenomenon" (or whatever term the class has adopted for the material).

***Supporting Students in Engaging in Asking Questions and Defining Problems**
Initial questions about a phenomenon are intended to clarify what information is known and not known; there are often more questions than answers when scientists begin their investigations. Develop a safe and supportive space for students' uncertainty, and focus on the need to ask and investigate questions that may require the entire unit to resolve. If necessary, explain that early in the question-asking stage, it is OK to not know much about the phenomenon—it is through a series of investigations that we will learn more as a class.

Additional Guidance

The anchoring phenomenon uses a one-way mirror. Some students may recognize the material when they watch the video. If a student names it as a “one-way mirror,” it is OK to use that terminology. However, if students do not use the term “one-way mirror” or “two-way mirror,” refer to it as a “mirror-window.” You can also invent a name like “mirdow,” “mindow,” or “mirrindow” to describe the curious material that acts like both a mirror and window. Even if students identify the material right away, the puzzling aspect of the phenomenon (i.e., how it works) will still be a mystery. The teacher guide will use “one-way mirror” starting on day 2. But if your class has adopted another term, modify the slides and other materials accordingly.

3. Identify parts and interactions to diagram our thinking.

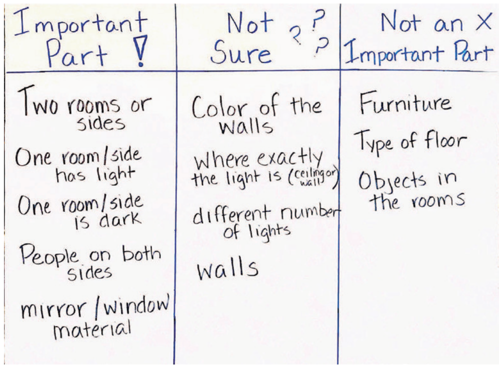
15 MIN

Materials: *Initial diagram to explain the phenomenon* (optional), science notebook, Parts chart (prepared in advance), markers

Turn and talk about initial explanations for the mirror-window phenomenon. Display **slide C**. Give students a couple minutes to discuss the slide’s questions with a partner:

- Why do the adults see the music student?
- Why does the student see themself and not the adults?

If students are not familiar with the Turn and Talk activity structure, take time now to introduce it and explain what is expected of them when they engage in partner talk (e.g., taking turns to listen carefully to each other, not talking over each other, not getting off topic).*



Identify the important parts to guide initial explanations. Display **slide D**. Although this activity engages students in systems thinking, wait to name it as such until day 4, when they can reflect on their use of this kind of thinking. For now, describing parts and interactions will help to scaffold students’ initial models for explaining the phenomenon in the video.*

Show students the Parts chart. Ask, *If we want to explain what’s happening in the video, what are the important parts we need to include in our explanation?* Have the class work together to evaluate whether a part in the video is important, not important, or not sure. Ask the following question about each part students propose to include:

- If the part was changed or missing, would it change the phenomenon?
    - If so, it’s important to include.
    - If not, it’s not important to include.
    - If we don’t know, then we’re uncertain about it.

As a decision is made for each proposed part, list the part in the appropriate column of the class chart. Once the class reaches agreement, say, *This is a good start to figuring out how this phenomenon works. We can add more parts later if we think we missed something important. Let’s use our list to make a diagram that helps us explain how the important parts are interacting.*

***Attending to Equity**

Supporting Universal Design for Learning: It is important to create opportunities to support student *engagement* in meaningful, accountable talk by utilizing socially safe activity structures. This is especially beneficial to Emerging Multilingual Learners. For this reason, partner talk or small-group talk should precede whole-class discussion whenever possible so students can share their ideas with one or two peers before “going public” with the class. During this unit, there will be instances in which students immediately engage in class discussion. Insert a partner talk prior to that larger discussion if you believe this would benefit your students’ ability to communicate and express their ideas.

Diagram interactions between the important parts.* Choose whether you want students to use the handout, *Initial diagram to explain the phenomenon*, or diagram directly in their science notebook.

- If the handout is selected, distribute one copy to each student. Modify **slide E** accordingly. Ask students to check that the diagram on the handout includes all the important parts we identified. Prompt them to add important parts from the class list if the diagram is missing them.
- If students are to diagram in their science notebook, display **slide E** (as is). Ask students to write the title "Mirror-Window Diagram" and the slide's two questions at the top of the next page in their notebook and then draw the diagram, making certain to include the important parts from the class list.

Once students get all the important parts into the diagram and labeled, ask them to add pictures, symbols, and words to show how the parts work and interact to answer the two questions, as their initial attempt to explain the phenomenon.*

Give students up to 5 minutes to work individually to diagram what they think is happening. Use this diagram as a formative assessment to monitor students' initial ideas about how we see objects; specifically, the extent to which their models reflect a "line of sight" or a "path of light."

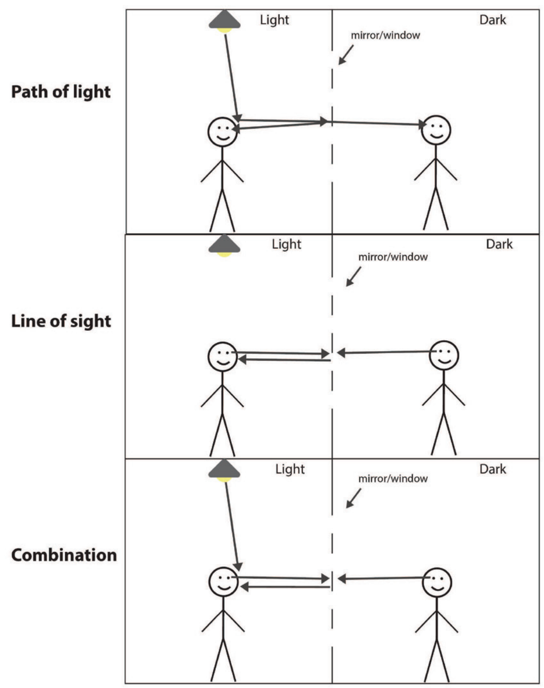
Assessment Opportunity

Building towards: 1.A Develop a model to identify the important parts of the system and how those parts interact that could cause an object to look different in different light conditions.

What to look/listen for: (1) Agreement on key components or parts to include, such as two rooms or sides, a mirror-window between the sides, one side being lit, one side being dark; (2) uncertainty or disagreement on whether the people or eyes are an important part; and (3) use of a "path of light" model, "line of sight" model, or combination, which can be indicated by the way students use or do not use arrows in their diagrams:

- arrows pointing away from the eyes, or
- arrows pointing away from the source of the light and bouncing away from objects, and arrows pointing into the eyes, or
- a combination of the above

Arrows pointing away from the light source may be a representation of the "path of light" (POL). If students also include an arrow entering the eyes, this may indicate a clear understanding of the 4th-grade model of light, tracing the light from a source, then bouncing off objects and into our eyes. Arrows pointing away from the eyes may be a representation of what is seen, or the "line of sight" (LOS). A combination of arrows may map partially onto both POL and LOS models.



*Supporting Students in Developing and Using Systems and System Models

In Lesson 1, students use systems thinking to scaffold their initial explanations of the phenomenon. They do not name it as a "system" or call it "systems thinking" until day 4. However, you can leverage what students know about systems from previous grades (i.e., "a system can be described in terms of its components and interactions"). Use this to help them articulate the important parts and interactions from the video. You may use "parts" or "components," whichever term makes sense to your students.

*Supporting Students in Three-Dimensional Learning

Like "system" and "systems thinking," the term "model" is not yet used explicitly while students are setting up their initial models for explaining the phenomenon. The reason to avoid the term right now is to give students an experience with the practice before naming it, which will happen on days 2 and 3 for different kinds of models. However, if your students are already familiar with modeling, it is OK to use "model" at this time.

What to do: Ask questions to probe students' understanding about how the individuals in the video are able to see what they see. Use these diagrammatic models as a pre-assessment of the ideas your students bring to this unit, and to make sense of and highlight their range and diversity. In Lesson 2, you will problematize the need to agree on conventions for using arrows in our models and what the arrows mean. Until that moment, it is OK that students use arrows in different ways.

4. Compare diagrams with a partner.

5 MIN

Materials: science notebook, *Initial diagram to explain the phenomenon* (optional)

Establish the purpose for comparing diagrams. Have a short conversation about why we want to look at one another's diagrams. You will spend more time developing classroom norms at the beginning of day 3, but touching indirectly on the subject now will make the comparison of diagrams more productive. Ask these questions:

- *What can we learn from looking at one another's diagrams?*
- *What if someone has different ideas than your own?*

Reinforce students' ideas by saying, *We want to see what other people in the class are thinking and how they are representing their ideas. We don't need to have the same ideas because we all think differently. We can learn from one another by closely looking at our classmates' work. Let's use this time to study their work and see how it can help our own thinking.**

Compare mirror-window diagrams with a partner. Display **slide F** to guide this comparison. Each student needs 1 minute to share their work with a partner. Encourage students to make a small check mark or question mark on their diagram to note areas of similarity or difference. They do not need to achieve consensus. On day 3, we will gather in a Scientists Circle to build an Initial Class Consensus Model.

5. Navigation

5 MIN

Materials: None

Elicit ideas for the scale model. Display **slide G**. Say, *I can't make our classroom into a full-size replica of the scene in the video, but I have some scale models that we can study.* Define this term by explaining that a scale model is a smaller representation of something in the real world, and that we can use it to develop and test our ideas for explaining a phenomenon. Pose the question, *If we want to investigate the phenomenon using a scale model, what are the important parts we need to include in the scale model?**

Listen for these suggestions:

- two rooms
- light in one room
- no light in the other room

***Attending to Equity**

Supporting Universal Design for Learning: Use this opportunity to encourage students' *action* and *expression* by using different representations—symbols, colors, words, and pictures. There will be moments throughout the unit when the class agrees on shared representations, but this is not necessary right now.

Supporting Emerging Multilingual Learners: Allow students to use the language of their choice for sharing and communicating their ideas.

***Attending to Equity**

Supporting Emerging Multilingual Learners: In this moment, it is helpful to intentionally group emerging multilingual students with peers who know their language(s) so they can communicate their initial ideas in the language of their choice. At other times, it could be useful to group them with peers whose English language development is slightly more advanced. It is important for this grouping to be thoughtful and to vary throughout the course of a unit so students benefit from working with different peers.

***Attending to Equity**

Supporting Universal Design for Learning: This subtle move to bring students into the design and use of the box model

- mirror-window material in between the two rooms
- people on both sides

Say, *I will get our scale models out for the next class. We'll check them with the list we just brainstormed to make sure we have what we need.*

End of day 1

on day 2 is important. If they make suggestions that you can incorporate, modify the model where possible; drawing from student ideas in this way supports *engagement* by optimizing relevance.

6. Navigation

5 MIN

Materials: 1 box model setup, 1 picture mat set with one-way mirror film, 1 flashlight, toys

Elicit students' experiences with scale models. Show students one of the box models they will use to represent the system in the video. Display **slide H**. Ask students to share their experiences using scale models to explain something in the real world or to design solutions to problems.

Listen for suggestions of models from science class or home, such as these:*

- replicas of body parts (e.g., skeletons) to explain how a body system functions or moves
- solar system models to explain why we have different moon phases
- watershed models to explain how water flows downhill within a certain area
- rocket models to test how different designs function to support flight
- ecosystem models that identify living things within an ecosystem and how they interact

Point out that in every case, the scale model had some features that were helpful for explaining a phenomenon or solving a problem in the real world but also had some limitations (e.g., the solar system scale model helps explain moon phases, but it doesn't show accurate sizes and distances between objects in space or represent the gravitational attraction between them).

Say, *Let's consider how this scale model is similar to and different from the scene in the real world that we want it to represent.*

***Attending to Equity**

Supporting Universal Design for Learning: The goals in this moment are (1) to support *engagement* by optimizing relevance for students and (2) to have students think about how physical models can be used for explaining phenomena or solving problems. Accept all examples, even if they only meet goal #1 (e.g., model cars, airplanes, or other physical replicas that are not used for explaining phenomena or solving problems).

Additional Guidance

When showing the box model, point out that you used one-way mirror film. From this moment on, refer to the material as a "one-way mirror" or the class's agreed-upon term (e.g., "mirdow," "mindow," or "mirrindow").

7. Map the box model to the video.

10 MIN

Materials: Mapping the Model to the ________ chart (prepared in advance), Parts chart (prepared in advance), markers

Introduce the mapping tool. Present the Mapping the Model to the ________ chart (**slide I** is optional). Fill in the blank on the chart's title (e.g., Mapping the Model to the One-Way Mirror and Rooms). Explain that this tool will help us to compare the box model to what it represents from the video.

Compare the box model to the video. Have students identify where each part from the video is represented in the box model.

Brainstorm how the parts in the model are similar to and different from the real world, completing as much as you can in the right two columns of the mapping tool. For answers that students are uncertain about, leave those blank and revisit after the *Box Model Investigation*.*

This part of the box model . . .	is like this part of the real world . . .	because . . .	and is not like it because . . .
Flashlight	Light in the room	Source of light, shining from the top	Different way it shines around the room; more direct/less direct
Box with the light	Room with the light	A room with a light Square spaces with walls	Not the same color walls, no door, no objects in the room
Box with no light	Room with no light	A room that is dark Square spaces with walls	Not the same color walls, no door, no objects in the room
One-way mirror film	One-way mirror in the room	See through it on one side and reflection on the other side	Not as large, does not have glass, not hard, the effect is not as clear or dimmer
Viewing holes	The people's eyes or the camera filming the video	Can see what people in the video may see	Viewing holes are us looking into the box and not the eye of the person

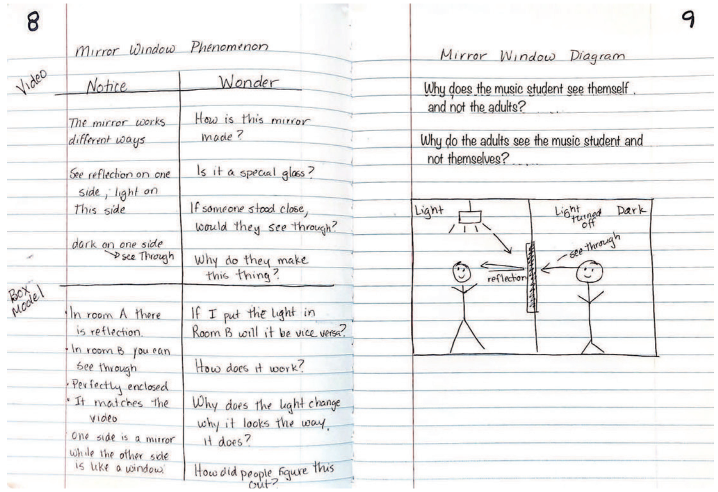
***Supporting Students in Engaging in Developing and Using Models**
Use this opportunity to make explicit the benefits and limitations of using physical representations (i.e., scale models) for explaining phenomena in the real world.

8. Carry out the box model investigation.

15 MIN

Materials: 1 box model setup, 1 picture mat set with one-way mirror film, 1 flashlight, toys

Set up the science notebook and preview the investigation procedures. Display **slide J.** Ask students to locate their Notice and Wonder chart in their science notebook. Direct them to draw a line under their last noticing from the video and use the remaining space in the chart to add noticings and wonderings from the *Box Model Investigation*.

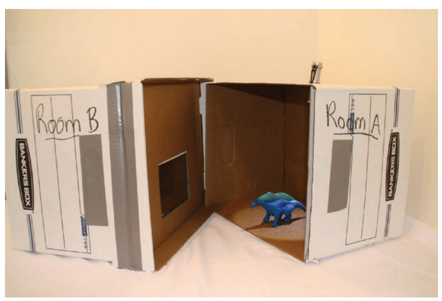


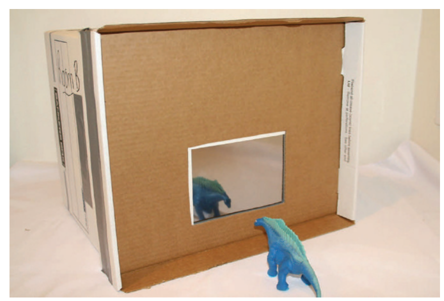
Explain expectations for working in groups and then arrange students in groups, each with a box model at their lab tables.

Observe the box model from the viewing holes. Give groups up to 8 minutes to investigate the box model *with the light on in Room A only*. Students should look through the viewing holes in both Room A and Room B several times and record their noticings and wonderings.*

Remove Room A. If time permits, turn on the classroom lights and prompt students to turn off the flashlight in Room A and carefully remove Room A from the model. With the classroom lights on and a darkened Room B, students should look at the one-way mirror and see themselves—the same experience the music student has. When we enclosed Room A, students had a different perspective of looking at the same thing, but through a viewing hole instead.

Have students carefully add Room A back to the model before returning to their seats.





Additional Guidance

If students want to manipulate the box model (e.g., move the light), tell them they will get a chance to test those ideas, so they should record their questions related to what they want to try (e.g., "What happens if we move the light from Room A to Room B?") in their chart's "Wonder" column. This will be the focus of Lesson 2.

*Supporting Students in Engaging in Asking Questions and Defining Problems

Circulate among the groups to support students as they notice and wonder about the box model. In this unit, you will help your students become more intentional with the questions they ask. Now is an opportunity to formatively assess the types of questions they are asking about the phenomenon, and if the opportunity presents itself, to model how to turn a wondering from a close-ended question answered with a yes or no to an open-ended question that could be investigated. For example, a close-ended question might be: "Is it a special glass?" This could be modified to: "How is the glass made to do this?" The theme of moving from close-ended questions to open-ended questions will continue throughout the unit, and small-group time is an opportunity to support students with this practice.

9. Share oberservations from the box model investigation.

12 MIN

Materials: Communicating in Scientific Ways handout, science notebook, Notice and Wonder chart (prepared in advance), markers

Introduce the *Communicating in Scientific Ways* sentence starters. Distribute a copy to each student to tape in their science notebook, or post it in the classroom as a class chart. Explain that these sentence starters are one way to help us better share our thinking during discussion.*

Share observations from the box model using sentence starters. Point out the "Observe" sentence starters and note that students can practice using them now to discuss observations. Display **slide K**. For about 5-7 minutes, use the slide's prompts to have students share out as a class what they noticed as they used the viewing holes in the box model.

Suggested prompts	Sample student responses
What was similar between what you saw in the video and what you saw in the box model?	*In Room A there was a reflection like in the video. In Room B you could see through the material. One side was a mirror and one side was a window.*
What was different?	*It wasn't as bright on the side with the light. It wasn't as clear in the box as in the video.*
What new things did you notice in the box model?	*Even when we took the walls away from Room A, it stayed the same.*

As they share, use the following prompts to help students practice clarifying their ideas and building on each other's ideas:

- *Can you say more about that?*
- *Does anyone else agree with what _______ observed?*
- *Who wants to add on to what ______ is saying?*
- *Did anyone observe something different?*

Record new noticings to the class's Notice and Wonder chart. During the discussion, make certain that students are starting to notice that one side of the model is dark and the other side is light, similar to the video. They are likely connecting that the one-way mirror acts like a mirror on the light side and a window on the dark side.

Return to the Mapping the Model to the _____ chart to complete any comparisons that students were uncertain about.

Evaluate limitations of the box model. Display **slide L.** Take a couple of minutes to reflect on differences between the box model and the real world it represents. Elicit student responses to the slide's prompt:

- If we use this box model to test ideas about the one-way phenomenon, what *differences* between the box model and the real system shown in the video could be important to keep in mind?

***Attending to Equity**

Supporting Emerging Multilingual Learners: Scaffolds such as sentence starters can model and facilitate oral or written language production skills such as formulating questions, hypotheses, explanations, or arguments based on evidence. Such scaffolds may be of particular benefit to help emerging multilingual students develop language skills to write or communicate their ideas to peers. These scaffolds are an effective approach to support all students in using tools for construction and composition of ideas on paper or through discussion (**Supporting Universal Design for Learning**). It is important that scaffolds be used purposefully and removed when no longer needed.

Listen for suggestions such as these:

- *Eyes outside the box looking through the viewing hole is not like the music student seeing themself.*
- *The color of the inside of the box is different from the colors on the wall.*
- *The flashlight isn't quite the same as the light in the room.*

10. Navigation

3 MIN

Materials: science notebook, index card

Have students complete an exit ticket. Display **slide M.** Distribute an index card to each student. Ask students to scan their Notice and Wonder chart and their initial diagram to see what ideas they want to bring to the next class discussion. Have students write their name and at least one idea on the exit ticket. Collect the exit tickets before students leave. Use them to prepare for the Consensus Discussion in the next class period.

End of day 2

11. Form a Scientists Circle and discuss classroom norms.

15 MIN

Materials: *Science Classroom Norms*, science notebook

Form a Scientists Circle.* Ask students to assemble their chairs in a circle and to bring their science notebook and something to write with. Students will remain in the circle for the whole class period, though they will move among partner, small-group, and whole-class discussions. This will help minimize the movement of chairs during class.

Scientists Circle

You will form a Scientists Circle in many future lessons. Setting up the norms and logistics for forming, equitably participating in, and breaking down that space is important to do now if this is your first time with this activity structure. As students get more comfortable with a Scientists Circle, they can move between it and other activity structures more quickly. Ideally they need to be able to see both the slides and the class whiteboard, but if that is not possible, the whiteboard (or chart paper) will be more critical for the discussion than the slides. If you have back-to-back science classes, ask students to leave the chairs in the circle.

Introduce the need for norms to guide our work. Tell students, *Next, we'll try to come to agreement with all our diagrams*. The purpose of introducing the consensus task before talking about classroom norms is to get students thinking about how difficult it will be to get all members of the learning community to agree and how to ensure everyone is included and heard. Point out productive behaviors you witnessed in the first two days of the lesson to communicate to students that they were already using some positive norms. Display **slide N**. Distribute one copy of *Science Classroom Norms* to each student.*

***Attending to Equity**
Supporting Universal Design for Learning: Having students sit in a circle so they can see and face one another helps support *engagement* and build a sense of shared mission as a community of learners working together. Throughout the course of the unit, convening a Scientists Circle to take stock of what the class has figured out and where to go next will be an important tool in helping students take on greater agency in steering the direction of their learning. This circle will also help build a sense of pride in their work. You may want to inform students that professional scientists also collaborate with one another to brainstorm, discuss, and review their work.

Additional Guidance

Supporting Classroom Culture and Norms: Use classroom norms to foster an equitable learning community that promotes trusting and caring relationships. The norms should reinforce the value of (1) the diversity of thought among all classroom community members in pushing our learning forward and (2) providing a safe learning environment that ensures fair participation. In addition, classroom norms should interrupt cultural norms or stereotypes that could make science experiences feel uncomfortable for some students (e.g., seeing themselves as being someone who is not intelligent enough to think like a scientist, who cannot do the relevant math, or who cannot share their thinking).

Discuss each norm and add or edit as needed. Talk through each norm and ask students to provide an example or paraphrase the norm. Provide opportunities for students to clarify a norm, ask for a modification, or develop new norms not on the list. Have them write on their handout if the class decides to change something. Norms are intended to be shared by the students and teacher, so even though a set has been provided, use it as a starting point.

Alternate Activity

The default approach described above is to present a set of norms and give students space to edit or add to them. Alternatively, you may want to *co-construct norms with your students*. If this option is chosen, explain what norms are and why we need them for productive science talk and positive classroom culture. Have students first share ideas for norms in small groups and then share out with the whole class. Compile a list of agreed-upon community norms from this process. As the teacher, you can add norms that may be missing from the students' proposed list. Make sure to explain how you think the norm you added is helpful. Consider the following questions to determine the best approach for your situation:

- Do you want students to participate in co-constructing the norms?
- Do you want the same set of norms for every section of science you teach?
- Do you want to work with your team teachers to establish a shared set of norms for students across all the team's classes?

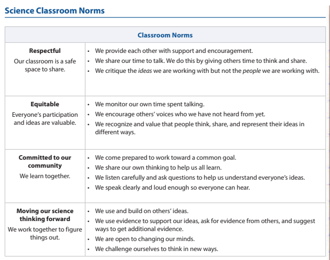
Choose a norm to work on during the Consensus Discussion. Ask students to nominate one norm that may be beneficial for the class discussion. Talk through the different nominations and select at least one to work on. Have students monitor their use of this norm during the discussion.

Additional Guidance

Before moving on to the next step, let students tape the handout into their notebook (or you can wait until they break from the Scientists Circle and return to their desks). If there are many edits, you may choose to modify and reprint the document first. It is important for the norms to appear early in the notebook. Consider having students tape it to the inside front cover so it is seen easily and often. Likewise, the *Communicating in Scientific Ways* handout could be taped to the inside back cover for easy reference. Also be sure to have a public place where the norms and *Communicating in Scientific Ways* are posted on the wall for reference.

*Attending to Equity

Many students may not know what a "norm" is, so describe norms as best practices that we all agree to work on so we have a productive and respectful learning environment. They are similar to rules but are used to guide how we work together as a learning community in positive and productive ways. Students should understand how norms help everyone in the community know what is expected of them.



Science Classroom Norms

Classroom Norms	
Respectful Our classroom is a safe space to share.	• We provide each other with support and encouragement. • We share our time to talk. We do this by giving others time to think and share. • We critique the *ideas* we are working with but not the *people* we are working with.
Equitable Everyone's participation and ideas are valuable.	• We monitor our own time spent talking. • We encourage others' voices who we have not heard from yet. • We recognize and value that people think, share, and represent their ideas in different ways.
Committed to our community We learn together.	• We come prepared to work toward a common goal. • We share our own thinking to help us all learn. • We listen carefully and ask questions to help us understand everyone's ideas. • We speak clearly and loud enough so everyone can hear.
Moving our science thinking forward We work together to figure things out.	• We use and build on others' ideas. • We use evidence to support our ideas, ask for evidence from others, and suggest ways to get additional evidence. • We are open to changing our minds. • We challenge ourselves to think in new ways.

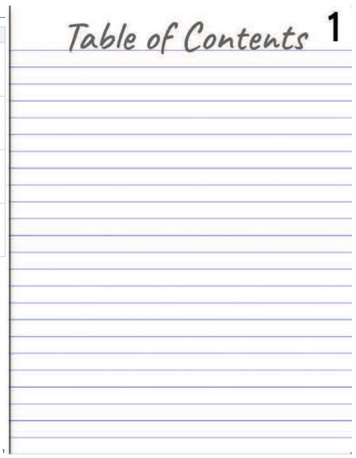
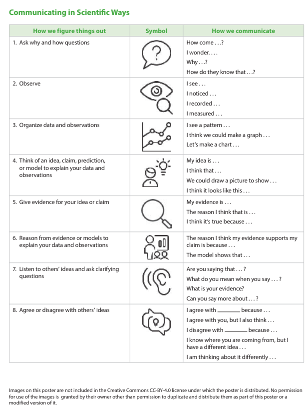


Table of Contents 1



Communicating in Scientific Ways

How we figure things out	Symbol	How we communicate
1. Ask why and how questions		How come . . .? I wonder. . . . Why . . .? How do they know that . . .?
2. Observe		I see . . . I noticed . . . I recorded . . . I measured . . .
3. Organize data and observations		I see a pattern . . . I think we could make a graph . . . Let's make a chart . . .
4. Think of an idea, claim, prediction, or model to explain your data and observations		My idea is . . . I think that . . . We could draw a picture to show . . . I think it looks like this . . .
5. Give evidence for your idea or claim		My evidence is . . . The reason I think that is . . . I think it's true because . . .
6. Reason from evidence or models to explain your data and observations		The reason I think my evidence supports my claim is because . . . The model shows that . . .
7. Listen to others' ideas and ask clarifying questions		Are you saying that . . . ? What do you mean when you say . . . ? What is your evidence? Can you say more about . . . ?
8. Agree or disagree with others' ideas		I agree with ________ because . . . I agree with you, but I also think . . . I disagree with ________ because . . . I know where you are coming from, but I have a different idea . . . I am thinking about it differently . . .

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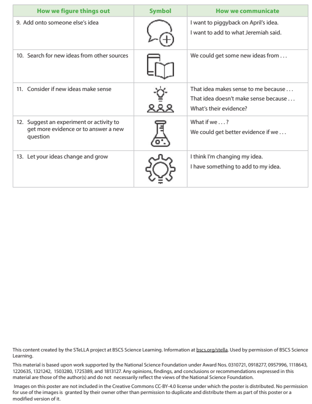

How we figure things out	Symbol	How we communicate
9. Add onto someone else's idea		I want to piggyback on April's idea. I want to add to what Jeremiah said.
10. Search for new ideas from other sources		We could get some new ideas from . . .
11. Consider if new ideas make sense		That idea makes sense to me because . . . That idea doesn't make sense because . . . What's their evidence?
12. Suggest an experiment or activity to get more evidence or to answer a new question		What if we . . . ? We could get better evidence if we . . .
13. Let your ideas change and grow		I think I'm changing my idea. I have something to add to my idea.

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12. Develop an Initial Class Consensus Model.

18 MIN

Materials: science notebook, Initial Class Consensus Model (prepared in advance), markers

Additional Guidance

In this unit, you will need to coordinate the development of the Initial Class Consensus Model with the Driving Question Board (DQB). On day 4, students will generate questions for the DQB and layer them on top of the consensus model. This is critical for helping students ask questions about different parts or interactions in the system. If you are using a bulletin board for your DQB, for example, you will want to diagram the consensus model on the bulletin board paper.

Set the purpose for the Consensus Discussion. Display **slide O**. Say, *The goal of this consensus discussion is to find areas of agreement and disagreement between our diagrams. Knowing where we agree and disagree will help us decide how we might want to proceed in figuring out what is happening in the video. We also want to use this time to practice our norms.**

Tell students that as they listen to one another, they should evaluate their work in terms of where they have some promising ideas and where they are confused or uncertain about what is happening.*

Key Ideas

Purpose of this discussion: to agree upon what we know, and more importantly, to agree on where we have gaps in our understanding of the phenomenon.

Listen for these ideas:

Areas of agreement:

- One side is dark and one side is light, and this is probably important.
- The light side is the side where you see a reflection.

***Strategies for this Consensus Discussion**

This discussion has two goals: (1) to continue to help students build the habit of sharing their ideas publicly and (2) to come to consensus on what we agree is happening, and more importantly, agree on where we have gaps in our understanding. Accept all responses and encourage students to share their ideas. Use probing questions to help them clearly articulate their thinking. Be careful not to favorably respond to any one idea over another so as not to implicitly communicate that one answer is more correct than another.

- The dark side is the side where you see through the material.
- The one-way mirror material can be both a mirror and a window, and this is likely related to the light.

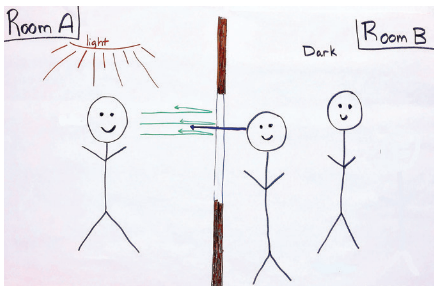
Areas of disagreement or uncertainty:

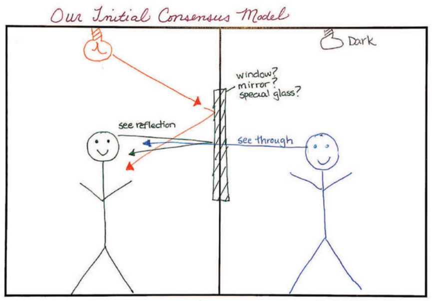
- arrows showing what you see or showing what the light is doing, but little agreement about how to use arrows
- what the one-way mirror does that allows us to see through it and also see a reflection on it
- how different amounts of light in the two rooms contribute to the outcome
- how light's interaction with the one-way mirror causes the phenomenon

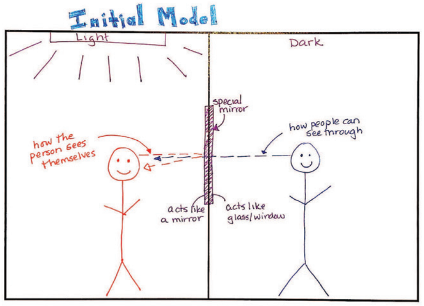
Discuss why we see a reflection on the light side. Display **slide P**. Focus students on the first question. Ask at least 3 students to share their diagrams to obtain a diverse representation of ideas. Prompt the other students to look at their own diagram to compare their own ideas with those being shared.

Move the class toward representing what we think could be happening to answer the first question. Record what is and is not agreed upon for this question on the class chart.*

Discuss why we see through from the dark side. Repeat the same process to answer the second question. Allow at least 3 students to present their work, and then record on the class chart where the class has agreement or uncertainty and disagreement.







Assessment Opportunity

Building towards: 1.A Develop a model to identify the important parts of the system and how those parts interact that could cause an object to look different in different light conditions.

What to look/listen for: The key ideas listed above.

What to do: As your students suggest ways to represent how the one-way mirror works, use probing questions, particularly when they suggest using a line or arrow (e.g., *Where does the line need to start and stop?* or *What direction is the arrow pointing?* and *Why does it point that way?*). Allow both "line of sight" (LOS) and "path of light" (POL) suggestions on the Initial Class Consensus Model. Use this moment as a pre-assessment of your students' prerequisite 4th-grade understanding of light. Continue to monitor their use of lines and arrows in Lesson 2 to help you decide if you need to take advantage of the additional Building Prerequisite Understanding activities offered. These modifications can be used to ensure all students have the necessary foundational understandings to move forward in the unit.

***Attending to Equity**

Supporting Universal Design for Learning: This is an important opportunity to emphasize that each individual has contributions to make to our community of learners. Throughout this unit, students will be asked to be open to sharing knowledge products that represent their current thinking and learning from their classmates, which can support their *engagement* if the classroom culture values diverse thinking and ideas. It is through differences in thinking that the class will grow their knowledge together.

Use *representations* like color coding and/or letter or number coding to foreground parts of the Initial Class Consensus Model. Create a key to track what colors, symbols, or letter or number codes represent different parts of the system. Although color coding is a useful way to quickly reference the parts of the model, letter or number coding ensures accessibility for any student who may be color-blind. If color coding is used, consider a color palette that uses orange, blue, black, or dark brown.

***Attending to Equity**

Supporting Emerging Multilingual Learners: Students have likely used everyday language to describe the one-way mirror in their diagrams. Explain that it is

Reintroduce the concept of modeling. Once the class has created a consensus diagram, introduce students to the idea that we just developed a (diagrammatic or conceptual) *model*, which includes our ideas for how and why something in the world happens: In trying to explain why the music student sees only themself, but the adults see the music student, we developed a model.

Reiterate that, *Scientists use models to explain phenomena and represent their ideas in a variety of ways—in this case, we used a diagrammatic model.* Remind students we also used the box model to develop and test our ideas about what was happening in the real world. Tell them this conceptual model includes our current thinking but our ideas may change over the course of the unit, so we'll have opportunities to revise this model.*

Slide Q is provided as an optional norms check-in moment.

Additional Guidance

Students will share vocabulary words that the class will continue to develop meaning for and use throughout the unit. Words that students will earn in the unit include **reflect**, **transmit**, **model**, and **system**. Have these words on your radar now and be attentive to how students' understanding of them changes, but do not add them to the Word Wall until later lessons when students have developed a better understanding of their meaning.

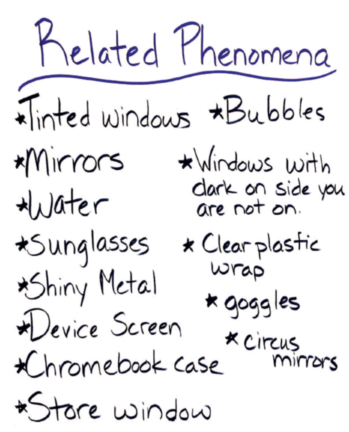
normal to switch from everyday language to specialized language, depending on what is most useful. Encourage students to use both content-specific and everyday terms when expressing their ideas. This helps students fully express themselves, allowing others to question, evaluate, and build off their ideas. Switching back and forth between different registers is especially important for emerging multilingual students because it helps them draw on their full range of meaning-making resources. Emphasize that students can choose the language that will help them most in their sensemaking.

13. Brainstorm related phenomena and assign self-documentation. 12 MIN

Materials: Related Phenomena list (prepared in advance), markers

Conduct an initial brainstorm in partners or small groups. Have students remain in the Scientists Circle. Display **slide R**. Assign students to partners or small groups and instruct them to turn and talk about ideas for related phenomena for about 2 minutes.

Record a class list of related phenomena. Keep **slide R** displayed and ask students to share out their ideas for related phenomena. Record these on the Related Phenomena list.



Connect the chart to the Initial Class Consensus Model. Ask, *Do you think our ideas so far in our class model might apply to some of these related phenomena too?* Elicit a few initial ideas.

Introduce the self-documentation home learning assignment. Display **slide S**. Explain that self-documentation is a way to see where these things we are talking about in class actually happen in our lives and communities.* Ask students to "photo document" or hand-draw an example of a related phenomenon they see outside of the classroom.

*Supporting Students in Engaging in Developing and Using Models

Use this moment as an opportunity to expand on the practice of modeling. Describe it as a way of making thinking visible through diagrammatic representations, physical models, or even computer models. Foreground that modeling is a verb, which indicates it's not a "thing" but an "activity" that includes articulating, predicting, and testing ideas as we explain how or why phenomena occur. Emphasize that we use models for a purpose and that models can change as new information

Preview the logistics for how to share the photos via the class's website, email, or airplaying them for the class, or for bringing in hand-drawings. The final product from the Self-Documentation will be a collection of related phenomena posted in the classroom or digitally. Tell students to be prepared to share their self-documentation in three days.

Additional Guidance

The purpose of the self-documentation is to

1. have students "document" aspects of their everyday lives (e.g., about a phenomena or topic) using photos or other visual representation,
2. cluster their photos into similar types of phenomena,
3. identify which ones present possible areas of investigation for the unit,
4. support students in engaging in investigations related to their focus, and
5. arrange for students to present their results to members of the community/STEM experts.

This home learning assignment supports students in step 1. They will complete step 2 on day 3 of Lesson 2 and will continue to add to the collection as they identify more phenomena. How students share photos or drawings and how these are organized can vary by classroom. The unit does not provide guidance to complete steps 3-5, but these are valuable opportunities for students to go further with their self-documentation work and could be included as extensions for additional class or home learning opportunities. Please visit STEM Teaching Tools at http://stemteachingtools.org/sp/self-doc for more guidance.

End of day 3

is learned. Avoid asking students to simply recite parts of a model as "facts"; push them to think about models as representations of ideas that can help us explain a phenomenon.

***Attending to Equity**

Supporting Universal Design for Learning: This home learning assignment is used to broaden students' thinking to related phenomena and leverage these everyday science experiences they have outside of school to augment the learning in the classroom. Locating the anchoring phenomenon in the context of their community makes it more personally meaningful to each student, supporting their *engagement* with it. It also provides students an opportunity to talk about the phenomenon with family members and other community members.

If your students do not feel safe completing the self-documentation in their neighborhood, have them complete the assignment around the school or their home, or look for an example that interests them online.

14. Write questions for the Driving Question Board.

6 MIN

Materials: 2 sticky notes, marker

Set the purpose for asking questions. Tell students that all of our observations and questions so far are going to be captured today on a Driving Question Board (DQB). Say, *The purpose of this work is to generate a set of questions that can guide our investigations to explain this phenomenon. To do that, we first need to brainstorm individually and write down our questions.*

Do a light pass at how to ask productive questions. Display **slide T**. Take a minute to review how to generate productive questions. Productive, testable questions are those that can help us deepen our understanding of how or why a phenomenon occurs.*

Write questions individually. Display **slide U**. Hand out 2 sticky notes to each student (more sticky notes if you have more time to build the DQB). Give students a few minutes to review their Notice and Wonder charts, their initial models, the Initial Class Consensus Model, and the Related Phenomena list to brainstorm questions. Ask them to use a marker to write one question per sticky note and put their initials on the back in pencil.*

***Supporting Students in Engaging in Asking Questions and Defining Problems**

Open-ended questions can be more productive than close-ended questions for advancing understanding of the phenomenon. An Asking Questions Tool: Open/Closed Questions is provided as a resource that you can use later in this unit and in subsequent units to help students turn close-ended questions into open-ended ones.

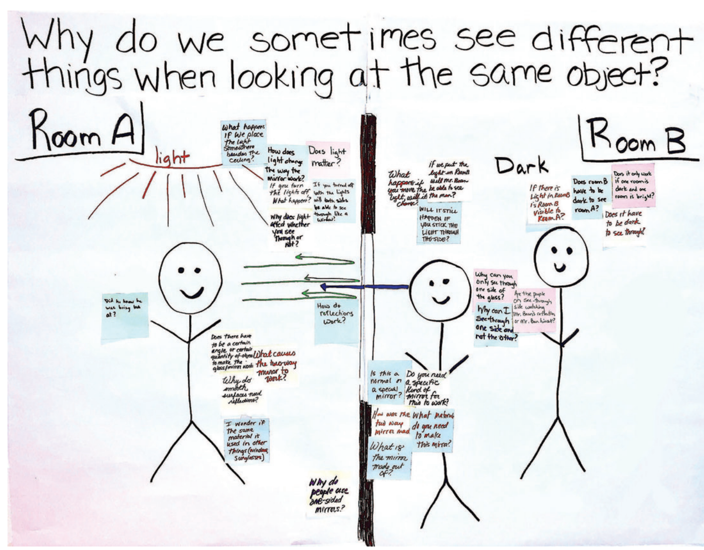
15. Develop a Driving Question Board.

24 MIN

Materials: Driving Question Board (overlaid on the Initial Class Consensus Model)

Explain how we will create the DQB. Use **slide V** if needed.

- The first student reads their question aloud to the class, then posts it on the DQB, near the part of the model the question most relates to.
- Students should raise their hand if one of their questions relates to the question that was just read aloud.
- The first student selects the next student whose hand is raised.
- The second student reads their question, says why or how it relates, and posts it near the question it most relates to on the DQB.
- The student selects the next student, who may have a related question or a new question.
- We will continue until everyone has at least one question on the DQB.



***Supporting Students in Three-Dimensional Learning**

Using the consensus model as the backdrop of the DQB does two important things: (1) It provides a scaffold to help students make connections among their models, the phenomenon, and the questions they ask, and (2) it allows students to leverage the crosscutting concept of Systems and System Models as a lens for identifying the parts of the system where a lot of question generation happened compared to parts of the system where there may be fewer questions.

Have students share their questions. Have one student start the sharing process and continue until all questions are shared.

Organize questions into categories. The questions will naturally start to cluster in groups on various parts of the model. Once students have finished sharing, ask them to look at the DQB and consider the following questions:*

- What parts represented in our model, or interactions between parts, do we have a lot of questions about?
- Are there any parts or interactions that we need to ask more questions about?

Assessment Opportunity

Building towards: 1.B Ask questions that arise from observations of a phenomenon in which an object appears different depending on the light conditions within the defined system.

What to look/listen for: All questions should be accepted at this time, but pay close attention to the types of questions your students ask.

Open-ended questions require a full and meaningful answer and are productive questions to prompt investigation and conversation. How and why questions are examples of this type. Students may also ask open-ended questions that are more similar to ideas for investigations (e.g., *What happens if . . .?*). When we pursue these investigations later in the unit, students will discover new aspects of the phenomenon to be explained, motivating a need to pose new explanatory questions (how or why) about the phenomenon.

Close-ended questions require a yes or no response or a simple, one-word answer. Sometimes close-ended questions are productive for prompting us to do an investigation (e.g., *If you turned the lights off in both rooms, will both sides be able to see through?*), but they do not lead to fruitful conversation.

What to do: If important parts of the mirror-window model have few or no questions posted on the DQB, prompt students to generate more questions in this space so they can investigate each important part or interaction.

After the DQB is built, count the number of questions (on your own, not with students) that are close-ended versus open-ended. If your students ask mostly close-ended questions, have them use the Asking Questions Tool: Open/Closed Questions when adding new questions to the DQB in later lessons. If your students asked mostly open-ended questions, shift their focus to refining their questions into testable ones using the Asking Questions Tool: Testable Questions.

Close-ended question	Possible revision to make later in the unit
Is there any other way to make this mirror?	How is this mirror made?
Do you need to use a specific mirror to make this work?	Why does this specific mirror work this way and other mirrors don't work the same way?
Does the lighting affect the results?	Why does the lighting affect the results?
Does it only work if one room is dark and the other is bright?	Why does it only work when one room is dark and the other room is bright?
If you turned the lights off in both rooms, will both sides be able to see through?	Why would making both rooms dark affect the results?

*Supporting Students in Developing and Using Systems and System Models

It's important to make students aware of the crosscutting concepts (CCCs) as useful lenses for studying phenomena with equal importance as disciplinary core ideas and science and engineering practices. Use this opportunity to name what students have been doing as systems thinking, and have them reflect on when they used systems thinking in their sensemaking work.

Name the boundary of the system we are investigating. Say, *We've been using parts and interactions between parts to help us decide what is important for explaining the one-way mirror effect. How did we decide the boundary of what we need to include?* Discuss the boundary concept using the prompts below.

Suggested prompts	Sample student responses
How did we decide the boundary of what we need to include?	*Seems like it was all happening inside the rooms, so the walls are the boundary.*
How do we know this is a good boundary to use? What do we think would happen if we didn't have it?	*If you opened the doors, it might change what is seen. If you took away the walls, the one-way mirror might not work.*
Was there a boundary on our box model?	*The sides of the cardboard boxes.*
Did anything cross the boundary when we investigated with the box model?	*Maybe light from the classroom when we opened the viewing holes.*

Name what students have been doing as systems thinking.* Display **slide W**. Introduce the idea of systems thinking as a way to organize what is known about a system to make sense of a phenomenon. Ask students when we've done this kind of thinking already. Listen for responses such as these:

- *when we did the Parts chart*
- *when we did initial models*
- *when we had a class Consensus Discussion*
- *when we generated questions about different parts*

Connect the DQB to the unit question. The question for this unit is "Why do we sometimes see different things when looking at the same object?" Ask students if that question could work as the main DQB question or whether they want to modify it to capture all the other questions we have posted. Write the unit question, with any student modifications, at the top of the DQB.

16. Develop ideas for future investigation.

12 MIN

Materials: Ideas for Investigations chart (prepared in advance), markers

Brainstorm investigation ideas. Display **slide X**. Arrange students in partners or small groups while they remain in the Scientists Circle. Assign students to work on one cluster of questions. Have them turn and talk for a few minutes about ideas for investigating their cluster of questions.*

Record a class chart of investigation ideas. Ask students to share their ideas for investigations with the class while you record a list that will remain public throughout the unit. Emphasize that the Ideas for Investigation chart can change in later lessons as we learn more. If students think of new ideas along the way, we can add to the list.

Science Notebook

At some point toward the end of Lesson 1, remind students to update their notebook by titling each page (if not done previously) and then adding entries to their table of contents. Going forward, it is recommended to have students update the table of contents whenever they add to their Progress Tracker. This periodic time for organization helps them look back on the trajectory of their learning journey. For many students, this is a helpful way to support coherence.

***Supporting Students in Engaging in Asking Questions and Defining Problems**

As students brainstorm investigations, probe their understanding of how gathering evidence will help them answer a question or set of questions. Use this information to gauge their experience with testable questions and the data necessary to answer them. Testable questions can include both experimental ones (which students will generate in Lesson 3) and non-experimental ones.

17. Decide where to go next.

3 MIN

Materials: None

Decide where to go next. Use **slide Y** to remind students of the class's mission: to figure out how the one-way mirror can act as both a mirror and a window at the same time. Explain that on day 2, you heard lots of suggestions for switching the light from Room A to Room B and figured this was a good starting place. Have students share their initial thinking about what they predict will happen.

Listen for suggestions such as these:

- *The phenomenon will reverse itself.*
- *The phenomenon won't be able to reverse itself. It'll look different.*
- *The phenomenon may kind of reverse but not completely.*

Slide Z is an optional slide that you can use at any moment to check in on the classroom norms. Modify as necessary.

Additional Guidance

In this lesson, students overlay their DQB questions onto the Initial Class Consensus Model. As the unit unfolds, you may want to work with this model to add to or revise the class's thinking. Therefore, the sticky notes need to be moved off the model, but students still need a way to match the clusters of questions to where they were originally placed.

Below are two suggestions:

1. Move each group of questions to the chart paper just outside of the model. Tape string or yarn from each group to its original location on the model.
2. If your model used letter or number coding, move the group of questions from each letter or number to the chart paper just outside of the model or to a nearby whiteboard. Write the corresponding letter or number next to each group.

If you plan to keep the Initial Class Consensus Model untouched, then students' DQB sticky notes can remain in place.

ADDITIONAL LESSON 1 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-Literacy.SL.6.1.c: Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.

When building the DQB, if a student forgets to explain why or how their question is linked to someone else's question, press that student to try to talk through their own thinking. This is a key way to emphasize the importance of listening to and building off each other's ideas, and it also helps to scaffold student thinking.

Don't worry if some questions are raised that are not part of topics in this unit. Over time students will get better and better at forming testable questions within the scope of the driving question. This type of activity gives them practice at doing that.

If students can't figure out which question to connect theirs to, encourage them to ask the class for help. After an idea is shared, ask the original presenter if there is agreement and why, and then post the question.

Supporting Students in Making Connections in ELA

Science Classroom Norms are intended to support constructive collaboration and communication during partner, small-group, and whole-class discussion. These norms support similar goals in the Common Core State Standards for ELA for Speaking and Listening:

CCSS.ELA-LITERACY.SL.6.1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.

CCSS.ELA-LITERACY.SL.6.1.A: Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.

CCSS.ELA-LITERACY.SL.6.1.B: Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed.

CCSS.ELA-LITERACY.SL.6.1.C: Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.

CCSS.ELA-LITERACY.SL.6.1.D: Review the key ideas expressed and demonstrate understanding of multiple perspectives through reflection and paraphrasing.

LESSON 2

What happens if we change the light?

Previous Lesson

We watched a video of a music student who could see their reflection in what seemed to be a mirror. The student couldn't see the adults on the other side, but the adults could see the student. We investigated the scenario using a box model and developed an Initial Class Consensus Model. We brainstormed related phenomena that might help us explain how the one-way mirror works. We developed our Driving Question Board and ideas for investigations to help answer our questions.

This Lesson

Investigation

3 DAYS

In this lesson, we take the one-way mirror out of the box model and observe that it is partially reflective and partially see-through and looks the same from both sides. We wonder about the role of light in affecting what we see. We move the flashlight to Room B and investigate making both rooms light and both rooms dark. We agree that the one-way mirror phenomenon is strongest when there is a large difference in light between the rooms. We reach consensus that arrows in our models should represent the path of light rather than our line of sight. We document and share related phenomena from our lives.

Next Lesson

To figure out why the one-way mirror acts like a mirror and a window, we will observe what happens when light shines on three different materials. We will develop a testable question, plan an investigation, and use a light meter to measure the amount of light that transmits through and reflects off each material.

Building Toward NGSS

MS-PS4-2, MS-LS1-8

What Students Will Do

2.A Ask questions that can be investigated in the classroom and frame a hypothesis about what we will see from both sides of the box model if we change the amount of light on either side (structure).

2.B Modify a model based on evidence to match changes in what we see when we change the light in the box model (structure).

What Students Will Figure Out

- When we change the location of the light in the box system, the phenomenon reverses.
- Reflection happens on the side that is lit, while the side that is dark is see-through.
- The one-way mirror phenomenon is strongest when there is a large difference in light between the rooms.

- Light travels in straight lines (reinforce 4th-grade understanding).
- For us to see an object, light must leave a light source, bounce off the object, and travel in a direct path to enter our eyes (reinforce 4th-grade understanding).

Lesson 2 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	7 min	**NAVIGATION** Remind students about Lesson 1's home learning self-documentation assignment. Motivate taking the one-way mirror out of the box model to make observations.	A-B	
2	6 min	**OBSERVE THE ONE-WAY MIRROR OUTSIDE THE BOX MODEL** Take the one-way mirror out of the box model to make and discuss observations.	C	1 picture mat set with one-way mirror film
3	10 min	**SWAP THE LIGHT AND MAKE OBSERVATIONS OF THE BOX MODEL** Move the light from Room A to Room B and make observations.	D-E	Light Swap Investigation
4	10 min	**IDENTIFY QUESTIONS ABOUT LIGHT THAT WE CAN INVESTIGATE IN THE CLASSROOM** Discuss related phenomena involving a light difference. Identify new questions about changing the light to test using the box model.	F-G	Related Phenomena list (from Lesson 1), Driving Question Board (from Lesson 1)
5	12 min	**TEST DIFFERENT LIGHTING SCENARIOS IN THE BOX MODEL** Investigate what we see when there are lights on in both rooms and lights off in both rooms.	H-J	Testing Light Scenarios Investigation
				End of day 1
6	5 min	**NAVIGATION** Collect Lesson 1's home learning self-documentation assignment.	K	
7	8 min	**MAKE SENSE OF THE TESTING LIGHT SCENARIOS INVESTIGATION** Remind students of the box model investigations from the previous class session. In small groups, make sense of why we see what we see when (1) the lights are on in both rooms and (2) the lights are off in both rooms.	L-M	*Testing Light Scenarios*, Initial Class Consensus Model (from Lesson 1)
8	10 min	**GALLERY WALK** Introduce idea pirating as a way to collectively build understanding and discuss norms that will make this productive. Have each group visit at least two other groups' models to share and compare ideas.	N-O	*Testing Light Scenarios*

Part	Duration	Summary	Slide	Materials
9	22 min	**BUILDING UNDERSTANDINGS DISCUSSION** In a Scientists Circle, facilitate a Building Understandings Discussion to come to agreement about the role of light in the phenomenon and how to use arrows to represent the path that light travels.	P-S	*Testing Light Scenarios*, chart paper or whiteboard, Initial Class Consensus Model (from Lesson 1), blank Class Consensus Model on chart paper (optional if needed to revise for line of sight arrows), blank Science Ideas chart on chart paper *End of day 2*
10	10 min	**INTRODUCE AND ADD TO THE PROGRESS TRACKER** Set up a Progress Tracker in students' science notebooks and document important ideas about the one-way mirror phenomenon and light.	T	
11	30 min	**CREATE A SELF-DOCUMENTATION COLLECTION** Share images from Lesson 1's home learning assignment to build a Self-Documentation Collection with related phenomena that students have observed outside of school.	U-V	Photos or drawings from Self-Documentation home learning, Self-Documentation Collection (on chart paper or the classroom bulletin board or digital space), Related Phenomena chart (from Lesson 1), Driving Question Board (from Lesson 1), sticky notes
12	5 min	**NAVIGATION** Consider how the music student phenomenon would change if we swapped the one-way mirror material for regular glass or a regular mirror. Brainstorm ways to investigate this.	W-X	*End of day 3*
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 2, students are ready to read Student Reader Collection 1 and then respond to the writing exercise.		Student Reader Collection 1: *Light and Color*

Lesson 2 • Materials List

	per student	per group	per class
Light Swap Investigation materials		• 1 modified box model setup (see lab preparation) • 1 flashlight • 1 picture mat set with one-way mirror film	
Testing Light Scenarios Investigation materials	• 1 highlighter • *Testing Light Scenarios*	• 1 modified box model setup (see lab preparation) • 2 flashlights • 1 picture mat set with one-way mirror film • 2 pieces of cardboard	
Lesson materials **Student Procedure Guide** **Student Work Pages**	• science notebook • *Testing Light Scenarios* • Photos or drawings from Self-Documentation home learning	• 1 picture mat set with one-way mirror film • *Testing Light Scenarios*	• Related Phenomena list (from Lesson 1) • Driving Question Board (from Lesson 1) • Initial Class Consensus Model (from Lesson 1) • chart paper or whiteboard • blank Class Consensus Model on chart paper (optional if needed to revise for line of sight arrows) • blank Science Ideas chart on chart paper • Self-Documentation Collection (on chart paper or the classroom bulletin board or digital space) • Related Phenomena chart (from Lesson 1) • sticky notes

Materials preparation (45 minutes)

Online Resources

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Day 1: *Light Swap Investigation*

Group size:

- Group size will vary across the 6 box models depending on class size.

Setup:

- Check batteries in flashlights and replace as needed.
- If not done previously, modify each box model by using a box cutter to cut a flashlight hole in the top of Room B. See detailed instructions in *Box Model Modification Instructions*. Tape a piece of cardboard to cover the flashlight hole in the top of Room A. Then, slide the picture mat set with one-way mirror film inside each box.

Storage:

- Find a location where you can stack the box models to the side of the classroom.

Day 2

If your students are using line of sight models in Lesson 1 and day 1 of this lesson, be prepared to insert one or more of the three Building Prerequisite Understanding activities in *Building Prerequisite Understanding Activities* during the Building Understandings Discussion. Note: Some of these activities require additional materials and preparation.

Activity 1: Tracing the Path of Light with a Flashlight and Laser

- 1 laser pointer (optional)
- 1 flashlight (adjustable zoom to focus light in tighter beam, high powered)
- 1 sheet of paper or cardboard
- chalk dust or flour
- small mirror
- chart paper or whiteboard

Activity 2: Conditions for Sight

- 1 object in the room that some students can and some cannot see from their seats
- chart paper or whiteboard, markers

Activity 3: Representing the Path of Light in Different Scenarios

- 1 *Representing the Path of Light in Different Scenarios* handout per student

If your Initial Class Consensus Model from Lesson 1 uses any line of sight arrows, draft a new Class Consensus Model version on chart paper that you can revise at the end of day 2. Be sure to include the two rooms from the video scene and the people in both rooms.

Prepare a Science Ideas chart on chart paper in advance of the discussion. This chart will be a running record of science ideas the class agrees upon and supports with evidence.

Testing Light Scenarios Investigation

Group size:

- Group size will vary across the 6 box models depending on class size.

Setup:

- Prepare an additional 2 pieces of cardboard for each box setup so students can cover the flashlight hole in the top of both Room A and Room B. Prepare two flashlights for each group.

Day 3

Identify a physical or digital space for your class to develop their Self-Documentation Collection. Students need to be able to organize their related phenomena similar to how they organize questions on a Driving Question Board. Have your class list of Related Phenomena from Lesson 1 ready to post near the Self-Documentation Collection.

If using the laser pointer in the Building Prerequisite Understanding activities:

- Some states prohibit the use of lasers or laser pointers at the elementary and middle school levels. Check your state regulations. Provide students with laser protective eyewear if using the laser.
- Follow these additional safety precautions when using a laser in the classroom:
  1. Wear laser protective eye-wear during the setup, hands-on, and take down segments of the activity.
  2. When using laser beams, put a caution sign at the door.
  3. Remove all reflective items (watches, jewelry, etc.)
  4. Before turning on the laser pointer, always be sure that it is pointed away from yourself and others.
  5. Never look directly into a laser pointer.
  6. Never direct a laser pointer at another person.
  7. Remove all potential trip/slip fall hazards for darkened room movement.
  8. Windows are covered with blinds, shades or other non-flammable barriers that reduce transmission of the beam.
  9. Wash your hands with soap and water immediately after completing this activity.

Lesson 2 • Where We Are Going and NOT Going

Where We Are Going

In this lesson, students deepen their understanding of the one-way mirror phenomenon. They first discover that when you take the one-way mirror out of the box model and observe the material in a well-lit classroom, the phenomenon changes again: they can both see some reflection and see through and, importantly, the material looks the same from both sides. When they reinsert the one-way mirror into the box model after switching the light from Room A to Room B, they discover that the phenomenon is the same as before but reversed. They also test making both rooms light and making both rooms dark. At this point, students should recognize that a difference in the amount of light on the two sides is what causes the phenomenon, but they don’t need to be able to explain why yet.

Students should come into this lesson with prerequisite understandings from 4th grade that light comes from a light source, bounces off objects, and enters our eye, which is how we see things. Therefore, this lesson builds from:

- PS4.B: Electromagnetic Radiation: An object can be seen when light reflected from its surface enters the eyes. (4-PS4-2)

If students do not have these foundational understandings from 4th grade, there is a point during the Building Understandings Discussion on day 2, after discussing what happened when both rooms were dark, where you can use Building Prerequisite Understanding activities from *Building Prerequisite Understanding Activities* to help students develop or reinforce ideas related to a path of light model rather than a line of sight model.

Where We Are NOT Going

Students may use everyday language or use scientific vocabulary in imprecise ways to describe or explain the phenomenon. For example, many students will use the word “reflection” from Lesson 1 as a noun to describe what is seen in the mirror. This is the everyday use of “reflection.” Students are not likely to use the term as a verb to describe what light is doing as it interacts with objects, such as the mirror. Students will likely talk about being able to “see through” the one-way mirror. They may use language like “transparent.” Take up the students’ language to describe the phenomenon and avoid correcting their use of the words right now. At this point, avoid defining these words in terms of light reflecting or transmitting. Beginning in Lesson 3, students will refine their use of scientific terms, after they have had more time to develop their conceptual ideas.

Students may want to test many different scenarios. In this lesson, they will make both rooms light and both rooms dark. However, they will not have a chance to move the light to a location other than the top of each room, change the angle of the light, or try out different materials. Some of these investigations will happen later in the unit when they’ve further developed their understanding of reflection and transmission and are able to explain how the phenomenon works, and why certain manipulations within the system affect the observed outcomes. Encourage students to record their ideas for investigations, but wait to investigate them until later in the unit.

1. Navigation

7 MIN

Online Resources

Materials: None

Remind students to document and provide images of related phenomena. Present **slide A**. Have students send you their Lesson 1 home learning images to print for sharing on day 3.

Motivate removing the one-way mirror and predicting what we'll observe. Present **slide B**. Remind students that we agreed the one-way mirror looked like a mirror from one side and a window from the other side. Prompt students to consider whether we could see the cause of the one-way mirror phenomenon by taking the one-way mirror out of the box model.

Suggested prompts	Sample student responses
If we take the one-way mirror out of the box model to look at it up close, what do you think we'll observe?	*(Accept all responses.)*

2. Observe the one-way mirror outside the box model.

6 MIN

Materials: 1 picture mat set with one-way mirror film

Remove the one-way mirror and make observations. Display **slide C**. Demonstrate how to slide the one-way mirror out of the box model. Assign students to small groups, and then give them time to remove their mirror and make observations of the material.

Discuss observations as a class.* Come to consensus about observations when the one-way mirror material is out of the box model in the classroom:

- Outside the box model, you can see your reflection and see through it at the same time.
- It doesn't have the same effect of being a mirror and window when it's outside the box model. It doesn't matter which direction the material is facing, it looks the same.
- The material looks different in different lighting situations.
- The light difference between the sides in the box model is important for causing the one-way mirror phenomenon.

***Attending to Equity**
Supporting Emerging Multilingual Learners: Scaffolds such as the Communicating in Scientific Ways sentence starters can model and facilitate oral or written language production skills. Remind all students that they have this tool and can use the sentence starters to help them communicate. Such scaffolds may be of particular benefit for emerging multilingual students to help them develop language skills to write or communicate their ideas to peers. It is important that scaffolds be used purposefully and removed when no longer needed.

Suggested prompts	Sample student responses	Follow-up questions
What did you observe?	*The material is flimsy, grayish, and seems to only have one layer.* *I could see my reflection and could see through it at the same time.*	*Does it look the same or different from either side?*
How is this similar to, and different from, what you observed when the one-way mirror was in the box model?	*It's acting like a mirror and a window at the same time rather than one or the other.* *When it's out of the box, you can see through it and see your reflection at the same time.*	*What about the classroom is different from the box model setup that might be causing the phenomenon to change?*

3. Swap the light and make observations of the box model.

10 MIN

Materials: Light Swap Investigation, science notebook

Motivate investigating the light further. Emphasize that our observations with the one-way mirror in the classroom did not involve any differences between the amount of light on the two sides of the one-way mirror, whereas all of our previous observations in the box model had one side dark and one side light. Remind students of the light-related questions we posted on the DQB.

Introduce the lesson question. Present **slide D**. Remind students that many of them wondered whether light causes the one-way mirror phenomenon. Introduce the lesson question: "What would happen if we changed the light?"*

Establish the purpose of moving the light. Ask students to consider how moving the light to Room B would help us investigate our idea that having the light on one side matters for the one-way mirror effect. Have a few students share.

Suggested prompts	Sample student responses
If we move the light to the other side of the box model and make observations, how would that help us support our claim that light on one side is important for the one-way mirror phenomenon?	*If we see the same thing as before, but reversed, then having light on one side of the one-way mirror is what's important for causing the one-way mirror phenomenon, no matter which side it's on.* *If we see something different when we move the light, then it matters which side the light is on.*

Show the modified box models for investigation. Describe the following modifications you made to the box models:

- a piece of cardboard to cover the flashlight hole in Room A's ceiling so it can be dark
- a flashlight hole in Room B's ceiling

***Supporting Students in Engaging in Asking Questions and Defining Problems**

The lesson question is a "what would happen if" question, which is open-ended because it does not have a simple yes or no answer, yet prompts little explanation from students. "What would happen if" questions lead students to do two important things:

- to discover new aspects of the phenomenon that students may not have noticed before
- to generate and record new how or why explanatory questions about the phenomenon

To press students to explain the phenomenon, we often follow "what would happen if" questions with how and why explanatory questions.

Swap the light and make observations. Present **slide E**. Arrange students in groups around the 6 box models.* Have them move the flashlight to the hole in the top of Room B and cover the flashlight hole in Room A. Then instruct them to turn on the flashlight and make observations through the viewing holes.

Additional Guidance

It is important that students **only** put the flashlight in the Room B flashlight hole. They should not put it through any other opening in the box (e.g., either viewing hole or the flashlight hole in Room A). They should also not put two flashlights into the box model at once (e.g., one in Room B and one in Room A). This will happen later on day 1. If students attempt any of these investigations, tell them it is a great idea to add to the Ideas for Investigation and that we will return to it later in the unit.

Discuss observations as a class. Have students briefly share their observations and work toward reaching consensus around the following idea:

- The difference in the amount of light between the two rooms is what matters.

Suggested prompts	Sample student responses
What did you observe?	*In Room B, it's like a mirror now, and in Room A, it's like a window.*
How is this similar to and different from what we observed when it was light in Room A and dark in Room B?	*It is the same, but now what we see is reversed.*
Why doesn't it matter which side the light is on?	*The setup is basically the same, so it makes sense that we see the same thing.* *When we took the one-way mirror out of the box model, we saw the same thing from both sides, so it must function the same way inside the box model as long as there's a difference in light between the two rooms.*

***Attending to Equity**

Supporting Emerging Multilingual Learners: This is an opportunity to talk about how language is used to construct different types of scientific questions, such as (1) **what is happening** or **what would happen if** and (2) **how** or **why** is something happening. This kind of talk supports emerging multilingual students in understanding that how a question is phrased changes the meaning of the question and how to approach answering it.

***Attending to Equity**

Small group labs and investigations are designed to position all students to intellectually engage during the activity. When thinking about assigning roles to group members, it is important to avoid putting students in less intellectually engaging roles, like materials manager; instead, use a range of intellectual roles associated with the collaborative learning process (e.g., idea connector, causal checker, evidence wrangler, relevance hunter). For additional guidance, visit the Ambitious Science Teaching website. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

4. Identify questions about light that we can investigate in the classroom.

10 MIN

Materials: Related Phenomena list (from Lesson 1), Driving Question Board (from Lesson 1)

Celebrate initial progress in figuring out the phenomenon. Point out that we have already gathered evidence to suggest the phenomenon works because of the light difference.

Share related phenomena that involve a light difference.* Present **slide F**. Have students consider the list of Related Phenomena generated in Lesson 1 to see which ones may involve a light difference between the two sides of a material. Listen for suggestions such as these:

- eyewear (sunglasses, ski goggle, swim goggles)
- windows (home, car, classroom, school, store)
- one-way mirrors in museums and amusement parks
- one-way mirrors on television shows

Say, *Seems like we're onto something about how the amount of light on either side affects the one-way mirror effect. Let's dig into other questions we had about changing the light to see what additional evidence we can collect.*

Identify other testable questions about changing the light. Present **slide G.** Ask students to look at the DQB from Lesson 1. Have them share questions from the DQB about light that are feasible to test right now in the classroom. List these questions on the board.*

Assessment Opportunity

Building towards: 2.A Ask questions that can be investigated in the classroom and frame a hypothesis about what we will see from both sides of the box model if we change the amount of light on either side of the box model (structure).

What to look/listen for: (1) Questions that focus on changing one aspect of the light in the box model at a time, (2) questions that are feasible in terms of time and materials, and (3) hypotheses framing what students expect to see.

What to do: Focus on helping students consider changes they could make to the structure of the box model specific to the light. Press them to explain *why* they think their questions are feasible to investigate in the classroom. Point them back to the box model to help them evaluate the ease with which some of their questions could be investigated given limitations of the materials on hand.

Use feasibility criteria to determine which questions to test. Reiterate the feasibility criteria for our investigation questions: fast, easy, and doable with resources in the classroom right now. From the list of questions students want to test, select the following two. Discuss what would change from the original system in each case.

Question	Change from the original system
What would happen if it was light in both rooms?	Turn on lights in Rooms A and B.
What would happen if it was dark in both rooms?	Have no lights and cover the flashlight holes in Rooms A and B.

***Attending to Equity**

Supporting Universal Design for Learning: Use this opportunity to discuss examples of phenomena from students' own contexts. Highlight examples in which lighting conditions affect the function of the object, similar to what we think is happening with the one-way mirror. This can increase student engagement by broadening the class's mission to explain not only the one-way mirror but also familiar everyday phenomena. On day 3, the class will build out a Related Phenomena Board to further emphasize this broader mission.

***Supporting Students in Engaging in Asking Questions and Defining Problems**

An important aspect of supporting students to ask testable questions is to help them consider what is feasible to investigate, particularly in terms of being able to gather evidence. While students likely have many questions they want to pursue, focus them on what is feasible in the classroom in terms of available resources and amount of time.

Below are additional questions students may want to investigate and recommendations for how to handle them if they arise.

Questions we will investigate later in the unit, and how to respond	Questions we will not investigate in this unit, and how to respond
Question: What would happen if we change the one-way mirror material to a regular mirror or glass? **Recommendation:** Note that this question is not about changing the light but is a very interesting question that we should investigate soon. Students will investigate this in Lesson 3.	**Question:** What would happen if we use a different-colored light? **Recommendation:** If you have access to different-colored lights or colored films, it's fine to test this now. The phenomenon should remain the same, though possibly not as pronounced; however, the unit will not cover color.
Question: What would happen if we added a dim light to Room B? **Recommendation:** We will investigate this question in Lesson 8. Tell students this is a great question and we can start by adding the same bright light to Room B and return to this question later in the unit.	**Question:** What would happen if we change the light angle? **Recommendation:** While this is easy to test, the unit does not investigate this question because what students see when they change the light angle in the box model can vary greatly.
	Question: What would happen if we change the distance to the one-way mirror? **Recommendation:** Note that this question is not about changing the light. The unit does not investigate this question because it is logistically difficult to modify the box model to adjust distance from the viewing hole to the one-way mirror. Point out this is a limitation with our box models.

Assign each group to focus on one investigation question. Tell students they will investigate both of the selected questions, but each group will be responsible for modeling only one of the two situations on paper.

Additional Guidance

Students' modeling work for the two questions emphasizes different understandings about light. The model that focuses on explaining both rooms when they are dark can be used to reinforce prerequisite understandings about a path of light model. If you noticed students in Lesson 1 lacking these foundational understandings, assign them to model this question.

***Supporting Students in Developing and Using Structure and Function**
Emphasize that students are changing the ***structure*** of the box model by changing the location of the light. Point out that their questions are about how the one-way mirror will ***function*** differently given the change to the light.

5. Test different lighting scenarios in the box model

12 MIN

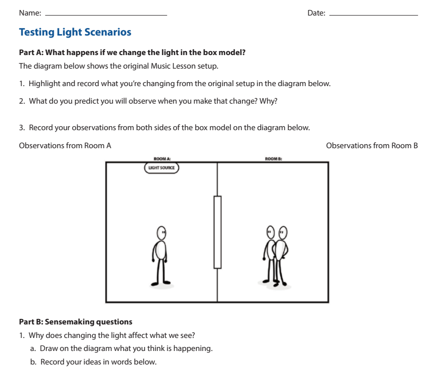
Materials: Testing Light Scenarios Investigation

Introduce new materials. Present **slide H.** Introduce new materials:

- two pieces of cardboard
- two flashlights

Record prediction for the investigation questions. Distribute a copy of *Testing Light Scenarios* to each student. Review Part A of the handout, which is also on **slide H**. Because time may be short, have students complete #1 and #2 in Part A for their assigned question only. If time allows, you can have them do this for both questions.

Investigate both questions in small groups. Present **slide I**. Arrange students in groups around the 6 box models. Remind them to test both setups but to complete Part A for only their assigned question. Give students 10 minutes to use the flashlights and cardboard to observe the box model when it is light on boths sides and dark on both sides.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Testing Light Scenarios

Part A: What happens if we change the light in the box model?

The diagram below shows the original Music Lesson setup.

1. Highlight and record what you're changing from the original setup in the diagram below.
2. What do you predict you will observe when you make that change? Why?
3. Record your observations from both sides of the box model on the diagram below.

Observations from Room A

Observations from Room B

Part B: Sensemaking questions

1. Why does changing the light affect what we see?
   a. Draw on the diagram what you think is happening.
   b. Record your ideas in words below.

Additional Guidance

If you decided to have students conduct investigations beyond these two setups (e.g., changing the light color), give them time to complete the additional investigations. If desired, use Part A of the handout for documentation.

Foreshadow future sensemaking. Present **slide J**. Tell students we'll make sense of these observations during the next class session. Make sure to save 1-2 minutes for students to return supplies before the class ends.

End of day 1

6. Navigation

5 MIN

Materials: None

Collect students' images of related phenomena. Present **slide K**. Remind students to document the related phenomenon for Lesson 1's home learning assignment. Have them turn in their drawing or photo to you. They will be shared on day 3 of this lesson.

7. Make sense of the Testing Light Scenarios Investigation.

8 MIN

Materials: *Testing Light Scenarios*, Initial Class Consensus Model (from Lesson 1)

Revisit the lesson question and investigations from the previous session. Present **slide L**. Remind students that with our results from the *Light Swap Investigation* and *Testing Light Scenarios Investigation*, we're making progress toward our goal of explaining the music student phenomenon by testing what happens if we change the light.

Set the purpose for modeling. Tell students we are trying to understand why the phenomena we tested were different from the original phenomenon we saw in the *Music Lesson* video.

Revisit Lesson 1's Initial Class Consensus Model. Point out that the ideas in that model may help us explain what we observed when we changed the light and provide more evidence to explain the music student phenomenon.*

Make sense of the *Testing Light Scenarios Investigation*. Present **slide M**. Review Part B of *Testing Light Scenarios*. Have students return to their small groups from the investigation. Give them time to model and record their ideas to explain what they observed after changing the light.

Assessment Opportunity

Building towards: 2.B Modify a model based on evidence to match changes in what we see when we change the light in the box model (structure).

What to look/listen for: Students documented observations about what they could see from each side of the box model. Look for the use of arrows that may represent light entering the eye for an object to be seen. If students draw arrows pointing away from the eye, this may represent ideas related to a line of sight model.

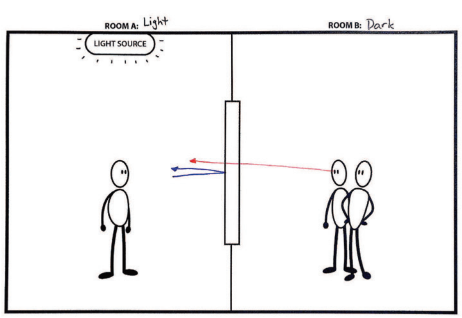
What to do: Ask students what the arrows in their models represent to assess if students are using arrows to represent the path of light or the line of sight. If you hear a lot of the latter, be prepared to facilitate one or more of the Building Prerequisite Understanding activities described in *Building Prerequisite Understanding Activities*. These activities require additional preparation and materials but are easy to insert. Being prepared to sidestep into these activities will allow you to respond just in time to your students' needs.

Additional Guidance

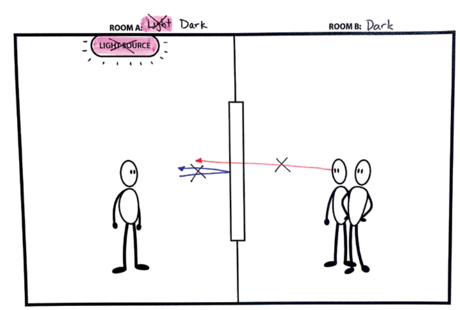
If groups struggle with modeling what happened when there was no light in both rooms, you can suggest they start by drawing the Initial Class Consensus Model, showing what can be seen when there was light in Room A, and then identifying the effects of removing the light from Room A. You can prompt them as follows:

- *Draw a model of what you would need to see and then show what's missing.*

Example consensus model using arrows to represent line of sight (red) and line of sight or path of light (blue)



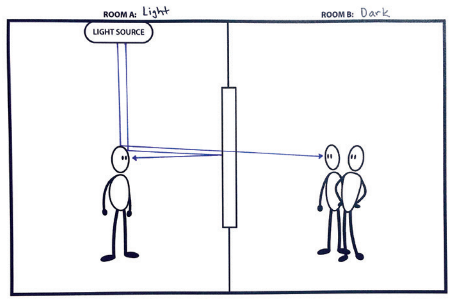
Example modified student model



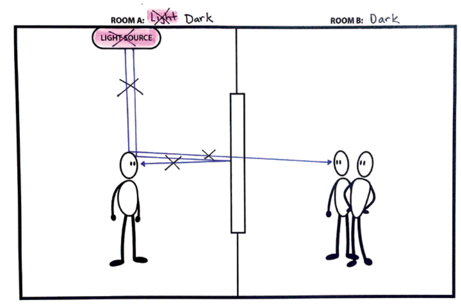
*Supporting Students in Three-Dimensional Learning

Before students model the different scenarios, have them think about Lesson 1's Initial Class Consensus Model and how to modify their diagrammatic model to account for changes we made and investigated in the box model. This may be particularly helpful for students who are modeling what happens when it's dark in both rooms. Cue students to use structure and function as a lens for thinking about how their model is different from the one in Lesson 1. This will help them make sense of why they could be seeing different things than what they observed in Lesson 1.

Example consensus model using arrows to represent path of light



Example modified student model



8. Gallery Walk

10 MIN

Materials: science notebook, *Testing Light Scenarios*

Introduce idea pirating and discuss norms to use when sharing and comparing ideas. Present **slide N**. Introduce the idea of idea pirating, which is reviewing ideas from other students and taking up ideas you agree with. Have the class discuss why this is beneficial. Then, remind students of the classroom norms and discuss what norms to focus on during this time.*

Conduct a gallery walk and visit at least two other groups. Present **slide O**. Have each group display one representative's model on *Testing Light Scenarios*. Give students time to circulate to at least two other groups—one that worked on their same question and one that worked on the other question—spending about 4 minutes at each group's model. Students can make notes in their notebook about what they notice or discuss it with their group. Encourage students to note which ideas are coming from each group so they can acknowledge that group's contribution during the Building Understandings Discussion.

***Attending to Equity**
The gallery walk will support students in collectively making sense of these phenomena. It also presents an opportunity to practice the norm of "Moving our science thinking forward" as we work together to figure things out. Encourage students to be open to changing their minds if they see a good idea from someone else. Highlight norms from this category:

- We use and build on other's ideas.
- We are open to changing our minds.
- We challenge ourselves to think in new ways.

9. Building Understandings Discussion

22 MIN

Materials: science notebook, *Testing Light Scenarios*, chart paper or whiteboard, Initial Class Consensus Model (from Lesson 1), blank Class Consensus Model on chart paper (optional if needed to revise for line of sight arrows), blank Science Ideas chart on chart paper

Gather in a Scientists Circle to discuss the *Testing Light Scenarios Investigation*.* Have students bring their science notebook and *Testing Light Scenarios* handout, along with a chair. Have chart paper or whiteboard space prepared for easy documentation of student ideas. If your Initial Class Consensus Model from Lesson 1 used line of sight (LOS) arrows, have a blank Class Consensus Model on chart paper ready for revision with path of light (POL) arrows.

This Building Understandings Discussion contains three important moves and two optional detours about the path of light:

1. Make sense of what happened when it was dark in both rooms. (Starting by explaining why we don't see anything when it's dark may support student progress toward using POL ideas rather than LOS.)
2. Make sense of what happened when it was light in both rooms.
3. Do Building Prerequisite Understandings activities (optional, requires additional instructional time).
4. Come to consensus about the phenomenon and what the arrows should represent (POL, not LOS).
5. Revise the Initial Class Consensus model (optional, if the Initial Class Consensus model contained LOS arrows and the class modifies the redrawn Class Consensus Model to use POL arrows).

Throughout these moves, it is important to probe students about the meaning of the arrows in their models. Use these prompts:

- *Why would we use an arrow as opposed to a line? What does an arrow show that a line may not show?*
- *What does the direction of the arrow represent in your model?*

Listen for these ideas:

- the arrows represent what the person sees (LOS)
- the arrows represent the direction and path that light travels (POL)

Key Ideas

Purpose of this discussion: To make claims supported by some evidence about the following ideas:

1. For us to see an object, light must leave a light source, bounce off the object, and travel in a direct path to enter our eyes.
2. Arrows in our diagrammatic models should represent the path that light travels (POL), not what we see (LOS).
3. In our box model, the phenomenon works best when there is a big difference between the amount of light in the two rooms.

Listen for agreement about the following ideas:

- When it's dark in both rooms, we don't see anything because there is no light source, so light does not bounce off people and enter our eyes.
- When it's light in both rooms, we see the people in both rooms because light from a light source bounces off the people in each room and enters our eyes.
- The one-way mirror phenomenon works best when there is light on one side.
- Arrows in our models should represent the path that light travels, not what we see.

Make sense of what happened when it was dark in both rooms. Present **slide P**. Work toward the big idea that when there is no light in the room, there is no light bouncing off people and entering our eyes, so we don't see anything. Use these prompts:

- *What did you observe when you made this change?*
- *What do you think is happening?*

*Strategies for this Building Understandings Discussion

As students share, encourage them to use evidence from the *Testing Light Scenarios Investigation* to explain their observations and use what they've learned to explain the original one-way mirror phenomenon. It is not necessary to reach a consensus during this discussion, but students should be pushed to support their ideas with evidence. Remind them to use their Communicating in Scientific Ways sentence starters to help them share their thinking.

*Supporting Students in Engaging in Developing and Using Models

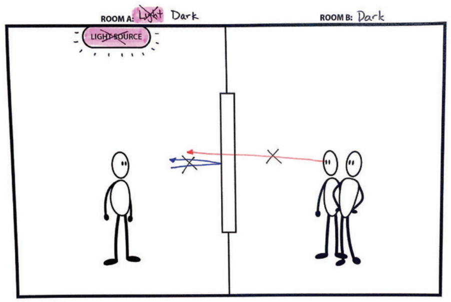
Developing models to match what happened when students changed a lighting component of the system may draw out new ideas about the original phenomenon. This is a chance to revise the Initial Class Consensus Model with the classes' updated ideas.

*Attending to Equity

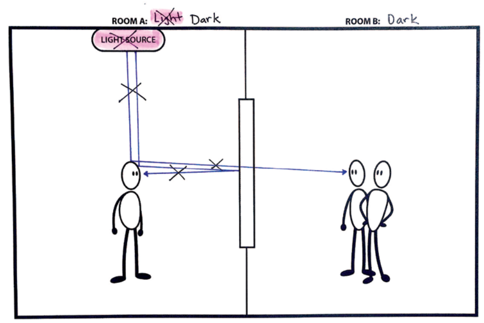
Supporting Emerging Multilingual Learners: Before whole-class discussions, it can be helpful to first provide students an opportunity to work with others—in pairs, triads, or small groups—on ideas related to their reasoning. These smaller group

- *How did you represent what was happening?*
- *What does the direction of the arrow represent in your model?*

If the arrows in student models represent the line of sight, models might look like this:



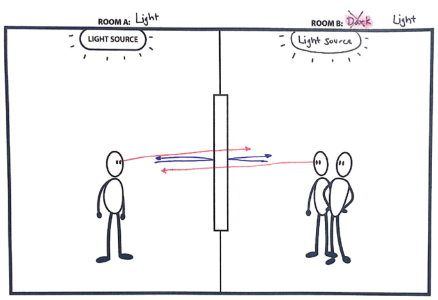
If the arrows in student models represent the path of light, models might look like this:



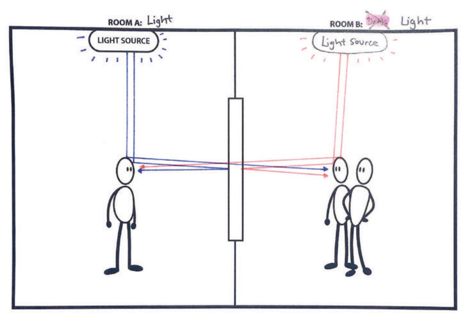
Make sense of what happened when it was light in both rooms. Present **slide Q.** Work toward the big idea that when there is light in both rooms, it bounces off the people in each room and enters our eyes, so everyone can see through the one-way mirror and see themselves. Use these prompts:

- *What did you observe when you made this change?*
- *What do you think is happening?*
- *How did you represent what was happening?*
- *What does the direction of the arrow represent in your model?*

If the arrows in student models represent the line of sight, models might look like this:



If the arrows in student models represent the path of light, models might look like this:



Highlight areas of agreement and disagreement. Present **slide R**. Remind students of the lesson question: "What happens when we change the light?" Record a list on chart paper or whiteboard, as shown on the slide, of what we currently agree on and where we still have different ideas. Students will likely agree about what was observed but disagree about their explanations or ways to represent their ideas.*

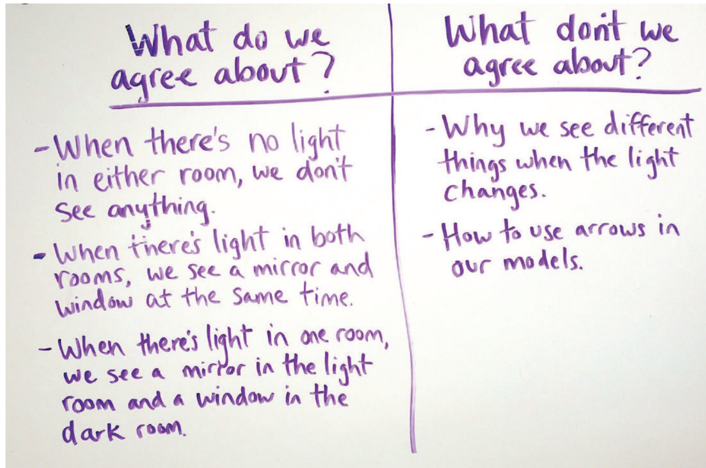
structures can be especially helpful for emerging multilingual students as (1) a chance to engage in sensemaking with their peers and (2) a space to use their linguistic and nonlinguistic resources to express their ideas (and learn from other students' use of these resources). If you have Emerging Multilingual Learners, consider adding a Turn and Talk before any class discussion to help students process their ideas before sharing them with a larger group of their peers.

Use these prompts to push students toward consensus about the phenomenon:

- *What can we summarize about the phenomenon?*
- *When is the one-way mirror phenomenon the strongest?*
- *How was our use of arrows in our models similar?*

Use these prompts to push students toward noticing different ideas and uses of arrows:

- *How did our explanations differ?*
- *How did our use of arrows in our models differ?*



Example chart

Assessment Opportunity

Building towards: 2.B Modify a model based on evidence to match changes in what we see when we change the light in the box model (structure).

What to look/listen for: The Key Ideas highlighted on the previous pages.

What to do: If students don't have the 4th-grade understanding that light bounces off objects and enters our eyes, do not continue the Building Understandings Discussion. Instead, redirect now to one or more of the Building Prerequisite Understanding activities presented in *Building Prerequisite Understanding Activities* as a way to develop and reinforce these foundational concepts. These activities require a little preparation and additional materials but are easy to insert into your instruction.

Alternate Activity

Building Prerequisite Understandings: *Building Prerequisite Understanding Activities* contains three activities to help students develop a path of light model to explain how we see objects. These activities take varying amounts of time. You can do one or all three depending on how much time your students need to work through these important foundational concepts. If you notice your students are struggling or uncertain about how light allows us to see, then it is important to take time now to review the concepts so all students can make progress later in the unit.

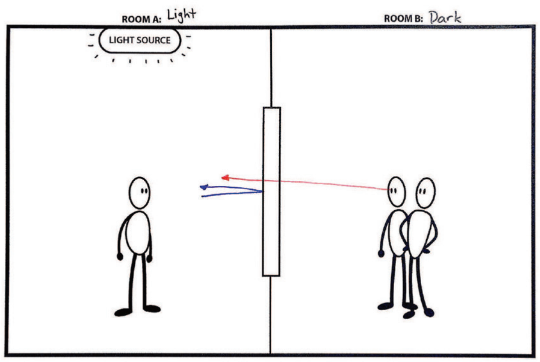
Come to consensus about what the arrows should represent. Present **slide S**. Suggest that we have more work to do on explaining why the phenomenon works, so it's okay if we disagree about our explanations. However, highlight that people may be using arrows in different ways, and this could be one thing we could agree on right now. Help students come to consensus through these steps:

- Show different ways students used arrows by projecting models on a document camera or by drawing them on the board if you don't want to highlight specific groups or students. Prompt students to explain what the arrows represent in each case.

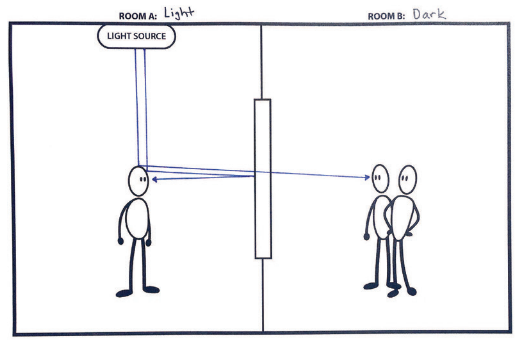
- Have students explain how we all see an object in the room right now, like the whiteboard. Highlight that light is coming from a light source, bouncing off the object, and entering our eyes and draw that on the board. Emphasize that if we see something, that means the arrow (light) is entering our eyes.

Revise the Initial Class Consensus Model if it used any LOS arrows. If the Initial Class Consensus Model contained any LOS arrows pointing out of eyes to show what someone sees, rather than POL arrows, revise those now on a revised Class Consensus Model.*

Example Initial Class Consensus Model where the red arrow is a LOS arrow and the blue arrow could be a LOS or a POL arrow.



Example revised Class Consensus Model where blue arrows now show only POL, indicating that light bounces off the music student and must pass through and bounce off the one-way mirror so it enters both the student and the adults' eyes.



Start a class Science Ideas chart to track important ideas we figured out. Throughout the unit, the class will co-construct a diagrammatic model to explain the one-way mirror phenomenon. The diagrammatic model will use symbols, colors, and pictures, but underlying those symbols are the science ideas they represent. Keep track of those on a Science Ideas chart that serves as a running record of what the class has figured out and agrees upon. An example is shown to the right.

Below are additional tips and guidance for the Science Ideas chart:

1. In this unit, refer to this chart as documenting "science ideas" and not "model ideas". In future units, you may want to transition to "model ideas" if it makes sense.
2. The class-level science idea recorded to this chart does not need to match what students choose to record in their Progress Tracker. Students should feel free to record what they figure out in words that make the most sense to them and should not simply copy the class chart.
3. Keep this chart displayed near the DQB or where you conduct Scientists Circles. Be prepared to record new ideas hereon. They do not need to match the example science ideas provided in the teacher guide, as they should reflect your class's co-construction of ideas, which could be phrased in different ways.

Science Ideas

- Light travels in straight lines.
- For us to see an object, light must leave a light source, bounce off the object, and travel in a direct path to enter our eyes.

End of day 2

10. Introduce and add to the Progress Tracker.

Materials: science notebook

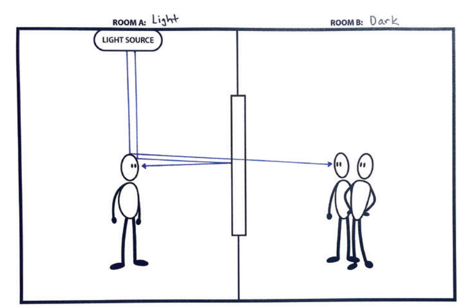
Motivate a need to record ideas we've figured out and introduce the Progress Tracker. Say, *We've answered a lot of questions from our DQB and figured out some important ideas about how light travels. Let's start to keep track of these ideas in a Progress Tracker in our notebook.*

Set up a Progress Tracker. Display **slide T**. Have students count out 10 pages in their science notebooks after the table of contents, if they have not already, to reserve for the Progress Tracker. At the top of the first page they should record the driving question for the unit and draw a two-column chart below it. Then they should label the left side "Question/Lesson #" and the right side "What I figured out," as shown on the slide.

Record students' ideas in the Progress Tracker. Direct students to record the lesson question in the left column of the table ("What happens if we change the light?"), along with the lesson number (2). Then have them add their ideas in the right column. Tell them they can use any combination of words and pictures. An example of what students might record is shown below. If there is time, ask 2-3 students to share some of the important ideas that they decided to record.

Additional Guidance

Tell students that the Progress Tracker is a thinking tool designed to help them keep track of their ideas. The sample Progress Tracker included in these materials serves as teacher guidance for what students may say at various points throughout the unit; some may say more, others may say less. It is important that what they write and draw in the Progress Tracker reflects their own thinking at that particular moment. In this way, it can be used to formatively assess individual progress throughout the unit. When the class comes to consensus in future lessons, students will record this in their Progress Tracker with sources of evidence, making it clear that the entry is a classroom consensus model rather than a record of individual thinking.

Question / Lesson #	What I figured out
"What happens if we change the light?" (2)	• When we change the location of light in the box system, the phenomenon reverses. • Reflection happens on the side that is lit, while the side that is dark is see-through. • The one-way mirror phenomenon is strongest when there is a large difference in light between the rooms. • Light travels in straight lines. • For us to see an object, light must leave a light source, bounce off the object, and travel in a direct path to enter our eyes. 

11. Create a Self-Documentation Collection.

30 MIN

Materials: Photos or drawings from Self-Documentation home learning, Self-Documentation Collection (on chart paper or the classroom bulletin board or digital space), Related Phenomena chart (from Lesson 1), Driving Question Board (from Lesson 1), sticky notes

Broaden the class's mission to answering the generalized unit question. Present **slide U**. Remind students that we're trying to explain not only the one-way mirror phenomenon in the *Music Lesson* video, but also why we might see different things when looking at **any** object. If you printed the students' home learning images for them, distribute them.

Gather in a Scientists Circle to build the Self-Documentation Collection. Have students bring their related phenomena images to a Scientists Circle around the Self-Documentation Collection. Explain how we will create the Self-Documentation Collection (use **slide V** if needed):

- The first student explains their related phenomenon image, then posts it to the board.
- Students should raise their hand if their image relates to the image that was just shared.
- The first student selects the next student whose hand is raised.
- The second student shares their image, says why or how it relates, and posts it near the image it most relates to.
- The student selects the next student, who may have a related image or a new image.
- We will continue until everyone's image is on the board.

Organize the Self-Documentation Collection into categories. As students share, images of related phenomena will naturally start clustering. Example categories include these:

- glass or see-through materials: windows, eyeglasses, cups, plastic wrap
- tinted glass: sunglasses, car windows, ski goggles
- mirrors: circus mirrors, illusions
- reflections observed on objects: whiteboard, metals, calm water, eyes

Assessment Opportunity

Self-documentation is a type of cultural formative assessment. This opportunity allows you insight into what students understand in terms of the phenomenon and allows aspects of students' cultural lives to surface (source: http://stemteachingtools.org/sp/self-doc). This is a good formative assessment opportunity to see how students make sense of the phenomenon as it applies to their lives.

Generate new questions for the DQB. Give students time to generate new questions about related phenomena, write them on sticky notes, and add them to the DQB.

12. Navigation

5 MIN

Materials: None

Motivate comparing the one-way mirror to other materials from the Self-Documentation Collection. Say, *we have a lot of related phenomena and questions about different materials, like glass and regular mirrors. How are these materials similar to, and different from, the one-way mirror?* Reference the DQB for student questions about trying out different materials in the box model.

Introduce a thought experiment about different materials. Show **slide W**. Present this question as a thought experiment: "How would the phenomenon change if the one-way mirror was a different material, such as glass or a regular mirror?" Have students do this thought experiment with glass and regular mirrors. Use the prompts below to guide the discussion.

Suggested prompts	Sample student responses	Follow-up questions
If we swapped the one-way mirror with a regular mirror, how would that change what the student and adults saw?	*(Accept all responses.)*	*How do you think the regular mirror would change the path of light?* *Why might light be doing something different with the one-way mirror compared to a regular mirror?*
If we swapped the one-way mirror with regular glass, how would that change what student and adults saw?	*(Accept all responses.)*	*How do you think the regular glass would change the path of light?* *Why might light be doing something different with the one-way mirror compared to glass?*

Generate ideas for investigating different materials. Present **slide X**. Have a few students share ideas for how to investigate and compare these different materials.

Suggested prompts	Sample student responses
How can we investigate some of our ideas using our box model?	*We could put regular glass and a regular mirror in the box model and see how it's different from the one-way mirror.*

Navigate to the next lesson. Tell students that we'll investigate regular glass and a regular mirror in the next session.

ADDITIONAL LESSON 2 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-Literacy.SL.6.1.a: Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.

When the class is looking at each other's models and engaging in the Building Understandings Discussion to explain the different lighting scenarios, celebrate when students share evidence from the investigation or from their model or another student's model. This is a key way to emphasize the importance of referring to evidence when discussing and reflecting on collective ideas.

If students are not referring to evidence, press them to back up their ideas with evidence. Encourage them to probe each other's thinking and reflect on each other's ideas under discussion, listening to their peers and being open to changing their mind.

SCIENCE LITERACY: READING COLLECTION 1

Light and Color

Literacy Objectives

- ✓ Summarize key points related to electromagnetic waves.
- ✓ Identify patterns related to waves, light, and color.
- ✓ Translate text to a visual/graphic representation summarizing the readings.

Literacy Activities

- Read varied text selections related to the topics explored in Lessons 1–2.
- Evaluate the reading selections according to provided prompts and criteria.
- Compare and contrast information gained from reading text with information gained from class investigation.
- Prepare a graphic organizer in response to the readings.

Instructional Resources

Student Reader
Collection 1

Science Literacy Student Reader, Collection 1
"Light and Color"

Exercise Page
EP 1

Science Literacy Exercise Page
EP 1

Prerequisite Investigations

Assign the Science Literacy reading and writing exercise *after* class completion of this lesson group:

- Lesson 1: How can something act like a window and a mirror at the same time?
- Lesson 2: What happens if we change the light?

Standards and Dimensions

NGSS

Disciplinary Core Ideas:
PS4.A: Wave Properties A simple wave has a repeating pattern with a specific wavelength, frequency, and amplitude;
PS4.B: Electromagnetic Radiation When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.

Science and Engineering Practice: Developing and Using Models

Crosscutting Concepts: Patterns; Systems and System Models

CCSS

English Language Arts
RST.6-8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

RST.6-8.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 6-8 texts and topics*.

RST.6-8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

RST.6-8.10: By the end of grade 8, read and comprehend science/technical texts in the grades 6-8 text complexity band independently and proficiently.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. However, these terms are not intended for isolated drill or memorization.

electromagnetic radiation

light

light source

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

absorb	**intensity**	**visible light**
amplitude	**photon**	**wave**
frequency	**reflect**	**wavelength**

A Glossary at the end of the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction.

1. Plan ahead.

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the assignment.
- Wednesday: Plan to touch base briefly with students in the middle of the week to answer questions about the reading, to clarify expectations about the writing exercise, and to help students stay on track.
- Friday: Set aside time at the end of the week to facilitate a discussion about the reading and the writing exercise.

You'll proceed with the next in-class lesson investigations during this week.

2. Preview the assignment and set expectations. (Monday)

- Let students know they will read independently and then complete a short writing assignment. The reading selection relates to topics they are presently exploring in their Light and Matter unit science investigations.
- The reading and writing will be completed outside of class (unless you have available class time to allocate).
- Preview the reading. Share a short summary of what students can expect.
    - *You will read a one-page introduction to the science of waves, what they are, and how they are compared.*
    - *Next, you'll interpret a diagram showing the full range of wavelengths in the electromagnetic spectrum, including how certain wavelengths affect humans.*
    - *Then you'll read a mock science podcast transcript. Who knew that light rays are good at explaining science?*
    - *Next up is a photo gallery of fascinating light sources and animals that sense light in different ways.*
    - *Finally, you will read a science article explaining why you see so many different colors around you.*
- Distribute Exercise Page 1. Preview the writing exercise. Share a brief summary of what students will be expected to deliver. Emphasize that Science Literacy exercises are brief. The focus is on thoughtful quality of a small product, not on the assignment being big and complex.
    - *For this assignment you will be expected to generate a graphic organizer that summarizes the big ideas in the readings about light and color.*

Exercise Page

EP 1

- Remind students of helpful strategies they can employ during independent reading. Offer the following advice:
    - *The reading should take approximately 30 minutes to complete.* (Encourage students to break reading into smaller sections over multiple short sittings if their attention wanders.)
    - *A good reading strategy is to scan through the collection first to see the titles, section headers, graphics, and images to see what the selections are going to be about before fully reading.*
    - *Next, "cold read" the selections without yet thinking about the writing assignment that will follow.*
    - *Then, carefully read the Exercise Page to understand the expectations for the writing part of the assignment.*
    - *Revisit the reading selections to complete the writing exercise.*
    - *Jot down any questions for the midweek progress check in class.* (Be sure students know, though, that they are not limited to that time to ask you for clarification or answers to questions.)

3. Touch base to provide clarification and address questions. (WEDNESDAY)

Touch base midweek with students to make sure they are on track while working independently. You may choose to administer a midweek minute-quiz to give students a concrete reason not to postpone completing the reading until the last minute. Ask questions such as these, and have students jot answers on a half sheet of paper:

Suggested prompts	Sample student responses
What kind of pattern can you see in a diagram of a wave?	*an up-and-down pattern* *a crest-trough-crest-trough pattern*
What is the electromagnetic spectrum?	*all the wavelengths of electromagnetic radiation* *all the kinds of waves that transfer energy from the sun through empty space*
What are some sources of light in nature other than the sun?	*other stars* *lightning* *lava* *wildfire* *fireflies*

Ask a few brief discussion questions related to the reading that will help students tie the text content to students' classroom investigations.

Suggested prompts	Sample student responses
The readings and your investigations refer to "models." What are some kinds of models that help people understand light?	*models you can build, like with the mirror-window and box model* *models you can draw, like a diagram showing where the light goes* *models that you just think about, such as how light can act like a wave or a particle*
How do the moon's surface and the mirror-window both interact with light?	*They can both reflect light.*
How are your diagrams of the mirror-window phenomenon like the painting of Isaac Newton in the reading titled "Color"?	*My drawing and the painting show that light goes from one place to another.* *They both show that light can sometimes pass through materials like glass.*

- Refer students to Exercise Page 1. Provide more specific guidance about expectations for students' deliverables due at the end of the week.
  - *The writing expectation for this assignment is to draw a graphic organizer to summarize each of the readings in Collection 1 and to highlight some scientific vocabulary.*
  - *That means you'll have to think about the big ideas in each reading.*
  - *Don't worry about understanding all of the terms in the readings. Focus on terms you want to learn or you think are helpful in understanding the big idea.*
  - *Consider lightly sketching your graphic organizer in pencil so that you can adjust the layout to make space for the sentences you'll write.*
  - *Don't forget to add color to make your organizer attractive!*
  - *The important criteria for your work are that you identify a light source, that you identify a big idea from each of the five readings, and that your organizer is attractive and easy to read.*
- Answer any questions students may have relative to the reading content or the exercise expectations.

Exercise Page

EP 1

4. Facilitate discussion.

(FRIDAY)

Facilitate class discussion about the reading collection and writing exercise. Students begin the reading activity by learning that understanding waves and their properties is fundamental to exploring the science of light and color.

Student Reader

Collection 1

Page 4 **Suggested prompts**	**Sample student responses**
What is the general purpose of the first selection, "Why Are We Talking about Waves?"	*Its purpose is to explain what light is and describe some of its properties.*
How does the diagram titled "Transverse Wave" help you understand the text that says, "Energy transmission involves a regular, repeating pattern"?	*I can see in the diagram that the line representing the wave moves up and down, repeating itself.*

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

The next reading in the collection include a visual-verbal presentation of the electromagnetic spectrum, focusing on how various wavelengths affect humans.

Pages 5–7 **Suggested prompts**	**Sample student responses**
What is the general purpose of the second selection, "Electromagnetic Radiation"?	*It uses a graphic to show all the kinds of electromagnetic radiation.* *It explains how different kinds of electromagnetic radiation affect people.*

How did you choose a big idea from this selection to include in your graphic organizer?	*I looked for a sentence that defined the title—"Electromagnetic Radiation."* *I used the subheading "The Electromagnetic Spectrum" and summarized the captions in the art.*
Which part of the electromagnetic spectrum are you investigating in class with the mirror-window box model?	*visible light*

The third reading is a somewhat fanciful conversation between a science podcaster and a ray of sunlight named "Ray."

Pages 8–9 **Suggested prompts**	**Sample student responses**
What is the general purpose of the third selection, "Science Interviews Podcast"?	*It is a written record of what was said on a podcast interview between an imaginary ray of light and the host.* *The purpose is to explain, in an entertaining way, the wave-particle theory of EM radiation.*
How does this selection help you build knowledge on top of what you learned in the first selection about how light moves?	*The first article explained that light can be thought of as transferring energy as a wave. This article explains that light can also be thought of as transferring energy as particles.*
What are particles of light called?	*They're called "photons." They are more like packets of energy.*
The imaginary podcast guest is named "Ray." How was thinking about light as rays or beams helpful when you tried to explain the mirror-window setup in class?	*Rays and beams can be thought of in models as forming straight lines, which are easy to draw in diagrams.* *The sun, lamps, or flashlights seem to send out straight rays or beams of light. That's what we see, even if the light is really a wave.*

The final two readings of the collection connect the Earth and life sciences to physical science, discussing light sources in nature, animal light-detecting structures, and color perception.

Pages 10–13 **Suggested prompts**	**Sample student responses**
What is the general purpose of the fourth selection, "Light and Sight in Nature"?	*It identifies light sources in nature and gives examples of how some animals sense light—specifically thresher sharks, flies, scallops, peregrine falcons, and coral animals.*
How does the intensity of the light produced in nature vary?	*Some light sources are brighter than others. Lightning and the sun are very bright (or intense). Fireflies and glowing lava are less bright (or intense).*

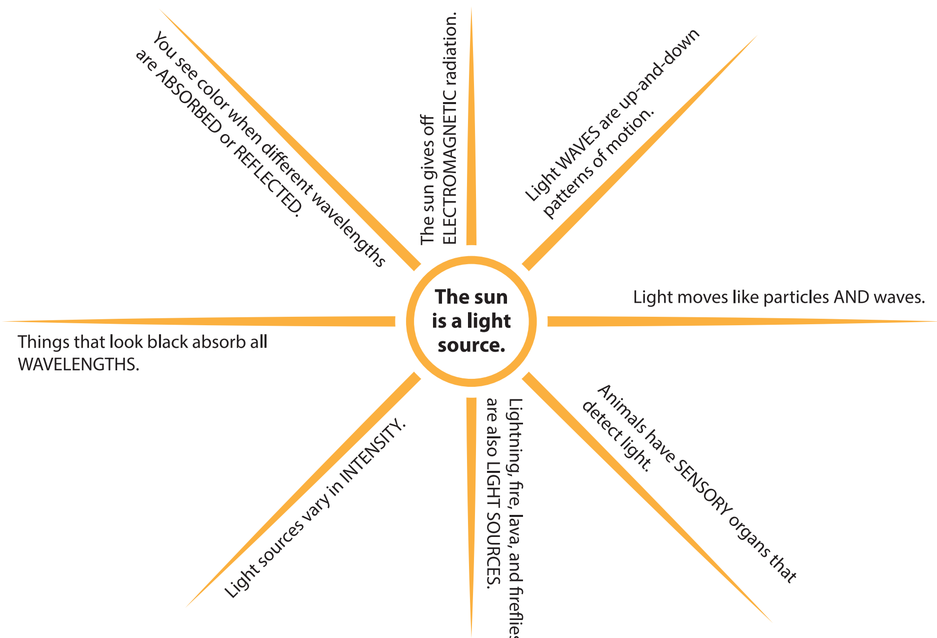
SUPPORT—Show students a video that uses water waves as a model for light waves. Explain that water waves also exhibit the properties of wavelength, amplitude, and frequency. Stop and start the video, and connect the information there to the definitions of these properties under Words to Know.

Is sunlight that reaches Earth more intense at sunrise or at midday?	*at midday*
What is the general purpose of the fifth selection, "Color"?	*It explains where the colors of light come from and what causes objects to appear different colors.*
What property of light is related to color?	*wavelength*
How could you draw a diagram (model) to show why a mantis insect looks green?	*I could draw a ray of white light hitting the mantis and then rays of green light reflecting to my eyes and then add labels to show that the other colors of light are absorbed.*

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 1, students should draw an appropriate light source and write five to eight big ideas that come from all five readings. The big ideas should incorporate some of the scientific vocabulary used in the readings. The layout of the organizer should show care in getting the visual elements to support the written ideas. A sample response is shown below. Consider having students who score a 1 work with a peer tutor to revise their organizers.



Use the rubric provided on the Exercise Page to supply feedback to each student.

EXTEND—Have students work in pairs to draw the diagrams they described in the discussion. Refer them to the diagrams of the box model they made in class, and have them think about how showing colors of light will be similar and different. Look for evidence that students recognize that there should be a light source and that the green light reflects off of the insect and into their eyes while the other wavelengths of visible light are absorbed by the mantis.

CHALLENGE—It is likely that you have one or more students with color vision deficiency, a condition affecting 8% of human males and 0.5% of females. Challenge interested students to find out what structures in the human body are responsible for perceiving color and how types of color deficiency vary. Encourage students to share the results of their research with the class by giving a brief science talk.

What happens when light shines on the one-way mirror?

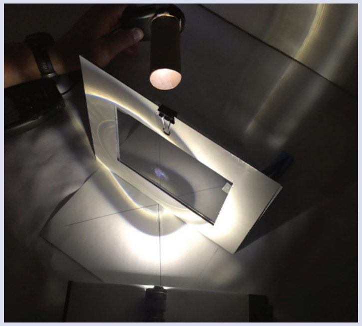
Previous Lesson

We moved the flashlight to Room B, made both rooms light, and made both rooms dark. We agreed that the phenomenon is strongest when there is a large difference in light between the rooms and that the arrows in our models should represent the path of light rather than our line of sight. We shared related phenomena from our lives.

This Lesson

Investigation

3 DAYS



We know that the one-way mirror acts like a mirror in a brightly lit room and acts like a window in a dark room. To figure out why, we compare what happens when light shines on the one-way mirror, a pane of glass, and a regular mirror. We record initial observations and use a light meter to measure the amount of light transmitted through and reflected off each material. We develop a testable question and plan an investigation. We document our observations and analyze data to figure out what happens when light shines on the one-way mirror.

Next Lesson

We will investigate how similar amounts of light are transmitted through and reflected off the one-way mirror due to how it's made. We will read about how one-way mirrors are made compared to regular mirrors. We will find out that one-way mirrors have a thin layer of silver embedded in a plastic film. We will modify a model to explain that light transmits through the transparent structures of the one-way mirror and reflects off the silver structures.

Building Toward NGSS

MS-PS4-2, MS-LS1-8

What Students Will Do

3.A Ask a testable question to determine how an object's material (structure; independent variable) influences the amount of light transmitted and reflected (function; dependent variable).

3.B Use evidence to modify a model to explain how an object's material (structure) influences the path of light as it transmits through or reflects off the material (function).

What Students Will Figure Out

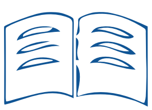
- Light travels in straight lines. (reinforcing 4th grade)
- When light shines on an object, it is reflected (bounces off), transmitted (passes through), or some combination of these, depending on the object's material.

Lesson 3 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	10 min	**NAVIGATION AND OBSERVATIONS IN THE BOX MODEL** Make observations from the box models with glass, a regular mirror, and a one-way mirror and briefly share some observations with the whole class.	A-B	Observations of Materials in the Box Model Investigation
2	10 min	**OBSERVE AND COMPARE HOW LIGHT INTERACTS WITH THE MATERIALS** Work in groups to shine light on the one-way mirror, glass, and regular mirror and observe and compare what happens to the light.	C-D	chart paper, markers, Light Interactions Investigation
3	13 min	**FACILITATE A BUILDING UNDERSTANDINGS DISCUSSION** Facilitate a Building Understandings Discussion to share observations and create models of what we observed.	E-G	chart paper, markers
4	10 min	**DEVELOP AN EXPERIMENTAL QUESTION** Work in partners using Part A of the *Asking Questions Tool - Experimental Questions* to develop an experimental question to determine the amount of light reflected and transmitted by the one-way mirror, glass, and regular mirror.	H	*Asking Questions Tool - Experimental Questions*, *Asking Questions Tool - Experimental Questions Key*
5	2 min	**NAVIGATION** Preview next steps to complete the experiment measuring light.		*Asking Questions Tool - Experimental Questions*, tape
				End of day 1
6	5 min	**NAVIGATION** Add the science terms "transmit" and "reflect" to the Word Wall.	I	6-×-8 sticky notes, markers, tape
7	12 min	**REFINE OUR EXPERIMENTAL QUESTION** Work as a class using Part A of the *Asking Questions Tool - Experimental Questions* to further develop an experimental question to be used to determine the amount of light reflected and transmitted by the one-way mirror, glass, and regular mirror.	J-L	*Asking Questions Tool - Experimental Questions*, chart paper, markers
8	25 min	**PLAN AND CONDUCT THE MEASURING LIGHT INVESTIGATION** Use the experimental question to plan and conduct the *Measuring Light Investigation*. Use light meters to measure the amount of light reflected and transmitted by the one-way mirror, glass, and a regular mirror.	M-R	*Measuring Light Investigation Procedures*, chart paper, markers, *Measuring Light Investigation Guidance*, Measuring Light Investigation

Part	Duration	Summary	Slide	Materials
9	3 min	**NAVIGATION** Summarize what we have accomplished today and share next steps.		*Measuring Light Investigation Procedures*, tape
				End of day 2
10	2 min	**NAVIGATION** Remind students where we are in terms of completing the *Measuring Light Investigation* and share next steps.	S	*Measuring Light Investigation Procedures*
11	8 min	**ANALYZE DATA FROM THE MEASURING LIGHT INVESTIGATION** Work in groups to analyze class data from the *Measuring Light Investigation*, looking for patterns in the data.	T-V	*Measuring Light Investigation Procedures*
12	20 min	**CONDUCT A CONSENSUS DISCUSSION** Meet in a Scientists Circle and conduct a Consensus Discussion. Share analysis of the data from the *Measuring Light Investigation*, discuss patterns, and make sense of what those patterns indicate about why we sometimes see different things when looking at the same object. Update the class consensus model and the Science Ideas Chart.	W	chart paper, markers, sticky notes, tape, Science Ideas chart
13	10 min	**UPDATE PROGRESS TRACKER** Synthesize what we have figured out and add it to our Progress Tracker.	X	
14	5 min	**NAVIGATION** Revisit the Driving Question Board as a class to find and discuss questions about the properties of the one-way mirror, glass, and regular mirror.	Y-Z	Driving Question Board
				End of day 3
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 3, students are ready to read Student Reader Collection 2 and then respond to the writing exercise.		Student Reader Collection 2: *Reflection and Absorption*

Lesson 3 • Materials List

	per student	per group	per class
Observations of Materials in the Box Model Investigation materials			• 3 or 6 box model setups • 1-2 picture mat sets with 8″ x 8″ glass • 1-2 picture mat sets with 8″ x 8″ mirror • 1-2 picture mat sets with one-way mirror film
Light Interactions Investigation materials		• 1 picture mat set with one-way mirror film • 2 binder clips • 1 - 8-×-8 mirror (with edges taped) • 1 - 8-×-8 piece of glass (with edges taped) • 1 flashlight • *Template for the Measuring Light Investigation*	
Measuring Light Investigation materials		• 1 picture mat set with one-way mirror film • 2 binder clips • 1 - 8-×-8 mirror (with edges taped) • 1 - 8-×-8 piece of glass (with edges taped) • 1 flashlight • 1 *Template for the Measuring Light Investigation* • 1 cardboard tube • clear tape • wooden block or stack of books	
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• science notebook • *Asking Questions Tool - Experimental Questions* • tape • *Measuring Light Investigation Procedures*		• chart paper • markers • *Asking Questions Tool - Experimental Questions Key* • 6-×-8 sticky notes • tape • *Measuring Light Investigation Guidance* • sticky notes • Science Ideas chart • Driving Question Board

Materials preparation (25 minutes)

Online Resources

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Be sure you have the materials (e.g., markers, sticky notes) ready to add the following words to the Word Wall: Transmit, Reflect. Do not post these words until after your class has developed a shared understanding of their meaning.

Day 1: ***Observations of Materials in the Box Model Investigation***

Group size: Set up at least 3 and up to 6 box models, depending on class size. Students will not work in groups, but rather will walk around individually to different models to make observations.

Setup:

- Arrange 3 to 6 box models around the classroom.
- Place an 8-×-8 (or 8-×-10) piece of glass in between 1 picture mat set and seal with 2 binder clips. Insert this inside 1 box model in place of the one-way mirror. Repeat with an 8-×-8 (or 8-×-10) mirror in a second box model. In the third, use an 8-×-10 one-way mirror film as done in Lessons 1 and 2.
- If needed, set up 2 box models for each material (glass, mirror, one-way mirror) to facilitate observations by larger classes.

Notes for during the lab:

- Darken the room as much as possible to recreate the classroom conditions in Lessons 1 and 2 when students made observations from the box models.
- Students do not need their science notebook or a pencil and should be encouraged to talk about their observations with peers as they make them.
- You may need to remove the inserted materials from the box models to complete the next lab investigation. Make sure to reinsert them before your next section of science students enters the classroom.

Day 1: ***Light Interactions Investigation***

Group size: Group size will vary depending on class size and the number of light meters available. Below is guidance for 6 groups.

Setup:

- Cut sheets of one-way mirror film to approximately 8-×-8 in size (up to 8-×-10). Leave the clear backing on the one-way mirror film to keep the material stable.
- Place painter's tape (or equivalent) around the edges of each piece of glass and mirror. Although the edges should be smooth, it is possible that students could be cut when handling these materials. Taping the edges ensures students can safely handle them. **PLEASE NOTE:** You can use plexiglass instead of glass. However, taping the edges is suggested because plexiglass can cut as easily as glass.
- Prepare a bin for each group containing: 1 picture mat set, 2 binder clips, 1 - 8-×-10 piece of one-way mirror film, 1 - 8-×-8 mirror (with edges taped), 1 - 8-×-8 piece of glass (with edges taped), 1 flashlight, 1 *Template for the Measuring Light Investigation*.

Notes for during the lab:

- Darken the room as much as possible by closing any shades and turning off floor lamps. Some light from windows is OK. You can leave the classroom lights on until it is time to conduct the lab.
- Since the one-way mirror is not rigid, students should leave it in the picture mat with the binder clips to keep the material rigid. For the mirror and glass, students will not need the picture mat.
- Monitor groups to make certain they are recording observations using pictures and words in their science notebook.

Safety:

- Make sure tape has been placed on all edges of the glass (or plexiglass) and mirrors. Remind students to be careful when handling glass and mirrors and of the safety procedures to follow if one breaks.
- Remind students not to shine flashlights directly into each other's eyes.

Storage:

- All materials should be left in the bins for the *Measuring Light Investigation* on day 2.

Day 2*: Measuring Light Investigation*

Group size: Group sizes will vary depending on class size and the number of light meters available.

Setup:

- Check that the batteries in the light meters are charged and installed correctly.
- Prepare a bin for each group containing: 1 picture mat set, 2 binder clips, 1 - 8-×-10 piece of one-way mirror film, 1 - 8-×-8 mirror (with edges taped), 1 - 8-×-8 piece of glass (with edges taped), 1 flashlight, 1 *Template for the Measuring Light Investigation*, 1 light meter, 1 cardboard tube, clear tape, and a wooden block or stack of books on which to place the flashlight (it should elevate the flashlight about 3-4 inches above the table top). You can prepare the light meters in advance by taping the cardboard tube to the light sensor. **PLEASE NOTE:** As before, you can use plexiglass instead of glass, but the edges should be taped.
- Make a duplicate set of **slide U** and **slide V** for each class that will participate in this investigation. This will give each class a set of slides for documenting group data, which will be used for analysis and discussion.

Notes for during the lab:

- Use *Measuring Light Investigation Guidance* as guidance during the lab.
- Prior to darkening the room, students need to tape the cardboard tube to the light meter so the tube surrounds the sensor (if you have not previously done this). They also need to place the flashlight on top of a wooden block or a set of books so it is elevated about 3-4 inches above the table top. This will ensure the light is not blocked by the picture mat holding the one-way mirror material.
- Darken the room as much as possible by closing any shades and turning off floor lamps. Some light from windows is OK. You can leave the classroom lights on until it is time to collect data.
- Since the one-way mirror is not rigid, students should leave it in the picture mat to keep it stable. For the regular mirror and glass, students will not need the picture mat.
- Monitor groups to make certain they are recording measurements at the appropriate angles designated by the lab procedures.

Safety:

- Check all edges of the 8-×-8 pieces of glass (or plexiglass) and the 8-×-8 pieces of regular mirror to ensure the tape is in place and has not peeled away. Replace any peeling tape with a fresh strip.
- Remind students not to shine flashlights directly into each other's eyes.

Storage:

- All materials can be safely stored in a materials cabinet or closet.
- Remove cardboard tubes and batteries from light meters for long-term storage. Remove batteries from flashlights for storage.

Lesson 3 • Where We Are Going and NOT Going

Where We Are Going

In this lesson, students investigate their questions about the one-way mirror material in comparison to glass and a regular mirror. The data from the investigation will suggest that all three materials are reflective to varying degrees. Students who predict that the glass will transmit all light may be surprised when they find out it also reflects light. This provides an opportunity to remind students of what they have learned in previous grades: to see any object, light must reflect off the object and into our eyes. This also leads to a few important understandings that students must develop:

- First, they must learn the distinction between what light is doing when it bounces off objects (reflects) and the image we see on smooth, shiny surfaces, such as mirrors (a reflection). The verb "reflect" refers to what happens to light when it interacts with an object, while the noun "reflection" refers to an image on a mirror or shiny surface that is in our line of sight. See *Guidance for Developing your Word Wall*.
- Second, each material will reflect and two will transmit light; however, the amount reflected and transmitted will vary. The one-way mirror will reflect about half the light and transmit the other half. It will not reflect as well as a mirror, which reflects almost 100% of the light, nor will it transmit as well as the glass, which transmits most light. As students come to understand (or earn) these science words (*reflect* and *transmit*), add them to the Word Wall on day 2.

Students may be curious about these (and other) materials and what characteristic of the material's structure makes it more or less reflective. As part of the middle school NGSS, students learn to explain how light does more than one thing when it interacts with objects (transmits, reflects, absorbs), and they can quantify (to some degree) the amounts of light doing each thing. In this lesson, students learn to use light meters to gather quantitative data during an investigation and analyze that data to notice differences in the amount of light reflected by and transmitted through each material. They discuss how to represent different quantities of light in their models. This will lead students to wonder about the structure (properties) of materials that cause different amounts of light to transmit and reflect. Prior to middle school, students have not learned about the properties of materials that allow them to reflect and transmit light in different ways, only that light reflecting off objects into the eye allows us to see. In Lesson 4, students will gain a deeper understanding of how an object's material structure causes this to work.

Where We Are NOT Going

Results showing how light transmits through the clear glass will mostly make sense to students. However, the small amount of light reflecting off the glass may surprise some. This, along with data on the transmission and reflection of light when testing the one-way mirror material, will create a need to further investigate the structure of each material, which is the focus of Lesson 4.

Some of the light that is not detected by the light meter will either be scattered by the surface of the material (in a direction where it is not detected by the light meter) or absorbed. Students will learn about the scattering of light in an extension opportunity offered later in the unit. They will learn about the absorption of light in *Unit 6.2: How can containers keep stuff from warming up or cooling down? (Cup Design Unit)*.

LEARNING PLAN FOR LESSON 3

1. Navigation and Observations of the Box Model

10 MIN

Materials: *Observations of Materials in the Box Model Investigation*

Make observations from box models with three different materials inside. Display **slide A**. Remind students that in the previous class we were curious about how changing the material would change the phenomenon. Ask groups to quickly and quietly circulate to each box model to make observations of the material inside each of them. Remind them to make sure the light is turned on in Room A, and then to make observations from both sides. Encourage students to share their observations with each other as they make them, but it is not necessary to record observations in their science notebook.

Share observations. After 5 minutes, have students return to their seat. Display **slide B**. Use the prompts on the slide to elicit students' observations of the different materials inside the box models.

Suggested prompts	Sample student responses	Follow-up questions
What did we notice was similar or different between the glass, regular mirror, and one-way mirror inside the box models?	*For the one with the regular mirror, we could see the reflection from Room A but we couldn't see through it from Room B.* *For the one with the glass, we could see some reflection from Room A but it wasn't as much as the one-way mirror. We could see through it from Room B.*	*What do we think it is about the material that changes what we see?*
What do we think could cause these similarities or differences?	*The regular mirror blocks Room A so you can't see through it into Room B.* *The glass is completely clear so it's easier to see through it.*	*How do you think the path of light could be affected in each case?*

Say, *It seems we can agree that the materials do different things when we put them in the same light conditions with light on only one side. How could closer examination of the materials and shining light directly on them give us clues about what is happening?*

Listen for students to make these suggestions:

- Maybe we can see what is blocking the light.
- Maybe we can see what is causing the reflection.
- Maybe we can see if the one-way mirror is more like glass or more like a mirror.

2. Observe and compare how light interacts with the materials. 10 MIN

Materials: Light Interactions Investigation, science notebook, chart paper, markers

Brainstorm what to watch for when shining light on the materials. Say, *As we conduct this next investigation, what are some things we need to pay attention to as we shine light on each of the materials—the one-way mirror, glass, and a regular mirror—to figure out why the one-way mirror behaves like a mirror and a window?*

Listen for students to make these suggestions:

- Look closely at what is happening at the surface of the one-way mirror as light reaches it.
- Look closely at what is happening at the surface of the glass and the regular mirror as light reaches each of them.
- Observe what light does beyond the materials. For example, does it shine through or does it shine in a different direction?

- Look for similarities and differences in how light interacts with each of the materials.
- Pay attention to how we represent the path of the light in our models.

Set up science notebook and preview the investigation instructions. Show **slide C**. Have students set up their notebook with the investigation question and observation table.

Show **slide D**. Preview the instructions with students. Remind them to

- look closely at what is happening at the surface of each material as light shines on it;
- observe what light does beyond each of the materials (goes through, goes in a different direction); and
- look for similarities and differences in how light interacts with each of the materials.

Remind students to document their observations in pictures and words as they conduct the investigation and to use arrows according to what the class agreed upon in Lesson 2.

Conduct the *Light Interactions Investigation*. Arrange students in groups and provide students with lab materials for the investigation. Give them about 8 minutes to conduct the investigation and document their observations in their science notebook. As you walk around the classroom, listen for students trying to compare the amounts of light transmitting or reflecting, and ask groups to think about how they might better observe these differences.

3. Facilitate a Building Understandings Discussion.

13 MIN

Materials: science notebook, chart paper, markers

Review norms and sentence starters. As you prepare to lead this discussion, refer to the norms discussed in Lesson 1 and give students a few moments to review them. Tell students, *These norms should guide us as we share what we think is happening as light interacts with each of the three materials. Remember, our norms will help us to work together so we can build our understanding as individual learners and as a community of learners.**

Discuss observations from the *Light Interactions Investigation*. Show **slide E**. Remind students to focus on describing what happened as light shined on the surface of each material. As they share, encourage them to use evidence from the investigation to support their observations and comparisons between the one-way mirror, glass, and regular mirror. Encourage them to show how they modeled what happens as light hits and moves beyond the three materials.

Key Ideas

Use this Building Understandings Discussion to accomplish three things:

1. Share observations from the investigation that will serve as evidence for the class to work with.
2. Summarize what the class can conclude from the evidence.
3. Develop diagrammatic models to represent the initial conclusions for how light interacts with each of the three materials.

***Strategies for this Building Understandings Discussion**

The goals of a Building Understandings discussion include

- sharing claims and reasoning based on evidence;
- connecting, critiquing, and building on one another's findings, claims, evidence, and explanations; and
- arriving at tentative conclusions.

If students need support in sharing their ideas, remind them to use their Communicating in Scientific Ways sentence frames.

Purpose of this discussion: Use evidence from the *Light Interactions Investigation* to compare how light interacts with the one-way mirror, glass, and regular mirror and to motivate the need to use a tool to measure the amount of light transmitted through and reflected off each material.

Listen for these ideas:

- All three materials reflect light and two transmit light.
- We can make comparisons, but these are subjective and not accurate.
- Using a tool to measure the amount of light transmitted through and reflected off each material would give us data to make an accurate comparison of the materials.

Suggested prompts	Sample student responses	Follow-up questions
What did you observe when light interacted with each material?	*The one-way mirror allowed some light to go through and some light bounces off.* *Some light went through the glass and some bounced off. It seemed to let more light through it than the one-way mirror, but it is hard to be sure.* *When light shined on the regular mirror, no light went through. All of it bounced off.*	*What did you do to try to determine if one material allowed more or less light to transmit through (or reflect off) than another material?*
What similarities and differences did you notice as you observed the materials interacting with light?	*We noticed the one-way mirror material is thinner and flexible, while the glass and regular mirror are thicker and do not bend.* *Almost all of the light went through the glass, some went through the one-way mirror, and no light went through the mirror.*	*Do you think the thickness or flexibility plays a role in why the one-way mirror acts like a mirror and a window?*
	Light bounced off all three materials. It looked like all the light bounced off the regular mirror, some bounced off the one-way mirror and the glass.	*Do you think measuring the amount of light that either transmitted through or reflected off each material would help us figure out why the one-way mirror behaves like it does?*

Draw initial conclusions from the evidence. Show **slide F**. Have students discuss the first question. As they discuss, ask them to look for similarities among their observations. Look for the following patterns to surface across the observations:

Use the following prompts to help students to dig deeper into their own thinking and the thinking of others:

- *What's your evidence?*
- *Did it work that way for all three materials?*
- *Can you say more or give an example?*
- *Do you agree/disagree? Why?*
- *What can we conclude?*
- *What else do we need to find out?*

*Supporting Students in Three-Dimensional Learning

When students develop models of observed phenomena, they need to represent the relevant structures and interactions, sometimes at a scale that may not be visible to the human eye. Provide support for students to consider how the material's structure impacts how it functions when interacting with light. At this moment in time their models may have inaccuracies or incomplete ideas about structural components. This is OK. Students will refine their models in Lesson 4 as they learn more about microscale structures. Students can find support in refining and representing their ideas while discussing and working with partners or in small groups.

- Glass: A lot of light goes through, some bounces off.
- One-way mirror: Some light goes through, some bounces off.
- Regular mirror: No light goes through, all bounces off.

Model the interactions. Transition to the second question on **slide F**. On chart paper, represent how light interacts with each material by developing a model.* These models should reinforce the following ideas:

- Light travels in straight lines.
- When light shines on an object, it can pass through, bounce off, or do a combination of both.
- Arrows should show the direction light travels (path of light, POL) from the source and then when it bounces off or goes through a material.*

Assessment Opportunity

Building towards: 3.B Use evidence to modify a model to explain how an object's material (structure) influences the path of light as it transmits through or reflects off the material (function).

What to look/listen for:

As students discuss their observations in small groups and as a class, listen for the following:

- All three materials reflect light and two transmit light.
- The one-way mirror reflects more light than the glass but less than the regular mirror; the one-way mirror transmits more light than the regular mirror but less than the glass.
- Using a tool to measure the amount of light transmitted through and reflected off each material would give us data that would make our comparisons more accurate and help us better represent what we observe in a consensus model.

As students revise the class consensus model, the following ideas should be represented for each material:

- Light travels in straight lines.
- When light shines on an object, it can pass through, bounce off, or do a combination of both.
- Arrows should show the direction light travels (path of light, POL) from the source and then when it bounces off or goes through a material.

What to do: The *Light Interactions Investigation* is the students' first opportunity to observe and compare how light interacts with the one-way mirror, glass, and a regular mirror. The small-group and class discussions give them opportunities to try to make sense of the one-way mirror phenomenon using qualitative data. If they struggle to make comparisons, guide them as follows:

- Focus on students' observations of the amount of light transmitted through each material, one at a time, and document them on chart paper.

- Move to observations of the amount of light reflected off each material, one at a time, and document them on chart paper.
- Compare the amount of light transmitted by the one-way mirror with the other two materials. This should help students see that the one-way mirror's data falls somewhere between the other two.
- Then compare the amount of light reflected by the one-way mirror with the other two materials. Again, students should be able to determine that the one-way mirror falls somewhere between the other two.
- After making these comparisons, students should notice that they can only compare the three materials using words like "more" and "less" but cannot be much more accurate than this.

While revising the consensus model, if students struggle to represent what they observed, guide them to build the model using a systematic process such as this:

- Focus on one material at a time.
- Draw the material in a zoomed-in bubble.
- Represent light (using a straight arrow) coming into contact with the material.
- Represent what light does after it hits the material using arrows, as appropriate.
- Repeat the process with each material.

Summarize observations and determine next steps. Show **slide G**. Say, *We know light bounces off all three materials, because we saw the light shine on each material and reflect back at us. We also know light goes through glass and the one-way mirror, because we saw the light shine on each material, then go through and shine on the wall behind it. What we don't know is how much light transmitted through or reflected off each material. How might measuring the amount of light that transmits and reflects be important for explaining the one-way mirror phenomenon? How could we determine how much light transmits and reflects?*

Give students a minute to turn and talk with a partner, before discussing a few students' ideas as a class.

Suggested prompts	Sample student responses
How might measuring the amount of light that goes through and bounces off the one-way mirror be important for explaining the one-way mirror phenomenon?	*We do know the amount of light in a room affects how the one-way mirror behaves. In a lit room, it acts like a mirror, and in a dark room, it acts like a window.* *If we know the amount of light that goes through and bounces off the one-way mirror, the glass, and the regular mirror, we can make even better comparisons between the three materials, which might help us figure out what is happening when the light hits the one-way mirror.*
How could we determine how much light goes through and how much bounces off?	*The amount of light seems to be an important part in the system. If we want to understand why the one-way mirror acts differently in different amounts of light, we need a way to measure how much light is going through and how much is bouncing off each material.*

Say, *Since we think it is probably a good idea to determine how much light goes through and bounces off each material, we need to figure out how we can investigate that.*

4. Develop an experimental question.

10 MIN

Materials: *Asking Questions Tool - Experimental Questions, Asking Questions Tool - Experimental Questions Key*

Use the handout to develop experimental questions. Distribute the *Asking Questions Tool - Experimental Questions* handout to each student. Say, *Scientists develop questions that they can test by collecting evidence about a phenomenon or problem. To do this, they need to know what to observe or measure that would answer their questions*. Explain how the Asking Questions Tool will help the students develop an experimental, testable question they can use to guide their next investigation.

Show **slide H**. On the handout, for Part A's question 1, have students write down the original question they used to investigate the materials with the flashlight. Preview the rest of the tool with students. Give students 8 minutes to work with a partner to revise the original question by following the steps in Part A of the handout.*

As students work, walk around and listen to their conversations. If necessary, use questions to guide their thinking. Possible responses to the questions on the handout are provided in *Asking Questions Tool - Experimental Questions Key*.

Additional Guidance

Part A of the *Asking Questions Tool - Experimental Questions* handout guides students in writing experimental questions. Part B gives teachers and students an opportunity to provide feedback on the experimental questions developed. In this lesson, only Part A is completed due to time constraints. However, if you would like to use Part B, feel free to do so. Keep in mind that this may add 15-20 minutes to the lesson.

Assessment Opportunity

Building towards: 3.A Ask a testable question to determine how an object's material (structure; independent variable) influences the amount of light transmitted and reflected (function; dependent variable).

What to look/listen for:

As students work in pairs to construct testable questions, listen and look for

- accurate identification of the dependent variable (amount of light reflected and amount of light transmitted) and the independent variable (one-way mirror, glass, and regular mirror), and
- an understanding of the cause-and-effect relationship between the dependent and independent variables.

What to do: Listen for the independent and dependent variables and the cause-and-effect relationship students identify as they construct their testable questions. Use that information to anticipate how you will guide day 2's whole-class discussion and to consider the kinds of questions you might need to ask.

***Supporting Students in Engaging in Asking Questions and Defining Problems**
Students are bringing foundational ideas about testable and untestable questions from previous grade levels. In this lesson you will deepen their understanding of one type of testable question: experimental ones. Students will ask an experimental question to determine the relationship between the material (independent variable) and light transmitting and reflecting (dependent variable). The evidence they collect will help them better model the interaction between light and the one-way mirror.

5. Navigation

2 MIN

Materials: science notebook, *Asking Questions Tool - Experimental Questions*, tape

Motivate next steps. Say, *We have developed testable questions, and during our next class period, we will share our questions and come to agreement about a testable question that will guide our next investigation.*

Direct students to tape their handout into their notebook.

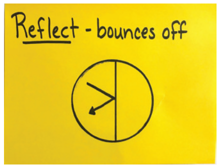
End of day 1

6. Navigation

5 MIN

Materials: 6-×-8 sticky notes, markers, tape

Add the new words we earn to the Word Wall. Tell students, *Over the last few class periods, we have described light interactions with a one-way mirror, glass, and a regular mirror using phrases such as "light bounces off" and "light passes through." We know that light bounces off a regular mirror, because we saw the light shine on the mirror and bounce back at us. We also know that light passes through glass, because we saw the light shine on the glass and go through it to the wall behind it. Because we can describe these two behaviors, we can use science words that mean the same thing.*



Show **slide I**. Share that the first word is *reflect,* which describes what happens when light bounces off an object. Share the second work is *transmit,* which describes what happens when light passes through an object.

As you share and define the two science vocabulary, write each word on a 6-×-8 sticky note, along with its definition and a simple diagram. Place the sticky notes on the Word Wall in the classroom. Remind students to practice using these two words in the next investigation when they observe light bounce off or go through an object or material.

Additional Guidance

Sometimes a word that means one thing in students' everyday talk is used differently in the science classroom. Making sense of everyday and scientific talk is an important part of developing scientific literacy.

When we say light is reflected by an object, we are referring to what light is doing—it is bouncing off the object. Students may be familiar with the word "reflection" in reference to what we see in a mirror; however, they may not be familiar with using the word to describe a light ray bouncing off a surface, an invisible process that results in the image they see.

If students are using "reflection" in both ways, do not discourage them, but make the distinction visible to them. If a student uses the word ambiguously, use questions to probe and clarify their intention.

7. Refine your experimental question.

12 MIN

Materials: science notebook, *Asking Questions Tool - Experimental Questions*, chart paper, markers

Revisit observations and next steps for investigation. Show **slide J**. Say, *Think about the* Light Interactions Investigation *we conducted during our last class period. Can someone remind us what we figured out when we shined light on the one-way mirror, glass, and the regular mirror, and what we decided our next steps would be?*

Select a few students to share, and encourage them to use evidence from the investigation.

Suggested prompts	Sample student responses
What did we figure out when we shined light on the one-way mirror, glass, and regular mirror?	*Light transmits through the one-way mirror and the glass. Light reflects off the one-way mirror, the glass, and the regular mirror.*
What did we decide we needed to do next?	*Since we could not determine the amount of light that transmits through and/or reflects off each material, we decided that we need to use a tool to measure how much light each material allows to transmit and/or reflect.*

Introduce the light meter. Show **slide K**. Introduce the light meter as a tool that can help the students measure the amount of light transmitted or reflected off an object. Say, *Given that we can use this tool to measure light, let's rethink our experimental question and what we want to measure.*

Revisit the handout to refine our experimental question. Ask students to open their science notebook to the *Asking Questions Tool -Experimental Questions*. Explain that the class will now share their ideas for experimental, testable questions to come to an agreement on one to pursue together.

Discuss initial ideas for questions and come to consensus about the question to investigate next. Show **slide L**. Guide students as they share their ideas using the questions on the slide. Jot down their responses on chart paper, focusing the conversation on how they adjusted the original question into a testable question using independent and dependent variables.*

When students share their responses to questions 2 and 3, point out that the materials we are testing are the independent variable and the amount of light each material reflects and the amount each transmits are the dependent variable, because the amount depends upon the material we test. The goal of this conversation is to select a testable question that can be used to guide the next investigation.

Additional Guidance

The way that "independent variable" and "dependent variable" are introduced to students at this moment qualifies them as words we encounter. We recommend not adding these terms to the Word Wall right now. Over time, as your students practice using them in setting up additional experiments, they will become words we earn and should be added to the Word Wall. The right time to add them to the Word Wall will depend on when it makes sense for your class once the students have done the work to develop their understanding of the terms.

***Supporting Students in Engaging in Asking Questions and Defining Problems**

When working with students to collaboratively develop or refine an experimental question, keep in mind that this is not about voting for the question that students think is the best choice. It is about using student-generated ideas for experimental questions and student input to co-develop a question together, which will most likely reflect a number of ideas and allow the class to plan and carry out an investigation that will yield data to answer the question.

Suggested prompts	Sample student responses
What is the original question we wanted to investigate?	*How much light is reflected off and transmitted through each material?*
What will cause an effect?	*Each of the materials—the one-way mirror, the glass, and the regular mirror—will cause different amounts of light to reflect and transmit (effect).*
What will we measure to see if the change we made has had an effect?	*We will measure the amount of light that is reflected and the amount of light that is transmitted by each material.*
What experimental question did you and your partner develop?	*(Answers will vary.)*

Assessment Opportunity

Building towards: 3.A Ask a testable question to determine how an object's material (structure; independent variable) influences the amount of light transmitted and reflected (function; dependent variable).

What to look/listen for:

As students share their testable questions and select one to use in the second investigation, listen for

- accurate identification of the dependent variable and independent variable, and
- an understanding of the cause-and-effect relationship between the dependent and independent variables.

What to do:

If students have difficulty identifying independent and dependent variables for this investigation, write the question frame "How does __________ affect __________?" on a whiteboard or chart paper. Write "one-way mirror," "glass," "regular mirror," "amount of light transmitted," and "amount of light reflected" on large sticky notes and let students place a sticky note in each blank. Read and discuss the resulting question to determine if the cause-and-effect relationship is correct. Continue to use this process until students correctly identify which sticky notes have independent variables and which have dependent variables.

8. Plan and conduct the Measuring Light Investigation.

25 MIN

Materials: Measuring Light Investigation, science notebook, *Measuring Light Investigation Procedures*, chart paper, markers, *Measuring Light Investigation Guidance*

Use the experimental question to plan the investigation. Once the class agrees on an experimental question, we are ready to collaboratively plan the investigation. Write the question on chart paper and say, *Our question has a few important components that we need to think about in order to plan the investigation.*

***Supporting Students in Engaging in Planning and Carrying Out Investigations**
The goal in this moment is to give students experience in collaboratively planning

Additional Guidance

On **slide M**, you will find the experimental question, **"How does the material (one-way mirror, glass, or regular mirror) affect how much light is reflected and how much is transmitted?"** This question is placed on this slide and in the Teacher Guide as a sample. This does not mean that you should use this exact question. When you and your students select your own experimental question, edit the question (in red font) on the slide and make sure the facilitation of this section reflects the question that you developed together.

Show **slide M** and use the questions to guide students in planning the investigation.*

Suggested prompts	Sample student responses
What materials are we testing?	*We are testing 3 materials: a one-way mirror, glass, and a regular mirror.*
What data will we collect?	*We will measure the amount of light that each material reflects and the amount each transmits.*
What must not change as we are conducting tests?	*However we test the one-way mirror material, we have to test the glass and regular mirror in the same way.* *We should shine the same amount of light on each material.* *We should also make sure the flashlight is the same distance from each material.* *That should probably also apply to the light meter that we will be using to collect our data—it should be held at the same distance from the material.*

As students share responses, document their ideas on chart paper to record the basic setup for the investigation. Use markers of different colors to specify independent and dependent variables, what will be held constant, and the data we will collect. Have students practice identifying the "independent variable" and "dependent variable." Since these are "words we encounter" rather than "words we earn," don't expect them to use the terms accurately without guidance from you. An example of documented student ideas is provided as guidance.

Demonstrate how to use the light meter. Say, *Remember, in our first investigation, we observed how each material reflected and transmitted light, but we weren't sure how similar the one-way mirror was to the glass or the regular mirror, because we needed a more accurate way of measuring what the light was doing (reflecting and transmitting).*

Display **slide N**. Hold up a light meter, take off the cover, and show how to turn the light meter on. Tell students the light meter detects light similar to our eyes and can only detect light that directly enters the sensor area. Explain that it measures the amount of light in a unit called a "lux." Set the light meter at medium sensitivity (x10 lux) and tell students that a reading of "024" represents 24 x 10 lux or 240 lux. If students need to review place value from 5th grade, write the numbers on the board and show how x10 represents moving the decimal one place to the right.

an investigation, identifying independent and dependent variables and controls, and determining what data will be collected and used to support a claim. Use the questions provided to prompt students to think about variables, controls, and data.

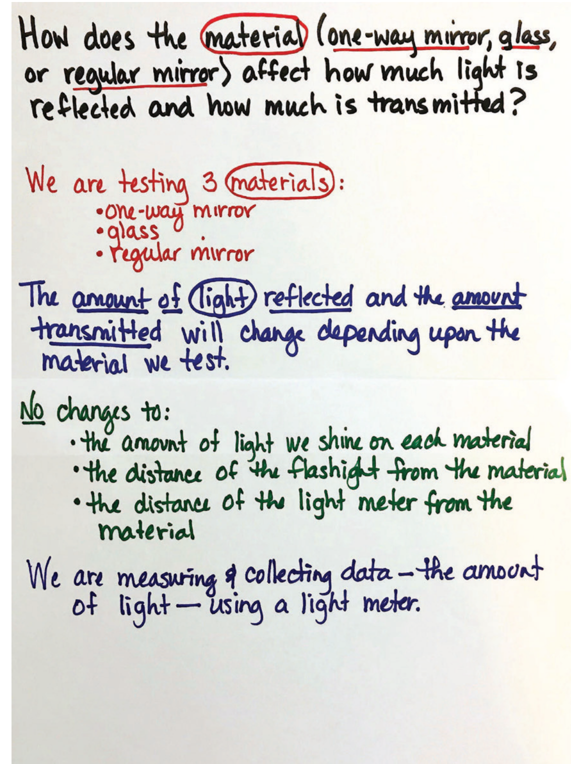
*Supporting Students in Engaging in Planning and Carrying Out Investigations

The purpose of reviewing and making sense of the *Measuring Light Investigation* procedures in this moment is to give students an opportunity to evaluate whether the investigation design will get them the data they need to answer questions about how much light is reflected by and transmitted through the materials. Use the prompts on **slides O**, **P**, and **Q** to encourage students to scrutinize the plan closely and to think about how this data will help them answer their questions.

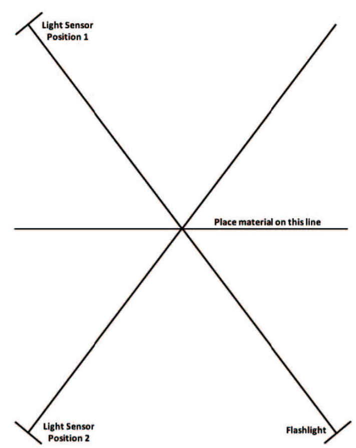
Demonstrate how to take a measurement of the ambient light in the classroom. Point out that the numbers on the light meter jump around, and tell students that holding the sensor very still for several seconds will make it easier to get a reliable reading. Then, tape a cardboard tube around the sensor, and tell students that this will help us more accurately measure the amount of light from the flashlight that is reflected and transmitted by each material rather than measuring the ambient light in the classroom. Explain that they should record the highest value observed.

Orient students to the lab setup. Display **slide O**. Show students the light meter setup on the slide and use the prompts to guide a quick discussion.*

Suggested prompts	Sample student responses
What light is detected by the light sensor in position 1?	*In position 1, the sensor detects the light that is transmitted by (goes through) the material.*
What light is detected by the light sensor in position 2?	*In position 2, the sensor detects the light that is reflected by (bounces off) the material.*
Why is the light sensor in these two different locations?	*We need to determine both the amount of light that is transmitted and the amount of light that is reflected by the material.*
Does this seem like it will get us the data we need to answer our experimental question? Why or why not?	*These two positions should get us the data we need because we will measure the amount of light transmitted and reflected by the material.*



Project **slide P** and hold up the *Template for the Measuring Light Investigation*. Show students the template they will use to help them keep straight lines between the flashlight and the sensor. Show students where to place the light sensor in position 1 to measure the amount of transmitted light and position 2 to measure the reflected light.



Introduce the investigation procedures and make predictions. Distribute the *Measuring Light Investigation Procedures* to students and tell students it is the procedure for the *Measuring Light Investigation*.

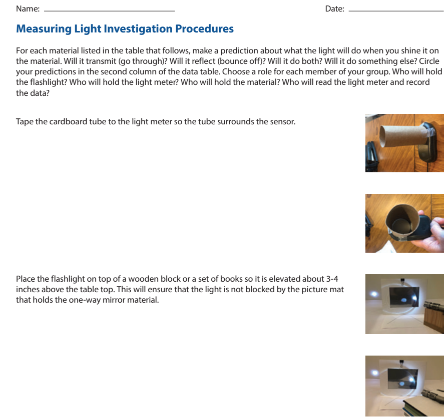
Display **slide Q**. Have students take a few minutes to predict what they expect for each material using their handout to record their predictions.

Display **slide R**. Tell students to follow the handout's procedure with their group, step-by-step, and that each person in their group needs to take one of the following roles as the group conducts the investigation:

- Hold the flashlight or prop into books or a block of wood. Adjust the light so it directly enters the cardboard tube.
- Hold the light meter.
- Hold the material.
- Read the light meter.

Having group members carefully hold materials and take measurements is important because it will help them collect data that is as precise as possible.

Conduct the *Measuring Light Investigation*. Give students 10-12 minutes to conduct the investigation. Walk around to make sure each group's setup is correct and provide guidance as needed. Check students' data to be sure they are correctly recording the measurements from the light sensor. You can reference the *Measuring Light Investigation Guidance* as you work with groups.


Name:

Date:

Measuring Light Investigation Procedures

For each material listed in the table that follows, make a prediction about what the light will do when you shine it on the material. Will it transmit (go through)? Will it reflect (bounce off)? Will it do both? Will it do something else? Circle your predictions in the second column of the data table. Choose a role for each member of your group. Who will hold the flashlight? Who will hold the light meter? Who will hold the material? Who will read the light meter and record the data?

Tape the cardboard tube to the light meter so the tube surrounds the sensor.

Place the flashlight on top of a wooden block or a set of books so it is elevated about 3-4 inches above the table top. This will ensure that the light is not blocked by the picture mat that holds the one-way mirror material.

Additional Guidance

If you want students to test additional materials, you can add additional rows to the data table in the *Measuring Light Investigation Procedures* handout. Keep in mind that this will add prep and instructional time to the lab. However, this gives students an additional opportunity to think about the structure and properties of materials and the role those play in how these materials interact with light.

9. Navigation

3 MIN

Materials: science notebook, *Measuring Light Investigation Procedures*, tape

Compile group data and clean up. Have students tape the *Measuring Light Investigation Procedures* handout into their science notebook. Each group should send one person to the front of the room to fill in their group data on the charts on **slide U** and **slide V**. **NOTE:** The completed charts will be used during the next class period. Groups should also collect and return all lab materials and equipment.

Summarize by saying, *We have tested the three materials to determine the amount of light each reflects and the amount each transmits. We will begin our next class by sharing our data and figuring out what we have learned.*

Additional Guidance

If you think it will take too long to collect each group's data on your computer before the end of class, there are a number of other ways you can collect the data by the beginning of the next class period:

- Use a smartphone or tablet to take a picture of one completed data table from each group.
- If students are particularly tech-savvy, have a student from each group take a picture of their completed data table and send it to your computer (via email or airdrop).

- Create a chart on chart paper and have one student from each group write their data on sticky notes and put them on the chart. When all sticky notes for the class have been added to the chart, take a photo of the chart, then remove the sticky notes before the next class. Repeat the process for each class, and at the end of the day, use the photos to record the data into the slides.
- Print the charts on **slides U** and **V** for each class and have one student from each group fill in the group data.

However you choose to collect the data, make sure you transfer the data to the charts on **slide U** and **slide V** before the next class period.

End of day 2

10. Navigation

2 MIN

Materials: science notebook, *Measuring Light Investigation Procedures*

Review the investigation procedures and share next steps. Say, *Last class period, for the* Measuring Light Investigation*, we used a light meter to measure the amount of light reflected and the amount transmitted by the one-way mirror, glass, and a regular mirror. You recorded your data in the data table on the Measuring Light Investigation Procedures, and we are now ready to share our data and make sense of what we observed.*

Show **slide S**. Ask, *Who can remind us what we are trying to figure out from this investigation?*

Solicit a response or two, then remind students that we now have data we can use to better compare the three materials.

Suggested prompts	Sample student responses
What are we trying to figure out from this investigation?	*We know the one-way mirror can act like a mirror and a window, but we don't know why. We do know the amount of light in a room makes a difference in how the one-way mirror acts. In a well-lit room, it acts like a mirror. and in a dark room, it acts like a window.* *If we know the amount of light that transmits through and the amount of light that reflects off the one-way mirror, the glass, and the regular mirror, it might help us figure out what is happening at the point where the light hits the one-way mirror, so we can explain what we see.*

11. Analyze data from the Measuring Light Investigation.

8 MIN

Materials: science notebook, *Measuring Light Investigation Procedures*

Analyze class data. Show **slide T**. Have students turn to the next available page in their notebook and set it up following the directions on the slide. This should give them easy access to the *Measuring Light Investigation Procedures*, if they need to refer to their own data.

Show **slide U.** Give students 3 minutes to look at the class data for the amount of **light transmitted** by each material and talk with their group. Remind them to look for patterns across the data and to document what they notice.

Show **slide V** and give students 3 minutes to look at the class data for the amount of **light reflected** by each material and talk with their group. Then ask them to bring their science notebook and a chair and meet in a Scientists Circle.

12. Conduct a Consensus Discussion.

20 MIN

Materials: science notebook, chart paper, markers, sticky notes, tape, Science Ideas chart

Convene a Consensus Discussion and share data patterns. As students settle into a Scientists Circle, show **slide W**. Ask students to quietly read the questions on the slide.

Key Ideas

Purpose of this discussion: Use evidence from the *Measuring Light Investigation* to (1) compare how light interacts with the one-way mirror, glass, and regular mirror and (2) motivate the need to further investigate the structure and properties of the one-way mirror to try to explain the one-way mirror phenomenon.

Listen for this main idea:

- When light shines on an object, it reflects off, transmits through, or some combination of these, depending on the object's material.

Listen for these other ideas:

- All materials reflect some amount of light; otherwise we would not be able to see them.
- When most of the light transmits through a material, we can see through the material (glass).
- When no light transmits through a material, we cannot see through that material (regular mirror).
- The one-way mirror reflects and transmits light in almost equal amounts, which is unlike either the glass or regular mirror.

Share observations from the investigation and patterns in data. Give students from different groups an opportunity to share their observations during the investigation and patterns they found in the data. If needed, show **slide U** (transmitted light) and **slide V** (reflected light) as students point out the patterns. Record their ideas on chart paper.

Listen for the following ideas to surface:

Transmitted light	Reflected light
• The glass transmitted the most light. In fact, it transmitted a very large amount of the light that came from the flashlight. • The one-way mirror transmitted quite a bit less light than the glass. • The regular mirror did not transmit any light at all.	• The regular mirror reflected almost all the light from the flashlight. • The one-way mirror reflected just a bit more light than it transmitted. • The glass reflected a very small amount of light.

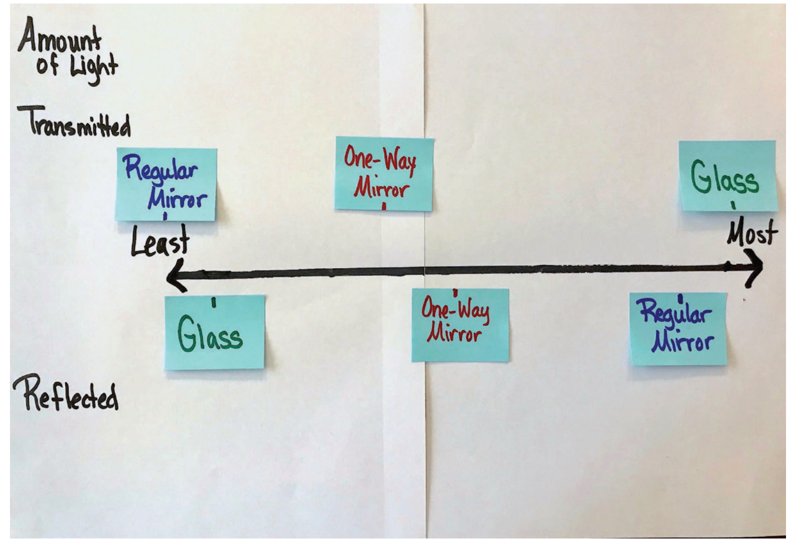
***Supporting Students in Engaging in Developing and Using Models**

Through a collaborative process—starting with individual, then small-group, and finally whole-class discussion—students develop and revise shared models that represent a class consensus. Emphasize productive and respectful discourse during discussions to support collaboration by asking questions like these:

- *How might we represent our thinking?*
- *Does anyone disagree with the idea presented?*
- *Is there anything about the phenomenon that we haven't explained yet? Are there any gaps that need filling?*

Using questions such as these will help students come to agreement on the representations used in the model and how our consensus model represents our current understanding of the phenomenon under study.

Rank the materials. After students share the patterns they found, have them rank the materials—from most to least—for the amount of light transmitted and the amount of light reflected. You can document this on chart paper, or you can write the name of each material on sticky notes and have students rank the materials on a continuum. (It might look similar to the image provided.)



After ranking the materials, say, *We used words and phrases like "most," "some," "almost all," "very large amount," and "very small amount" to describe the amount of light that was either reflected off or transmitted by each of the materials. Then we ranked the materials based on those observations. Do you think it would be helpful to put numbers on our scale of "most to least"? Why?*

Add a scale and create a key. Give students a chance to share their thinking, and listen for them to suggest that adding a scale might make our placement of each sticky note more accurate. Then guide them in adding a scale on the chart.

Additional Guidance

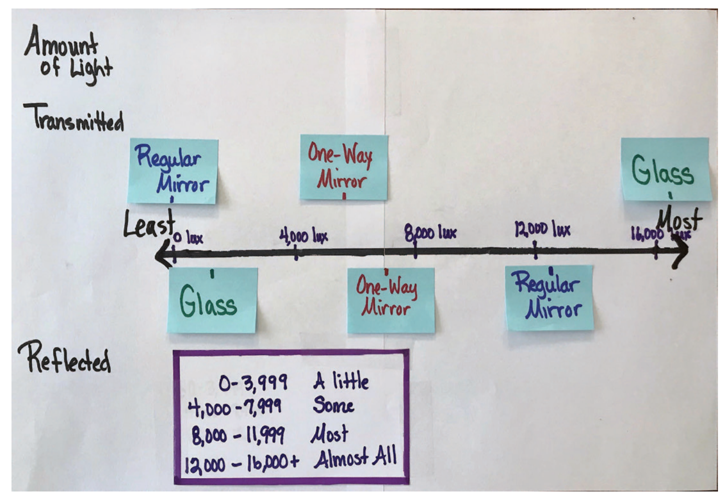
The following data was used to determine the scale on the sample chart in the teacher guide below:

Material	Light transmitted	Light reflected
Glass	16,400 lux	1,300 lux
One-way mirror	5,300 lux	7,000 lux
Regular mirror	0 lux	12,500 lux

The scale used on your class chart may differ, depending on the flashlights used in your classroom. Therefore, use the light data that your class collects to help determine a scale that will work with their data. Keep in mind that the maximum amount of light on the scale depends upon the flashlight that you use and the amount of ambient light that may still be in the classroom when the lights are turned off. In addition, you may want to round the maximum amount of light to a number that is easy to divide into fourths for purposes of building a simple scale on the chart.

Students may need to adjust the sticky notes on the chart to more accurately reflect where each material falls on the continuum for both the amount of light transmitted and reflected.

Guide students to create a key with the terms we used to describe the amount of light either transmitted or reflected. Suggest using terms such as "A little," "Some," "Most," and "Almost all," then add numbers to reflect the scale. The revised chart with added scale and key might look similar to this:



Discuss conclusions. After students have adjusted the sticky notes, ask, *What did the patterns in the data and our observations help us figure out about each material?*

Solicit responses. Listen for the following ideas to surface:

<table>
<tr><th>Material</th><th>What have we figured out about each material</th><th>What we have figured out about all materials</th></tr>
<tr><td>One-way mirror</td><td>• The one-way mirror reflects and transmits light.
• The one-way mirror reflects about half of the light that shines on it.
• The one-way mirror reflects slightly more light than it transmits.</td><td rowspan="3">• When a material transmits light, light passes through it.
• When a material reflects light, light bounces off it.
• All materials reflect some amount of light; otherwise we would not be able to see them.
• When most of the light transmits through a material, we can see through the material.
• When no light is transmitted through a material, we cannot see through the material.</td></tr>
<tr><td>Glass</td><td>• The glass reflects and transmits light, too.
• The glass reflects much less light than it transmits.</td></tr>
<tr><td>Regular mirror</td><td>• The regular mirror does not allow any light to pass through—it only reflects light.
• The mirror reflects almost all the light from the flashlight.</td></tr>
</table>

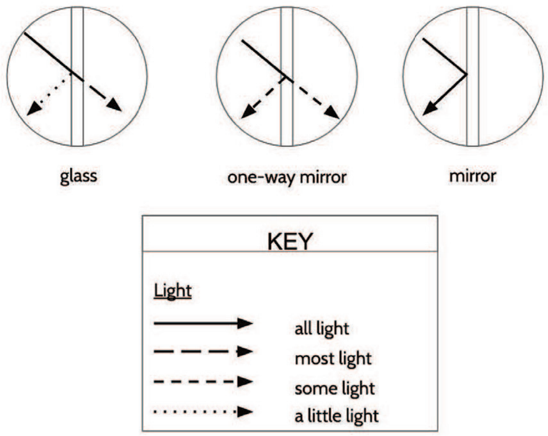
Update the class consensus model. Ask students to share their ideas about how to represent what the class just figured out.

Suggested prompts	Sample student responses	Follow-up questions
How might we represent what we have figured out about these three materials?	*We need to show different amounts of light using arrows.*	*What could we do with the arrows to show different amounts of light?*

Work with students to recreate the key from the class chart of the amount of light transmitted and reflected, and use arrows with various sizes of dashes to correspond to the varying amounts of light. Then update the consensus model from day 1 to show different amounts of light reflecting and transmitting for the three materials. Add the key to the model so everyone understands the changes in this updated consensus model. Your updated consensus model might look like that shown on the following page.

Update the Science Ideas Chart. Summarize the main science idea your students developed in this lesson and add it to the Science Ideas chart.* The main science idea may be similar to this:

- When light shines on an object, it reflects off or transmits through it or some combination of these, depending on the object's material.



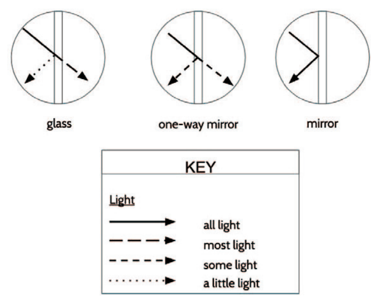
Science Ideas

- Light travels in straight lines.
- For us to see an object, light must leave a light source, bounce off the object, and travel in a direct path to enter our eyes.
- When light shines on an object, it is reflected (bounces off), transmitted (passes through), or some combination of these depending on the object's material.

13. Update Progress Tracker. 10 MIN

Materials: science notebook

Document what we have figured out in the Progress Tracker. Ask students to return to their desk, then show **slide X**. Have students add an entry to their Progress Tracker to record what they can now conclude about the question they were investigating. Look for the following ideas in students' work:

Question	What I figured out in words/pictures
What happens when light shines on the one-way mirror?	Light travels in a straight line. When light shines on the one-way mirror, about half of the light reflects off, which is slightly more than the amount of light transmitted. The one-way mirror does not reflect as much light as a regular mirror, and it does not transmit as much light as a window. 

Assessment Opportunity

Building towards: 3.B Use evidence to modify a model to explain how an object's material (structure) influences the path of light as it transmits through or reflects off the material (function).

What to look/listen for:

- While analyzing class data in small groups and as a class, look and listen for students to
    - use light data to compare the one-way mirror to the regular mirror and glass, and

    - create a continuum and place each material along the continuum based on the amount of light each transmitted and reflected.
- When students individually complete their Progress Tracker, look for the following ideas in their representations:
    - Light travels in a straight line.
    - When light shines on the one-way mirror, about half of the light reflects off, which is slightly more than the amount of light transmitted.
    - The one-way mirror does not reflect as much light as a regular mirror, and it does not transmit as much light as a window.

What to do: The *Measuring Light Investigation* gives students the opportunity to analyze and use quantitative data to make sense of the one-way mirror phenomenon.

- If students struggle to analyze the data and compare the one-way mirror to glass and the regular mirror, you can help them with these steps:
    - Simplify the data on **slides U** and **V** (e.g., select one set or use an average).
    - On chart paper, use the data to build a key, then put numbers on a continuum.
    - Use the scale on the continuum to compare the materials, focusing first on the amount of light transmitted, and place e*ach material on the continuum before moving on to the amount of light reflected.*
- While revising the consensus model, if students struggle to represent what they observed, guide them to build the model using a systematic process such as this:
    - Determine how to represent the scale and key on the continuum with solid and dashed arrows.
    - Focusing on one material at a time, draw each in a zoomed-in bubble.
    - Then, represent light (using a solid straight arrow) coming into contact with the material.
    - Next, represent what light does after it hits the material using dashed arrows, as appropriate based on the data.
    - Repeat the process with each material.

If students struggle to complete their Progress Tracker, remind them to use their observations in their notebook, as well as charts around the room, for support. You can also allow students to work with a partner if needed. In addition, you can use what you learn from students' work in the Progress Trackers to inform your next steps for moving their thinking forward. This could include

- giving students feedback in their notebooks, such as additional probing questions, suggestions for improvement, or a request for additional evidence or reasoning;
- revisiting, reteaching, or reinforcing ideas from the lesson to help students fill in gaps in their learning;
- using examples of actual student work to prompt discussion about what we have and haven't figured out up to this point; and
- asking additional questions at the beginning of the next lesson to probe students' thinking and help them make connections and build understanding.

14. Navigation

5 MIN

Materials: Driving Question Board

Review the Driving Question Board. Show **slide Y**. Have students gather around the DQB, then ask, *What questions do we have about the one-way mirror itself that could be important to investigate to understand why it interacts with light differently from a regular mirror and a piece of glass?*

Give students a minute or two to look through the questions on the DQB. Let them share some of the questions they find. If the relevant questions are not identified right away, point students toward their questions about the one-way mirror. Show **slide Z** and ask, *What do we think the one-way mirror is made of that allows it to do different things with light?*

Call on a few students to share their thinking.

Suggested prompts	Sample student responses
What do we think the one-way mirror is made of that allows it to do different things with light?	*I think the one-way mirror is made of some kind of plastic that has a special film on it that lets it act like a mirror.* *The one-way mirror must have something in common with a regular mirror, because it behaves like a mirror.* *The one-way mirror can't be exactly like a mirror, because some light transmits through it. The regular mirror doesn't let any light transmit.* *The one-way mirror behaves like glass, because both allow light to transmit through and reflect off, but the amounts are not the same. We just don't know exactly how much light is reflected and transmitted by each.*

Navigate to the next lesson. Summarize by saying, *So we think the one-way mirror acts like a regular mirror because the two materials have something in common. But, we know they are not exactly the same, since the one-way mirror lets some light transmit and the regular mirror does not. I think our next step is to try to figure out what the one-way mirror and the regular mirror have in common.*

ADDITIONAL LESSON 3 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

Following each investigation in this lesson, students engage in discussion when they work in small groups to make and compare observations, as well as when they work as a class to analyze class data and revise class consensus models.

CCSS.ELA-LITERACY.SL.6.1: Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.

Student groups follow a multistep procedure outlined in the *Measuring Light Investigation Procedures*, which calls for using a light meter to measure the amount of light transmitted through and reflected off a one-way mirror, glass, and a regular mirror. Students record their group data in a class chart and analyze class data, looking for patterns that might help them explain the one-way mirror phenomenon.

CCSS.ELA-LITERACY.RST.6-8.3: Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Additionally, this lesson provides an opportunity for students to use a CER graphic organizer to construct claims supported by evidence and reasoning.

CCSS.ELA-LITERACY.W.6.1: Write arguments to support claims with clear reasons and relevant evidence.

- **CCSS.ELA-LITERACY.W.6.1.A. Introduce claim(s) and organize the reasons and evidence clearly.**

Supporting Students in Making Connections in Math

CCSS.MATH.CONTENT.5.NBT.1 Understand the place value system. Recognize that in a multi-digit number, a digit in one place represents 10 times as much as it represents in the place to its right and 1/10 of what it represents in the place to its left.

During the *Measuring Light Investigation*, students work in small groups using light meters to determine the amount of light transmitted through and reflected by a one-way mirror, glass, and a regular mirror. Students are required to take readings that must be multiplied by 10 to determine the amount of light as measured in lux.

CCSS.MATH.CONTENT.5.NBT.2 Understand the place value system. Explain patterns in the number of zeros of the product when multiplying a number by powers of 10~~, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole number exponents to denote powers of 10~~.

Students work collaboratively to develop a relative scale to accurately compare the light data for the one-way mirror, glass, and regular mirror, and to create a key that can be used to show relative amounts of light transmitted through and reflected off these materials. The scale will range from 0 to 16,000 lux or more, depending upon the amount of light emanating from the flashlights used.

Reflection and Absorption

1 **Light Cooking**
2 **Light in the Atmosphere**
3 **Photography and Light Metering**
4 **Clarity of Water**

Literacy Objectives

- ✓ Summarize key points related to interactions between light and Earth materials.
- ✓ Distinguish causes and effects related to light and matter.
- ✓ Distinguish between credible and noncredible sources.
- ✓ Translate text to visual/graphic representation of ideas.

Literacy Activities

- Read varied text selections related to the topics explored in Lessons 2–3.
- Evaluate the reading selections according to provided prompts and criteria.
- Compare and contrast information gained from reading text with information gained from class investigation.
- Prepare an infographic in response to the reading.

Instructional Resources

Student Reader

Collection 2

Science Literacy Student Reader, Collection 2
"Reflection and Absorption"

Exercise Page

EP 2

Science Literacy Exercise Page
EP 2

Prerequisite Investigations

Assign the Science Literacy reading and writing exercise *after* class completion of this lesson group:

- End of Lesson 2: What happens if we change the light?
- Lesson 3: What happens when light shines on the one-way mirror?

Standards and Dimensions

NGSS

Disciplinary Core Ideas:
PS4.B Electromagnetic Radiation: When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2)

Science and Engineering Practices: Obtaining, Evaluating, and Communicating Information; Analyzing and Interpreting Data

Crosscutting Concepts: Structure and Function; Cause and Effect

CCSS

English Language Arts
RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

RST.6-8.10: By the end of grade 8, read and comprehend science/technical texts in the grades 6–8 text complexity band independently and proficiently.

WHST.6-8.2.D: Use precise language and domain-specific vocabulary to inform about or explain the topic.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. However, these terms are not intended for isolated drill or memorization.

absorb

reflect

transmit

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

aerosol	**independent variable**
correlation	**turbidity**
dependent variable	**variable**

A Glossary at the end of the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction.

1. Plan ahead.

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the assignment.
- Wednesday: Plan to touch base briefly with students in the middle of the week to answer questions about the reading, to clarify expectations about the writing exercise, and to help students stay on track.
- Friday: Set aside time at the end of the week to facilitate a discussion about the reading and the writing exercise.

You'll proceed with the next in-class lesson investigations during this week.

2. Preview the assignment and set expectations. (MONDAY)

- Let students know they will read independently and then complete a short writing assignment. The reading selection relates to topics they are presently exploring in their Light and Matter unit science investigations.
- The reading and writing will be completed outside of class (unless you have available class time to allocate).
- Preview the reading collection. Share a short summary of what students can expect.
    - *You will read a fictional chef's blog about solar cooking and learn how a solar cooker transmits, reflects, and absorbs light.*
    - *The newspaper called "The Springfield Banner" may be made up, but the article and letter to the editor are based on real science and a true incident.*

- *Then, you'll read an article about how digital photography tools measure and adjust for several variables related to light conditions.*
- *Finally, you'll dig into the data reported in a mock high school science investigation report.*

- Distribute Exercise Page 2. Preview the writing exercise. Share a brief summary of what students will be expected to deliver. Emphasize that Science Literacy exercises are brief. The focus is on thoughtful quality of a small product, not on the assignment being big and complex.
  - *For this assignment you will be expected to generate an infographic that gives examples from the readings of three ways light interacts with Earth.*

Exercise Page

EP 2

- Remind students of helpful strategies they can employ during independent reading. Offer the following advice:
  - *The reading should take approximately 30 minutes to complete.* (Encourage students to break reading into smaller sections over multiple short sittings if their attention wanders.)
  - *A good reading strategy is to scan through the collection first to see the titles, section headers, graphics, and images to see what the selections are going to be about before fully reading.*
  - *Next, "cold read" the selections without yet thinking about the writing assignment that will follow.*
  - *Then, carefully read the Exercise Page to understand the expectations for the writing part of the assignment.*
  - *Revisit the reading selections to complete the writing exercise.*
  - *Jot down any questions for the midweek progress check in class.* (Be sure students know, though, that they are not limited to that time to ask you for clarification or answers to questions.)

3. Touch base to provide clarification and address questions. (Wednesday)

Touch base midweek with students to make sure they are on track while working independently. You may choose to administer a midweek minute-quiz to give students a concrete reason not to postpone completing the reading until the last minute. Ask questions such as these, and have students jot answers on a half sheet of paper:

Suggested prompts	Sample student responses
What happens to a ray of light when it is reflected by a material or object?	*It bounces back and is not absorbed or transmitted.*
What is the reason geoengineers are talking about putting certain aerosols into the atmosphere?	*to reduce climate change* *because these aerosols reflect sunlight and could make Earth cooler*
What does turbidity measure?	*how clear water is*

Ask a few brief discussion questions related to the reading that will help students tie the text content to students' classroom investigations.

Suggested prompts	Sample student responses
Do materials such as glass, aluminum foil, and black pots transmit, reflect, or absorb 100 percent of light that strikes them? Explain.	*No, each material may transmit, reflect, or absorb most of the light but not all of it. In many cases, some light passes through a material.*
When sunlight strikes Earth's atmosphere, what happens to the light?	*Some of the light passes through the atmosphere and reaches Earth's surface, some is reflected into space, and some is absorbed by particles in the air.*
How does knowing that light travels in straight lines help explain how a turbidity sensor works?	*Because light moves in straight lines, you can point the sensor's light at a particular place, and you know that light will be reflected off particles it hits and that only some of it will travel back to the sensor.*

Exercise Page

EP 2

- Refer students to Exercise Page 2. Provide more specific guidance about expectations for students' deliverables due at the end of the week.
    - *The expectation for this assignment is that you'll create an infographic that uses quantitative data from the readings to show your understanding of three ways light interacts with Earth materials—by reflection, absorption, and transmission.*
    - *By "quantitative," I mean examples that involve numbers or mathematical comparisons.*
    - *You'll want to review all four readings to find examples for your infographic.*
    - *Collect your facts first, and write at least one sentence about each that uses one of the three terms.*
    - *Then draw some thumbnail sketches of possible layouts. When you have one you like, enlarge it to fill a sheet of paper, and add the text.*
    - *Try using colored pencils or highlighters to add color. Remember: infographics are supposed to catch the eye!*
    - *The important criteria for your work are in the evaluation rubric. Refer to them as you plan, write, and add color to your design.*
- Answer any questions students may have relative to the reading content or the exercise expectations.

4. Facilitate discussion.

(Friday)

Facilitate class discussion about the reading collection and writing exercise. Students begin the reading activity by learning that surfaces on Earth vary in how much they absorb, reflect, and transmit sunlight.

Pages 14–15 **Suggested prompts**	**Sample student responses**
What is the general purpose of the first selection, "Light Cooking"?	*It is a light-hearted description of how a chef learns about cooking using sunlight for heat.* *It also explains three science terms related to light—* absorb, reflect, *and* transmit.
How would you draw the path of light involved in the solar oven?	*as straight lines, called rays, with arrow pointing from the sun through the plastic roof* *Some of the rays would go right into the pot of food, and other lines would strike the foil sides of the box.* *Then, lines from the foil point into the pot or food.*
How was this selection useful in planning your infographic?	*The vocabulary box helped define the terms* absorb, reflect, *and* transmit *that I had to use in the infographic.* *Also, there is a piece of interesting numerical data I could add to the infographic.*

The next selection requires students to compare and contrast two parts while considering the reliability of sources.

Pages 16–17 **Suggested prompts**	**Sample student responses**
What is the general purpose of the second selection, "Light in the Atmosphere"?	*It is an informational newspaper article and a letter to the editor complaining that the article was not accurate.*
How do aerosols in Earth's atmosphere affect sunlight?	*Some absorb light [or infrared light], which causes matter to heat up, and others reflect sunlight back into space.*
How was this selection useful in planning your infographic?	*It includes interesting numerical data on Mount Pinatubo and the materials from an eruption that reflected sunlight into space.*
Look at the Consider the Source box. What can people do to make sure they are getting accurate science news?	*They can check other news sources to see if the stories agree.* *They can find and read the original report that the newspaper writer used.*

Student Reader

Collection 2

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

Pages 18–20 Suggested prompts	Sample student responses
What is the general purpose of the third selection, "Photography and Light Metering"?	*It is an informational article explaining how digital cameras manage light.*
What does the word "variables" mean in the context of this article?	*factors that affect the images produced*

The final reading in this week's collection addresses two difficult concepts related to experimentation: correlation versus causality and dependent versus independent variables.

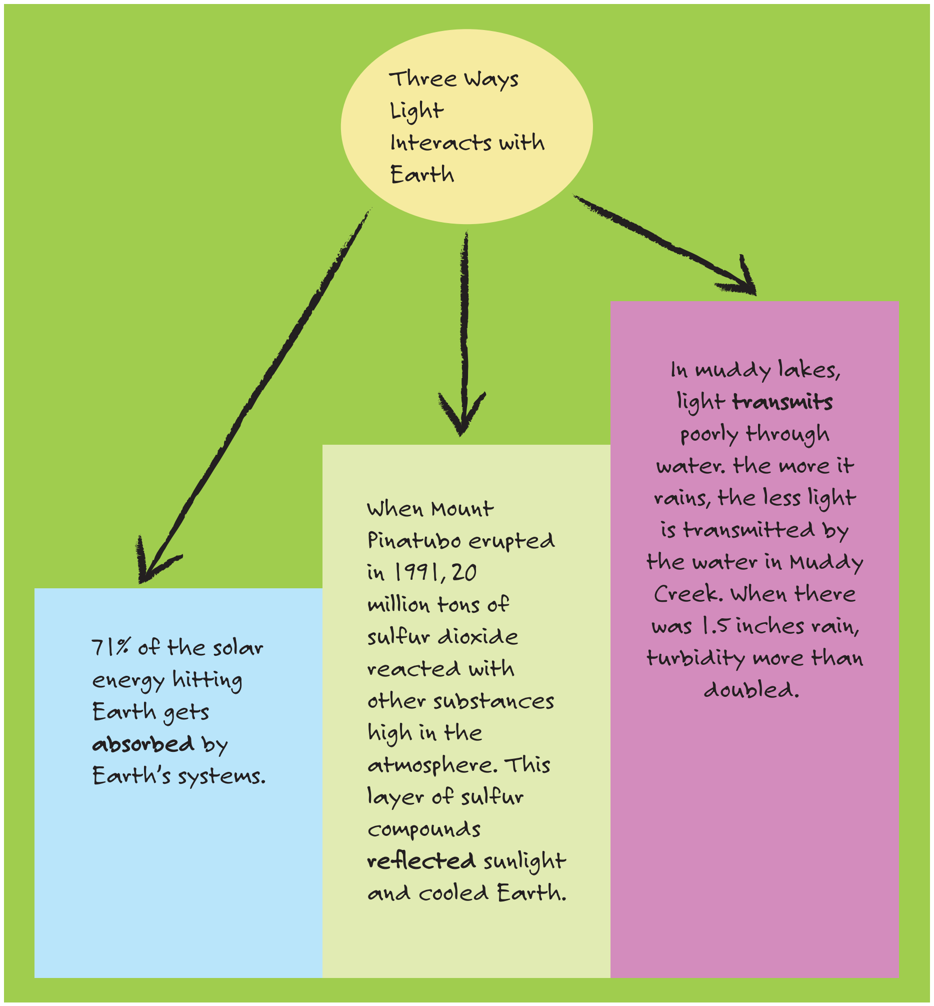
Pages 21–23 Suggested prompts	Sample student responses
What is the general purpose of the fourth selection, "Clarity of Water"?	*It is a science investigation report about the connection between rainfall and turbidity written by three high school students.*
Why would scientists want to investigate turbidity?	*Turbidity might affect the organisms living in the creek, such as fish that people like to eat.* *If the water cannot transmit light to plants and algae at the bottom of the creek, fish that eat them might starve.*
Why is turbidity the dependent variable?	*because the amount of turbidity depends on the amount of rainfall—at least that is what the students think is going on*
Which were the students most certain about—a correlation in their data or the cause of their data? Explain.	*They were surer that rainfall and turbidity correlated. They said they needed to investigate more to find out how the rain could cause increased turbidity.*
How was this selection useful in planning your infographic?	*I could choose some numerical data from the table or graph when describing light transmission.*

SUPPORT—Allow EL students to compare the lighting tools available with a smartphone camera to what they read in the text. While smartphones don't necessarily label these lighting settings as was done in the reading, students can use trial and error to observe the effects of changing each setting.

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 2, students should produce an attractive, easy-to-read infographic on paper demonstrating their understanding of how light interacts with Earth materials (matter), while providing data from the readings in Collection 2. A sample is shown. Look for evidence that students know that light is sometimes reflected, absorbed, or transmitted by matter. Also look for evidence that students were able to provide examples by locating and reporting quantitative data from a variety of readings. Give feedback on the overall design of the infographics, sharing examples that use layout or color in inviting ways.



Use the rubric provided on the Exercise Page to supply feedback to each student.

EXTEND—Some students may want to transform their paper infographics into a polished digital product by using design apps or websites. These tools have templates that help students choose layouts, design text, and make color decisions and can be used with tablets or computers. Check the privacy policy of any tool before students use it to make sure it conforms with your school district's internet-use policies.

Online Resources

LESSON 4

How do similar amounts of light transmit through and reflect off the one-way mirror?

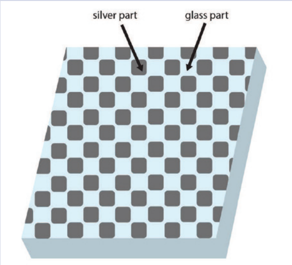
Previous Lesson

To figure out why the one-way mirror acts like both a mirror and a window, we observed what happened when light shined on the one-way mirror, a pane of glass, and a regular mirror. We developed a testable question, planned the investigation, and used a light meter to measure the amount of light that transmitted through and reflected off each material.

This Lesson

Investigation

1 DAY



We wonder how similar amounts of light transmit through and reflect off the one-way mirror. We think it has something to do with how the one-way mirror is made. We read more about regular mirrors and one-way mirrors. We find out that regular mirrors have a thick layer of silver on the glass, and one-way mirrors have a thin layer of silver embedded in a plastic film on the glass. We modify a model to explain what happens when light shines on the different structures in each material. We think we can explain how the structures of the one-way mirror interacting with light cause the phenomenon.

Next Lesson

We will model interactions between light, people, and the one-way mirror to explain why the music student and adults can see the music student. We will model how light from Room A's light source transmits through the one-way mirror, reflects off the adults, and enters the student's eyes.

Building Toward NGSS

MS-PS4-2, MS-LS1-8

What Students Will Do

4.A Develop a model to describe the unobservable mechanisms that affect how a material's microscale structures change how light reflects off and transmits through the material (function).

What Students Will Figure Out

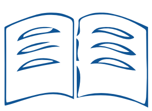
- A material can have different structures, even at a microscale, that cause different amounts of light to transmit through or reflect off of it.

Lesson 4 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Review data from the *Measuring Light Investigation* and possible explanations for the patterns seen in the data.	A	
2	22 min	**READ MORE ABOUT ONE-WAY MIRRORS** Follow a close reading protocol to gather information about how one-way mirrors are made in comparison to regular mirrors.	B-F	*Reading: How is a one-way mirror made?*
3	15 min	**FACILITATE A CONSENSUS DISCUSSION AND MODEL MICROSCALE STRUCTURES AND LIGHT** Facilitate a Consensus Discussion to revise models to explain how light transmits through and reflects off different structures of the materials.	G-I	*Reading: How is a one-way mirror made?*, whiteboard or chart paper, markers, yardstick, class consensus model from Lesson 3, tape, Science Ideas chart
4	3 min	**NAVIGATION** Celebrate what students just figured out and elicit their initial ideas of how the structure of the one-way mirror interacting with light causes the phenomenon.	J	

End of day 1

Lesson 4 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide**  **Student Work Pages** 	• *Reading: How is a one-way mirror made?* • science notebook		• whiteboard or chart paper • markers • yardstick • class consensus model from Lesson 3 • tape • Science Ideas chart

Materials preparation (20 minutes)

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

During the Consensus Discussion, be prepared to project **slide H** over a whiteboard or chart paper for the class to annotate. If that is not possible, recreate the diagrams from the students' handout on the whiteboard or chart paper in advance of the lesson.

Have the Lesson 3 class consensus model ready for referencing during the Consensus Discussion.

Online Resources

Lesson 4 • Where We Are Going and NOT Going

Where We Are Going

In Lesson 3 students collected evidence that light transmits through and reflects off the one-way mirror differently than a regular mirror and glass. By the end of the lesson they agreed that about the same amount of light transmits and reflects, or possibly that slightly more light reflects than transmits. Students could not explain how this happens. In this lesson, students work towards an explanation of how the one-way mirror interacts with light, while also satisfying their curiosity about how it is made. They do this by reading information about how regular mirrors and one-way mirrors are made (Lexile reading estimate: 810L-1000L). The reading describes the visible structures of mirrors as well as the microscale structures of one-way mirrors that are too small to see. This new information allows students to explain how similar amounts of light transmit through and reflect off the one-way mirror, and to start formulating ideas about how light's interactions with the one-way mirror structures lead to the one-way mirror phenomenon.

Students use structure and function as a lens for accounting for microscale structures that affect how the one-way mirror interacts with light and causes the one-way mirror phenomenon. They will also use evidence from the reading and the *Measuring Light Investigation* to argue for modifications to their class consensus model from Lesson 3. The focus of this modeling work is to account for microscale structures that interact with light at a scale we cannot see, which can help to explain why the one-way mirror reflects and transmits light the way it does, resulting in the phenomenon.

Students will encounter new terms in the reading, including "silvering", "transparent", "opaque", and "impurities". These are words we encounter, though "transparent" and "opaque" can become words we earn if you continue to support students' understanding of those concepts beyond the reading in this lesson.

Where We Are NOT Going

Students do not need to understand the chemistry of how silver nitrate is applied to create one-way and regular mirrors. They only need to understand that a reflective coating is applied in a very thin coat (one-way mirror) or thick coat (regular mirror), leaving some parts of the one-way mirror uncovered so light can pass through it. Another important difference is that the thick silver reflective coating is applied to the backside of glass to create a regular mirror, whereas the silver is embedded within film and then applied to the frontside of glass to create a one-way mirror. These structural differences are reflected in the diagrams students work with throughout the lesson, but it is not necessary for students to explain how having the silver in front of or behind the glass relates to the phenomenon—only that thin versus thick silvering is important.

1. Navigation

5 MIN

Materials: None

Motivate what still needs to be explained. Display **slide A**. Have students turn and talk about what they know about the one-way mirror compared to other materials based on data from the *Measuring Light Investigation*, and decide what information they still need to explain *why* light transmits through and reflects off the one-way mirror differently from a regular mirror and glass.

After 1 - 2 minutes, convene the class for a brief whole-class sharing. It is OK if students do not manage to discuss all the questions in the Turn and Talk.

Suggested prompts	Sample student responses	Follow-up questions
What did we learn about the one-way mirror from the Measuring Light Investigation?	*It transmits about half the light and reflects half the light.* *It reflects a little more light than it transmits.*	*Do we know why we saw these patterns? What caused them?* *Why do we think the one-way mirror transmitted and reflected light differently than the glass and regular mirror?*
How was the amount of light reflected or transmitted different from glass and the regular mirror?	*Glass transmitted almost all the light. The regular mirror couldn't transmit any light—it was all reflected.* *We think the one-way mirror can block some light. We think because the one-way mirror is shiny, it reflects some light.*	*Why do we think each material did something different with light?*
What other information do we need to explain the observed patterns?	*We need to know what the one-way mirror is made of and how it works.* *We need to know how the one-way mirror blocks some light but lets some of it through.*	*How could this information help us?*

Use gaps in our understanding to develop a question. Summarize key pieces of evidence the class has gathered about the one-way mirror (e.g., *It works best when light is on one side. When light is shined from one side, similar amounts of light transmit and reflect*). Say, *We have evidence that the one-way mirror does* _______ (fill in with evidence), *and we think this is important for explaining the one-way mirror phenomenon. But we have not been able to explain how it does these things. Last class, we planned to investigate some of our questions from the DQB about how the one-way mirror is made, because we think this might be related to how it works.**

*** Supporting Students in Engaging in Constructing Explaining and Designing Solutions**

Scientific explanations include three important components: they (1) answer a question about a phenomenon, (2) include a how-or-why account of the phenomenon, and (3) are based on evidence. Lesson 4 marks an important transition for students as they start working towards explaining the one-way mirror phenomenon. They have a question about the phenomenon and have gathered evidence. They will continue to gather evidence in this lesson, but they will also start working toward a how-or-why account. By Lesson 7 students will develop a complete scientific explanation of the phenomenon.

Restate the class's mission using the DQB. Point to the category of questions the students had about the one-way mirror material, which was discussed at the end of Lesson 3 (e.g., these questions were likely "what" questions, such as *What is the one-way mirror made of?* and "how" questions, such as *How is the one-way mirror made?*). Emphasize that we agreed that answering these questions from the DQB could help us make progress on explaining *how* similar amounts of light transmit through and reflect off the one-way mirror, which we agreed was important.

2. Read more about one-way mirrors.

22 MIN

Materials: *Reading: How is a one-way mirror made?*

Introduce the reading with the purpose of answering the lesson question. Distribute a copy of *Reading: How is a one-way mirror made?* to each student. Use the handout version of this reading for students to write on (and later, attach to their notebook). There is a color copy of this reading in the student edition for reference. Give students a brief introduction to the reading.

Preview the close reading strategies. Project **slide B**. Describe that close reading requires reading more than once and with different purposes and strategies for interacting with the text each time. Use the slides to go through the close reading steps:

1. Project **slide C**. Say, *Let's do the first step together.* Ask students to identify the main question in the reading. Tell them to circle the question "How is a one-way mirror made?" at the top. Ask how this question connects to our purpose of explaining our lesson question, "How do similar amounts of light transmit through and reflect off the one-way mirror?"
2. Project **slide D**. Give students time to read the text on their own.
3. Project **slide E**. Show students an example of step 3 by reading the first few sentences of the first paragraph aloud. As you read, pause and share your thinking, highlighting a few ideas that seem important. Model for students how they can annotate the text to emphasize important ideas.

Before students reread, take a moment to pull terms from the text that may be unfamiliar. Talk through the meanings of these words, such as "transparent", "opaque", "impurities", and "silvering". Allow students to offer additional terms from the reading.*

Once students feel comfortable with the words we encounter from the text and with the goal of annotation, give them time to reread the text on their own. Note that partner reading is another option. Remind students to be selective about what they highlight, keeping in mind that they are looking for information to help them answer our question about how similar amounts of light transmit through and reflect off the one-way mirror.

4. Project **slide F**. Tell students to work with a partner to summarize the key ideas from the reading that can help them answer the question, "How do similar amounts of light transmit through and reflect off the one-way mirror?" Then, cue students to use the 10 light ray diagrams at the bottom of the handout to help them make sense of how light interacts with the different structures of the materials. Lastly, cue students to record new questions the reading raised for them.

Circulate among the partners to see how they are modeling their ideas on the diagrams on their handouts. Use your observations to guide the following Consensus Discussion.

*** Attending to Equity**

Universal Design for Learning: Support students to clarify academic language they encounter in the text, which is important for developing facility with linguistic *representation*. Most of these terms are words we encounter that students need only understand to make sense of the text in this moment. However, a few terms, such as "transparent" and "opaque", can become words we earn if students continue to use and develop an understanding of those terms beyond this reading. The Lexile Reading estimate is 810L-1000L.

Supporting Emerging Multilingual Learners: Provide opportunities for emerging multilingual students to break down the meaning of scientific words used in the lesson. Provide an opportunity to discuss any preconceptions about the meaning of the word(s) and draw upon their personal experiences to make sense of them.

3. Facilitate a Consensus Discussion and model microscale structures and light.

15 MIN

Materials: *Reading: How is a one-way mirror made?*, science notebook, whiteboard or chart paper, markers, yardstick, class consensus model from Lesson 3, tape, Science Ideas chart

Additional Guidance

Supporting Classroom Culture and Norms: At the start of this discussion, consider doing two things: (1) pick a norm for the class to focus on during the discussion and circle back to reflect on after the discussion and (2) review the Communicating in Scientific Ways sentence starters to choose some that may be useful to use during the discussion.

Facilitate a Consensus Discussion to model how light interacts with microscale structures. This discussion has three goals:

1. Share new ideas learned from the reading.
2. Use what students learned about microscale structures to model light interactions with the structures and revise the representations in the previous class consensus model.*
3. Answer the question, "How do similar amounts of light transmit through and reflect off the one-way mirror?"

Key Ideas

Purpose of this discussion: To come to consensus about how similar amounts of light transmit through and reflect off the one-way mirror and to deepen our understanding about using representations to model what we figure out.

Listen for these ideas:

- Areas of agreement about what happens at the surface of a regular mirror.
  - The glass is fully covered with a thick silver layer and a paint layer. All the light reflects off these two layers.
- Areas of agreement about what happens at the surface of a one-way mirror.
  - The glass has a thin coat of silver material (half-silvered), which means there are gaps in the silver layer. Some of the light reflects off the silver parts, but some of the light transmits through the places without silver.
- Areas of agreement about what happens at the surface of glass.
  - A little light reflects off the impurities and dust, but most light transmits through the glass.

Students will use these ideas to work toward the main idea: A material can have different structures, even at a microscale, that cause different amounts of light to transmit through or reflect off of it.

Share new information learned. Display **slide G**. Reorient students to the question they are trying to explain, "How do similar amounts of light transmit through and reflect off the one-way mirror?" Elicit new ideas learned from the reading that helped students make progress toward answering this question.

*** Supporting Students in Developing and Using Structure and Function**

Make explicit to students that they are examining the structure of the one-way mirror to help them understand how it functions when light shines on it. This crosscutting concept becomes particularly useful at this moment as students make sense of what they need to account for in their models to explain the phenomenon. At the macroscale, it is difficult to discern any structures that would cause light's special interaction with the one-way mirror, but looking at the microscale, new structural features are revealed to help solidify why some light transmits and some reflects. Students now understand the unobservable mechanisms that can explain this observable phenomenon.

*** Supporting Students in Three-Dimensional Learning**

Students are working towards a model that can help them explain the one-way mirror phenomenon. The structure of the material is critical for making sense of how light interacts with the material to cause the one-way mirror effect. This moment is when students add structure to their models and begin to account for how light interacts with different structures of materials.

Suggested prompts	Sample student responses
What key ideas did you summarize that help us answer our question, "How do similar amounts of light transmit through and reflect off the one-way mirror?"	*One-way mirrors are made out of glass or plastic. They put on reflective material that doesn't completely cover the whole surface, so some light can go through it.*
What does the surface of the one-way mirror look like?	*It has a layer of thin silver material that partially covers it. Some areas have no silver and are transparent.*
What does the surface of a regular mirror look like?	*It has a thick layer of silver material on the back of the glass, which keeps light from going through it.*

*** Attending to Equity**

Universal Design for Learning: Use this opportunity to clarify the meaning of the different *representations* students have used to explain amounts of light transmitting and reflecting. The purpose of creating the 10 light ray model is to deepen students' understanding of the dashed and dotted arrow representation.

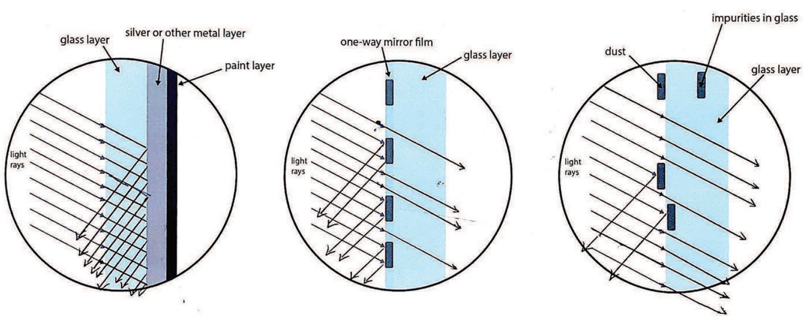
Revise the model to represent structures interacting with light. Project **slide H** over a whiteboard or chart paper. This will allow you to annotate the slide's diagrams as students share their thinking.

Use a yardstick to trace straight lines to different structures within the materials to show how they affect whether the light transmits or reflects. Students should have their notes on this already completed on their handout. As the class represents together how the structures allow for light to transmit or reflect, connect students back to the data from the *Measuring Light Investigation*. Ask, *How does this information now help us explain the observed data?* *

*** Supporting Students in Engaging in Developing and Using Models**

Use this opportunity to discuss how both modeling representations—the 10 light rays and the dashed and dotted arrows—are trying to show that the one-way mirror transmits half and reflects half of the light that shines on it. In the 10 light ray representation, we can model the unobservable mechanisms that cause this to happen when light shines on different microscale structures.

Suggested prompts	Sample student responses	Follow-up questions
How does light interact when it shines on the transparent structures?	*The light transmits through because the material is clear (transparent).*	*Does all of the light transmit? If all of the light transmits through, then how can we see the glass?*
How does light interact when it shines on the silver structures?	*The light reflects off the silver pieces.*	*How would this change if you had more or less silver?*



10 light ray model

Assessment Opportunity

Building towards: 4.A Develop a model to describe the unobservable mechanisms that affect how a material's microscale structure changes how light reflects off and transmits through that material (function).

What to look/listen for: The key ideas listed on the previous page.

What to do: If students struggle with representing how light interacts differently with structural features of glass, regular mirrors, and one-way mirrors, have students use the yardstick overlaid on the projected diagram to trace straight lines to different structures within the materials. Have students connect the number of arrows that transmit or reflect to the light sensor data gathered in Lesson 3.

Additional Guidance

One idea you may need to reiterate from the reading is that most transparent surfaces reflect a very small amount of light, due to impurities within the material or particles (like dust) on it. This is why we can see glass doors or windows. You can also give the example of glass windows or doors that are so clean and clear that people or birds don't realize they are there and run into them.

Discuss the 10 light ray representation versus the previous class consensus model.* Have the class consensus model from Lesson 3 viewable to all students. Say, *In the last class, we used dashed and dotted arrows to represent how much light was transmitting and reflecting. How is this new representation with 10 arrows similar to or different from that one?*

Suggested prompts	Sample student responses
How is this new representation similar to or different from our previous one?	*In the previous one we only had 1 light ray. In this one we have 10 light rays.* *In the previous one we didn't have structures. In this one we have a lot more detail about the structure.* *In the previous one it was more about how much light was reflecting and transmitting. This one uses individual rays to show how much light is reflected by or transmitted through materials.*
What benefits or limitations do you see with the 10 light ray representation?	*It helps us to understand what it means for some or all of the light to reflect or transmit through materials.* *We can use the individual rays to understand why some light transmits through and some light reflects off each material.*

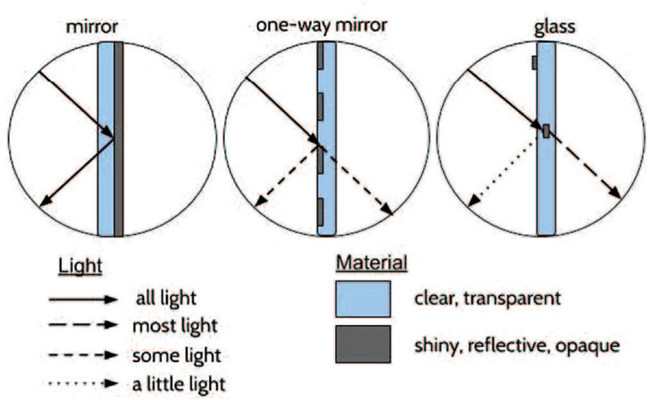
Suggested prompts	Sample student responses
What benefits or limitations do you see with the dashed and dotted arrow representation?	*It's a lot more arrows to draw!* *It doesn't show why certain amounts of light transmit or reflect off each material.* *It's a lot easier to draw, and shows us the amount of light that is reflected or transmitted through each material.*

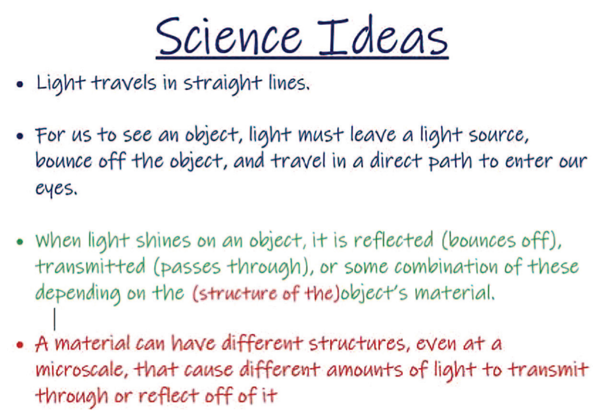
Ask how we can take the best points of the 10 ray model and the dashed/dotted arrow model to make a new model the class can use. Guide students toward a hybrid model like that shown below, though your specific hybrid model can vary depending on students' suggestions.

Conclude the discussion by answering the lesson question and recording a science idea. Display **slide I**. Elicit explanations for how the one-way mirror transmits and reflects about the same amount of light. Work with students' ideas to construct a science idea to add to the Science Ideas chart, such as:

- A material can have different structures, even at a microscale, that cause different amounts of light to transmit through or reflect off of it.

Have students attach their handout to their science notebook and update their table of contents.





Dashed and dotted arrow model with microscale structures

4. Navigation

3 MIN

Materials: None

Make connections to the one-way mirror phenomenon. Display **slide J**. Celebrate that we just accomplished something important—we now have a mechanism to help explain the one-way mirror phenomenon. Say, *We've gathered a lot of evidence about the one-way mirror, but at the start of this class we didn't really know* how *it worked the way it did. We just figured out something big. We now know more about how it works.*

Have students turn and talk with a partner to discuss the question, "How does the structure of the one-way mirror interact with light to cause the phenomenon?"

Tell students to be prepared to share their thinking to explain the one-way mirror phenomenon in the next class.

Slide K is provided as an optional Progress Tracker entry if you have time in class or want to assign it for home learning.

ADDITIONAL LESSON 4 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-Literacy.RST.6-8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

The close reading strategy in this lesson connects to ELA standards that ask students to read text closely to determine the central ideas and then to summarize those ideas. In step 3 of the reading strategy, students are asked to highlight the central ideas of the text that describes how regular and one-way mirrors are made. Then, in step 4, they are asked to summarize those ideas in words and a diagram.

How do light and the one-way mirror interact to cause the one-way mirror phenomenon?

Previous Lesson

We thought the one-way mirror transmits and reflects light differently from mirrors and glass because of how it's made. We read about how the one-way mirror is made compared to a regular mirror. We found out that one-way mirrors have a thin layer of silver embedded in a plastic film on the glass. We modified a model to explain that light transmits through the transparent structures of the one-way mirror and reflects off the silver structures.

This Lesson

Putting Pieces Together, Problematizing

1 DAY

In this lesson, we revisit the anchoring phenomenon and model interactions between light, the people, and the one-way mirror to explain why the music student and the adults only see the music student. We wonder why the student doesn't see the adults even though the adults are lit up a little. We model what happens when light from Room A's light source shines directly on the one-way mirror toward the adults. We figure out that the light that has reflected off the adults also enters the student's eyes. Because light from the adults enters the student's eyes, we again wonder why the student doesn't see them.

Next Lesson

If different amounts of light enter the student's eyes from each side of the one-way mirror, why can't the student see the adults? To figure this out, we will investigate what happens when light enters the eye and how the eye transforms light into signals sent to the brain. We will think about personal experiences to help us explain what happens when there are two inputs of light and why we only "see" one input or "see" one input better.

Building Toward NGSS

MS-PS4-2, MS-LS1-8

What Students Will Do

5.A Revise a model to explain the observable one-way mirror phenomenon caused by unobservable interactions between light, the people, and the one-way mirror, which reflects and transmits about the same amount of light.

What Students Will Figure Out

- When light reflects off the music student and travels to the one-way mirror, about half of the light reflects off the silver structures back to the student's eyes and the other half transmits through the transparent parts to the adult's eyes.
- The light that transmits through the one-way mirror reflects off the adults and travels to the one-way mirror. About half of that light reflects off the silver structures back to the adults' eyes and the other half transmits through the transparent parts to the student's eyes.

Lesson 5 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	8 min	**PREPARE TO EXPLAIN THE ANCHORING PHENOMENON** Revisit the Music Lesson video and create a Gotta-Have-It checklist to help us model what's happening in the phenomenon. Add the science term "model" to the Word Wall.	A-C	Music Lesson video, Science Ideas chart, chart paper, 6-×-8 sticky notes, 4 different color markers, tape
2	5 min	**CREATE INDIVIDUAL MODELS TO EXPLAIN WHAT IS SEEN** Individually model the path light travels to explain why the music student and adults can all see the student.	D	*Why do the music student and the adults all see the music student?*, 4 different colored pencils, tape
3	7 min	**CREATE A CLASS CONSENSUS MODEL TO EXPLAIN WHAT IS SEEN** Come to consensus about the path light travels to develop a model to explain why the music student and adults can all see the music student.	E-F	4 different colored pencils, large chart paper version of *Why do the music student and the adults all see the music student?*, 4 different color markers
4	7 min	**PROBLEMATIZE WHY THE STUDENT CAN'T SEE THE ADULTS** Rewatch the video as a class and prepare to model what happens when light from the Room A light source shines directly on the one-way mirror toward the adults.	G-H	Music Lesson video, large chart paper version of *Why do the music student and the adults all see the music student?*
5	15 min	**MODEL WHAT HAPPENS TO LIGHT THAT SHINES ON THE ADULTS** In pairs and then in a class Consensus Discussion, model what happens to light as it reflects off the adults in Room B and travels back to the one-way mirror.		pencil, 4 different colored pencils, *Why do the music student and the adults all see the music student?*, large chart paper version of *Why do the music student and the adults all see the music student?*, 4 different color markers
6	3 min	**NAVIGATION** Problematize that the student cannot see the adults even though light from the adults enters the student's eyes.	I	

End of day 1

Lesson 5 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide** **Student Work Pages**	• *Why do the music student and the adults all see the music student?* • 4 different colored pencils • tape • pencil		• Music Lesson video • Science Ideas chart • chart paper • 6-×-8 sticky notes • 4 different color markers • tape • large chart paper version of *Why do the music student and the adults all see the music student?*

Materials preparation (20 minutes)

Online Resources

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Check the Music Lesson video to ensure that it plays on your device and can be viewed by the whole class. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

If your class developed different modeling conventions for the amount of light (i.e., other than the dashed or dotted arrows) or ways to describe the materials, modify the key at the bottom of *Why do the music student and the adults all see the music student?* and the diagram on **slide D** accordingly.

Make a large version of *Why do the music student and the adults all see the music student?* on chart paper to use for class modeling. Include the two rooms, a light source, the one-way mirror, the people in both rooms, and your agreed-upon key with modeling conventions (your conventions may be different from those on *Why do the music student and the adults all see the music student?*).

Have 4 different color markers ready for use throughout this lesson for the class modeling including the two colors you used previously for the microstructure of the one-way mirror and two new colors to trace light that reflected off the music student and light that reflected off the adults.

Be sure you have the materials (e.g., markers, sticky note) ready to add the following word to the Word Wall: *Model*. Do not post this word on the wall until after your class has developed a shared understanding of its meaning.

Have the Science Ideas chart ready from the previous lessons.

Lesson 5 • Where We Are Going and NOT Going

Where We Are Going

In this lesson, students trace the path of light (1) as it leaves the light source in Room A and reflects off the music student toward the one-way mirror and (2) as it leaves the light source in Room A and travels directly toward the one-way mirror, transmitting through to reach the adults. Through tracing the path of the light that reflects off the student, they are able to explain why the student and the adults can both see the student. Through tracing the path of light that reflects off the adults, your students will realize that their explanation is not quite complete because some of the light that reflects off the adults enters the student's eyes. Your students will leave this lesson wondering why the music student doesn't also see the adults, because some light that has reflected off them is entering the music student's eyes.

This lesson focuses heavily on modeling with the purpose of progressing toward an explanation of the phenomenon. Students model the unseen path that light travels from the Room A light source and between the people and one-way mirror. They engage in argumentation about their models and make progress toward a full explanation of the phenomenon with their models.

Students have been engaging in the practice of modeling and using the language of models informally throughout the unit. At the start of this lesson, after reviewing the phenomenon and preparing to develop a model to explain what is happening, students earn the word "model" and add it to the Word Wall.

Where We Are NOT Going

Students will not yet unpack what happens when light enters the eye that causes us to see objects. That will happen in Lesson 6.

Lesson 7 focuses on developing an explanation using models. Students will use the model they develop in this lesson showing the path of light throughout the system, along with the model they develop in Lesson 6 showing what happens when light enters the eye, to develop a full explanation for the phenomenon in Lesson 7.

LEARNING PLAN FOR LESSON 5

1. Prepare to explain the Anchoring Phenomenon.

8 MIN

Materials: Music Lesson video, Science Ideas chart, chart paper, 6-×-8 sticky notes, 4 different color markers, tape

Rewatch the Music Lesson video, focusing on what is seen and not seen. Display **slide A** and watch the Music Lesson video located at **https://youtu.be/ocs6BXQPOgg**. Focus students with these prompts:

- **What is seen?** Why does the music student see themself? Why do the adults see the music student?
- **What is not seen?** Why can't the student see the adults?

Create a Gotta-Have-It Checklist to help model what is seen. Display **slide B**. Prompt students to share aloud what we need to include in our models to explain why the student sees themself and the adults also see the student. Remind students of the resources they can use to generate ideas for the checklist, such as the Science Ideas chart.*

Listen for and publicly record ideas such as these:

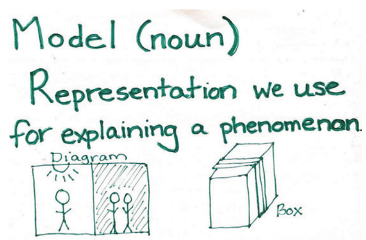
- light source in Room A and no light source in Room B
- light leaving the light source
- light reflecting off the music student
- one-way mirror between the rooms
- the structure of the one-way mirror material (e.g., half-silvered, silver structures, transparent structures)
- light reflecting off and transmitting through the one-way mirror material
- the student's and adults' eyes
- light from the student entering the eyes

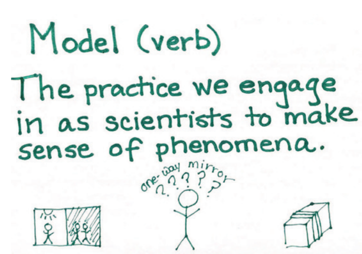
Add "model" as a word we earn to the Word Wall. Tell students, *Over the last few class periods, we have been trying to explain the one-way mirror phenomenon. We've been using the language "model" regularly, but we've never specifically defined models. We've used two types of models to help us with our explanations:*

- *Our box models are a physical representation that we've used to test different aspects of the phenomenon.*
- *Our diagrammatic models have helped us visualize and explain what is happening with light and the structure and function of objects like the one-way mirror, things that we can't see.*

Both types of models, or representations, help us explain the one-way mirror phenomenon. When we engage in representing for the purpose of explaining, we are modeling the world.

Show **slide C** and share and define the new science vocabulary for model as a verb and model as a noun. Write the word "model" on a 6-×-8 sticky note, along with its definition and a simple diagram. (See images at right.)





*** Supporting Students in Developing and Using Systems and System Models**
As students create the Gotta-Have-It Checklist, use a systems lens to help them include the parts of the system (e.g., light source, music student, adults, the one-way mirror and its structure) and the unseen interactions between those parts (e.g., the interaction between light and the music student, the interaction between light and the one-way mirror).

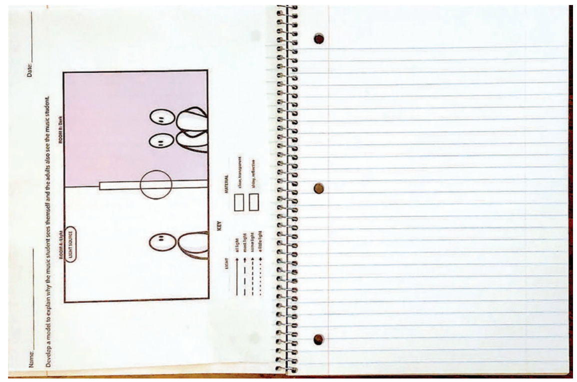
*** Supporting Students in Engaging in Developing and Using Models**
"Models" as a noun are representations of the world. "Modeling" as a verb involves students using a representation for a purpose: to explain a real-world phenomenon. A helpful heuristic is developing a "*model for*" making sense of a phenomenon, rather than developing a "*model of*" a phenomenon. If you find yourself asking students to make a representation or "model of" a phenomenon, but they aren't using those models for sensemaking, you may not be engaging them in the reasoning practice of modeling. For example, a common science activity is asking students to make

Place the two sticky notes on the Word Wall in the classroom and say, *I encourage you to use the word "model" whenever we are developing a representation of our thinking to explain the one-way mirror phenomenon or when we engage in the practice of modeling to explain the phenomenon.**

2. Create individual models to explain what is seen. 5 MIN

Materials: *Why do the music student and the adults all see the music student?*, 4 different colored pencils, tape

Individually model why all the people can see the music student. Display **slide D**. Remind students of the agreed-upon modeling conventions from Lessons 3 and 4. Distribute a copy of *Why do the music student and the adults all see the music student?* to each student. Give students time to individually model on the handout what happens to light as it leaves the light source, to explain why the music student and adults all see the music student.*



Have students tape the *Why do the music student and the adults all see the music student?* handout into their science notebook on a left-side page, leaving the right-side page blank. They will add another model to the right-side page in Lesson 6.

Assessment Opportunity

Building towards: 5.A Revise a model to explain the observable one-way mirror phenomenon caused by unobservable interactions between light, the people, and the one-way mirror, which reflects and transmits about the same amount of light.

What to look/listen for:

- Ideas from Lesson 2: The model represents how light travels from the light source in Room A and reflects off the music student.
- Ideas from Lessons 3 and 4: About half of the light transmits through the one-way mirror and the other half reflects back to the student.
- Ideas from Lesson 4: The structure of the one-way mirror is half-silvered, which allows about half of the light to reflect off the silvered structures and the other half to transmit through the transparent structures.
- Ideas from Lessons 2, 3 and 4: Light rays enter both the student's and the adults' eyes from objects that are seen.

What to do: Cue students to use their Progress Tracker and other resources from their science notebook or class consensus models to develop their individual model. If students struggle, help them break down the task into smaller components. Start with what happens when light leaves the light source and reaches the student. Next, have them model what happens when light reaches the one-way mirror. You can also have students turn and talk with a partner or small group prior to the individual modeling to help them generate ideas.

a model of all the parts of a cell. This representation is often not used to explain any real-world phenomenon, so they are simply developing a "model of" that system. However, if they developed that "model for" explaining how and why we get energy from food, they would be using their model to explain a real-world phenomenon. Units are designed to support students in developing models for making sense of phenomena.

*** Supporting Students in Engaging in Developing and Using Models**

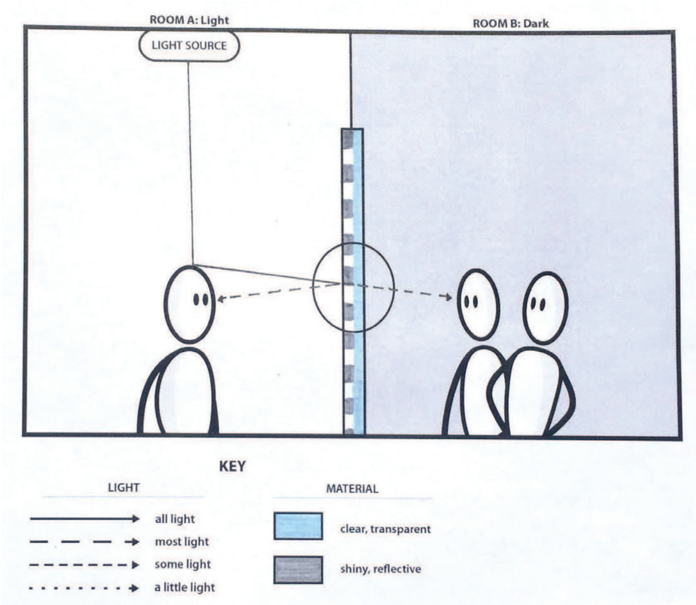
To emphasize the iterative process of modeling and revision, revisit the class consensus model from the end of Lesson 2 to frame this modeling task as an opportunity to revise our models to account for the new ideas we figured out in Lessons 3 and 4 about the structure and function of the one-way mirror.

3. Create a Class Consensus Model to explain what Is seen.

7 MIN

Materials: 4 different colored pencils, large chart paper version of *Why do the music student and the adults all see the music student?*, 4 different color markers

Have a Consensus Discussion to model what is seen. Display **slide E**. Facilitate a class discussion to reach consensus about the path that light travels starting with the light source.* Once students come to consensus, use the large chart paper version of *Why do the music student and the adults all see the music student?* to record their consensus ideas. Use two colors in this class consensus model to represent the microstructure of the one-way mirror material as agreed upon at the end of Lesson 4.



Here are suggested prompts for the discussion:

- How did you represent the path light takes when it shines on the music student?
- How did you represent the path light takes when it reflects off the student and reaches the one-way mirror?
- Why does the light interact with the one-way mirror in this way?
- How did you represent the path that light takes as it enters the student's eyes and the adults' eyes?
- Based on the arrows that you drew entering the student's and adults' eyes, what can they see?

Key Ideas

Purpose of the discussion: To make claims supported by some evidence about why the student and adults all see the student.

Listen for agreement about the following ideas:

- Some of the light that reflects off the student travels back to the student's eyes, and some transmits through the one-way mirror to the adults' eyes.
- About half of the light reflects off the silver structures back to student's eyes and the other half transmits through the transparent parts of the one-way mirror to the adults' eyes.
- Light that has reflected off the student enters both the student's and the adults' eyes. This is why they all see the student.

Motivate a need to color code arrows to keep track of the light. Display **slide F**. Say, *Light from the source is reflecting off a lot of other objects too. Let's consider what happens to the light when it reflects off those objects. To keep things easy to follow, I suggest we color the arrows after the light reflects off an object.*

* Supporting Students in Engaging in Argument from Evidence

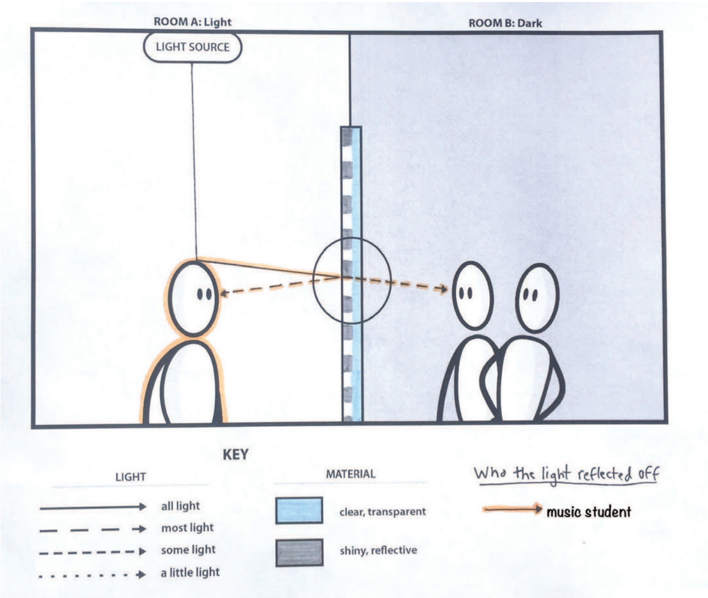
In this discussion, students are arguing for a model or parts of a model. While many students may be in agreement about what to include in the model, use this opportunity to push them to use evidence to support their ideas. Uncertainty or alternative ideas may still exist for some students, so talking through evidence can surface student thinking and facilitate coming to consensus. Here are example prompts:

- What evidence do we have to support that idea?
- Do you agree with the points being made? Why?
- How is that idea related to what we previously discussed?

* Attending to Equity

Universal Design for Learning: Use *representations* like color coding the objects that the light reflects off to foreground the connection between the path light travels and what people see. This becomes important later in this lesson when students add another set of arrows showing the light that reflects off the adults. If color coding is used, consider a color palette of orange, blue, black, gray, and dark brown so it can be seen by students who may be color blind (see example images).

Add color to music student and the arrows representing light reflecting off the student. Say, *Let's also use that same color to keep track of what the light does after it reflects off the student.* As a class, add color (the third color) to the arrows reflecting off the student. Update the key with the new color. Have students add color to their own models on *Why do the music student and the adults all see the music student?* using colored pencils.*



4. Problematize why the student can't see the adults.

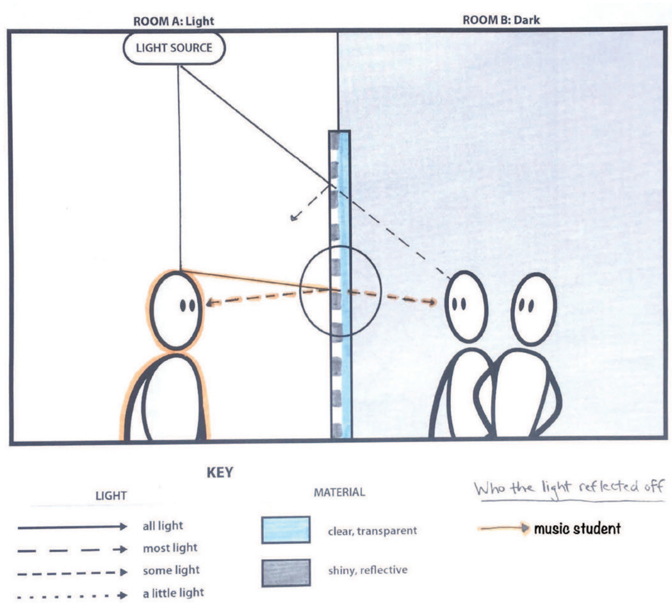
7 MIN

Materials: Music Lesson video, large chart paper version of *Why do the music student and the adults all see the music student?*

Problematize that the adults are lit up, but the student doesn't see them. Display **slide G.** Rewatch the video to notice that there is some light entering the dark room and that the adults are actually lit up.

Suggested prompts	Sample student responses
Where is the light coming from that lights up the adults?	*It's coming from the light source in Room A and transmitting through the one-way mirror.*
What happens when light from the Room A light source reaches the one-way mirror on its way to the adults?	*Some of it reflects back into Room A, and some of it transmits through to the adults.*

Model what happens when Room A's light source shines directly on the one-way mirror toward the adults. Display **slide H**. Ask for volunteers to add arrows to the class consensus model to represent what happens when light shines on the one-way mirror and transmits through to the adults. These arrows should not yet be colored because they are coming directly from the light source and haven't yet reached and reflected off the adults.



5. Model what happens to light that shines on the adults.

15 MIN

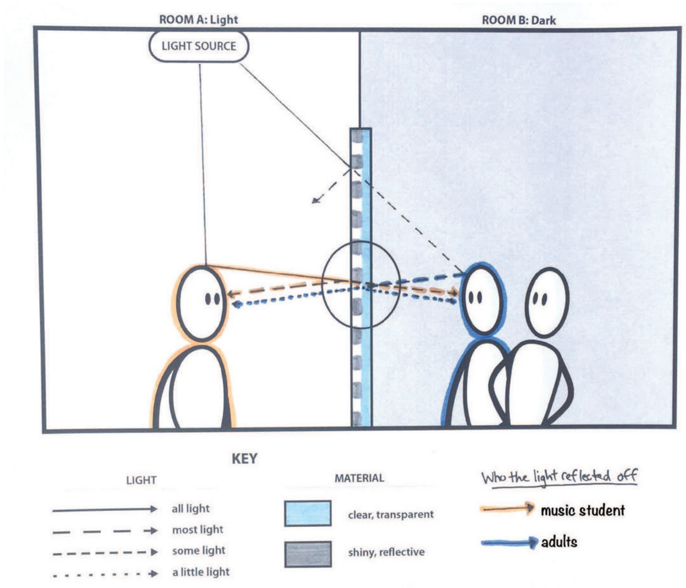
Materials: pencil, 4 different colored pencils, *Why do the music student and the adults all see the music student?*, large chart paper version of *Why do the music student and the adults all see the music student?*, 4 different color markers

Discuss in pairs where the light goes after it shines on the adults. Have students turn and talk with a partner to work out their initial ideas about what happens to the light *after* it shines on the adults. Encourage students to draft their ideas on their handout using pencil so they can easily revise their ideas later during the class discussion if needed.

Additional Guidance

If it is difficult for students to trace both (1) the light going directly to the music student and (2) the light going directly to the one-way mirror on the same sheet, give your students an extra copy of the handout. Have them model separately what happens to light that shines directly on the one-way mirror. After the discussion, they can add their ideas on their original model.

Lead a Consensus Discussion on what happens to the light after it shines on the adults. As a class, discuss ideas and add a new set of arrows to the class consensus model to explain what happens when light shines on the adults. Add a fourth color for this new set of arrows to keep track of what happens to the light once it reflects off the adults.



Key Ideas

Purpose of the discussion: To make claims supported by some evidence about the following ideas:

1. Some of the light that reflects off the adults transmits back through the one-way mirror to the student's eyes, and some of it travels back to the adults' eyes.
2. When light reflects off the adults to the one-way mirror, about half of that light reflects off the silver structures back to the adults' eyes and the other half transmits through the transparent parts of the one-way mirror to the student's eyes.
3. Light that has reflected off the adults enters the student's and the adults' eyes.
4. There is more light that reflects off the student than light that reflects off the adults entering the student's eyes.

Listen for agreement about the following ideas:

- Whenever light shines on the one-way mirror, about half transmits and half reflects.
- More light enters the student's eyes that has reflected off the student than light that has reflected off the adults.

Suggested prompts	Sample student responses	Follow-up questions
Where does the light go that shines on the adults?	*It reflects off them in all directions.*	
How can we represent that the light has reflected off the adults?	*Use a different color.*	*About how much light is reflecting off the adults? (some light)*
What happens when that light reaches the one-way mirror?	*Some reflects back at the adults, and some transmits.*	*About how much light is reflecting off and transmitting through the one-way mirror at this point? (a little)* *About how much of the light that has reflected off the adults enters the student's and the adults' eyes? (a little)*

Additional Guidance

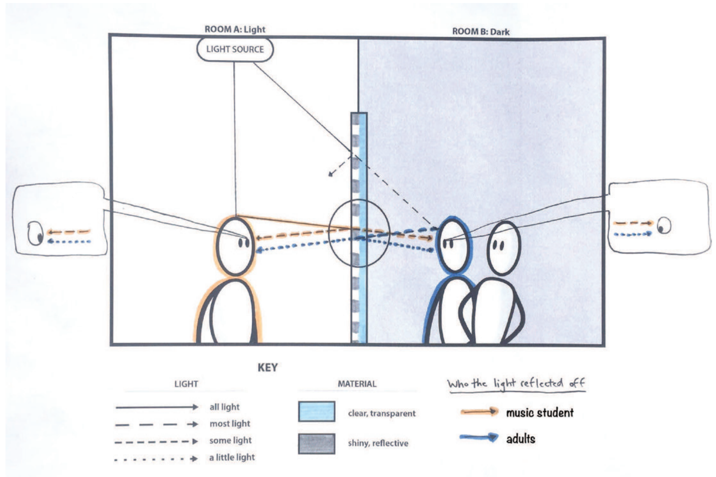
Be sure to emphasize that whatever amount of light reaches the one-way mirror, about half of that light will reflect and about half will transmit. So if there's a smaller amount of light hitting the one-way mirror, only about half of that light will reflect and transmit.

Zoom in on the eyes and consider the two light inputs. Discuss the following questions and add zoomed-in eyes to the class consensus model.

Suggested prompts	Sample student responses	Follow-up questions
What light is entering the student's eyes?	*Light that reflected off the student and light that reflected off the adults.*	*How much of the light that has reflected off each person enters the student's eyes?*
If we zoomed in on just the student's eyes, how could we represent these different amounts?	*Use our different arrows.*	
What light is entering the adults' eyes?	*Light that reflected off the student and light that reflected off the adults.*	*How much of the light that has reflected off each person enters their eyes?* *How could we zoom in and represent that?*

Update individual models based on the Consensus Discussion.

Once the class comes to consensus, give students time to update their handout with the revised class consensus model. Students will use this model in Lesson 7 to write explanations for the one-way mirror phenomenon.



6. Navigation

3 MIN

Materials: None

Share ideas for why the student cannot see the adults. Display **slide I**. Note that even though light that has reflected off the adults enters the student's eyes, the student does not see them.

Suggested prompts	Sample student responses	Follow-up questions
What would we expect the student to see, based on the light inputs to their eyes?	*We'd expect the student to themself and the adults, but maybe see themself a little more.*	*What does the student actually see?*
What do you think could be happening that the student is not seeing the adults?	*Maybe there's not enough light from the adults.* *Maybe the eye does something with the light. Maybe the brain is doing something with the light.*	

Additional Guidance

Lesson 6 will only focus on "Why doesn't the student see the adults?" for the sake of simplicity. However, students may recognize that light that has reflected off the adults also enters the adults' eyes, raising the question, "Why don't the adults see their reflection?" If students are curious about this, you can bring it into the discussion with additional questions:

- What would we expect the adults to see, based on the light inputs to their eyes?
- What do the adults actually see?

ADDITIONAL LESSON 5 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-Literacy.SL.6.1.a: Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.

When students are discussing models during the class discussions, encourage them to share the ideas they prepared during their individual or pair modeling work. Press students to share their rationale for their representations by asking for evidence from Lessons 2, 3, and 4 about light and the one-way mirror's structure and function.

LESSON 6

Why does the music student not see the adults?

Previous Lesson

We modeled interactions between light, people, and the one-way mirror to explain why the music student and adults can see the music student. We modeled how light from Room A's light source transmits through the one-way mirror, reflects off the adults, and enters the student's eyes. We wondered why the student doesn't see the adults.

This Lesson

Investigation

2 DAYS

We know different amounts of light enter the student's eyes from each side of the one-way mirror. Since light that has reflected off the adults enters the student's eyes, we wonder why the student can't see them. To figure this out, we obtain more information about what happens when light enters the eye. We watch a video and record what we notice. We wonder about the structure of the eye and how the eye and brain process light inputs. We model how light inputs transform into signals that the brain processes to tell us what we see. Then, we think about experiences from our everyday lives to help us explain what happens when there are two inputs of light and why we only "see" one input or "see" one input better than the other.

Next Lesson

We will develop a written explanation to answer the questions: (1) Why do the adults see the music student? and (2) Why does the music student see themself but not the adults? We will use self-assessment and peer feedback to revise our explanations. We will celebrate that we can fully explain the anchoring phenomenon.

Building Toward NGSS

MS-PS4-2, MS-LS1-8

What Students Will Do

6.A Ask questions to model the path of light as it travels through the lens of the eye, and to explain how the shape and composition of the lens causes the path of light to change directions (refract) before reaching the retina at the back of the eye.

6.B Develop a model that describes how the eye responds to (interacts with) different inputs of light and transforms those inputs to signals that travel along the optic nerve to the brain, which processes the signals into what we "see."

What Students Will Figure Out

- Light changes direction (refracts) when it travels between different transparent materials.
- When a light input is detected by sense receptors in our eye, it is turned into a signal that travels along the optic nerve to the brain, which processes it into what we see.
- When there are multiple inputs, the brain responds to the strongest signal.

Lesson 6 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Revisit the light inputs entering the music student's eyes and ideas for why the student cannot see the adults. Motivate the need to investigate what happens when light enters the eye.	A	Lesson 5 class consensus model
2	15 min	**TRACE THE PATH OF LIGHT AFTER IT ENTERS THE EYE** Watch a video that shows how the structures that make up the eye work together with the brain to enable us to "see" things. Record and share what we notice and wonder, then develop a model that traces a single light input into the eye.	B-C	Lesson 5 class consensus model, The Visual System: How Your Eyes Work video, chart paper, markers
3	23 min	**INVESTIGATE HOW A LENS FOCUSES LIGHT** Observe how light refracts when it passes through the lens of a magnifying glass. Compare observations with what happens when light passes through the lens of the human eye.	D-H	How Light Interacts with a Lens Investigation
4	2 min	**NAVIGATION** Motivate next steps to figure out why the music student only sees some of the light entering the eye but not light from the adults.		
				End of day 1
5	5 min	**NAVIGATION** Review what we have figured out and where we are going next.	I	
6	20 min	**USE EVERYDAY EXPERIENCES TO MAKE SENSE OF THE PHENOMENON** Observe everyday experiences that illustrate how the brain focuses on some inputs and not others. Leverage those experiences to develop group models.	J-P	colored pencils, *Why does the student see themself and not the adults?: Model Template*, tape, revised class consensus model from day 1
7	18 min	**CONDUCT A CONSENSUS DISCUSSION** Share group models during a Consensus Discussion and develop a class consensus model that explains why the music student can see themself but can't see the adults.	Q	chart paper, markers
8	2 min	**NAVIGATION** Summarize what we have figured out and share next steps.	R	
				End of day 2

Lesson 6 • Materials List

	per student	per group	per class
How Light Interacts with a Lens Investigation materials		• flashlight • magnifying glass	• flashlight • magnifying glass • laser light (optional) • chart paper • markers
Lesson materials **Student Procedure Guide** **Student Work Pages**	• science notebook • colored pencils • *Why does the student see themself and not the adults?: Model Template* • tape		• Lesson 5 class consensus model • The Visual System: How Your Eyes Work video • chart paper • markers • revised class consensus model from day 1

Online Resources

Materials preparation (20 minutes)

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Day 1 preparation

Check that the video, *The Visual System: How Your Eyes Work*, plays. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

An extension opportunity is offered if you have extra time and want your students to figure out and apply ideas about refraction to explain other everyday experiences. If you choose to complete the extension opportunity, be prepared to insert one or more activities from *Extension Opportunity: Refraction of Light Activities* after day 1 and before day 2. Note that some of these activities require additional materials and preparation.

Some states prohibit the use of lasers or laser pointers at the elementary and middle school levels. Check your state regulations. Provide students with laser protective eyewear if using the laser.

Follow these additional safety precautions when using a laser in the classroom:

1. Wear laser protective eye-wear during the setup, hands-on, and take down segments of the activity.
2. When using laser beams, put a caution sign at the door.
3. Remove all reflective items (watches, jewelry, etc.)
4. Before turning on the laser pointer, always be sure that it is pointed away from yourself and others.
5. Never look directly into a laser pointer.
6. Never direct a laser pointer at another person.

7. Remove all potential trip/slip fall hazards for darkened room movement.
8. Windows are covered with blinds, shades or other non-flammable barriers that reduce transmission of the beam.
9. Wash your hands with soap and water immediately after completing this activity.

Day 1: *How Light Interacts with a Lens Investigation*

Group size: 3-4 students

Setup:

- Gather the following materials for each small group: flashlight, magnifying glass
- Gather the following materials for the teacher demonstration: flashlight, laser light (optional), magnifying glass
- Check that the batteries in the flashlights are charged and installed correctly.
- Students will need their science notebook and a pencil to document observations.

Notes for during the lab:

- Darken the room as much as possible by closing any shades and turning off the lights. Some light from windows is OK. You can leave the classroom lights on until it is time to conduct the investigation.

Safety:

- Students should never look directly at bright light sources, even a flashlight. If using a laser, follow the safety precautions listed above. Inform students that even relatively small amounts of laser light can lead to permanent eye injuries. During this investigation, only the teacher handles the laser light.

Storage:

- All materials can be safely stored in a materials cabinet or closet.
- Remove batteries from the flashlights for long-term storage.

Lesson 6 • Where We Are Going and NOT Going

Where We Are Going

In the previous lesson, students figure out that two light inputs enter the student's eyes—a stronger input from the student's own reflection in the one-way mirror and a weaker input reflecting off the adults through the one-way mirror. This presents an opportunity for students to investigate why the student can't see the adults through the one-way mirror, even though light is reflected off the adults back to the student's eyes.

In this lesson, students learn how the eye and brain work together to process inputs of light. Students develop a number of important understandings about light and information processing, which help them figure out the phenomenon.

- Light that passes through the lens of the human eye is refracted and focused to a point on the retina at the back of the eye. Structures in the retina change the light input into an electrical signal that is transferred by the optic nerve to the brain, where this signal is processed into what we "see."

- When two (or more) inputs of light enter the eye and are sent to the brain as electrical signals, the brain attends to the stronger signal, which is why the student cannot see the adults.

Where We Are NOT Going

Refraction of light happens when light passes through the surfaces of different transparent materials. This lesson focuses on refraction through the lens of a magnifying glass, similar to the lens of the human eye, but does not include an in-depth investigation of refraction through a variety of transparent materials. *Extension Opportunity: Refraction of Light Activities* provides additional activities for students to further develop the concept of light refraction. These optional activities will require an additional day of instruction.

While in the process of figuring out why the student cannot see the adults, students might also recognize that some of the light reflected off the adults and into the one-way mirror also travels back into their eyes. This may prompt students to ask, “Why do the adults not see themselves in the one-way mirror?” This phenomenon is also explained by the structure of the one-way mirror and the way the eye and brain work together to process inputs of light, and it is addressed in an optional activity in Lesson 7.

1. Navigation

5 MIN

Materials: Lesson 5 class consensus model

Revisit what we figured out and our next steps. Display **slide A**. Point to the two light inputs into the student's eyes from the Lesson 5 class consensus model. Say, *We know two light inputs enter the student's eyes. We also know the one light input is stronger than the second. But we were left wondering why the student doesn't see the adults, because there is light reflecting off the adults into the student's eyes. What are some initial ideas about what could be happening to keep the student from seeing the adults?*

Partner students for a one-minute Turn and Talk. Reconvene the class for a brief sharing, using the questions on the slide and the follow-up questions below to surface students' thinking.

Suggested prompts	Sample student responses
What are some ideas for why the student does not see the adults?	*It's not enough light.* *It's less light from the adults.* *Maybe the eye needs a certain amount of light to see something.*

Say, *Let's keep these ideas in mind as we investigate the eye further. Let's make sure to circle back to them to decide why, if light from the adult enters the student's eye, the student doesn't see them.*

2. Trace the path of light after it enters the eye.

15 MIN

Materials: science notebook, Lesson 5 class consensus model, The Visual System: How Your Eyes Work video, chart paper, markers

Motivate figuring out what is seen. Say, *Let's start by figuring out what happens to light inputs once they enter the eye. To do this, we will watch a video and record what we notice and what we wonder about.*

Use **slide B** to guide students in setting up their science notebook to record noticings and wonderings.

Present the video. Tell students this video describes how our eyes work. Remind them to record what they notice and wonder as they watch the video. Let them know they will have a few extra minutes afterward to complete their Notice and Wonder chart.

Play the video, *The Visual System: How Your Eyes Work*. (See the **Online Resources Guide** for a link to this item. **www.coreknowledge.org/cksci-online-resources**)

When the video is over, give students about 3 minutes to finish recording their noticings and wonderings.

Share and record noticings and wonderings. Ask students to share what they noticed and what they wondered about as they watched the video. Document what they share on chart paper, asking for clarification as needed.

*** Supporting Students in Developing and Using Systems and System Models**
Use this opportunity to have your students reflect on the new system they are describing. Students may identify the eye as a system, the brain as a system, or the eye-brain system. Have students reflect on why it's helpful to describe the system we are working in, and how it can be useful to pay attention to interactions between systems, or subsystems within larger systems.

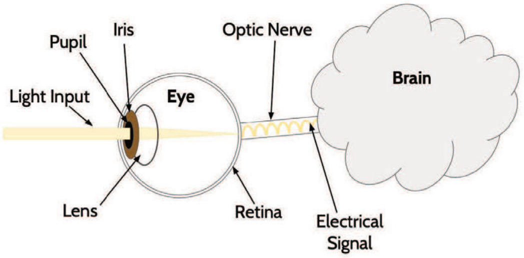
Summarize what we know to develop a class model. Show **slide C**. Tell students we now know more about what light does after it enters the eye. Suggest that we use these new ideas to develop a class model to explain what happens to light once it enters the eye for us to see objects. Explain that the model should show the path of light after it enters the eye and describe what happens from the time light enters the eye to the time the brain processes the signal. Work with students to develop the model on chart paper.

Additional Guidance

In this teacher guide, you will see refraction of light referred to as light "changing direction" instead of "bending." Describing light as bending may communicate to students that light curves. Unlike how a metal rod or a straw might bend, or curve, light does not. Rather, it travels in straight lines, but it can change direction as it moves between transparent materials, which makes it appear to bend. When discussing this concept, carefully choose how you will describe refraction. You can choose to use either "changing direction" or "bending," or both, but make sure you use language that will give students an accurate mental image of what light is doing as it moves through different transparent materials.

The class model should look similar to the image shown and include the following sequence of events:

1. Light enters the eye through the pupil to the lens.*
2. As the light passes through the lens, the lens causes the light to focus to a point on the retina at the back of the eye.
3. Structures in the retina change the light signal to an electrical signal.
4. The electrical signal travels from the retina to the brain along the optic nerve.
5. The brain processes the electrical signal and that is what we "see."



Additional Guidance

If students struggle with developing this model, you can guide them with a number of strategies:

- Students may need to watch the video a second time prior to modeling what happens to light after it enters the eye. This will give them a purpose for watching it again, and help guide their observations.
- To help students determine what should be included in the model, ask them to list the components or structures of the "visual system" described in the video. This could include a number of structures, the most important of which are the lens, retina, optic nerve, and brain. Students may want to list additional structures, such as the cornea, pupil, iris, and light-sensitive cells in the retina. These structures also play an important role in the visual system, but it is OK if students do not include them in the model. The goal is for students to focus on the structures most responsible for transforming light into electrical signals.
- If students did not notice that the light focuses to a point as it passes through the lens, show the video again and challenge them to identify when this happens.
- To help students describe the sequence of events after light enters the eye, refer back to the list of noticings recorded on chart paper. Students can most likely find and sequence the events that describe the process from within this list.

3. Investigate how a lens focuses light.

23 MIN

Materials: How Light Interacts with a Lens Investigation, science notebook

Note how light interacts with a lens. Say, *In the video, we observed light coming together to a point as it passed through the lens. We haven't accounted for anything like this before. We know light travels in straight lines, but this seems a little different. Let's make sure we understand how light is focused to a point on the retina at the back of the eye.*

Set up the science notebook. Use **slide D** to guide students to set up their next notebook. Hold up a magnifying glass for students to look at, and ask, *In what ways is the lens of the magnifying glass similar to the lens in the human eye?* Give students a minute to talk with their groups, then call on a few to share.

Suggested prompts	Sample student responses	Follow-up questions
In what ways is the lens of the magnifying glass similar to the lens in the human eye?	*The lens of the magnifying glass has a shape similar to the lens of the eye.* *Both lenses are transparent (clear) and allow light to transmit (pass through).*	*In what ways are the two lenses different?*

Preview the investigation procedures. Show **slide E** and walk students through the investigation procedures. Remind them to be prepared to share their observations with the class.

Arrange students in small groups and distribute their lab materials (magnifying glass and flashlight). When students are ready, turn off the classroom lights and give the groups about 10 minutes to work.

Safety Precautions

Prior to conducting this quick investigation, remind students that they should never look directly at sources of bright light, including a flashlight, and that even relatively small amounts of laser light can lead to permanent eye injuries. If a laser light is used, it should only be handled by you and following these additional precautions:

1. Wear laser protective eye-wear during the setup, hands-on, and take down segments of the activity.
2. When using laser beams, put a caution sign at the door.
3. Remove all reflective items (watches, jewelry, etc.)
4. Before turning on the laser pointer, always be sure that it is pointed away from yourself and others.
5. Never look directly into a laser pointer.
6. Never direct a laser pointer at another person.
7. Remove all potential trip/slip fall hazards for darkened room movement.
8. Windows are covered with blinds, shades or other non-flammable barriers that reduce transmission of the beam.
9. Wash your hands with soap and water immediately after completing this activity.

*** Strategies for this Building Understandings Discussion**

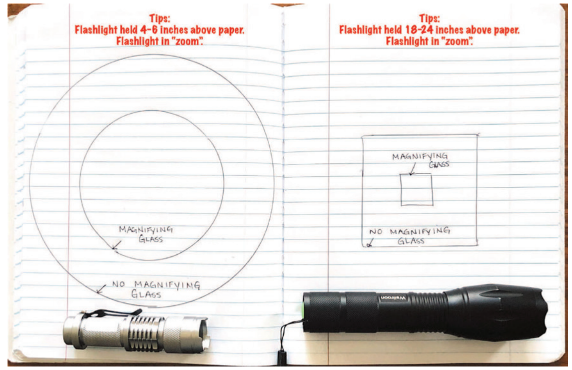
As students respond to the questions, encourage them to use their observations as evidence to support their thinking. The goals of this Building Understandings Discussion include:

- sharing observations
- connecting and building on the evidence and thinking of others
- describing what happens to light as it passes through transparent materials
- arriving at tentative conclusions about what happens to a light input when it enters the eye

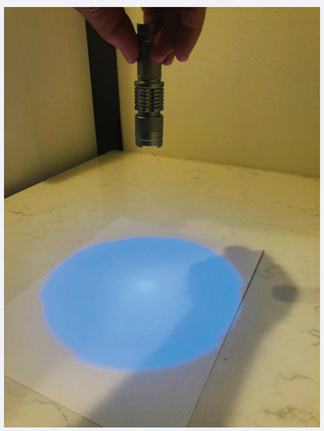
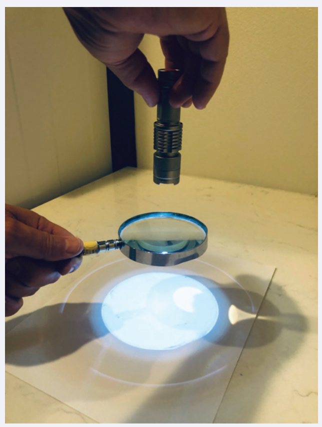
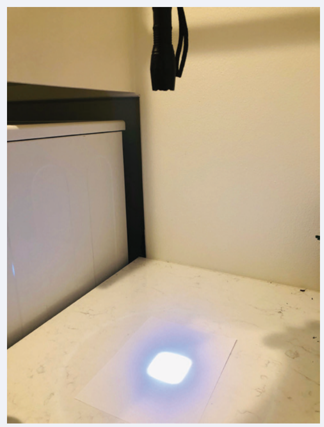
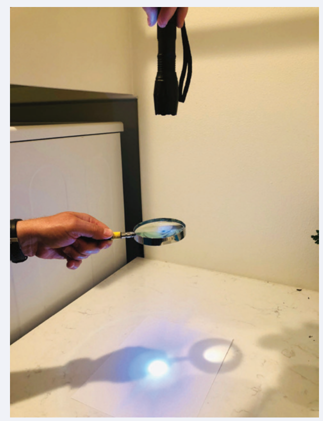
To help guide the discussion, invite students to share observations and encourage them to support their thinking with evidence from their observations.

Additional Guidance

When placing the magnifying glass between the flashlight and science notebook, students may or may not be able to get the light to focus into a point. They will, however, see the size of the beam decrease after transmitting through the lens. Changes in the shape and diameter of the beam depend on the flashlight used. The image shows examples of how students' drawings may differ accordingly.



Example observations are shown below.

Flashlight example #1		Flashlight example #2	
No magnifying glass	**Magnifying glass**	**No magnifying glass**	**Magnifying glass**
			

Conduct a Building Understandings Discussion. Conduct a Building Understandings Discussion.* Show **slide F** and use the questions on the slide to guide the discussion. Have a flashlight and magnifying glass handy for use during the discussion to help clarify students' ideas as needed.

Key Ideas

Purpose of this discussion: Give students opportunities to use evidence to compare what they observe when placing the magnifying glass in the path of light from the flashlight to what happens to light when it enters the lens of the human eye.

Listen for these ideas:

- A lens, like the lens of the human eye, changes the direction of (refracts) light so the light converges to a point.
- When light moves from the air and through a different transparent material, it changes direction (refracts).

(Optional) Demonstrate refraction with a laser light and magnifying glass. Only complete if safety precautions can be followed. While the room is still dark, further demonstrate refraction of light by shining a laser light through a magnifying glass onto a piece of paper below the lens. Students will see the thin beam of light change directions (refract) as it passes through the lens. As you move the laser to shine through different places on the lens, students will notice that the point of light on the paper moves very little. Ask students to imagine that the laser light is a single ray of light. Explain that multiple rays of light make up a beam of light, such as the beam from the flashlight. The shape of this lens changes the direction of each ray of light so all the rays in the beam end up focused to a point on the paper. This is what happens in the human eye. The rays of light that make up an input of light change direction as they pass through the lens of the eye and are focused to a point on the back of the eye.

Additional Guidance

This is a good opportunity to introduce the word "refract" as a word we encounter. Tell students "refract" is the science term for light changing direction when it passes through transparent materials, like the lens of the magnifying glass. If you complete the refraction activities in *Extension Opportunity: Refraction of Light Activities*, the term "refract" will become a word we earn and can be posted to the Word Wall at that time.

Develop a class consensus model. As students make sense of what they observed, use chart paper to draw a class model. Your model may look similar to the image shown.

Suggested prompts	Sample student responses	Follow-up questions
What happens when the magnifying glass is placed between the flashlight and the page?	*When we moved the magnifying glass into the path of light from the flashlight, the size of the circle of light changed—it was smaller.*	*What do you think is happening to the light as it passes through the lens of the magnifying glass?*
How does the magnifying glass and flashlight model compare to light entering the lens of the eye (the system we are modeling)?	*Both lenses cause the light to come together.* *The rays of light are changing direction and coming together.*	*What do you think will happen if we hold the flashlight higher (or lower), then move the magnifying glass up and down?*

After drawing a class model, show **slide G** and read the question aloud. Have students turn and talk to a partner about it, then ask a few to share with the class.

Suggested prompts	Sample student responses
What have we figured out about light transmitting through the lens of the eye?	*When light passes through a lens like the magnifying glass and the lens of the human eye, the light changes direction (refracts). We know this because the beam of light from the flashlight passes through the magnifying glass and comes together or focuses into a smaller circle.*

Summarize and record the class's science idea about refraction. As students verbalize what we have learned about the interaction between light and a lens like that of the human eye, add the following idea to the Science Ideas chart:

- Light changes direction (refracts) when traveling between different transparent materials.

Connect the model to why the student can see themself. Summarize this portion of the discussion by saying, *Now that we have a better understanding of what happens to light as it passes through the lens of the eye, let's use these ideas to describe what happens when light enters the student's eyes so that the student can see themself.*

Science Ideas

- Light travels in straight lines.
- For us to see an object, light must leave a light source, bounce off the object, and travel in a direct path to enter our eyes.
- When light shines on an object, it is reflected (bounces off), transmitted (passes through), or some combination of these depending on the (structure of the) object's material.
- A material can have different structures, even at a microscale, that cause different amounts of light to transmit through or reflect off of it
- Light changes direction (refracts) when traveling between different, transparent materials.

Additional Guidance

If your students need or want to learn more about refraction of light, three additional activities can be found in *Extension Opportunity: Refraction of Light Activities*.

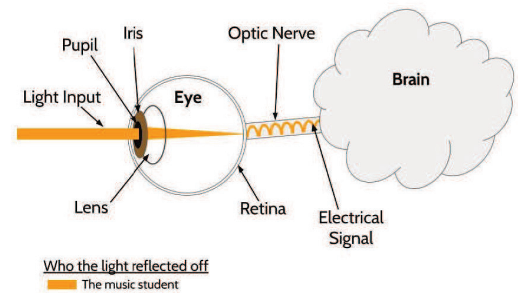
- Activity 1: *Refraction Reading* - a reading about everyday phenomena related to vision problems
- Activity 2: *Observing Refraction of Light* - additional reflection activities
- Activity 3: *Modeling Refraction of Light* - representing what happens when light refracts

If you choose to use these activities, the reading (Activity 1) should be assigned as home learning in preparation for the other two activities, which should be completed in class. Keep in mind that these will add an additional day of instruction.

Draw tentative conclusions. Show **slide H** and give students a few moments to read it. Tell them to work with their partner to apply what they have observed as evidence to describe what happens when light enters the student's eyes. Give them 3-4 minutes to talk, then call them back to the whole class and ask them to share.

Listen for the following description. As students share, use questions to surface missing steps in the process.

1. As the light passes through the lens, the lens causes the light to refract and focus to a point on the retina at the back of the eye.
2. Structures in the retina change the light signal to an electrical signal.
3. The electrical signal travels from the retina to the brain along the optic nerve.
4. The brain processes the electrical signal and the student sees themself.



Revise the class model to represent the light input into the student's eye. As students share, refer to the class model created after the video. Use the marker color that has been used to track the light reflecting off the music student to trace the light input and the electrical signal (orange in the example model). Add a key to indicate that the color represents the light that reflects off the music student.

Assessment Opportunity

Building towards: 6.A Ask questions to model the path of light as it travels through the lens of the eye, and to explain how the shape and composition of the lens causes the path of light to change directions (bend or refract) before hitting the retina at the back of the eye.

What to look/listen for: As students share what they have figured out about light that transmits through the lens of the human eye and draw tentative conclusions about what happens when light enters the music student's eyes, listen for students to share that:

- the shape and transparency of the lens of the human eye causes light to change direction (refract), and
- the refracted light is focused to a point on the retina at the back of the eye.

What to do: If students do not describe the lens of the human eye and how it refracts light and focuses it on the retina, you can surface that information in a number of ways:

- Ask students what we learned as we investigated how light interacts with the magnifying glass.

- Point to the class model and ask students to describe the role of the lens in processing the light that enters the eyes.
- Ask students to describe the similarities between the lens of the magnifying glass and the lens of the eye, and explain why those similarities were important to think about as we tried to figure out what happens to light when it enters the music student's eyes.

In addition, students will have opportunities to revisit these ideas if you choose to use the additional refraction activities in *Extension Opportunity: Refraction of Light Activities*.

4. Navigation — 2 MIN

Materials: None

Motivate next steps. Tell students, *We now know what happens to light inputs after the light enters the music student's eyes. We can describe how the light allows us to see things. Our next step is to figure out what's going on that the music student can't see the adults even though light reflects off them and enters the student's eyes.*

End of day 1

5. Navigation — 5 MIN

Materials: None

Revisit tentative conclusions and next steps. Show **slide I**. Have students turn and talk with a partner about the questions on the slide:

- What have we figured out so far?
- What are our next steps?

Give students 1-2 minutes to review what happens to light after it enters the eye. Transition by saying, *We know what happens to light so that we can see things. But we haven't yet explained why the music student can see one light input and not the other.*

6. Use everyday experiences to make sense of the phenomenon. — 20 MIN

Materials: science notebook, colored pencils, *Why does the student see themself and not the adults?: Model Template*, tape, revised class consensus model from day 1

Experience a related phenomenon. Use **slide J** to guide students in setting up their notebook. Have them record the lesson question, "Why does the music student not see the adults?" and draw a two-column Notice and Wonder chart. Instruct students to draw lines to create three rows on the chart and to number the rows. These will be used to document what they notice and wonder about three different sets of images.

Tell students they will observe three sets of images. For each set, they will have 2 minutes to record what they notice and wonder in their chart.

Show **slide K.** Say the flashlight was turned on in a well-lit room (Image A) and in a darkened room (Image B). Give students 2 minutes to record what they notice and wonder.

Show **slide L** and say the images are of the same cellphone with the same message on the screen. Image A shows the cellphone outside in bright sunlight, while Image B shows the cellphone indoors. Give students 2 minutes to record what they notice and wonder.

Show **slide M** and say the images are of the same tablet with a reading app open and set with a dark background.* Image A shows the tablet in a well-lit room, while Image B shows the same tablet in a dark room. Again, give students 2 minutes to record noticings and wonderings. If students need a little extra time to complete their chart, give them an additional 2 minutes after they have seen all three sets of images.

Share noticings and wonderings for the sets of images. Show **slide N** and ask students to turn and talk to a partner about the questions on the slide. Before calling on students to share their ideas, ask them to listen carefully for what is common among our shared ideas, because this will be important as they try to make sense of why the music student cannot see the adults.

Sample responses to the questions on **slide N** are below.

Suggested prompts	Sample student responses
When you look at each set of images, why do you think the object looks different in Image A than it does in Image B?	*When we look at Set #1, the flashlight in Image A is in a brightly lit room. The light from the flashlight is not as strong or as bright as all the light in the room. But, in Image B, the flashlight doesn't have to compete with any other light because the room is dark. So we only see the light from the flashlight.* *When we look at Set #2, it's hard to see the message on the cellphone in bright sunlight! In Image A, the sunlight is so much brighter than the light coming from the cellphone screen. But, in Image B, the indoor light is not as bright, so we can easily read the cellphone.* *In Set #3, the tablet in Image A is impossible to read because there is so little light coming from the screen and the light in the room is bright. In Image B, we see that the tablet's light is visible in a very dark room because there is no other light to compete with it.*
Have you had any experiences similar to these?	*When the headlights on my mom's car are on during the day, they don't light up the street in front of the car. But at night, the headlights really light up the street!* *When some of my teachers use the document camera in the classroom, it's easier to see what's under the camera when the room is dark than when it is bright.*

Discuss how the brain processes multiple inputs. As students share their observations and experiences, they should notice that all the image sets and the experiences we shared involve light. Show **slide K** and **slide L** and say that when light from a source like a cellphone or flashlight is competing with a brighter source of light, it is difficult to see the weaker light source (the cellphone or flashlight).

Ask students if they have any other experiences like these that are not based on light. For example, point out that the air conditioner (or heater) in the classroom turns off and on throughout the day, but we usually don't hear it. It's not that we can't hear it, we are probably just listening to other things going on in class.

* Attending to Equity

Students may or may not have personal experience using a reading app on a tablet at night, as not all students have access to the same technology at home. If you think this might be an issue, do not use **slide M** in this experience. Instead, you can

- eliminate row 3 in the Notice and Wonder chart on **slide J**, so students record noticings and wonderings for the sets of images on **slide K** and **slide L** only; or
- have students use the third row in the chart to record what they notice and wonder when observing the LCD projector's image on the screen in the classroom with the lights on and with the lights off.

* Supporting Students in Developing and Using Systems and System Models

If students struggle to revise their model, use systems thinking to guide them with questions such as these:

- What does your model need to explain or describe?
- What are the different systems you need to include in the model?
- What important components of those systems do you need to include in your model?
- What interactions do you need to represent?

Students may come up with other examples, such as these:

- When a television and a radio are both on at the same time, we usually only hear the one that is loudest or closest to us.
- We might not hear someone (like our mom or dad) calling us if we are watching TV.
- When we put a bite of very salty food in our mouth, it's hard to taste anything but the salt.
- We sometimes don't hear the doorbell when we are focused on homework.
- When someone in class wears really strong perfume or cologne, it's hard to smell anything else. Sometimes we get a headache from strong smells like that.

Determine our main takeaways. After a number of students have shared related phenomena, ask, *How can we summarize what we have learned?* Give students a few moments to think before asking a few to share. Listen for the following ideas to surface:

- Our senses (eyes, ears, and nose, for example) often experience more than one input from our environment.
- When there is more than one input, we usually focus on the strongest. This includes inputs of light, sound, taste, or smell.
- This doesn't mean the other inputs do not reach our brain, it just means we pay attention to only the strongest.

Summarize the discussion by saying that when there are multiple inputs into any of our senses, the brain filters out those that are weaker signals and pays attention to the signal that is the strongest.

Leverage what we have learned to develop a group model. Show **slide O** and use the questions to review the revised class consensus model from the end of day 1 (If you do not wish to use the image on this slide, delete the image and use your class model instead). Distribute 1 copy of *Why does the student see themself and not the adults?: Model Template* to each student.

Suggested prompts	Sample student responses
How many inputs of light enter the music student's eyes?	*We know two inputs of light enter the music student's eyes—light that reflects off the student to the one-way mirror and back to their eyes, and light that reflects off the adults and transmits through the one-way mirror to the music student's eyes.*
Which light input is stronger and which is weaker?	*The light input that reflects off the music student is stronger than the light input that reflects off the adults.*
Which light input is represented in our class model?	*Our class model shows only the input of light that reflects off the music student.*
We're talking about light reflecting off the music student and calling them "inputs". Using what you know about systems, why is this helpful to our thinking?	*Because the light is entering the eye so it's an input into something new. The eye is a new system.*

- How do the experiences you took part in help you revise our class model from day 1 so it explains why the student can't see the adults?

If students need more scaffolding, use the class consensus model from day 1 and ask questions like the following:

- What does the class model from day 1 represent?
- What do we need to add to this model to represent both inputs of light to the music student's eyes?
- Are the inputs of light the same strength?
- How might you represent the two inputs of light?
- What parts and interactions in the new eye-brain system do we need to include?
- How might you represent the electrical signals generated by the light inputs and sent to the brain?
- How might you represent what the student sees and doesn't see?

Display **slide P**. Tell students to discuss these questions with their group, then work together to develop a model on their handout that explains why the music student doesn't see the adults.* They can use colored pencils to layer new information onto the model. Encourage them to use the revised class model from day 1 to guide their work. Give them about 5 minutes to work. Have students attach their models on the notebook page opposite their Lesson 5 model.

7. Conduct a Consensus Discussion.

18 MIN

Materials: science notebook, chart paper, markers

Conduct a Consensus Discussion. Have students bring their notebook and a chair to a Scientists Circle.* Make sure they sit next to their group members.

Key Ideas

Purpose of this discussion: At this point in the lesson, students are ready to share their ideas and models regarding the lesson question: "Why does the student not see the adults?" This discussion allows students to share and to determine how we want to represent what we have figured out.

Listen for the following key ideas: These ideas should surface in this discussion and should be represented in the class consensus model:

- Two inputs of light enter the student's eyes.
- The input of light that has reflected off the student is a stronger input compared to the light reflected off the adults.
- Both inputs are refracted by the lens of the eye and focused on the retina, where they change into electrical signals.
- The two electrical signals are not the same strength.
- Both signals travel to the brain along the optic nerve.
- The brain responds to the stronger signal, which results in the student seeing themself and not the adults.

Share group models. Show **slide Q**. Use the questions to guide the conversation. Give groups 1-2 minutes to discuss the questions, then call on students from different groups to share their models and ideas.

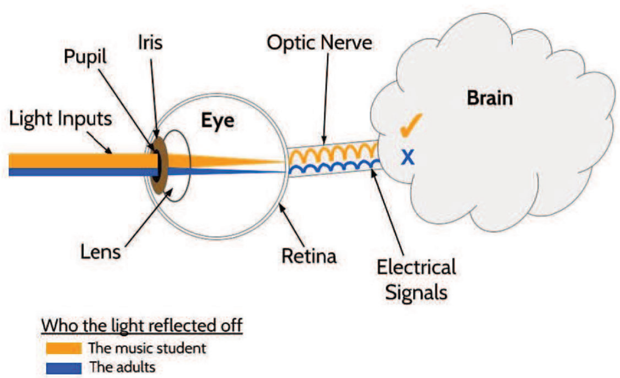
Suggested prompts	Sample student responses
What does your model need to explain?	*The model needs to explain why the music student can see themself but can't see the adults.*
What components did your group include in your model?	*We included the eye, the pupil and lens, the retina, the optic nerve, and the brain. We also included two light inputs into the eyes.*
How did you represent the two different light inputs into the student's eyes?	*We used different colors to represent the different inputs of light. One color showed light reflecting off the student. The other color showed the light reflecting off the adults.*

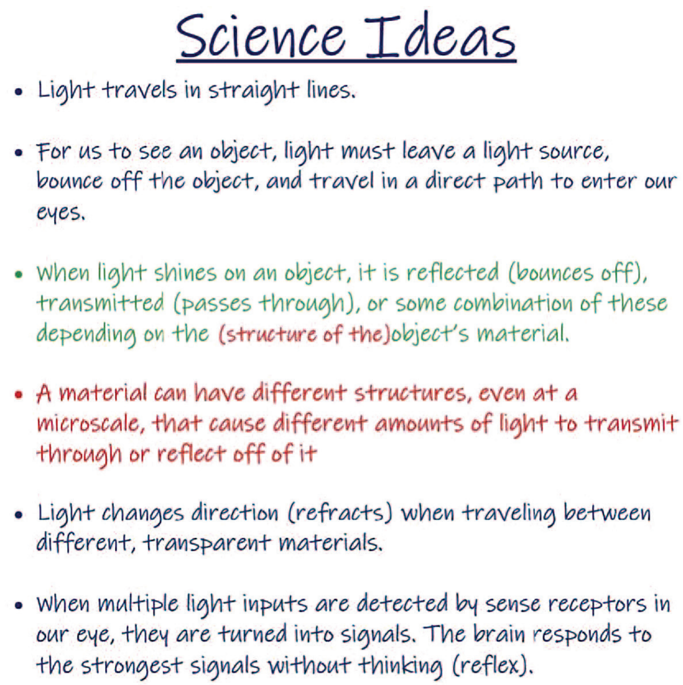
Suggested prompts	Sample student responses
How did you represent the two signals that travel to the brain?	*We represented the two signals as wiggly lines in the optic nerve.* *We used a thicker wiggly line to represent the signal from the light reflected off the music student, and we used a thinner wiggly line to represent the signal from light that reflects off the adults.*
How does the student's brain respond to the different signals it receives?	*The brain sees what comes from the stronger signal and it ignores the weaker signal.*

Construct a class consensus model. After students share their models work together to develop a class consensus model on chart paper.

After completing the consensus model, add the following science idea to the Science Ideas chart:

- When multiple light inputs are detected by the sense receptors in our eye, they are turned into signals. The brain responds to the strongest signal.





Assessment Opportunity

Building towards: 6.B Develop a model that describes how the eye responds to (interacts with) different inputs of light and transmits those inputs as signals along the optic nerve to the brain, which processes the inputs into what we "see."

What to look/listen for: Look for small-group models to accurately represent how the student's eye interacts with the light inputs. During the Consensus Discussion, listen for students to describe this interaction in their own words. Small-group models and students' descriptions should reflect the ideas outlined in the previous Key Ideas callout.

What to do: If small-group models do not accurately represent the ideas in the Key Ideas callout, use the strategies described in the Systems and System Models callout, as well as the questions on **slide Q**, to guide the Consensus Discussion and development of the class consensus model. In addition, you can print *Why does the student see themself and not the adults?: Model Template*, which includes an image of the model from the end of day 1. Students can revise the model on the handout during the small-group modeling task.

8. Navigation

2 MIN

Materials: None

Summarize our thinking. Show **slide R**. Have one or two students to summarize what they figured out. Close the lesson by saying, *We know a lot more about this phenomenon than we did at the start of our study. Let's use these ideas to explain how one-way mirrors work.*

ADDITIONAL LESSON 6 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-Literacy.SL.6.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.

There are numerous opportunities in this lesson for students to engage in discussions in pairs, small groups, and as a class. Some discussions are teacher-led, but not all. Guidance is included to help students share their experiences, express their own thinking, and build on the ideas of others as they work collaboratively to figure out the one-way mirror phenomenon. Additional strategies that can be used to help students include these:

- Strategically pair and group students.
- Provide numerous opportunities to respond to questions and share thinking (in pairs before class discussion, for example).
- Allow students to use drawings as well as writing to express ideas.

CCSS.ELA-Literacy.SL.6.2 Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.

In this lesson, students gather and interpret information from video, numerous images, and text, and they use that information as evidence to figure out how eyes process light inputs which are key to understanding the one-way mirror phenomenon. If students struggle to gather information from any of these formats, look for alternative ways to present information, such as paired reading of text, or utilize strategies that assist in gathering information, such as a graphic organizer or a close reading technique.

LESSON 7

Why do the music student and the adults see the music student but the music student can't see the adults?

Previous Lesson

We knew different amounts of light entered the student's eyes from each side of the one-way mirror, but we didn't know why the student cannot see the adults. To figure this out, we investigated what happens when light enters the eye and how the eye transforms light into signals that are sent to the brain. We think about personal experiences to help us explain what happens when there are two inputs of light and why we only "see" one input or "see" one input better.

This Lesson

Putting Pieces Together

1 DAY

In this lesson, we take stock of everything we've figured out by reviewing the class models from Lessons 5 and 6, the class science ideas list, and our individual Progress Trackers. As a class, we develop a written explanation to answer the question: Why do the adults see the music student? We individually draft an explanation to answer the question: Why does the music student see themself but not the adults? We self-assess our explanations and give and receive peer feedback on them. We then revise a final explanation. We celebrate that we can fully explain the anchoring phenomenon.

Next Lesson

We will investigate the best light conditions for the one-way mirror phenomenon to occur and conclude that there must be a large difference in light on both sides of the material. We will use this idea to investigate related phenomena. We will conclude that other materials, like glass and plastic, can act like a one-way mirror if there is a light differential. We will demonstrate what we have learned on an assessment. We will revisit the DQB to document the questions we have answered in the unit, and we will reflect on our learning.

Building Toward NGSS

MS-PS4-2, MS-LS1-8

What Students Will Do

7.A Construct and revise an explanation using a model to explain why an object appears different (effect) depending on the interaction between light and an object's material and how the brain processes signals (causes).

What Students Will Figure Out

We use the ideas we figured out in Lessons 1-6 to develop a full explanation for the one-way mirror phenomenon.

- The music student sees themself because light reflects off the music student to the one-way mirror and reflects back to their eye. This light input is the strongest signal that is processed by their brain.
- The adults see the music student because light reflects off the music student to the one-way mirror and transmits through the one-way mirror to their eyes. This light input is the strongest signal that is processed by their brains.
- The music student can't see the adults and they can't see their reflection because the light inputs from those objects are weaker and the brain doesn't respond to them.

Lesson 7 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	3 min	**NAVIGATION** Frame the work around developing an explanation for the one-way mirror phenomenon.	A	*Explaining the one-way mirror phenomenon*
2	8 min	**DRAFT AN EXPLANATION AS A CLASS** Review ideas from Lessons 5 and 6 class models, the Science Ideas chart, and entries in science notebooks. As a class, record a written explanation for why the adults see the music student.	B-C	*Explaining the one-way mirror phenomenon*, Science Ideas chart, Lessons 5 and 6 class models
3	7 min	**INDIVIDUALLY DRAFT AN EXPLANATION** Review ideas from class models, class Science Ideas chart, and entries in science notebooks. Individually, record a written explanation for why the music student sees themself but not the adults.	D	*Explaining the one-way mirror phenomenon*, Science Ideas chart, Lessons 5 and 6 class models
4	7 min	**INDIVIDUAL SELF-ASSESSMENT** Review the process for revising explanations and key elements for individual self-assessment. Individually self-assess and make notes about what to revise.	E-G	*Explaining the one-way mirror phenomenon*, *Self Assessment and Peer Feedback*
5	8 min	**PROVIDE PEER FEEDBACK** Review peer feedback guidelines and the key elements to include in the explanation. Provide peer feedback.	H-I	*Explaining the one-way mirror phenomenon*, *Self Assessment and Peer Feedback*, *Peer Feedback Guidelines*, 1 colored pencil
6	10 min	**DRAFT A REVISED EXPLANATION** Discuss how to respond to peer feedback and individually draft a revised explanation.	J	*Explaining the one-way mirror phenomenon*, *Peer Feedback Guidelines*, *Final explanation: One-way mirror phenomenon*, *Rubric Explaining the one-way mirror phenomenon*
7	2 min	**NAVIGATION** Celebrate that the class has explained the phenomenon.	K	
				End of day 1
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 7, students are ready to read Student Reader Collection 3 and then respond to the writing exercise.		Student Reader Collection 3: *Human Vision*

Lesson 7 • Materials List

	per student	per group	per class
Lesson materials **Student Procedure Guide** **Student Work Pages**	• *Explaining the one-way mirror phenomenon* • science notebook • *Self Assessment and Peer Feedback* • *Peer Feedback Guidelines* • 1 colored pencil • *Final explanation: One-way mirror phenomenon*		• Science Ideas chart • Lessons 5 and 6 class models • *Rubric Explaining the one-way mirror phenomenon*

Materials preparation (20 minutes)

Online Resources

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

The timing for this one-day lesson is very tight. In preparation for this lesson, aim to have students complete a first draft of their explanation, self-assess, and get peer feedback during the class period. The final revised explanation can be assigned for home learning.

Lesson 7 • Where We Are Going and NOT Going

Where We Are Going

In this lesson, students develop an explanation for the one-way mirror phenomenon. They draw on their knowledge building throughout the unit, including the Classroom Consensus Models from Lessons 5 and 6; the Science Ideas chart; their science notebooks with information from labs, readings, and videos; and their individual Progress Trackers.

This lesson focuses explicitly on constructing explanations. The practices of explanation and modeling are inextricably linked and, while students will use their models to construct explanations, they will not iterate on their models in this lesson. Instead, they will use the models they developed over the course of the unit to articulate an explanation. Students also will engage in the practice of argumentation by critiquing each other's explanations through peer feedback.

Cause and effect is used to help students articulate the different mechanisms that result in the one-way mirror phenomenon. In this case, students use cause-and-effect relationships to explain a phenomenon that occurs in a designed system.

Where We Are NOT Going

Students will not yet explain any of the related phenomena in the Self-Documentation Collection. This will happen in Lesson 8.

LEARNING PLAN FOR LESSON 7

1. Navigation

3 MIN

Materials: *Explaining the one-way mirror phenomenon*

Additional Guidance

The timing for this one-day lesson is very tight. In preparation for this lesson, aim to have students complete a first draft of their explanation, self-assess, and get peer feedback during the class period. The final revised explanation can be assigned for home learning.

Frame today's work around developing an explanation for the one-way mirror phenomenon. Display **slide A**. Share the two questions we'll be answering today in a written format:

1. Why do the adults see the music student?
2. Why does the music student see themself but not the adults?

Distribute *Explaining the one-way mirror phenomenon* with these two questions. Acknowledge that students made important progress toward this explanation through developing their models in Lessons 5 and 6 and that this activity will give them an opportunity to share their thinking by writing their explanation.

Additional Guidance

As written, this lesson will not answer the question: Why do the adults see the music student but not themselves? This question is not an obvious one in the context of the phenomenon. Students will use similar ideas to answer the question: Why does the music student see themself but not the adults? But students are not asked to consider why the adults do not see their own reflections. Consider adding this question for the following reasons:

- If your students were curious about this aspect of the phenomenon, and you chose in Lesson 6 to discuss and model this question.
- If you did not discuss and model this question in prior lessons, but you want to challenge students who have already met the performance expectation. In this case, students may not have modeled this part of the phenomenon, but they should be able to transfer ideas from modeling what the music student does not see to what the adults do not see.
- If you want an additional check to see if your students fully understand signal strength ideas.

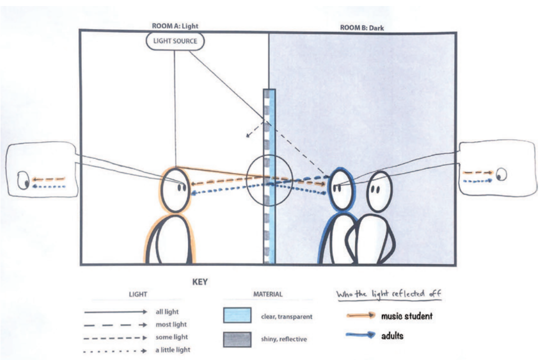
2. Draft an explanation as a class.

8 MIN

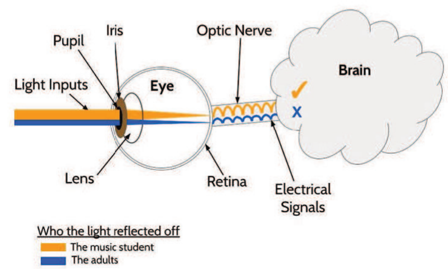
Materials: science notebook, *Explaining the one-way mirror phenomenon*, Science Ideas chart, Lessons 5 and 6 class models

Consider the ideas needed to answer question 1: Why do the adults see the music student? Display **slide B**. Give students a few minutes of quiet time to review the most important science ideas to answer just this question.

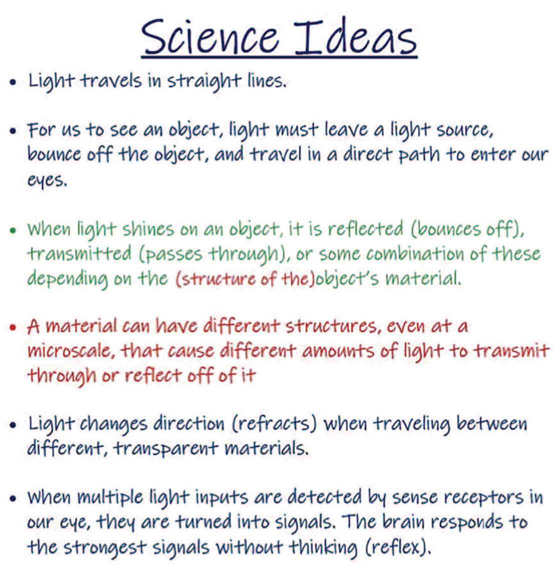
- the class models from Lessons 5 and 6
- the class Science Ideas chart
- students' individual Progress Trackers



Model from lesson 5



Model from lesson 6



Class Science Ideas chart

*** Supporting Students in Three-Dimensional Learning**

As you draft the class explanation, connect the practice of constructing explanations to the crosscutting concept of cause and effect. Specifically, call out that developing a how or why explanation (a mechanistic explanation) requires us to explain what causes the one-way mirror phenomenon, which is an effect we see. Encourage students to include multiple causes from the key science ideas list for the effect, including

1. how the half-silvered structure of the one-way mirror causes about the same amount of light to transmit through and reflect off the one-way mirror.
2. how the structure of the eye, nerves, and brain causes the brain to respond to one light input.

Share out a few key ideas and evidence to include in the explanation. Have a few students share out important ideas to include in the explanation.

Construct an explanation as a whole class using these ideas and evidence.* Display **slide C** to share sentence frames to start the explanation. Facilitate the class in constructing an explanation to answer the question: Why do the adults see the music student? Have students record that explanation on *Explaining the one-way mirror phenomenon* as their example of a scientific explanation.

Prompts to help the class develop a shared explanation include the following:

To solicit ideas about what science ideas to include in the how or why part of the explanation

- What important interactions between parts of the system do we need to include?*
  - Where does the light come from and go? Why?
  - What about the object, person, or material causes light to interact with it in this way?
- Are there additional causes for the one-way mirror phenomenon that we haven't accounted for yet?

To push students to back up ideas with evidence

- What evidence from our classroom investigations support this idea?
- How does this evidence support the science idea?

To invite support or critique

- Do we all agree with that?
- How could we modify what we have so that we account for the evidence we agree is important to consider?
- Who feels like there is an important science idea that is not quite represented here?
- Would anyone have put this point a different way?

Additional Guidance

Students may need additional support thinking through the important interactions that happen between parts of the system. When eliciting ideas to include in the explanation, prompt students to review the Lesson 5 model and name two parts of the system and the interaction between them.

Two parts	Interaction between the two parts
Light and the music student	Light from the light source reflects off the music student.
Light and the one-way mirror	About half the light reflects off the silvered parts of the one-way mirror and half the light transmits through the transparent parts of the one-way mirror.
Light and the adults' eyes	Light that reflected off the music student enters the adults' eyes.
The adults' eyes and their brains	Light inputs to the eye become signals that travel on the optic nerve to the brain.

Writing in Science

If your students need additional support for writing in science, consider using a document camera and as students share their ideas orally, modeling how to write the explanation. Have students record the class explanation on *Explaining the one-way mirror phenomenon* question 1 as a co-constructed model explanation to use as a resource when they write their own explanation individually.

If your students need less support for writing in science, consider discussing the explanation orally and then having students individually record an explanation for *Explaining the one-way mirror phenomenon* question 1.

1. Why do the adults see the music student?

The adults see the music student because light from the light source in Room A reflects off the music student, travels to the one-way mirror, and about half of that light transmits through the one-way mirror to Room B. That light enters the adult's eyes. Their eye translates the light input into a signal that goes through nerves to their brains. Their brains process the signal and register that they are seeing the music student.

Our evidence for this is in the Lesson 3 lab, we measured how much light transmits through the one-way mirror. We found that the one-way mirror is half-silvered which causes only about half of the light that shines on the one-way mirror to transmit through the transparent parts of it. In the Lesson 6 video, we got information about how light enters the eye. When it shines on the retina, the light input turns into a signal that goes along the optic nerve to the brain. The brain registers the signal as seeing the object, and it does this better when it is a strong signal.

Example written class explanation

3. Individually draft an explanation.

7 MIN

Materials: science notebook, *Explaining the one-way mirror phenomenon*, Science Ideas chart, Lessons 5 and 6 class models

Consider the ideas and evidence needed to answer question 2: Why does the music student see themself but not the adults? Display **slide D**. Give students a few minutes of quiet time to review any new ideas they need to answer this new question.

- the class models from Lessons 5 and 6*
- the class Science Ideas chart
- your individual Progress Tracker

Construct an explanation individually using these ideas and evidence. Give students time to record on *Explaining the one-way mirror phenomenon* a written explanation for question 2.*

Additional Guidance

If students struggle with what ideas to include in their explanation, support them in identifying important interactions that are happening between two parts of the system. Prompt students to review the Lesson 5 model and name two parts of the system and the interaction(s) between them.

Two parts	Interaction(s) between two parts
Light and the music student	Light from the light source reflects off the music student.
Light and the one-way mirror	About half the light reflects off the silvered parts of the one-way mirror and half the light transmits through the transparent parts of the oneway mirror.
Light and the music student's eyes	Some light that reflected off the music student to the one-way mirror, reflects back to enter the music student's eyes. A little light that reflected off the adults enters the music student's eyes.
The music student's eyes and their brain	Two light inputs to the music student's eyes become signals that go to their brain. The light input that reflected off the music student turns into a stronger signal than the light input that reflected off the adults.

*** Supporting Students in Engaging in Constructing Explaining and Designing Solutions**

Students use the class models from Lessons 5 and 6 to construct a first draft of an explanation for the one-way mirror phenomenon. If students get stuck, encourage them to review the models since they are helpful sensemaking tools for explaining the phenomenon.

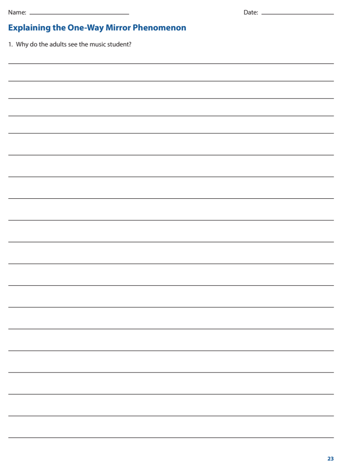
*** Attending to Equity**

Supporting Emerging Multilingual Learners: To support Emerging Multilingual Learners and/or other students who need additional support with writing in science, consider providing sentence starters. If the whole class needs support, consider posting a list of sentence starters on chart paper for everyone to use. If only some students need support, write sentence starters on strips and put them in an envelope that you can provide to individuals or groups of students who would benefit from the additional support.

Example sentence starters

- The music student sees themself because …
- My evidence for this is …
- I know this because …
- Light reflects when …
- Light transmits when …
- I see something when …

Materials: *Explaining the one-way mirror phenomenon, Self Assessment and Peer Feedback*


Name: ______ Date: ______

Explaining the One-Way Mirror Phenomenon

1. Why do the adults see the music student?

23

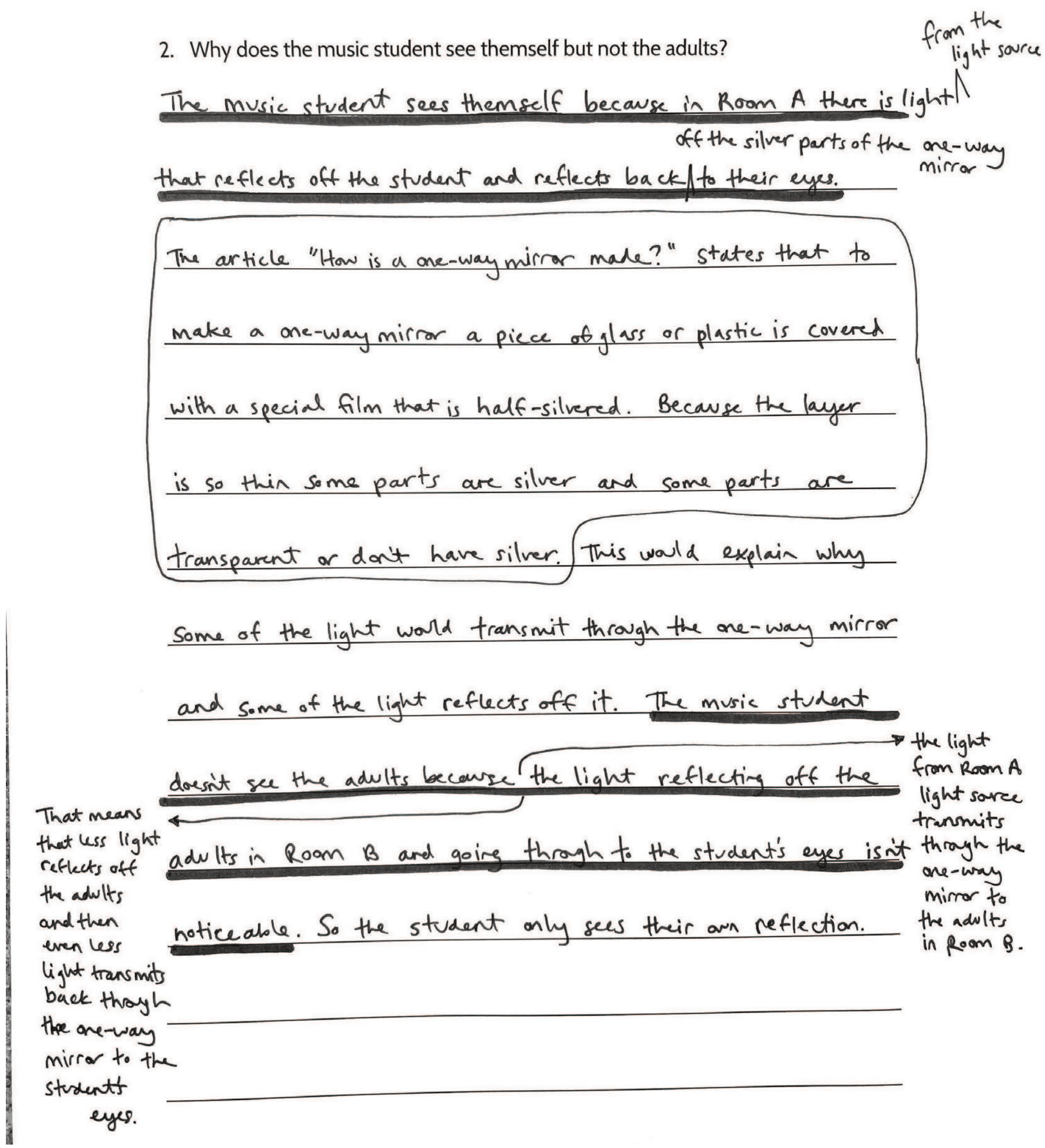
Provide an overview of the revision process. Display **slide E**. Explain that students will have a chance to self-assess their explanation first and then they'll engage in peer feedback. After all this feedback, they'll have an opportunity to revise their explanation.

Discuss the two key elements to individually self-assess explanations. Display **slide F**. Distribute 1 copy of *Self Assessment and Peer Feedback* to each student. Review as a class the two key elements of the explanation and the individual self-assessment task. Share instructions for how to self-assess using a pen or pencil.

- Underline places where you used key science ideas to explain how or why.
- Circle evidence that you used.

Discuss as a class how to note places to revise explanations. Display **slide G**. Explain that during the self-assessment, students should add notes directly to their explanation about what they want to revise. Tell students they'll have a chance to record a new written explanation at the end of class, so these notes do not need to be perfect.

Gives students time to self-assess and record notes about what to revise. While students self-assess their written explanations to question 2, circulate among the students and probe them for places where they could include additional science ideas, evidence, and description of interactions between parts of the system.


2. Why does the music student see themself but not the adults?

from the light source

The music student sees themself because in Room A there is light that reflects off the student and reflects back to their eyes.

off the silver parts of the one-way mirror

The article "How is a one-way mirror made?" states that to make a one-way mirror a piece of glass or plastic is covered with a special film that is half-silvered. Because the layer is so thin some parts are silver and some parts are transparent or don't have silver. This would explain why some of the light would transmit through the one-way mirror and some of the light reflects off it. The music student doesn't see the adults because the light reflecting off the adults in Room B and going through to the student's eyes isn't noticeable. So the student only sees their own reflection.

the light from Room A light source transmits through the one-way mirror to the adults in Room B.

That means that less light reflects off the adults and then even less light transmits back through the one-way mirror to the student's eyes.

Example first draft explanation with student self-assessment

5. Provide Peer Feedback

8 MIN

Materials: *Explaining the one-way mirror phenomenon*, *Self Assessment and Peer Feedback*, *Peer Feedback Guidelines*, 1 colored pencil

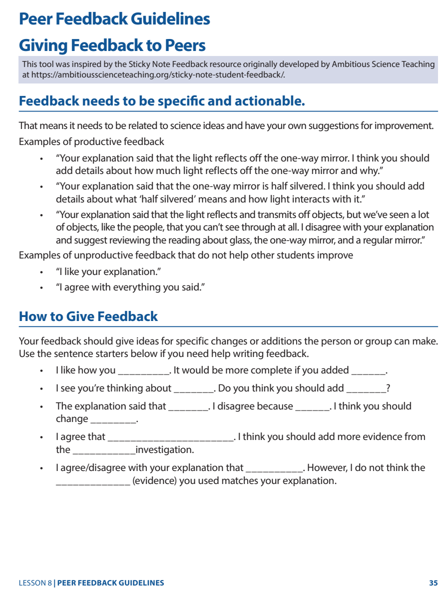
Discuss the two key elements to give peer feedback on. Display **slide H**. Review the "Peer feedback" column of *Self Assessment and Peer Feedback*. Review the two key elements of the explanation as a class. Share instructions for how to provide feedback.

- Underline places that explain how or why.
- Circle evidence that is used.

Discuss as a class how to provide useful feedback. Display **slide I**. Distribute 1 copy of *Peer Feedback Guidelines* to each student. Review elements of quality peer feedback. Give examples of productive and unproductive feedback. There is also a copy of the *Peer Feedback Guidelines* in the *Student Edition*.

Examples of productive feedback	Examples of unproductive feedback
"Your explanation said that the light reflects off the one-way mirror. I think you should add details about how much light reflects off the one-way mirror and why."	"I like your explanation."
"Your explanation said that light reflects off and transmits through objects. We've seen a lot of objects, like the people, that you can't see through at all. I suggest reviewing the reading about glass, the one-way mirror, and a regular mirror."	"I agree with everything you said."

Give students time to provide peer feedback to one person.* Have students swap their explanation with another student. While students provide peer feedback, circulate the class and probe students for places where they think their peers could include additional science ideas, evidence, and descriptions of interactions between parts of the system.



Peer Feedback Guidelines

Giving Feedback to Peers

This tool was inspired by the Sticky Note Feedback resource originally developed by Ambitious Science Teaching at https://ambitiousscienceteaching.org/sticky-note-student-feedback/.

Feedback needs to be specific and actionable.

That means it needs to be related to science ideas and have your own suggestions for improvement.

Examples of productive feedback

- "Your explanation said that the light reflects off the one-way mirror. I think you should add details about how much light reflects off the one-way mirror and why."
- "Your explanation said that the one-way mirror is half silvered. I think you should add details about what 'half silvered' means and how light interacts with it."
- "Your explanation said that the light reflects and transmits off objects, but we've seen a lot of objects, like the people, that you can't see through at all. I disagree with your explanation and suggest reviewing the reading about glass, the one-way mirror, and a regular mirror."

Examples of unproductive feedback that do not help other students improve

- "I like your explanation."
- "I agree with everything you said."

How to Give Feedback

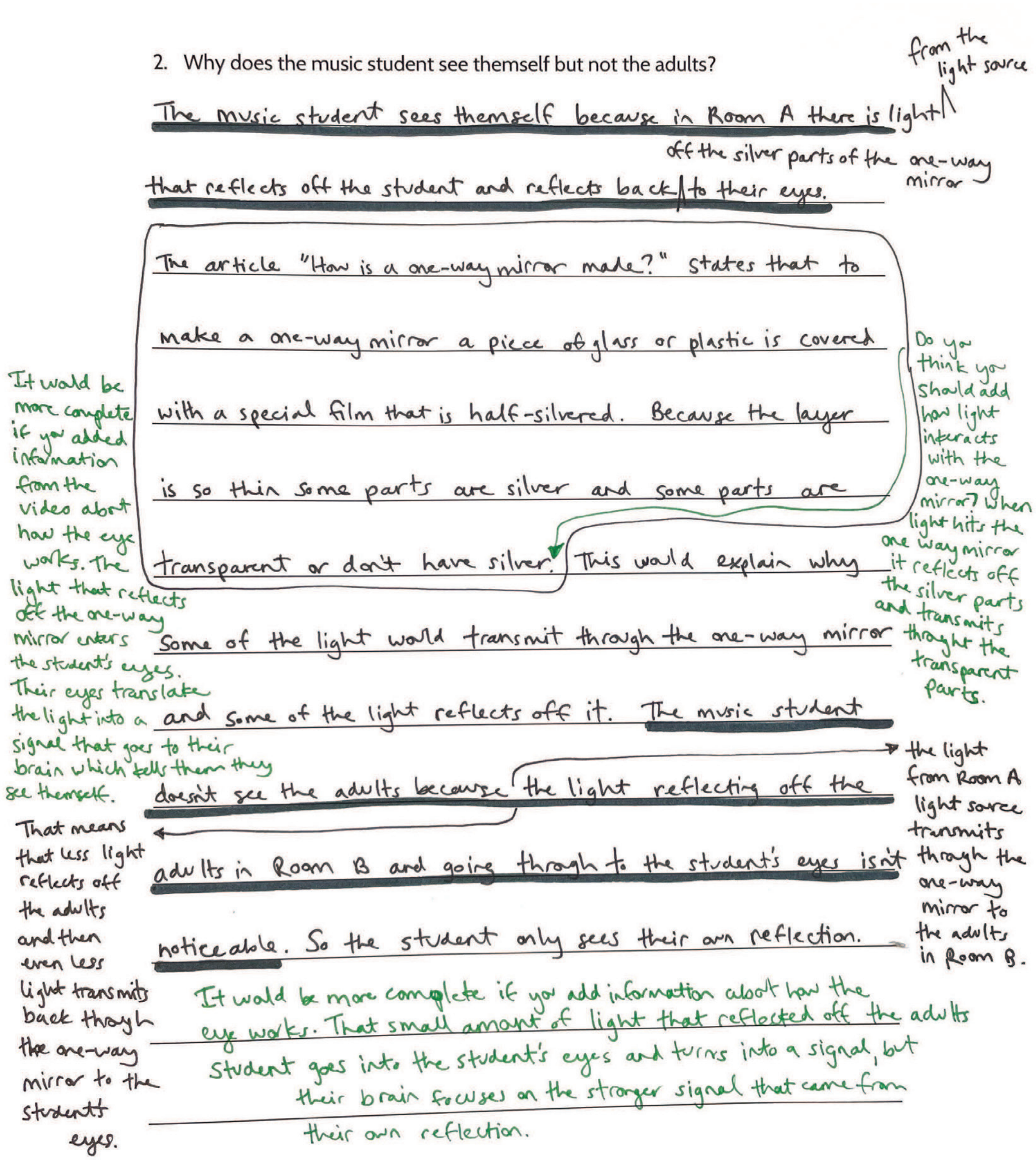
Your feedback should give ideas for specific changes or additions the person or group can make. Use the sentence starters below if you need help writing feedback.

- I like how you __________. It would be more complete if you added ______.
- I see you're thinking about ________. Do you think you should add ________?
- The explanation said that ________. I disagree because ______. I think you should change _________.
- I agree that _________________________. I think you should add more evidence from the ____________investigation.
- I agree/disagree with your explanation that ___________. However, I do not think the ______________ (evidence) you used matches your explanation.

LESSON 8 | PEER FEEDBACK GUIDELINES 35

* Supporting Students in Engaging in Argument from Evidence

Students respectfully provide critiques about each other's explanations, pointing out places where their peers have done a complete job and posing questions and offering suggestions for how to improve the explanation.



2. Why does the music student see themself but not the adults?

from the light source

The music student sees themself because in Room A there is light that reflects off the student and reflects back to their eyes.

off the silver parts of the one-way mirror

The article "How is a one-way mirror made?" states that to make a one-way mirror a piece of glass or plastic is covered with a special film that is half-silvered. Because the layer is so thin some parts are silver and some parts are transparent or don't have silver. This would explain why Some of the light would transmit through the one-way mirror and some of the light reflects off it. The music student doesn't see the adults because the light reflecting off the adults in Room B and going through to the student's eyes isn't noticeable. So the student only sees their own reflection.

Do you think you should add how light interacts with the one-way mirror? When light hits the one way mirror it reflects off the silver parts and transmits thought the transparent parts.

It would be more complete if you added information from the video about how the eye works. The light that reflects off the one-way mirror enters the student's eyes. Their eyes translate the light into a signal that goes to their brain which tells them they see themself.

the light from Room A light source transmits through the one-way mirror to the adults in Room B.

That means that less light reflects off the adults and then even less light transmits back through the one-way mirror to the student's eyes.

It would be more complete if you add information about how the eye works. That small amount of light that reflected off the adults student goes into the student's eyes and turns into a signal, but their brain focuses on the stronger signal that came from their own reflection.

Example of peer feedback on first draft explanation

6. Draft a revised explanation.

10 MIN

Materials: science notebook, *Explaining the one-way mirror phenomenon*, *Peer Feedback Guidelines*, *Final explanation: One-way mirror phenomenon*, *Rubric Explaining the one-way mirror phenomenon*

Discuss how to respond to peer feedback.* Display **slide J**. Review the second part of *Peer Feedback Guidelines*. Discuss how students take these steps when receiving feedback:

- Read the feedback carefully. Ask someone else to help you understand it, if necessary.
- Decide if you agree or disagree with the feedback and reflect on why you agree or disagree.
- Revise your work to address the feedback.

Individually draft a revised explanation and reflection on what was revised and why. Distribute a copy of *Final explanation: One-way mirror phenomenon* to each student. Give students time to write a new explanation, incorporating their own and the peer feedback. Remind students to explain one piece of feedback they used, one piece of feedback they didn't use, and why.*

Assessment Opportunity

Building towards: 7.A Construct and revise an explanation using a model to explain why an object appears different (effect) depending on the interaction between light and an object's material, and how the brain processes signals (causes).

What to look/listen for

- Idea from Lesson 2: Students explain how light travels from the light source in Room A and reflects off the music student.
- Idea from Lessons 3 and 4: About the same amount of the light transmits through the one-way mirror as reflects back to the music student.
- Idea from Lesson 4: The structure of the one-way mirror is half-silvered, which allows about the same amount of light to reflect off the silvered structures and to transmit through the transparent structures.
- Idea from Lessons 2, 3, and 4: Light rays enter both the music student's and the adults' eyes from objects that are seen.
- Ideas from Lesson 6: Light inputs to the eye are detected by sense receptors in the eye and turned into signals. When there are multiple light inputs, the brain responds to the strongest signal.
- Look for evidence that students have revised their explanation, based on their own and on peer feedback, by comparing the first draft and the revised explanation and reviewing their reflections on what feedback they used and didn't use.

What to do: Have students submit their revised explanation along with the first draft explanation that has their own revisions as well as peer feedback. If students struggle to include key science ideas, cue students to reference the class Science Ideas chart and their Progress Trackers. If students struggle to include evidence from investigations, direct them to their science notebooks to remember the evidence they gathered from Lessons 2, 3, 4, and 6. If students struggle to include all the interactions among parts of the system, encourage them to review the models from Lessons 5 and 6.

*** Supporting Students in Engaging in Argument from Evidence**

Students receive critiques about their explanations and respond to peer feedback and questions by determining how to add elaboration and detail and revising their explanation accordingly.

Use *Rubric Explaining the one-way mirror phenomenon* to assess students and provide feedback to them on their explanations and revisions.

Additional Guidance

If time is short, assign home learning to complete the revised explanation.

7. Navigation

2 MIN

Materials: None

Celebrate that we have explained the one-way mirror phenomenon. Display **slide K**. Celebrate the class accomplishments: the mission was to fully explain the music student and one-way mirror phenomenon, and we've accomplished that.

ADDITIONAL LESSON 7 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-Literacy.W.6.1: Write arguments to support claims with clear reasons and relevant evidence.
CCSS.ELA-Literacy.W.6.1B: Support claim(s) with clear reasons and relevant evidence, using credible sources and demonstrating an understanding of the topic or text.

CCSS.ELA-Literacy.W.6.2.b: Develop the topic with relevant facts, definitions, concrete details, quotations, or other information and examples.

When students are recording their first draft and revised explanations, they are writing an explanation, conveying their understanding of key science ideas, and drawing on evidence from investigations. While we are not yet using language of "claims", students are developing a how or why account for the phenomenon and backing up that explanation using evidence and reasoning from class investigations.

CCSS.ELA-Literacy.W.6.5: With some guidance and support from peers and adults, develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach.

Students revise and rewrite their explanation based on peer feedback.

SCIENCE LITERACY : READING COLLECTION 3

Human Vision

1 **Human Eyes**
2 **The Brain, Visual Decoder**
3 **Illusions and Mirages**
4 **Factoring in Refraction**

Literacy Objectives

- ✓ Summarize key points related to vision and light.
- ✓ Distinguish cause(s) and effect(s) related to vision and optical illusions.
- ✓ Develop original visual/graphic representation of ideas.

Prerequisite Investigations

Assign the Science Literacy reading and writing exercise *after* class completion of this lesson group:

- Lesson 4: How do similar amounts of light transmit through and reflect off the one-way mirror?
- Lesson 5: How do light and the one-way mirror interact to cause the one-way mirror phenomenon?
- Lesson 6: Why does the music student not see the adults?
- Lesson 7: Why do the music student and the adults see the music student but the music student can't see the adults?

Instructional Resources

Student Reader
Collection 3

Science Literacy Student Reader, Collection 3
"Human Vision"

Exercise Page
EP 3

Science Literacy Exercise Page
EP 3

Literacy Activities

- Read varied text selections related to the topics explored in Lessons 4–7.
- Evaluate the reading selections according to provided prompts and criteria.
- Compare and contrast information gained from reading text with information gained from class investigation.
- Prepare a meme in response to the reading.

Standards and Dimensions

NGSS

Disciplinary Core Ideas:
LS1.D: Information Processing Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories. (MS-LS1-8)

PS4.B: Electromagnetic Radiation The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends. (MS-PS4-2)

Science and Engineering Practice: Obtaining, Evaluating, and Communicating Information

Crosscutting Concepts: Structure and Function; Cause and Effect

CCSS

English Language Arts
RST.6-8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

RST.6-8.10: By the end of grade 8, read and comprehend science/technical texts in the grades 6-8 text complexity band independently and proficiently.

WHST.6-8.4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. However, these terms are not intended for isolated drill or memorization.

mirage **opaque** **refraction**

translucent **transparent**

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

context **electromagnetic** **intensity**

radiation

A Glossary at the end the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction.

1. Plan ahead.

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the assignment.
- Wednesday: Plan to touch base briefly with students in the middle of the week to answer questions about the reading, to clarify expectations about the writing exercise, and to help students stay on track.
- Friday: Set aside time at the end of the week to facilitate a discussion about the reading and the writing exercise.

You'll proceed with the next in-class lesson investigations during this week.

2. Preview the assignment and set expectations. (Monday)

- Let students know they will read independently and then complete a short writing assignment. The reading selection relates to topics they are presently exploring in their Light and Matter unit science investigations.
- The reading and writing will be completed outside of class (unless you have available class time to allocate).
- Preview the reading. Share a short summary of what students can expect.
    - *First, you will read a mock picture encyclopedia article about the human eye, its structures, and how it works.*
    - *Next, you'll read an interesting article about how the brain breaks codes, such as when you read, by identifying patterns and using context.*
    - *If you like optical illusions, you'll have fun learning how your brain interprets several images in this reading.*
    - *Lastly, you'll read a mock fishing blog entry explaining why the fish is not always where you think it is.*

- Distribute Exercise Page 3. Preview the writing exercise. Share a brief summary of what students will be expected to deliver. Emphasize that Science Literacy exercises are brief. The focus is on thoughtful quality of a small product, not on the assignment being big and complex.
    - *For this assignment you will be expected to generate a meme inspired by the readings in Collection 3.*
- Remind students of helpful strategies they can employ during independent reading. Offer the following advice:
    - *The reading should take approximately 30 minutes to complete.* (Encourage students to break reading into smaller sections over multiple short sittings if their attention wanders.)
    - *A good reading strategy is to scan through the collection first to see the titles, section headers, graphics, and images to see what the selections are going to be about before fully reading.*
    - *Next, "cold read" the selections without yet thinking about the writing assignment that will follow.*
    - *Then, carefully read the Exercise Page to understand the expectations for the writing part of the assignment.*
    - *Revisit the reading selections to complete the writing exercise.*
    - *Jot down any questions for the midweek progress check in class.* (Be sure students know, though, that they are not limited to that time to ask you for clarification or answers to questions.)

Exercise Page

EP 3

3. Touch base to provide clarification and address questions. (Wednesday)

Touch base midweek with students to make sure they are on track while working independently. You may choose to administer a midweek minute-quiz to give students a concrete reason not to postpone completing the reading until the last minute. Ask questions such as these, and have students jot answers on a half sheet of paper:

Suggested prompts	Sample student responses
How does the human eye let in more light in low-light situations?	*The pupil dilates.*
How does the brain decode words when the letters are all jumbled?	*It looks for patterns and uses context.*
What happens to a ray of light when it moves from air into water?	*The light is bent—or refracted.*

Ask a few brief discussion questions related to the reading that will help students tie the text content to students' classroom investigations.

Suggested prompts	**Sample student responses**
What is an example from class to support the idea that the brain makes decisions about information sent to it from the eyes?	*When people look at a one-way mirror, the brain has to ignore the reflected images so that it can concentrate on the images that are transmitted from the other side.*
Based on your investigations in Lesson 6, what can you infer the function of the eye's lens is?	*Like a magnifying lens, the eye's lens changes the direction of light as it enters the eye.* *Both make light converge to a point.*
Think about the reading about seeing the fish where it wasn't. How did you demonstrate in class that light that passes from one medium into another is refracted?	*We used a flashlight and a magnifying glass to show how light bends when it moves from the air into the glass and out again.*

- Refer students to Exercise Page 3. Provide more specific guidance about expectations for students' deliverables due at the end of the week.
    - *The writing expectation for this assignment is to create a meme that demonstrates your understanding of human vision in an entertaining way.*
    - *That means you'll show off what you have learned—but also your sense of humor.*
    - *Think about your audience as being other students in your school.*
    - *Look through the reading selections, and think about what ideas tie them all together—those are big ideas. Summarize one or more of those big ideas in your meme.*
    - *Play with your words in an amusing way, such as by making a pun.*
    - *While most internet memes have photos for the image, this assignment only requires a drawing. Drawing skill is not required—stick figures and simple outlines can work, too.*
    - *The important criterion for your meme is that it shows off your new understanding of vision and light with just a picture and a few words.*
- Remind students that many internet memes use foul language or are offensive in other ways. Their product must avoid this problem.
- Answer any questions students may have relative to the reading content or the exercise expectations.

Exercise Page

EP 3

4. Facilitate discussion. (Friday)

Facilitate class discussion about the reading collection and writing exercise. Students begin the collection with an image-with-text presentation describing human eye anatomy that reinforces the video they saw in class called "The Visual System: How Your Eyes Work."

Pages 24–28 **Suggested prompts**	**Sample student responses**
What is the general purpose of the first selection, "Human Eyes"?	*It describes the structures of the human eye and how each functions.*
How does the eye react to changes in the intensity of light?	*The iris muscles contract or relax to change the size of the pupil.*
Recall what you read about electromagnetic radiation in Collection 1. What part [section] of electromagnetic radiation affects rods and cones?	*visible light section*
What ideas did you have about using pictures or information about eyes for your meme?	*I've seen a lot of memes that show funny pictures of animal eyes.* *I thought about exaggerating some of the things eyes do, like bulging to show more sclera or making the pupils huge or winking one eye.*
What is the general purpose of the second selection, "The Brain, Visual Decoder"?	*It explains how the brain processes information from the eye using patterns and context to figure out what you are seeing.*
How did interacting with the examples in this reading affect your ability to understand it?	*It made it easier because it was more interesting and fun than it would be without the examples.*
How does this second selection help you build knowledge on top of what you learned in the first selection?	*The first article was mainly about how the eye works but said that the brain was involved, too. The second article gave details about how the brain interprets signals from the eye.*

The next two reading selections have to do with the brain seeing something more than is really there or different from what is really there.

Student Reader

Collection 3

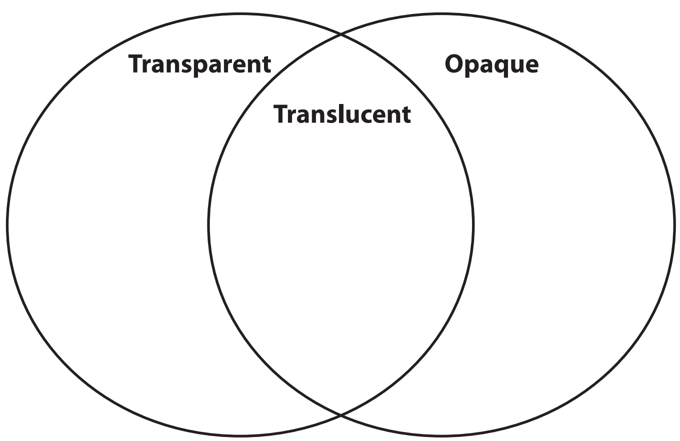
Online Resources

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

EXTEND—Students may enjoy trying to decode more examples of scrambled text—a phenomenon known as *typoglycemia*. Have them submit unscrambled text into website tools that do the scrambling for them according to a set of rules. Then students can share the puzzles with other students.

Pages 29–33 **Suggested prompts**	**Sample student responses**
What is the general purpose of the third selection, "Illusions and Mirages"?	*to explain that the brain doesn't always interpret things as they really are*
How do a person's memories affect what their brain sees?	*The brain tries to think of something it has seen before to decide what they are looking at.*
You know from your investigations that when light moves from a gas to a solid (such as from air to glass), it bends. Explain how a mirage is similar and different.	*Light is also bent to form a mirage, but the light is bent by moving from a gas of one temperature to the same gas of another temperature.*
What is the general purpose of the fourth selection, "Factoring in Refraction"?	*It describes a common fishing phenomenon and then explains why it occurs.*
What causes rays of light to bend?	*Their speed changes. If they hit the water at even very slightly different times, each ray will bend a little before another, and the result will be bending of an entire light beam.*
In the last paragraph, what does the author mean by "apparent image"?	*where the fish appears to be but really isn't*
What ideas for a meme did you get from this selection?	*I thought that the diagram of seeing the fish in the wrong place could have some text like "Things R not always what they seem."*

SUPPORT—Students building English vocabulary can be invited to collaborate in developing the Venn diagram shown below. Discuss with students how the diagram indicates that translucent materials have characteristics of both transparent and opaque materials. Have students list examples from the reading selections and their class investigations (or from natural observations) in each of the three spaces in the diagram.

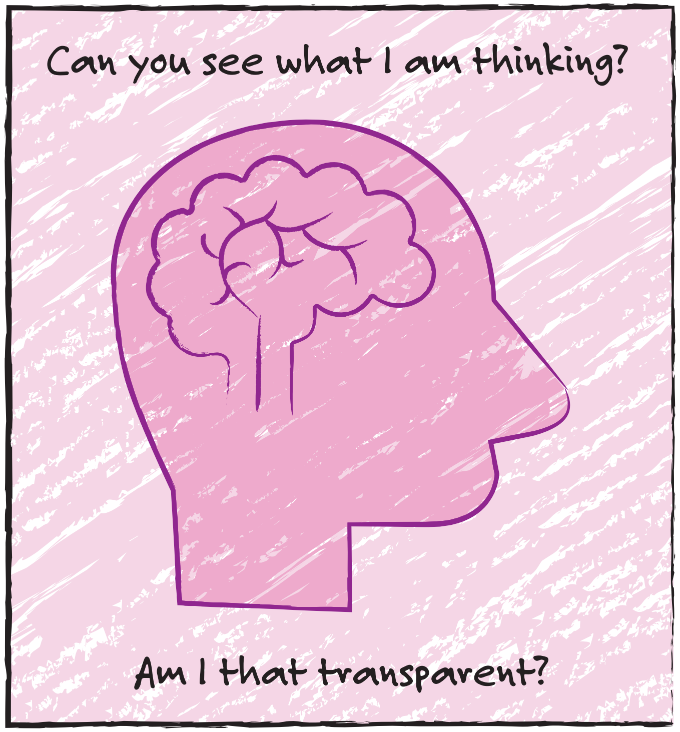


CHALLENGE—Challenge interested students to set up 3-D models to demonstrate how refraction of light changes what we see underwater. Students can search online for suggestions that show how to set up a model, gather materials, and allow classmates to use it.

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 3, students should create a meme that is inspired by what they learned about human vision in Collection 3. Students' memes should show their understanding that the brain works with the eyes to interpret reflected light and that the brain can be tricked into seeing things that are not quite as they exist. Look for students' use of vocabulary related to vision and light and wordplay such as puns. See the example shown.



Use the rubric provided on the Exercise Page to supply feedback to each student.

EXTEND—If students want to publish a digital version of their memes, allow them to use a drawing application, or point them to smartphone or online meme generators. Meme tools have templates students can edit and step-by-step directions for creating, downloading, and sharing their memes. Some allow animated GIFs or video clips instead of static images. Check the age requirements, content for vulgarity, and privacy policy of any tool before students use it to make sure it conforms with your school district's internet-use policies.

Online Resources

LESSON 8

Why do we sometimes see different things when looking at the same object?

Previous Lesson

We developed a full written explanation to answer the questions: (1) Why do the adults see the music student? and (2) Why does the music student see themself but not the adults? We used self-assessment and peer feedback to revise our explanations. We celebrated that we can fully explain the anchoring phenomenon.

This Lesson

Investigation, Putting Pieces Together

3 DAYS

We investigate the best light conditions for the one-way mirror phenomenon to occur. We decide that the effect is greatest when there is a large difference in light on both sides of the material. We use this idea to investigate related phenomena from our Self-Documentation Collection. We conclude that other materials, like glass and plastic, can act like one-way mirrors when there is a light differential on both sides of the material. We also figure out that objects that appear prominent to our eyes must mean more light is entering the eye from that object. We demonstrate what we have learned on an assessment. We revisit the DQB to document the questions we have answered in the unit and reflect on our learning.

Next Lesson

There is no next lesson.

Building Toward NGSS

MS-PS4-2, MS-LS1-8

What Students Will Do

8.A Use a model to describe how differences in light on both sides of a one-way mirror strengthen or weaken the one-way mirror phenomenon due to changing the components and interactions within and between systems.

8.B Apply science ideas and evidence from classroom investigations to explain a common, real-world phenomenon in which a material designed for light transmission and to look transparent to the eye and brain functions as a one-way mirror due to the relationship the material has to other parts in the system.

What Students Will Figure Out

- Differences in light on either side of an object or material can cause us to see different things when looking at the same object or material.
- The brighter or more prominent an object appears, the more light that reaches our eyes from the object.

Lesson 8 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	**NAVIGATION** Revisit our final model and identify that the difference in light on both sides of the material is important. Brainstorm ways to test light differences in the box model.	A	
2	8 min	**INVESTIGATION TO STRENGTHEN OR WEAKEN THE PHENOMENON** Have students work in small groups to make observations of the one-way mirror when there is a greater or lesser difference in light on both sides of the material.	B	Investigation to Strengthen or Weaken the Phenomenon
3	15 min	**FACILITATE A DISCUSSION ABOUT LIGHT DIFFERENTIAL** Work with the class to conclude that the greater the difference in light on both sides of the one-way mirror, the stronger the phenomenon. Use this idea to start examining related phenomena.	C-E	classroom consensus model (from Lessons 5 & 6), Related Phenomena list (from Lesson 1), Self-Documentation Collection (from Lesson 2), 6" x 8" sticky notes or 5" x 8" index cards, markers, tape
4	14 min	**CLOSER EXAMINATION OF GLASS IN THE BOX MODEL** Have students use the box model to test how to make glass act like a one-way mirror in certain light conditions.	F-G	Testing Glass in the Box Model Investigation
5	3 min	**NAVIGATION** Assign students to gather additional evidence at home by observing a window in their house under different light conditions.	H	
				End of day 1
6	15 min	**FACILITATE A CONSENSUS DISCUSSION** Have students share observations and conclusions about conditions that led to glass acting like a one-way mirror. Draw conclusions about how light interacting with objects and materials causes us to see different things.	I-K	Science Ideas chart, markers
7	30 min	**DEMONSTRATE UNDERSTANDING ON AN ASSESSMENT** Students individually demonstrate understanding on an assessment.	L-P	*Portraits Through Glass: Individual Assessment, Portraits Through Glass: Scoring Guidance, Extension Opportunity: Surface Scattering and Everyday Phenomena* (optional)
				End of day 2

Part	Duration	Summary	Slide	Materials
8	15 min	**REVIEW DQB QUESTIONS IN SMALL GROUPS** Have students work in small groups to evaluate questions from the DQB and decide if the class made progress on the questions.	Q	*Let's Answer Questions from Our Driving Question Board!*, Driving Question Board
9	25 min	**REVISIT OUR DRIVING QUESTION BOARD (DQB)** Students revisit the DQB and take stock of all the questions we've now answered.	R	*Let's Answer Questions from Our Driving Question Board!*, Driving Question Board, 3 colors of sticker dots, chart paper (optional), markers (optional)
10	10 min	**CELEBRATE AND REFLECT ON OUR EXPERIENCES** Students reflect on and then share what was challenging and rewarding about their learning experience in this unit.	S-T	*Let's Answer Questions from Our Driving Question Board!*, Driving Question Board, 3 colors of sticker dots, chart paper (optional), markers (optional) *End of day 3*
		SCIENCE LITERACY ROUTINE Upon completion of Lesson 8, students are ready to read Student Reader Collection 4 and then respond to the writing exercise.		Student Reader Collection 4: *A Closer Look at Light*

Lesson 8 • Materials List

	per student	per group	per class
Investigation to Strengthen or Weaken the Phenomenon materials		• 1 box model setup • 1 picture mat set with one-way mirror film • 2 flashlights (dimmable)	
Testing Glass in the Box Model Investigation materials		• 1 box model setup • 1 picture mat set with 8" x 8" glass • 2 flashlights (dimmable)	

Lesson materials **Student Procedure Guide** **Student Work Pages**	• science notebook • *Portraits Through Glass: Individual Assessment* • *Let's Answer Questions from Our Driving Question Board!*		• classroom consensus model (from Lessons 5 & 6) • Related Phenomena list (from Lesson 1) • Self-Documentation Collection (from Lesson 2) • 6″ x 8″ sticky notes or 5″ x 8″ index cards • markers • tape • Science Ideas chart • *Portraits Through Glass: Scoring Guidance* • *Extension Opportunity: Surface Scattering and Everyday Phenomena* (optional) • Driving Question Board • 3 colors of sticker dots • chart paper (optional) • markers (optional)

Materials preparation (20 minutes)

Online Resources

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Day 1 preparation. Do the following:

- Check batteries in flashlights and replace as needed.
- Be sure you have the materials (e.g., markers and paper, index card, or sticky note) ready to add the following word to the Word Wall: *system*. Do not post this word on the wall until after your class has developed a shared understanding of its meaning.
- See additional lab preparation.

Day 2 preparation. If possible, replace images on **slide J** with examples from around your school. One image should display looking into a darkened classroom from a brightly lit hallway. The other image should be taken from the same location, looking into a brightly lit classroom from a darkened (or relatively darker) hallway.

An extension opportunity is offered to you if you have extra time available and you want your students to explain additional related phenomena. This extension opportunity can also be offered to students who have already achieved the performance expectation. The extension opportunity will engage your students in explaining phenomena about shiny materials and mirror reflection. If you choose to complete the extension opportunity, be prepared to insert one or more of the activities from *Extension Opportunity: Surface Scattering and Everyday Phenomena* after the assessment on day 2 but before closing out the DQB on day 3. Note, some of these activities require additional materials and preparation.

Day 3 preparation. Prepare *Let's Answer Questions from Our Driving Question Board!* to include all questions from the DQB for students to work in small groups to identify which of the questions they can answer now.

Day 1: Investigation to Strengthen or Weaken the Phenomenon

- **Group size:** Group size will vary across the 6 box models depending on class size.
- **Setup:** Insert the picture mat set and one-way mirror film into each box model. Place the box models around the classroom to allow for students to make observations of the box models in small groups. Have two dimmable flashlights available to each group.

Day 1: Testing Glass in the Box Model Investigation

- **Group size:** Group size will vary across the 6 box models depending on class size.
- **Setup:** Modify each box model by inserting the 8″ x 8″ glass into the picture mat set to replace the one-way mirror film. Secure with tape and binder clips and insert into the box model.
- **Safety:** Ensure that the sharp edges of the glass are taped.
- **Storage:** Find a location where you can store the box models for future use (next year and beyond). Remove batteries from the flashlights.

Lesson 8 • Where We Are Going and NOT Going

Where We Are Going

The students explained the one-way mirror phenomenon in the previous lesson. In this lesson, students will use their understanding of the light conditions necessary for the one-way mirror phenomenon and their models (e.g., Science Ideas chart and diagrammatic models) to explain a set of their related phenomena, focusing specifically on situations when glass acts like a oneway mirror.

This lesson will help students apply science ideas from two DCIs in the contexts of related phenomena:

- PS4.B Electromagnetic Radiation: When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- LS1.D Information Processing: Each sense receptor responds to different inputs (electromagnetic, mechanical, chemical), transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.

The science ideas in these DCIs are necessary for explaining how glass, a material with different structural properties compared to the one-way mirror, exhibits a similar phenomenon as a one-way mirror when light conditions are just right. Students will connect the two DCIs to explain that the more pronounced the light differences are on both sides of the material, the greater the difference in light inputs into the eyes from objects and, therefore, in signal strength processed by the brain.

In examining related phenomena, students will draw parallels between the systems in which these phenomena occur and the system they investigated with the one-way mirror. They will articulate the new parts, interactions, and boundaries of these systems, which will help the class co-construct a definition for *system* to be placed on their Word Wall as a word we earn. Co-constructing this definition for system will be foundational for future learning in subsequent units. This is particularly true for establishing the idea of a boundary, so that in future system models students can bound systems that may be interacting with each other, and can pay attention to inputs and output from within or outside the system. Students will start to do a little of this kind of thinking in this lesson but may not be ready yet to add it to their definition for system.

Students will deepen their understanding of structure and function in two ways. First, they will consider how changing a structure in the system (e.g., going from a one-way mirror to glass) can result in similar functions of the materials even when the materials have different compositions. Second, they will consider how a structure in a system, like a glass window in a home, does not change over time, but its function in the system does change due to its relationship with light (e.g., sometimes the glass is transparent and sometimes it's like a mirror). Students talk about how glass is designed to serve a function of being able to see through it, but it can function differently depending on relationships to other things in the system.

Where We Are NOT Going

In this unit, students do not explain that when light interacts with matter, it is also absorbed. Students will engage with this idea in *Unit 6.2: How can containers keep stuff from warming up or cooling down? (Cup Design Unit)*, particularly Lesson 8. They will model how light's interaction with the particles that make up objects results in an energy transfer. If you plan to teach *Cup Design Unit* next, use **slide T** as a segue between the units. One-way mirror film is often used on the windows of office buildings and homes to slow down energy transfer into the buildings. Present this problem-solution to your students in anticipation of engaging them more deeply with light and energy transfer in the next unit. If you are not teaching *Cup Design Unit* next, consider using this related problem-solution when you do teach about energy transfer.

LEARNING PLAN FOR LESSON 8

1. Navigation

5 MIN

Materials: None

Focus students on light differences on both sides of the material.* Display **slide A**. Use probing questions to elevate the idea that there must be a difference in light in order for the one-way mirror phenomenon to occur.

Suggested prompts	Sample student responses
We have this special material that is half silvered. But it only seems to work in certain light conditions even when the material does not change. Let's remind ourselves, what are the light conditions needed for the one-way mirror phenomenon to occur?	*Light on one side, dark on the other side.*

*** Attending to Equity**

Supporting Universal Design for Learning: This lesson will focus on supporting student comprehension and maximizing their ability to transfer and generalize some of the science ideas they figured out in previous lessons (*representation*). Students will revisit the ideas they feel

Suggested prompts	Sample student responses
How could we change the light to make the one-way mirror phenomenon stronger or weaker?	*The bigger the difference in light on both sides, the stronger the effect. The less difference in light on both sides, the weaker the effect.*
*In the system that we've been investigating, how does changing light change our system?**	*It changes a part of the system.* *Light interacts with other things in the system like the one-way mirror, so changing light will change how it interacts with other things in the system.*

Say, *It seems like we are claiming that the difference in light on both sides of the material is important for the phenomenon and that maybe a greater difference in light leads to a stronger one-way mirror effect because we are changing how it interacts with the one-way mirror. Let's gather additional evidence to test whether our thinking is supported. How could we go about testing this idea?*

Elicit students' ideas, such as these:

- Make the light really different on both sides.
- Make the light more similar on both sides.
- Go from really different to really similar and observe how the one-way mirror phenomenon changes.

Say, *Let's test these ideas using the box model to see how changing the light on both sides of the material affects the strength of the one-way mirror phenomenon.*

Additional Guidance

Supporting Classroom Culture and Norms: In this lesson, focus on cultivating *Moving our science thinking forward* norms. In particular, hone in on *We challenge ourselves to think in new ways*. After Lesson 7, students may feel they have finished the unit because they explained the one-way mirror phenomenon. It's important to challenge their thinking to see if students can use the science ideas developed to explain the one-way mirror phenomenon in new contexts. Make this work explicit to students so that they understand the importance of pushing their thinking in new ways.

they know well, thus offering the opportunity for students to practice using those ideas in new ways. The lesson will offer the opportunity to generalize those ideas to new situations, but ones with a high degree of familiarity and relevance to all students. Students will never look at window glass the same after this lesson!

*** Supporting Students in Developing and Using Systems and System Models**

Take this opportunity to elicit from students how changes to the light will change the system they have been investigating. If students focus on changing the light as only changing a part of the system, challenge them to consider how the light interacts in the system and what may change in these interactions if the light were different.

2. Investigation to Strengthen or Weaken the Phenomenon

8 MIN

Materials: Investigation to Strengthen or Weaken the Phenomenon

Make observations using the box model. Display **slide B**. Arrange students in groups for investigations. Explain that they should use the two flashlights, which offer different levels of brightness, to test how the one-way mirror phenomenon is affected if there is a greater or lesser difference in light on both sides of the material. Students do not need their science notebooks and should be encouraged to orally discuss their observations as they make them using these questions:

- What light conditions led to the best one-way mirror phenomenon?
- What light conditions led to the worst one-way mirror phenomenon?
- What can you conclude about the relationship between light conditions and the phenomenon?

Dim the classroom lights and allow groups to conduct their investigations. It is expected that students will need minimal guidance for these investigations.* If students need more guidance, modify **slide B** to add specific situations to test, such as the following:

- Bright light on one side, no light on the other side
- Bright light on one side, dim light on the other side
- Bright light on both sides

Example images of what students may observe are shared below.

Room A: Bright light on Scooby Doo Room B: No light on monsters	Room A: Bright light on Scooby Doo Room B: Dim light on monsters	Room A: Bright light on Scooby Doo Room B: Bright light on monsters
		

*** Attending to Equity**

Supporting Universal Design for Learning: This quick investigation is intended to *engage* students in new ways of thinking about and exploring the phenomenon. By allowing for additional testing of ideas and giving the students independence and choice in how to test them, the investigation can promote active participation, exploration, and experimentation by the students.

Additional Guidance

This investigation should be brief and is intended to gather additional evidence to support students' thinking about the light differential and how the light differential affects what is seen. Do not spend a great deal of time making observations. Rather, prioritize the discussion from the observations that occurs next.

3. Facilitate a discussion about light differential.

15 MIN

Materials: classroom consensus model (from Lessons 5 & 6), Related Phenomena list (from Lesson 1), Self-Documentation Collection (from Lesson 2), 6″ x 8″ sticky notes or 5″ x 8″ index cards, markers, tape

Share observations and draw conclusions. Display **slide C**. Have groups share their observations from the box model investigation. After 3 or 4 groups share, focus the students on drawing conclusions from the investigation using the following three questions:

- What can we conclude about light conditions based on our observations?
- How does the difference in light on both sides of the material affect the light inputs to our eyes?
- How does changing a part within the system represented by the box model also change how light interacts with our eye and brain system?

Have the classroom consensus model close by for reference as students share how they changed parts of the system (e.g., the light sources), which affected how the light interacted with the one-way mirror. Challenge students to think about how this change in light interacting with the one-way mirror within the system led to different light outputs toward the eye. Then push students to articulate how those changes led to different light inputs into the eye and brain system.

Suggested prompts	Sample student responses
What did you observe about light conditions and the one-way mirror phenomenon?	*The phenomenon was the best when it was light on one side and dark on the other side. It was the worst when it was bright on both sides. It was weak when it was bright on one side and dim on the other side.*
What can we conclude about light conditions based on our observations?	*The greater the difference in light on both sides of the one-way mirror, the stronger the phenomenon. If the light difference is not that great, the phenomenon will be weaker or not be clear.*
How do the light conditions relate to the amount of light reflecting off objects and into our eyes?	*If there is a big difference in light, the amount of light from objects would also be really different. One light input will be a lot more, so we see it better. The other input would be less, so we don't see it as clearly.*
	If the light on both sides is more similar, then the amount of light from objects into our eyes will be more similar.
How does changing a part within the system represented by the box model also change how light interacts with our eye and brain system?	*When you make a greater light difference in the one-way mirror system, there is more light coming from one object and less from the other object. Then our eye detects more and less light from those objects.*

*** Supporting Students in Developing and Using Systems and System Models**
Students will be familiar with identifying the parts and interactions within a system based on their previous experiences with systems in grades 3-5. Use this opportunity to challenge what students know about systems as they work to determine the boundary of the new system in which these phenomena occur. The boundaries may be difficult to decipher because the important parts are not closely connected in space. For example, the Sun may be the light source in the new system. To push students even further, have them consider how the new system interacts with another system, such as the eye.

Suggested prompts	Sample student responses
	When the light difference is weaker there is about the same amount of light coming from each object to our eye and brain system. Our eye and brain system interprets these as about the same light, which changes what we see.

Assessment Opportunity

Building towards: 8.A Use a model to describe how differences in light on both sides of a one-way mirror strengthens or weakens the one-way mirror phenomenon due to changing the components and interactions within and between systems.

What to look/listen for

- Students agree that there is a one-way mirror phenomenon when there is a difference in light, but the greater the difference in light, the stronger the phenomenon.
- Students explain that changing the light on either side of the one-way mirror affects how light interacts with the one-way mirror (interaction within the system).
- Students agree that the greater difference in light on both sides of the one-way mirror leads to a greater difference in the amount of light reflecting off objects toward our eyes (outputs) (interaction between systems).
- Students explain that the phenomenon changes because the light coming from the one-way mirror system to our eye changes, resulting in different signals to the brains affecting what we see (interactions between systems).

What to do: If students do not immediately agree on these conclusions, help them order their observations from those with the clearest one-way mirror phenomenon to those with the least clear one-way mirror phenomenon. Record the strength of light (bright, dim, off) on the side that had a greater reflection versus the side that was easier to see through. Ask students to think about the light source(s) and how the light is reflecting off objects in the box model. Identify these as outputs from the system represented by the box model. Trace those outputs from the box to light inputs into our eye and brain system when we view the objects. Establish the importance of changing interactions within the one-way mirror system (light source and one-way mirror film), leading to different things seen (interaction between one system and another system).

Use the conclusion about light differential to examine related phenomena. Gather around the Related Phenomena list from Lesson 1 and Self-Documentation Collection from Lesson 2. Say, *We've figured out a lot about one-way mirrors, but this material is not commonly used. Yet, early on we saw a lot of related phenomena that we thought could be similar to the one-way mirror using common materials. Each of these phenomena is probably different in some ways than the one-way mirror, but they may have similarities too. Let's identify ones that have different amounts of light on either side of the materials and try to explain them using our model.*

Have students turn and talk to identify related phenomena with light differences. Display **slide D**. Cue students to turn and talk to discuss related phenomena from their collection that may be explained, at least in part, by light differences on both sides of the material.

* Attending to Equity

Supporting Universal Design for Learning: Support students in building their understanding of domain-specific vocabulary by clarifying the meaning of academic words and *representing* them in multiple ways. Allow students to use both content-specific and everyday registers (i.e., different in language formality) when expressing their ideas in order to co-construct an accurate definition of new vocabulary words using language accessible to students. Include a pictorial representation of the word.

Supporting Emerging Multilingual Learners: Teachers can provide additional support for emerging multilingual students by helping them link vocabulary words to definitions and pronunciations in both dominant and heritage languages**.**

* Supporting Students in Developing and Using Systems and System Models

This definition should reinforce their understanding from grades 3-5. If you are teaching this unit later in your school year and your students have developed more experience with systems and system models prior to this unit, add to this definition by including what your students know about inputs and outputs within a system and between interacting systems.

Share related phenomena. Reconvene the class to share examples of related phenomena that include light differences on either side of the material. Students may share examples like these:

- store, school, home windows
- sunglasses, goggles, eyewear
- tinted car windows

In each situation, use the following probing questions:

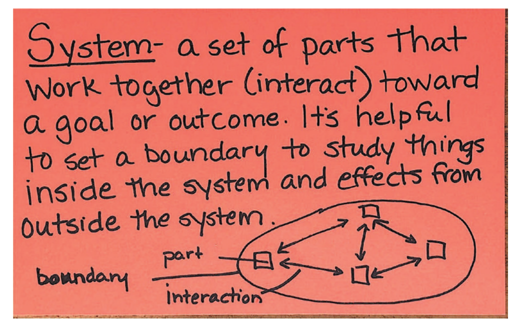
- Where are the differences in light in this situation?
- Where can people see their reflection? Why?
- What allows people to be able to see through the material?

Describe the systems in which these new phenomena occur.* Point out that when they investigated the one-way mirror phenomenon with the music student, they listed out the important parts and interactions of the system and decided that the boundary of the system was the walls of the two rooms. Display **slide E**. Ask students to turn and talk about the system in which one new phenomenon occurs, using these questions:

- What are the important parts?
- What are the interactions among those parts?
- How would you decide the boundary of the "system" in which this new phenomenon occurs?
- Is the new system interacting with another system, like our eye?

Elicit students' ideas about the systems and co-construct a definition to add to the Word Wall.* Ask a few partners to share what they know about the systems in which these new phenomena occur.

After a few partners share, help the class to define *system* for the Word Wall. Say, *We've been using this word,* system, *for a few weeks, but we've never defined what it means. Now that we know more, let's define what it means to us and use that in our science class going forward. As we learn more about systems this year, we can add to our definition.**



As the class articulates a definition, write the word on a 6" x 8" sticky note or 5" x 8" index card, along with its definition and a simple diagram. Place the sticky note (or index card) on the Word Wall in the classroom.

Example definition: A set of parts that work together (interact) toward a goal or outcome. To study a system, it's helpful to set a boundary and look at (1) how things work together inside the boundary and (2) effects from things outside the boundary.

4. Closer Examination of Glass in the Box Model

14 MIN

Materials: Testing Glass in the Box Model Investigation, science notebook

Compare glass windows to the one-way mirror. Point out that windows in homes, schools, buildings, and cars were related phenomena the students thought were similar to the one-way mirror, but none of them use one-way mirror film. Display **slide F**. Ask students to articulate some of the similarities and differences between windows and one-way mirror phenomena by considering the first question:

- What is similar or different about the one-way mirror and a glass window?

Similarities	Differences
See a reflection on one side, see through from the other side Bright light on one side, dark (or dimmer) light on the other side	Glass is transparent and transmits most light. One-way mirrors are half silvered and reflect about half the light and transmit about half the light. You can still see through the glass from the bright side if you look closely.

Use structure and function to compare glass to one-way mirrors. Continue to display **slide F**. Ask students to discuss the questions:

- How can a glass window that is designed to see through act like a one-way mirror even though it has a different structure?
- How could you test your ideas using the box model?

Prompt students to reconsider what they learned in Lesson 4 about the structure of glass compared to one-way mirrors. Use structural comparisons to create a sense of puzzlement, for example, by saying, *We know that one-way mirror film was structured to reflect over half the light, but glass is structured to transmit most light. So it seems weird that a material designed to transmit light is actually reflecting it.** Listen for students to suggest the following kinds of investigations:

- Change the material in the box model to glass.
- Test different light conditions to see which one makes the glass appear most like a one-way mirror.

Give students time to work in groups to test their ideas and record observations. Display **slide G** and preview instructions with students. Explain that the goal is to investigate the best conditions for glass to act like a one-way mirror. Arrange students in small groups, each around a box model. As they work, encourage students to record in their science notebooks the different conditions they test and their observations of the phenomenon.

*** Supporting Students in Developing and Using Structure and Function**

Throughout this lesson, students will deepen their understanding of structure and function in two ways: they will consider (1) how structures designed for different functions can function in similar ways depending on relationships to other parts of the system in which they are placed, and (2) how a structure, like a glass window, remains structurally the same, but functions in different ways due to its relationship with light. In this moment, help students work on number 1. To do this, explicitly point out that glass windows were designed to transmit light to be transparent, while one-way mirrors were designed to both reflect and transmit light. Use the difference in structures to create curiosity among students about how and why the two different materials designed for different functions, end up functioning in similar ways.

5. Navigation

3 MIN

Materials: None

Assign home learning. Display **slide H**. Ask students to make observations at home of window glass under different light conditions. Encourage them to make observations and take photographs (without flash), focusing on these questions:

- Can you see your reflection? How strong or weak is it?
- Can you see through? How much can you see through?
- What is the difference in light inside and outside?

End of day 1

6. Facilitate a Consensus Discussion. 15 MIN

Materials: science notebook, Science Ideas chart, markers

Share observations of glass in the box model and at home. Give students a minute to review their observations from the previous class and the ones they made for home learning. Display **slide I** and facilitate a sharing of observations in response to these questions.

- What did you notice when you tested glass in the box model?
- What did you notice when you observed a window at home at different times of day?
- In what light conditions did the glass act most like a one-way mirror?

Listen for students to share that the glass acted most like a one-way mirror when there was a great difference in light on both sides of it.

Additional Guidance

At this point in the unit, the class's diagrammatic model for explaining the one-way mirror phenomena reveals its limitations. If you use this model to explain how light interacts with glass, you will notice that tracing amounts of light (i.e., dashed and dotted arrows) does not hold up when the material is glass. Therefore, from this point forward, avoid having students trace the *amounts of light* as light interacts with different objects in the system. Instead, have students articulate what is seen clearly and prominently and use logic to draw conclusions about the amount of light reflecting off those objects into the viewer's eyes. For example, if an object is seen prominently, there is more light reflecting off the object into the eyes as opposed to the amount of light reflecting off an object that is more difficult to see.

Make sense of two common experiences through a Consensus Discussion.* Transition the class to a Consensus Discussion. Say, *It sounds like we have some good ideas about how glass functions like a one-way mirror in certain light conditions. Let's use our ideas to explain a couple of experiences we've all had around our school. This will be a good test to see if we can use what we've been learning about one-way mirrors to explain one of our related phenomena. I'm going to show you images taken from a school hallway looking into a classroom. Let's develop some explanations together for why we see what we see in each situation.*

Articulate the question about the phenomenon. Display **slide J** showing a view from a hallway looking into a brightly lit classroom and looking into the classroom when it is dark. Make sure all students understand the question we are asking about this new phenomenon: Why do we see different things when looking at the same object, like the classroom window?

Keep in mind the three parts to constructing scientific explanations to help guide your facilitation of this discussion:

- answering a question about a phenomenon
- providing a how or why account using science ideas and the model the class developed
- based on evidence

Likewise, help your students to use both system and system models and structure-function as useful lenses for explaining the new phenomenon.

*** Strategies for This Consensus Discussion**

- It is important that, as you write the suggested new science ideas on the Science Ideas chart, you ask everyone to weigh in on each proposed idea.
- It is also important for students to work on restating and rephrasing the ideas that you write down and to make sure each idea captures what everyone thinks are the essential pieces.
- Do not have students write these ideas. Have students work on listening and linking to the ideas that other people share.

*** Supporting Students in Developing and Using Structure and Function**

Now is the opportunity to work on the second use of structure and function: how a structure in a system, like a glass window, does not change structurally, but functions in different ways due to its relationship with light. Help students to identify that glass only functions as a one-way mirror in certain light conditions, so it is the interaction with light that allows it to function as a one-way mirror at certain times and as a regular window at other times.

Key Ideas

Purpose of this discussion: To explain common experiences with window glass (a new structure) using what we know about light interactions with materials within a system and how this affects the light input into our eyes (another system).

Listen for these ideas:

Areas of agreement

- The glass is designed to mostly transmit light, but in certain light conditions, glass reflects more light than is transmitted (evidence: investigations, images of and experiences with glass windows).
- Differences in light on either side of the glass can cause us to see different things when looking at the glass because there are different amounts of light reflecting off objects and entering our eyes.
- The brighter or more prominent an object appears, the more light that is given off by the object (output) reaches our eyes from the object (input). If an object is hard to see, there is less light that reaches our eyes from the object.

Assessment Opportunity

Building towards: 8.B Apply science ideas and evidence from classroom investigations to explain a common, real-world phenomenon in which a material designed for light transmission and to look transparent to the eye and brain functions as a one-way mirror due to the relationship the material has to other parts in the system.

What to look/listen for: See Key Ideas above.

What to do: Encourage students to utilize the Science Ideas chart and to reference ideas already on the chart or add to the chart as needed as they develop their how or why account for explaining the glass phenomena. Allow students to search for and reference evidence from previous lessons, though their personal experiences with this phenomenon outside of the classroom may constitute an important piece of evidence too.

Suggested prompts	Sample student responses
What do we notice is different in each scenario?	*The classroom is lit up in one image and dark in the other image.*
How do we think the classroom light compares to the hallway light?	*In the one image, the classroom light is really bright, probably brighter than the hallway. In the other image the hallway is probably brighter than the classroom.*
What science ideas can we use to help us explain how or why this happens?	*[Ideas may vary but should come from the Science Ideas chart and any new ideas the class agrees upon.]*
How do the different light conditions change how light is interacting with objects within the system? What about between the classroom system and our eye system?	*When there is a bright light in the classroom, it reflects off the objects in the room and into our eyes. When there is no light in the classroom, the hallway light is the main light source. It reflects off us, to the glass, and back to our eyes.*

Suggested prompts	Sample student responses
In the picture with the light on in the classroom, our reflection is not very prominent or we can't see it at all, but when the classroom is dark it becomes more prominent. What does this tell us about light entering our eyes from objects in the system?	*If we see an object really well, there must be light entering our eyes and our brain processing the signal. If we can't see it very well, the signal is probably weaker from that object.* *When the light is on in the classroom, the light reflecting off of us to the glass and back to the eyes is less than the light transmitting through the glass from inside the classroom. When the light is off in the classroom, then the light reflecting off of us to the glass and back to the eyes is the stronger input.*

As the discussion unfolds you will need to be prepared to record new science ideas the class agrees upon as they explain the glass phenomenon. Display **slide K** if needed. These new science ideas may include something similar to the following ideas, though wording can vary as your class co-constructs the ideas:

- Differences in light on either side of an object or material can cause us to see different things when looking at the same object.
- The brighter or more prominent an object appears, the more light that is reaching our eyes from the object.

7. Demonstrate understanding on an assessment.

30 MIN

Materials: *Portraits Through Glass: Individual Assessment*, *Portraits Through Glass: Scoring Guidance*, *Extension Opportunity: Surface Scattering and Everyday Phenomena* (optional)

Introduce the assessment. Say, *In this unit, we've figured out how a one-way mirror works through examining how light interacts with materials and how our eyes and brain process light inputs. We also investigated how other materials, like glass, can reflect and transmit light. Sometimes these materials, like windows, can even look like a one-way mirror if the light is just right.*

Discuss examples of the window phenomenon together. Display **slide L**. Orient students to the photographs they are about to examine. Use the cross-sectional diagram on the slide to help students understand where the photographer is standing in relation to the people inside the buildings.

Examine the images on slides L-O together. With each image, discuss the following questions:

1. What object(s) is/are most prominent, or clearest, in the photograph?
2. What object(s) is/are less prominent, or hard to see, in the photograph?
3. Imagine you were standing next to the photographer and you saw this image. What does the prominence of an object in the photograph tell you about the light that would be entering your eyes from it?

For each photograph, assume the only or the brightest light source is the Sun outside. Trace the path of light from the Sun to the more and least prominent objects. Avoid making students account for exact amounts of light. Rather, focus on the fact that if an object appears more prominent or less prominent, its prominence indicates something about the amount of light entering our eyes from the object.

Administer assessment individually to students. Display **slide P** and pass out one copy of *Portraits Through Glass: Individual Assessment* to each student. This assessment will take students the remainder of the class period to complete. Once completed, students should turn in their assessment to you for feedback. Note to students that they have a choice in modality for sharing their answers, which include written or pictorial or a combination of the two.

Assessment Opportunity

Building towards: 8.B Apply science ideas and evidence from classroom investigations to explain a common, real-world phenomenon in which a material designed for light transmission and to look transparent to the eye and brain functions as a one-way mirror due to the relationship the material has to other parts in the system.

What to look/listen for: This is a transfer task to give students an opportunity to use the three dimensions to make sense of light interactions with objects within a system and between the system and our eyes, causing us to see different things. Students also have the opportunity to demonstrate their understanding of how glass functions in different light situations. For specific guidance, use *Portraits Through Glass: Scoring Guidance*. Allow students to choose how to share their understanding through written response, pictorial response, or a combination of both.

What to do: This is meant to be a summative assessment task for the unit, and it gives you a grading opportunity. The task includes a scoring guide located in *Portraits Through Glass: Scoring Guidance*. Scoring guides are meant to highlight important ideas students should include in their responses. If students share these ideas elsewhere in the assessment, it is up to you to decide if that understanding is sufficiently demonstrated.

Alternate Activity

Extension Opportunity: Throughout the course of this unit, your students may ask questions about light reflecting off mirrors and shiny surfaces compared to light reflecting off non-shiny surfaces. These questions require additional science ideas to answer. The extension opportunity offered in *Extension Opportunity: Surface Scattering and Everyday Phenomena* supports students in investigating scattering and specular reflection in order to explain everyday experiences. These activities can be completed by your entire class, if time permits, or offered to high-interest learners or those who have mastered the performance expectations in the main storyline. The extension opportunities can be completed in one additional class period if Activity 1 is assigned as home learning prior to the class. The extension opportunity includes these activities:

- Activity 1: Students read a case study about the Walt Disney Concert Hall and share related experiences of being “blinded” by a glare. Students are introduced to a model for scattering and specular reflection in the context of this case study.
- Activity 2: Students use flashlights and assorted materials to make observations of how tightly focused or dispersed light is once reflected off the materials. They observe microscope images of the materials and return to the model for scattering and specular reflection to add new science ideas to their class list.

- Activity 3: Students choose one related phenomenon in which to apply the new science ideas and the model to explain it. This can be completed individually as a formative assessment or in partners or small groups to facilitate additional collaborative sensemaking. Furthermore, allow students to choose the modality in which they communicate their thinking, pictorially, orally, or written.

End of day 2

8. Review DQB questions in small groups. 10 MIN

Materials: science notebook, *Let's Answer Questions from Our Driving Question Board!*, Driving Question Board

Say, *We've figured out so much! I bet we can answer many of our questions on the Driving Question Board.*

Assign reviewing the DQB questions for small groups. Present **slide Q**. Tell students that they will revisit their DQB and celebrate all that they have figured out.* Arrange students in small groups and hand out one copy of *Let's Answer Questions from Our Driving Question Board!* to each student, which contains all the student questions from the DQB.

Have students work with their small group to evaluate which questions the class has answered. Students may use their science notebook as a resource. Have students indicate whether they think the class has answered each question by putting a symbol next to it:

- We did not answer this question or any parts of it yet: **?**
- Our class answered some parts of this question, or I think I could answer some parts of this question: ✓
- Our class answered this question, or using the ideas we have developed, I could now answer this question: ✓✓

*** Attending to Equity**
Revisiting the Driving Question Board is important for students to feel as though their questions are valued and recognized. While not all questions will have been addressed (it is more likely that 50–75% will at least be partially answered), this helps students see the hard work that they have done to answer many of their own questions.

9. Revisit Our Driving Question Board (DQB) 25 MIN

Materials: science notebook, *Let's Answer Questions from Our Driving Question Board!*, Driving Question Board, 3 colors of sticker dots, chart paper (optional), markers (optional)

Mark patterns in questions answered using the sticker dots. Have students move into their Scientists Circle, bringing with them their science notebooks and *Let's Answer Questions from Our Driving Question Board!*. Focus the discussion on identifying (1) questions we agree that we can answer, (2) questions that we have at least a partial answer to, and (3) questions we cannot answer at all. Choose a different color of sticker dots to mark each of these categories.

Discuss the questions the class can now answer. Present **slide R** if needed. Have the class discuss the answers to those questions as a whole group. If you have space, you might make a Take Aways poster that has a record of the class's answers. To close out the discussion, pose the DQB question, *Why do we sometimes see different things when looking at the same object?* Elicit students' new ideas to this question.

Assessment Opportunity

While students are answering questions from the Driving Question Board, this is an excellent formative assessment opportunity to address partial understandings and see if any pieces need to be revisited at the conclusion of the unit.

There is also opportunity to reinforce or revisit some of these ideas in *Unit 6.2: How can containers keep stuff from warming up or cooling down? (Cup Design Unit)*, particularly Lesson 8, when students investigate how light interacts with matter to warm up materials.

Additional Guidance

Asking Questions and Defining Problems is a practice your students will continue to use in subsequent units. In this unit, you closely monitored your students' question-asking practice to gauge where they successfully demonstrated asking open-ended questions compared to close-ended ones, as well as their work in Lesson 3 asking an experimental, testable question. Now that you have a better sense of where your students excelled or struggled with Asking Questions, consider how you can support progress in subsequent units using the Asking Questions tools available as part of the program. These include the following:

- *Open and Closed Questions (Asking Questions Tool)*: Use this tool to support students in revising close-ended questions into open-ended ones. Avoid using it when students first offer questions for the DQB. Rather, use it throughout a unit to transform close-ended questions into ones the class can investigate together.
- *Testable Questions (Asking Questions Tool)*: Use this tool to support students in asking testable questions that include enough specific information that one could gather evidence (e.g., measurements, observations) to answer the question. Note that this tool includes testable questions that are not specifically experimental ones.
- *Experimental Questions (Asking Questions Tool)*: Use this tool to support students in asking experimental questions in which they will need to manipulate a variable in the system to work toward causal relationships between two variables.

Each tool includes a peer feedback component that allows students to gather feedback on their questions if time permits. These peer feedback components can be modified for teacher feedback as well.

10. Celebrate and reflect on our experiences.

10 MIN

Materials: science notebook

Celebrate the class's accomplishments. Say, *I can't believe how far we have come since we first wondered about the one-way mirror phenomenon. We should be very proud of what we have accomplished!*

Have students reflect on their experiences with the unit.* Have students return to their regular seats. Prompt students to find a new page in their science notebooks and title the page "Reflection." Display **slide S**. Give students about 5 minutes to write a personal reflection on their learning based on the following prompts:

- What was most challenging in this unit?
- What was most rewarding?
- Think about how you engaged in sensemaking discussions with classmates. How would you want to engage with those experiences the next time around?
    - What would you do the same?
    - What would you do differently?

*** Attending to Equity**
This unit asks students to do meaning-making that is difficult but potentially rewarding. Taking time to reflect on the process of this unit can allow students to think about what works well for them as learners. Consider giving more time to answer these questions if needed.

Alternate Activity

If you have time, you could also structure this reflection as a "blizzard." For a blizzard, have students anonymously record their reflections on a piece of loose paper, crumple it up, and then throw it up in the air. Students can then pick up a ball of paper and go around one by one and read aloud what is on the paper they picked up until everybody's reflection has been shared.

As a whole group, ask each student to share part of their reflection. Taking time to reflect upon the process of this unit can allow students to think metacognitively about what works well for them as learners.

Additional Guidance

One-way mirror film is often used on the windows of office buildings and homes to slow down energy transfer into the buildings. If you plan to teach *Unit 6.2: How can containers keep stuff from warming up or cooling down? (Cup Design Unit)* next, present **slide T** which includes this new problem-solution. Have your students share their initial ideas in anticipation of engaging them more deeply with light and energy transfer in the upcoming lessons. If you are not teaching the *Cup Design Unit* next, consider using this related problem-solution when you do teach about energy transfer.

ADDITIONAL LESSON 8 TEACHER GUIDANCE

Supporting Students in Making Connections in ELA

CCSS.ELA-Literacy.SL.6.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.

CCSS.ELA-Literacy.SL.6.2 Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.

In this lesson, students are asked to engage in a variety of discussion formats with small groups and whole groups to share observations, draw conclusions, and come to consensus in order to explain related phenomena. Students are asked to co-construct explanations for the new phenomena orally, which requires them to articulate a how or why account for the phenomenon and support their account with evidence. This evidence may draw from their use of physical models, observations in the real world, readings, images, videos, and classroom investigations.

The following ELA standard is supported if the extension opportunity is used:

CCSS.ELA-Literacy.RI.6.7 Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.

If students complete the *Walt Disney Concert Hall Case Study* reading as part of the extension opportunity, they will also engage with integrating images of everyday visual experiences with words to develop an understanding of scattering versus specular reflection that explains why we see mirror reflection on some surfaces and not others.

SCIENCE LITERACY: READING COLLECTION 4

A Closer Look at Light

1 **Blue Light and Eye Health**
2 **Color Temperature**
3 **Scattered Light**
4 **Polarization**

Literacy Objectives

- ✓ Summarize key points related to some behaviors and properties of light.
- ✓ Identify cause(s) and effect(s) related to interactions of light and Earth systems.
- ✓ Organize related details about light and matter in a well-developed paragraph.

Literacy Activities

- Read varied text selections related to the topics explored in Lesson 8.
- Evaluate the reading selections according to provided prompts and criteria.
- Compare and contrast information gained from reading text with information gained from class investigation.
- Prepare a well-constructed paragraph in response to the reading.

Instructional Resources

Student Reader

Collection 4

Science Literacy Student Reader, Collection 4
"A Closer Look at Light"

Exercise Page

EP 4

Science Literacy Exercise Page
EP 4

Prerequisite Investigations

Assign the Science Literacy reading and writing exercise *after* class completion of this lesson:

- Lesson 8: Why do we sometimes see different things when looking at the same object?

Standards and Dimensions

NGSS

Disciplinary Core Ideas:
PS4.B: Electromagnetic Radiation When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2)

Science and Engineering Practice: Obtaining, Evaluating, and Communicating Information

Crosscutting Concepts: Cause and Effect; Systems and System Models

CCSS

English Language Arts
RST.6-8.1: Cite specific textual evidence to support analysis of science and technical texts.

RST.6-8.8: Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

RST.6-8.10: By the end of grade 8, read and comprehend science/technical texts in the grades 6-8 text complexity band independently and proficiently.

WHST.6-8.4: Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Core Vocabulary

Core Vocabulary: Core Vocabulary terms are those that students should learn to use accurately in discussion and in written responses. During facilitation of learning, expose students repeatedly to these terms. However, these terms are not intended for isolated drill or memorization.

scatter

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about any concepts in this exercise. Students will benefit from your modeling the use of these words without the expectation that students will use or explain the words themselves.

intensity	**pigment**	**polarize**
system	**variable**	**wavelength**

A Glossary at the end of the Science Literacy Student Reader lists definitions for Core Vocabulary and selected Language of Instruction.

1. Plan ahead.

Determine your pacing to introduce the reading selections, check in with students on their progress, and discuss the reading content and writing exercise. If you are performing Science Literacy as a structured, weekly routine, you might implement a schedule like this:

- Monday: Designate a ten-minute period at the beginning of the week to introduce students to the assignment.
- Wednesday: Plan to touch base briefly with students in the middle of the week to answer questions about the reading, to clarify expectations about the writing exercise, and to help students stay on track.
- Friday: Set aside time at the end of the week to facilitate a discussion about the reading and the writing exercise.

You'll proceed with the next in-class lesson investigations during this week.

2. Preview the assignment and set expectations. (Monday)

- Let students know they will read independently and then complete a short writing assignment. The reading selection relates to topics they are presently exploring in their Light and Matter unit science investigations.
- The reading and writing will be completed outside of class (unless you have available class time to allocate).
- Preview the reading. Share a short summary of what students can expect.
    - *You will read a pair of fictional social media posts debating the health effects of blue light from electronic screens.*
    - *Then, you'll read a simulated photography e-zine article about what makes certain colors seem "cooler" or "warmer" than others.*
    - *Next, you'll learn that the answer to the age-old question "Why is the sky blue?" has to do with scattered light.*
    - *Lastly, you'll return to the simulated photography e-zine to read a blog post about how to control light with polarizing filters when using a camera.*

- Distribute Exercise Page 4. Preview the writing exercise. Share a brief summary of what students will be expected to deliver. Emphasize that Science Literacy exercises are brief. The focus is on thoughtful quality of a small product, not on the assignment being big and complex.
    - *For this assignment you will be expected to generate a well-constructed paragraph about one of three big ideas discussed in this collection.*

Exercise Page

EP 4

- Remind students of helpful strategies they can employ during independent reading. Offer the following advice:
    - *The reading should take approximately 30 minutes to complete.* (Encourage students to break reading into smaller sections over multiple short sittings if their attention wanders.)
    - *A good reading strategy is to scan through the collection first to see the titles, section headers, graphics, and images to see what the selections are going to be about before fully reading.*
    - *Next, "cold read" the selections without yet thinking about the writing assignment that will follow.*
    - *Then, carefully read the Exercise Page to understand the expectations for the writing part of the assignment.*
    - *Revisit the reading selections to complete the writing exercise.*
    - *Jot down any questions for the midweek progress check in class.* (Be sure students know, though, that they are not limited to that time to ask you for clarification or answers to questions.)

3. Touch base to provide clarification and address questions. (Wednesday)

Touch base midweek with students to make sure they are on track while working independently.

You may choose to administer a midweek minute-quiz to give students a concrete reason not to postpone completing the reading until the last minute. Ask questions such as these, and have students jot answers on a half sheet of paper:

Suggested prompts	Sample student responses
What are two concerns people have about blue light and their health?	*first, that it might damage the eyes* *second, that it disrupts sleep patterns*
What's contradictory about how people describe the colors they see and the colors of light sources?	*When you look at colored objects (reflected light), we say the blues are coolest and the reds are the warmest colors, but when you look at the temperatures of light sources, the sources that give off blue light are warmest and the sources that give off red light are coolest.*
Which of these ways light interacts with matter causes light to scatter—transmission, absorption, or reflection?	*Reflection—when light strikes particles in the atmosphere, some of the light is reflected.*

Ask a few brief discussion questions related to the reading that will help students tie the text content to students' classroom investigations.

Suggested prompts	Sample student responses
What two systems are interacting in the scenario about eye health?	*The tablet or any device that gives off blue light is a system, and the person's eyes and brain that sense and react to the light is a system. The two systems interact when a person uses the device.*
In our classroom investigations, we talked about "bright" and "dim" light conditions. What is the name for this property, as used in the readings?	*Intensity—some light sources have greater intensity than others.*
What general function does a polarizing filter have in common with a one-way mirror?	*Both control how light is transmitted to affect what people see.*

- Refer students to Exercise Page 4. Provide more specific guidance about expectations for students' deliverables due at the end of the week.
    - *The expectation for this assignment is that you will write a well-constructed paragraph demonstrating your understanding of the readings in this collection.*
    - *Think of your audience as being another student in your grade.*
    - *After choosing your topic sentence, you'll want to go over all the reading selections and find details that support it.*
    - *If some of the explanations were confusing to you, just keep in mind that light can be described as traveling in straight lines until some form of matter absorbs or reflects it.*
    - *Don't forget to look closely at the photos and images and read their captions.*
    - *If it helps you, you might want to sketch a tree map to organize the topic sentence and details before writing your paragraph.*
    - *The important criteria for your work are that the details supporting your topic sentence are accurately stated and that they come from a majority of the reading selections.*
- Explain to students' that their paragraphs should use language that signals causes and effects, such as "because," "as a result," "due to," and "consequently."
- Answer any questions students may have relative to the reading content or the exercise expectations.

Exercise Page

EP 4

4. Facilitate discussion. (Friday)

Facilitate class discussion about the reading collection and writing exercise. Students begin the reading activity by comparing two online posts about the health effects of blue light from electronic screens.

Pages 34–35 **Suggested prompts**	**Sample student responses**
What is the general purpose of the first selection, "Blue Light and Eye Health"?	*There are two online posts about the topic—one is trying to persuade us that blue light damages the eyes, and the other post is trying to persuade us that there is no conclusive evidence that blue light damages the eyes.*
Look at the Consider the Sources box. Why is a single person's experience not considered reliable evidence for a science claim?	*The claim could be correct, but scientists identify evidence that has been reported by many people, not one. Seeing a pattern makes conclusions more reliable.*
Recall the story about bedtime screens in the preface to this unit. What other kinds of internet sources might help convince the teen's parent that blue light may not be bad for their eye health?	*sources where the writers are also experts, such as in science journals and government health reports* *sources where experts are interviewed and describe the experiments that can be repeated to see if the results are similar*

The next selection explains a contradiction in terms when people use "warm" and "cool" to describe color.

Pages 36–41 **Suggested prompts**	**Sample student responses**
What is the general purpose of the second selection, "Color Temperature"?	*It explains how the way people talk about warm and cool colors of pigments differs from the colors of warm and cool light sources.*
Say your parents want to paint a wall in your home a warm color. What color paint might they choose?	*red, orange, or yellow*
If you want a digital photo to look warm in color, like the wall paint, would the light source temperature be less than or greater than sunlight at noontime?	*The temperature would be less (cooler) than noontime sunlight.*
How does the second selection help you build knowledge on top of what you learned in the first selection?	*The first article talks about blue light sources as having high levels of energy. The second article explains that blue light sources have high temperatures.*

Student Reader

Collection 4

SUPPORT—If you are using the recommended word envelope convention, check the envelope to see if it contains any words, phrases, or sentences that students need help understanding. Read key sentences aloud, and provide concise explanation.

CHALLENGE—Explain to students that circadian clocks follow a 24-hour cycle mostly affected by patterns of light and dark caused by the rising and setting of the sun. Challenge students to research reputable science websites to find out more about natural circadian clocks, including how scientists investigate them. Invite students to share what they learn by giving brief science talks or by creating infographics.

SUPPORT—English language learners may benefit from watching animated or video presentations answering the same question, "Why is the sky blue?" Encourage them to watch as many times as is helpful. Have them share with you how the video differed from the presentation in the reading selection.

What is the general purpose of the third selection, "Scattered Light"?	*It explains how sunlight interacts with the atmosphere to make the sky appear blue and sometimes other colors.*
How does wavelength affect which colors are scattered?	*Different colors of light have different wavelengths, and because blue light has shorter wavelengths, it is more easily scattered.*
How does this selection help you build knowledge about blue light on top of what you learned in the first selection?	*The first article explains that blue light has more energy than other visible light colors. The third article explains that blue light has shorter wavelengths than other visible light.*

The final selection gives students an opportunity to apply their understanding of waves from Collection 1.

Pages 42–43 **Suggested prompts**	**Sample student responses**
What is the general purpose of the fourth selection, "Polarization"?	*It explains how photographers control light by using polarizing filters.*
How does knowing that light travels as waves help explain how polarizing filters work?	*The filter lets only waves that oscillate in certain directions pass through and stops the others. This controls the light to bring out details in the photos by reducing glare.*
What systems interact when a nature photographer uses a polarizing filter?	*One system is the sun-atmosphere-ocean system as light from the sun interacts with particles in the atmosphere and water, and another system is the sun-atmosphere-filter system.*

5. Check for understanding.

Evaluate and Provide Feedback

For Exercise 4, students should, from a provided topic sentence that they select, write a well-constructed paragraph to summarize some characteristics of light discussed in this collection. They should emphasize the cause-and-effect relationships between properties of light and how objects in nature appear when those properties vary. Depending on the topic sentence chosen, look for evidence that students have understanding the following:

- Color is related to the frequency or wavelength of light, pigments that absorb or reflect light, the temperature of the light source, scattering in the atmosphere and ocean, and the use of polarizing filters.
- The intensity (brightness) of light depends on the source, how much atmosphere it passes through, and whether a polarizing filter is used.
- Polarizing lenses cut out some scattered light (glare), making the image less intense (bright).

Use the rubric provided on the Exercise Page to supply feedback to each student.

EXTEND—Parents may say that "Why is the sky blue?" is a common question four-year-olds ask, but point out that the answer is not an easy one to answer for most adults. Have students ask a random sampling of people over the age of 18 the question and record their answers. Then have them analyze the responses and score them from 0 ("I don't know") to 3 (an answer that is mostly correct in saying it has something to do with the nature of blue light and the kinds of matter in the atmosphere). Invite students to share their results and explanations with the rest of the class.

Teacher Resources

Table of Contents

ASSESSMENT SYSTEM OVERVIEW

Each unit includes an assessment system that offers many opportunities for different types of assessments throughout the lessons, including pre-assessment, formative assessment, summative assessment, and student self assessment. Formative assessments are embedded and called out directly in the lesson plans. Please look for the “Assessment Icon” in the teacher support boxes to identify places for assessments. In addition, the table below outlines where each type of assessment can be found in the unit.

Overall Unit Assessment

When	Assessment and Scoring Guidance	Purpose of Assessment
Lessons 1 & 2	Lesson 1 Handout 1: *Initial diagram to explain the phenomenon* Driving Question Board	**Pre-assessment** The student work in Lesson 1 available for assessment should be considered a pre-assessment. It is an opportunity to learn more about the ideas your students bring to this unit. Revealing these ideas early can help you be more strategic in how to build from and leverage student ideas across the unit. In particular, it can help you decide if your students need to engage in the Building Prerequisite Understandings activities offered in Lesson 2 or if they are ready to tackle more-challenging content. **When to check for understanding:** Students share initial models to explain the phenomenon in Lesson 1 on day 1, and the class engages in a Consensus Discussion on day 3. In Lesson 2, pay attention on day 2 when students develop their group models and share their thinking in the Building Understandings Discussion. **What to look for/listen for:** As a pre-assessment, pay particular attention to students’ inclusion of important parts of the system and arrows or lines showing interaction between the parts. Look for the following: (1) agreement on key components or parts to include, such as two rooms or sides, a mirror-window between the sides, one side being lit, one side being dark; (2) uncertainty or disagreement on whether the people or eyes are an important part; and (3) use of a “path of light” model, “line of sight” model, or combination, which can be indicated by the way students use or do not use arrows in their diagrams: • arrows pointing away from the eyes or • arrows pointing away from the source of the light and bouncing away from objects, and arrows pointing into the eyes or • a combination of the above Arrows pointing away from the light source may be a representation of the “path of light” (POL). If students also include an arrow entering the eyes, this may indicate a clear understanding of the 4th-grade model of light, tracing the light from a source, then bouncing off objects and into our eyes. Arrows pointing away from the eyes may be a representation of what is seen, or “line of sight” (LOS). A combination of arrows may map partially onto both POL and LOS models.

When	Assessment and Scoring Guidance	Purpose of Assessment
		What to do: It is important to not apply too many restrictions on students' initial models so that you can get a true picture of what students understand at the start of the unit. If your students use the LOS model, supplement the unit with the Building Prerequisite Understanding activities offered after Lesson 2, day 2. These activities will help your students transition to a POL model they can use going forward in the unit. The Driving Question Board is another opportunity for pre-assessment. You can see the types of questions your students ask and what they are asking about. It is also important that the class comes up with a set of questions to support investigations as you begin the unit. This means your class will need more open-ended, testable questions that are asking how or why something is happening. You may need to spend time helping students turn close-ended questions into open-ended ones that will lead the class toward more-productive investigations.
Lesson 5	Classroom consensus model	**Formative Assessment** This lesson is a Putting the Pieces Together lesson. It includes a midpoint assessment that can provide formative information for moving forward in the unit. **When to check for understanding:** Review student models of what is seen. **What to look for/listen for:** This midpoint assessment is important to make sure the class is on the same page and ready to move forward in the unit. At this point, students should be comfortable with the following ideas: • Ideas from Lesson 2: representing how light travels from the light source in Room A and reflects off the music student and that light travels in straight lines • Idea from Lessons 3 and 4: About the same amount of light transmits through the one-way mirror as reflects back to the music student. • Idea from Lesson 4: The structure of the one-way mirror is half-silvered, which allows about the same amount of light to reflect off the silvered structures and to transmit through the transparent structures. • Idea from Lessons 2, 3, and 4: Light rays enter both the student's and the adults eyes from objects that are seen. Example models are provided in the Teacher Guide for Lesson 5. **What to do:** If students struggle, help them break down the modeling task into smaller components. Start with what happens when light leaves the light source and reaches the music student. Next, have students model what happens when light reaches the one-way mirror. You can also have students turn and talk with a partner or small group prior to individual modeling to help them generate ideas for important details to represent in their model.

When	Assessment and Scoring Guidance	Purpose of Assessment
Lesson 7	Handout 1: *Explaining the one-way mirror phenomenon* Handout 2: *Self Assessment and Peer Feedback* Handout 3: *Final explanation: One-way mirror phenomenon* *Rubric Explaining the one-way mirror phenomenon* Teacher Reference: *Peer Feedback Guidelines*	**Summative Assessment** This is a Putting the Pieces Together lesson. It includes an end-point assessment as students construct an explanation to explain the one-way mirror phenomenon. Students engage in self-assessment of their explanation, gather feedback from peers, and revise their explanations. **When to check for understanding:** Students' final drafts of their explanation after receiving feedback on their first drafts **What to look for/listen for:** Students should be comfortable with the following ideas: • Idea from Lesson 2: explaining how light travels from the light source in Room A and reflects off the music student. • Idea from Lessons 3 and 4: About the same amount of light transmits through the one-way mirror as reflects back to the music student. • Idea from Lesson 4: The structure of the one-way mirror is half-silvered, which allows about the same amount of light to reflect off the silvered structures and to transmit through the transparent structures. • Idea from Lessons 2, 3, and 4: Light rays enter both the music student's and the adults' eyes from objects that are seen. • Ideas from Lesson 6: Light inputs to the eyes are turned into signals that travel from the eyes to the nerves and brain. When there are multiple inputs, the brain responds to the strongest signal. Look for evidence that students have revised their explanation, based on their own and peer feedback, by comparing the first draft and the revised explanation and reviewing their reflections on what feedback they used and didn't use. For explanation writing, look for students to provide a scientific account (how or why account) utilizing the science ideas above and based on evidence gathered throughout the unit. **What to do:** To facilitate the peer feedback process, review *Teacher Reference: Peer Feedback Guidelines*. Consider providing your own feedback as students self-assess and gather peer feedback. Have students submit their revised explanation along with the first draft explanation that has their own revisions as well as peer feedback. Use *Rubric Explaining the one-way mirror phenomenon* to assess students and provide feedback to them on their explanations and revisions.

When	Assessment and Scoring Guidance	Purpose of Assessment
Lesson 8	*Portraits Through Glass: Individual Assessment* *Portraits Through Glass: Scoring Guidance*	**Summative Assessment** This is a Putting the Pieces Together lesson. It includes an end-point assessment as students construct an explanation to explain a related phenomenon. **When to check for understanding:** The individual assessment on day 2 using *Portraits Through Glass: Individual Assessment* **What to look for/listen for:** This is a transfer task to give students an opportunity to use the three dimensions to make sense of light interactions with objects and our eyes, causing us to see different things in the context of a related phenomenon. For specific guidance, use *Portraits Through Glass: Scoring Guidance*. **What to do:** This is meant to be a summative assessment task for the unit, and it gives you a grading opportunity. The task includes scoring guidance located in *Portraits Through Glass: Scoring Guidance*. Scoring guides are meant to highlight important ideas students should include in their responses. If students share these ideas elsewhere in the assessment, it is up to you to decide if that understanding is sufficiently demonstrated.
After each lesson	*Lesson Performance Expectation Assessment Guidance*—See below.	**Formative Assessment** Use this document to see which parts of lessons or student activity sheets can be used as embedded formative assessments.
Occurs in some lessons	Progress Tracker	**Formative and Student Self-Assessment** The Progress Tracker is a thinking tool that was designed to help students keep track of important discoveries that the class makes while investigating phenomena and figure out how to prioritize and use those discoveries to develop a model to explain phenomena. It is important that what the students write in the Progress Tracker reflects their own thinking at that particular moment. We strongly suggest it is not collected for a summative "grade" other than for completion. The Progress Tracker is added to in Lessons 2, 3, 4, and 6.
Anytime after a discussion	*Student Self-Assessment Discussion Rubric*	**Student Self Assessment** The *Student Self-Assessment Discussion Rubric* can be used anytime after a discussion to help students reflect on their participation in the class that day. Choose to use this at least once a week or once every other week. Initially, you might give students ideas for what they can try next time to improve, such as sentence starters for discussions. As students gain practice and proficiency with discussions, ask for their ideas about how the classroom and small-group discussions can be more productive. We suggest the following lessons as good opportunities to incorporate this tool: • Lesson 2, day 3 after students share self-documentation examples • Lesson 5 after the classroom consensus model • Lesson 8 after the students close out the DQB

When	Assessment and Scoring Guidance	Purpose of Assessment
After students complete substantial, meaningful work	Lesson 7, Handout 2: *Self Assessment and Peer Feedback* Lesson 7, Teacher Reference: *Peer Feedback Guidelines*	There will be times in your classroom when facilitating students to give each other feedback will be very valuable for their three-dimensional learning. The Teacher Reference: *Peer Feedback Guidelines* document is designed to give you options for how to support this in your classroom. It also includes student-facing materials to support giving and receiving feedback along with self-assessment rubrics where students can reflect on their experience with the process. Peer feedback is most useful when there are complex and diverse ideas visible in student work and not all work is the same. Student models or explanations are good times to use a peer feedback protocol. They do not need to be final pieces of student work, rather, peer feedback will be more valuable to students if they have time to revise after receiving the peer feedback. It should be a formative, not summative, type of assessment. It is also necessary for students to have experience with past investigations, observations, and activities where they can use these experiences as evidence for their feedback.

For more information about the approach to assessment and general program rubrics, visit the Teacher Handbook.

Lesson-by-Lesson Assessment Opportunities

Every lesson includes one or more lesson-level performance expectations (LLPEs). The structure of every LLPE is designed to be a three-dimensional learning, combining elements of science and engineering practices, disciplinary core ideas and cross cutting concepts. The font used in the LLPE indicates the source/alignment of each piece of the text used in the statement as it relates to the NGSS dimensions: alignment to Science and Engineering Practice(s), alignment to Cross-Cutting Concept(s), and alignment to the Disciplinary Core Ideas.

The table below summarizes opportunities in each lesson for assessing every lesson-level performance expectation (LLPE). Examples of these opportunities include student handouts, home learning assignments, progress trackers, or student discussions. Most LLPEs are recommended as potential formative assessments. Assessing every LLPE listed can be logistically difficult. Strategically picking which LLPEs to assess and how to provide timely and informative feedback to students on their progress toward meeting these is left to the teacher's discretion.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 1	**1.A** Develop a model to identify the important parts of the system and how those parts interact that could cause an object to look different in different light conditions. **1.B** Ask questions that arise from observations of a phenomenon in which an object appears different depending on the light conditions within the defined system.	**1.A Develop and Use Models; Systems and System Models** **When to check for understanding:** Day 1 when students develop and share their initial models and day 3 when the class constructs an Initial Class Consensus Model. **What to look/listen for:** Students should agree that the material acts like a mirror on the light side of the system and acts like a window (or glass) on the dark side of the system. They should use arrows and lines in different ways to explain the phenomenon but express uncertainty about how it happens. **1.B Asking Questions; Systems and System Models** **When to check for understanding:** Day 4 when the class builds the Driving Question Board (DQB). **What to look/listen for:** Monitor which parts and interactions in the system have many or few questions. Also, monitor whether students are asking open-ended or close-ended questions.
Lesson 2	**2.A** Ask questions that can be investigated in the classroom and frame a hypothesis about what we will see from both sides of the box model if we change the amount of light on either side (structure). **2.B** Modify a model based on evidence to match changes in what we see when we change the light in the box model (structure).	**2.A Asking Questions; Structure and Function** **When to check:** Day 1 when students consider questions that are feasible to investigate in the classroom. **What to look/listen for:** (1) Questions that focus on changing one aspect of the light in the box model at a time, (2) questions that are feasible in terms of time and materials, and (3) hypotheses framed about what students expect to see. **2.B Developing and Using Models; Structure and Function** **When to check:** Day 2 initial group models and day 2 Building Understandings Discussion. **What to look/listen for:** Use of path of light arrows to represent what we see (i.e., arrows pointing away from the light source, bouncing off objects, and into the eyes) as opposed to line of sight arrows.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 3	**3.A** Ask a testable question to determine how an object's material (structure; independent variable) influences the amount of light transmitted and reflected (function; dependent variable). **3.B** Use evidence to modify a model to explain how an object's material (structure) influences the path of light as it transmits through or reflects off the material (function).	**3.A Asking Questions and Defining Problems; Structure and Function** **When to check for understanding:** • Day 1: When students work in pairs to construct a testable question using the *Asking Questions Tool - Experimental Questions* (**slide H**). • Day 2: As students share their testable questions with the class and collaboratively select a testable question (**slide L**). **What to look/listen for:** • Day 1: (1) Accurate identification of the dependent variable (amount of light reflected and amount of light transmitted) and the independent variable (one-way mirror, glass, and regular mirror) and (2) an understanding of the cause-and-effect relationship between the dependent and independent variables. • Day 2: (1) Accurate identification of the dependent variable and independent variable and (2) an understanding of the cause-and-effect relationship between the dependent and independent variables. **3.B Developing and Using Models; Structure and Function** **When to check for understanding:** • Day 1: (1) As students work in small groups to investigate how light interacts with the three materials (**slide D**) and (2) when students discuss their observations as a class, decide how to represent what they have figured out, and modify the class consensus model (**slides E** and **F**). • Day 3: (1) When students analyze class data in small groups and as a class (**slides T** and **W**) and (2) when students individually complete their Progress Tracker (**slide X**). **What to look/listen for:** • Day 1: As students discuss their observations in small groups and as a class, listen for the following ideas to surface: (1) all three materials reflect light and two transmit light; (2) the one-way mirror reflects more light than the glass but less than the regular mirror, and the one-way mirror transmits more light than the regular mirror but less than the glass; and (3) using a tool to measure the amount of light transmitted through and reflected off each material would give us data that would make our comparisons more accurate and help us better represent what we observe in a consensus model. • Day 1: As students revise the class consensus model, the following should be represented with each material (one-way mirror, glass, and regular mirror): (1) light travels in straight lines; (2) when light shines on an object, it can pass through, bounce off, or do a combination of both; and (3) arrows should show the direction light travels (path of light, POL) from the source and then when it bounces off or goes through a material. • Day 3: While analyzing class data in small groups and as a class, look for students to (1) use light data to compare the one-way mirror to the regular mirror and glass and (2) create a continuum and place each material along the continuum based on the amount of light transmitted and reflected.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
		• Day 3: When students individually complete their Progress Tracker, look for the following ideas in their representations: (1) Light travels in a straight line; (2) when light shines on the one-way mirror, about half of the light reflects off, which is slightly more than the amount of light transmitted; and (3) the one-way mirror does not reflect as much light as a regular mirror, and it does not transmit as much light as a window.
Lesson 4	**4.A** Develop a model to describe the unobservable mechanisms that affect how a material's microscale structures change how light reflects off and transmits through the material (function).	**4.A Developing and Using Models; Structure and Function** **When to check for understanding:** As students diagram their initial thinking on the handout and during the Consensus Discussion. **What to look/listen for:** Students (1) suggest modifying the class consensus model from Lesson 3 to include new structural features of the materials, such as thick and thin silver structures and (2) use evidence to argue that some light will reflect off silver structures and transmit through transparent structures.
Lesson 5	**5.A** Revise a model to explain the observable one-way mirror phenomenon caused by unobservable interactions between light, the people, and the oneway mirror, which reflects and transmits about the same amount of light.	**5.A Developing and Using Models; Systems and System Models** **When to check for understanding:** Review student models after they model what is seen by the characters in the video. **What to look/listen for:** Look for students to represent how light leaves the light source, reflects off the music student, and reflects and transmits when it reaches the one-way mirror, causing light to enter both student's and the adults' eyes. See examples in the teacher guide.
Lesson 6	**6.A** Ask questions to model the path of light as it travels through the lens of the eye, and to explain how the shape and composition of the lens causes the path of light to change directions (refract) before reaching the retina at the back of the eye. **6.B** Develop a model that describes how the eye responds to (interacts with) different inputs of light and transforms those inputs to signals that travel along the optic nerve to the brain, which processes the signals into what we "see."	**6.A Asking Questions and Defining Problems; Structure and Function** **When to check for understanding:** At the end of day 1, as students make connections and draw tentative conclusions about what happens when light enters the student's eyes that enables the student to see themself. **What to look/listen for:** Listen for students to describe how the shape and transparency of the lens of the human eye causes light to change direction (refract) and focuses the light to a point on the retina at the back of the eye. **6.B Developing and Using Models; Systems and System Models** **When to check for understanding:** At the end of day 2, as students take part in the Consensus Discussion and draw conclusions about why the student does not see the adults. **What to look/listen for:** Look for small group models to accurately represent the magnitude of two light inputs into the student's eyes and how the brain responds to the two signals. Listen for students to describe how the eye and brain work together to process multiple inputs of light. Detailed descriptions are included in the teacher guide.

Lesson	Lesson-Level Performance Expectation(s)	Assessment Guidance
Lesson 7	**7.A** Construct and revise an explanation using a model to explain why an object appears different (effect) depending on the interaction between light and an object's material and how the brain processes signals (causes).	**7.A Constructing Explanations and Designing Solutions; Cause and Effect** **When to check:** At the end of the class when students have drafted and revised an explanation for the one-way mirror phenomenon. **What to look/listen for:** (1) Explanation of how or why the phenomenon is occurring, (2) the use of science ideas about the interactions between light and an object's material and how the brain processes signals, (3) the use of evidence from classroom learning activities to support explanations, and (4) revisions to the explanation based on self-assessment and peer feedback.
Lesson 8	**8.A** Use a model to describe how differences in light on both sides of a one-way mirror strengthens or weakens the one-way mirror phenomenon due to changing the components and interactions within and between systems. **8.B** Apply science ideas and evidence from classroom investigations to explain a common, real-world phenomenon in which a material designed for light transmission and to look transparent to the eye and brain functions as a one-way mirror due to the relationship the material has to other parts in the system.	**8.A Developing and Using Models; Systems and System Models** **When to check for understanding:** On day 1 when the class discusses observations and conclusions from the box model investigation with the one-way mirror film and 2 flashlights **What to look/listen for** • students summarize that the greater the difference in light on both sides of the one-way mirror, the stronger the phenomenon (interaction within the system). • students connect that the greater the difference in light on both sides of the one-way mirror, the greater the difference in the amount of light reflecting off objects and into our eyes (interactions between systems). • students use systems thinking as they articulate their explanation, focusing on how they are changing an interaction within the system and interaction between systems, which is why we see different things. **8.B Constructing Explanations and Designing Solutions; Systems and System Models, Structure and Function** **When to check for understanding:** On day 2 during the Consensus Discussion and individual assessment **What to look/listen for** • Day 2 Consensus Discussion: Students to generalize that differences in light on either side of an object or material can cause us to see different things when looking at the same object and to share that the more prominent an object appears means that more light is entering the eyes from that object. • students should engage in both systems thinking and structure-function. They should identify that when glass is used in place of the one-way mirror, glass is structurally different, at the microscale, and interacts with light in different ways. This change to the structure leads to a change in interaction within the system. The result is that light outputs from the system are different, which influences the light inputs into the eye. • Day 2 Individual Assessment: See guidance on *Portraits Through Glass: Scoring Guidance*.

Box Model Assembly Instructions

Materials

Materials needed for each box model (multiply by 6 for a class set)

- 2 bankers boxes with lids
- 2 8″-×-10″ picture frame mats
- 2 small binder clips
- 2 toys or objects that are at least 5″ tall
- 1 cylindrical flashlight (zooming and dimming capabilities)
- removable mounting putty

Materials needed to make a class set of box models

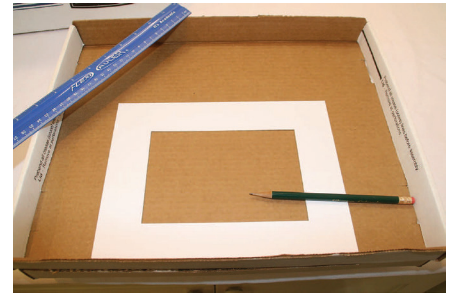
- 1 box cutter
- 1 roll of duct tape
- one-way mirror film, cut into 8″-×-10″ pieces for each model
- pencil or pen
- black marker
- ruler (optional)
- spare cardboard (optional)

Additional modifications to the box model are shown in *Box Model Modification Instructions*.

Instructions

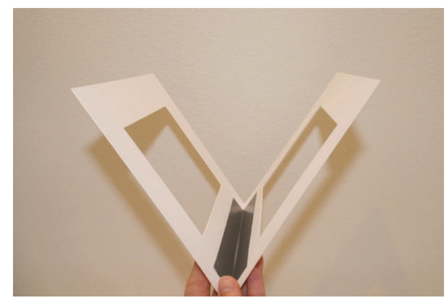
1. Assemble the boxes for Rooms A and B. The boxes will arrive flattened. Assemble them following the instructions on the box. If the box has openings for handles, do not punch those out. It is important to prevent any unwanted light from getting into the closed box. If needed, use duct tape to cover the handles to ensure they remain intact and closed.

2. Measure where to cut the holes. Remove the box lids from the boxes and place the lids on a countertop with the inside facing up. Place a picture frame mat on the first box lid, flush against one of the long sides, but centered in the middle (see photo). On each end of the mat, there should be approximately 2.5″ from the outside edge of the mat and a little over 4.25-4.5″ from the inside edge of the mat. Once centered, use the inside of the mat as a stencil to outline the opening on the lid in pencil or pen. Repeat for the second lid. Be sure to place the mat at the same exact location on both lids so the holes will line up when the lids are taped together.

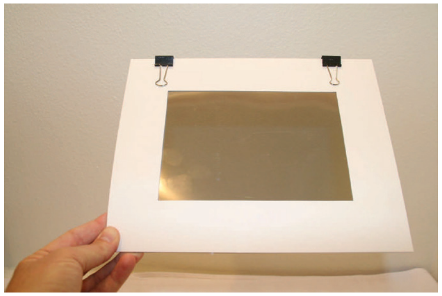


3. Cut a hole in each box lid. Use a box cutter to cut out the stenciled rectangle on each lid. Save the cut-out cardboard for use in step 6. Note: It is helpful when using the box cutter to place a spare piece of cardboard underneath so you don't damage your floor or countertop.

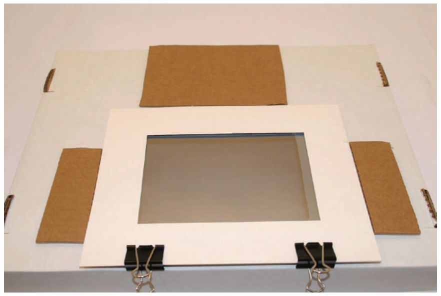
4. Assemble the mirror frame. Tape the two mats together along a long edge using duct tape. This creates a frame to make a one-way mirror with the one-way mirror film.



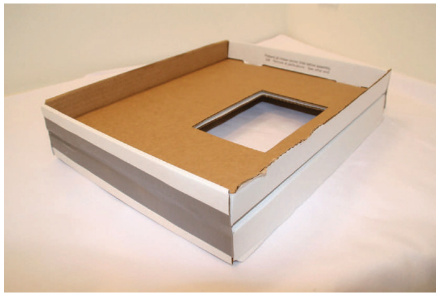
5. Prepare the one-way mirror. Cut out an 8”-×-10” (or slightly smaller) piece of one-way mirror film. The film has a layer of plastic on it. Keep that layer on. It will keep the one-way mirror stiff for better reflections. Insert the film between the two mats. Use the two binder clips to hold the mats together on the long side that is not taped.



6. Create the “window” frame for the one-way mirror to slide in and out. Place one lid topside up on the countertop. Set the second lid aside. Take the two small pieces of cardboard cut from the lids in step 3. Cut one in half lengthwise. Place the one-way mirror, which is inside the mats, on the top of the lid. Line up the one-way mirror with the rectangular hole. Then place the three pieces of cardboard around the edges of the one-way mirror mat, creating a “frame” around the mats on three sides. Tape the cardboard pieces solidly in place. These cardboard pieces create a space to guide (and hold in place) the one-way mirror when it slides in and out of the box model. Take the one-way mirror out of the frame and set aside.

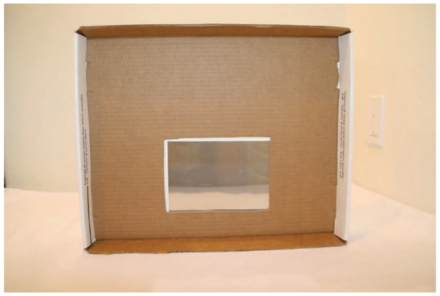


7. Tape both box lids together. Place the second lid upside down (i.e., inside of the box facing up) directly on top of the first lid. Line up the cut-out holes. Tape the two lids together along three sides. Do not tape along the long side that is closest to the holes. This is where you’ll slide the one-way mirror in and out of the box model.

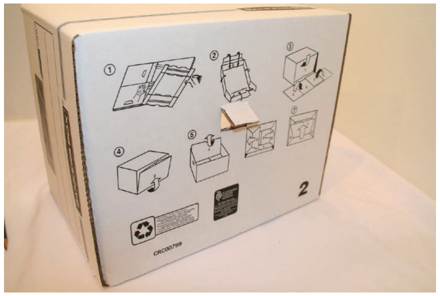


8. Slide the one-way mirror in the frame between the box lids to test it. Depending on the height of the toys or objects you will use, you need to decide if students will insert the one-way mirror from the bottom (with short objects) or from the top (with taller objects). This decision determines placement of the flashlight holes and viewing holes.

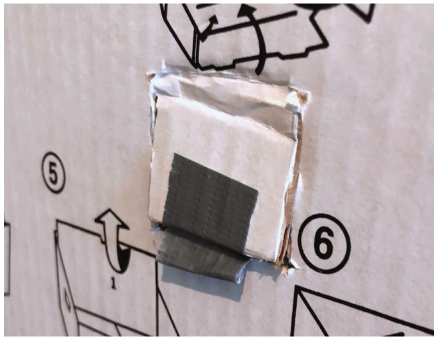
Example of flipping the lids to get the mirror to a lower height for shorter toys or objects.



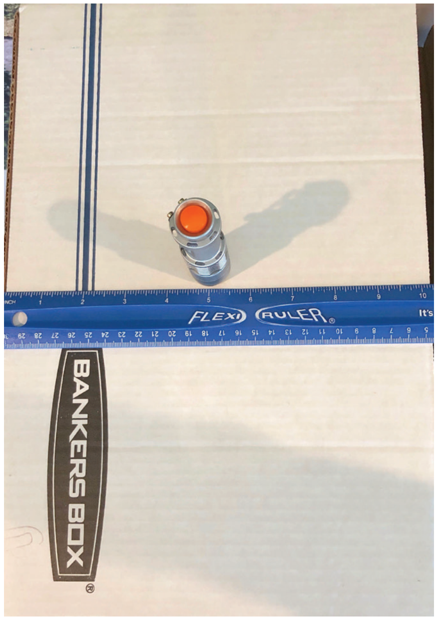
9. Cut a viewing hole in each box. Position the first box with the bottom down on a cutting surface (on the floor or table with scrap cardboard underneath). In the middle of the box panel, cut a three-sided rectangle along the sides and bottom (approximately 1-1.5"). This should be cut in the center of the box, approximately 7.5" from the edge of one of the short sides and 6" from the edge of one of the long sides. Repeat for the second box. Note: If the boxes have a double bottom, you will need to cut through both layers.



Fold the flaps (made by the three sides that are cut) outward. Add duct tape to the flaps to allow students to close and open them easily.

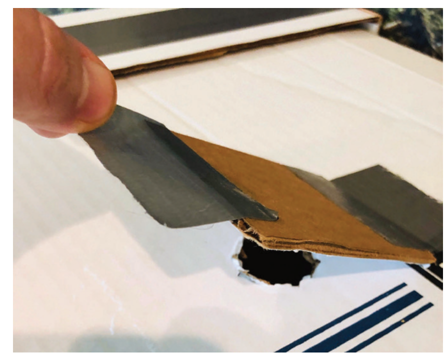


10. Measure where to place the flashlight holes. Label one box Room A and the other Room B. For Room A, measure approximately 5” in from the long sides of the box. Use the flashlight to trace a circle slightly smaller than the flashlight’s diameter. This will help to ensure the flashlight does not slip through the hole.



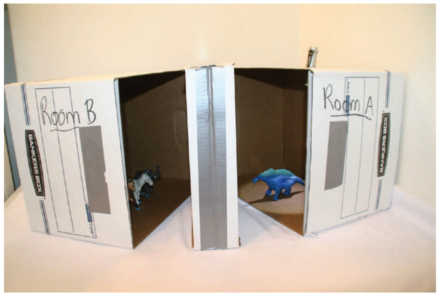
11. Cut the flashlight hole in Room A and add the flashlight. Use the box cutter to cut the hole. Flip the box over so the hole is now at the top, like the room's ceiling. Put the flashlight through the hole. The end with the on-off control should stick out the top of Room A and the light should shine down into the room.

12. (optional) Cut the flashlight hole in Room B and then cover the hole. Option: Do this now or just prior to Lesson 2. Students will not need a hole in Room B until Lesson 2's activities, so you may want to delay cutting this hole right now. Repeat steps 10 and 11 for Room B if doing now. Test that the flashlight can be inserted into Room B. Then remove the flashlight. Use a piece of scrap cardboard and duct tape to create a flap that will seal Room B's flashlight hole.

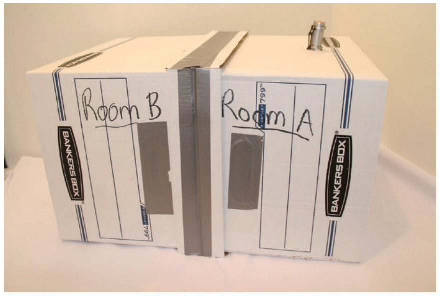


13. Add toys or objects to each room. Use removable mounting putty to adhere one toy or object in Room A and B. Place the toys in the middle of each room and press them firmly in place. If you have enough toys, consider putting a few in Room B to replicate the video as much as possible.

14. Put Rooms A and B together with the one-way mirror. Line up Room A, Room B, and the lids with the one-way mirror inserted from the bottom or top.



Close the boxes tightly together and ensure all openings are closed to minimize extra light entering the inside of the box model. Insert the flashlight into the flashlight hole for Room A and turn it on.



15. Check to make sure you're seeing the desired effect. When you look through the viewing hole in Room A, you should see the toy and its reflection. When you look though the viewing hole in Room B, you should see through to the toy in Room A.

LESSON 1: TEACHER REFERENCE 2

Example Student Ideas

Below is a list of student ideas compiled from piloting and field-testing the unit. These examples can help you anticipate some of the ideas your students may share to build the list of Related Phenomena or Ideas for Investigations and share as initial questions on the Driving Question Board (DQB).

Related Phenomena	Questions on the DQB	Ideas for Investigations
Reflection on water	How can you see yourself in a store window?	Add light to Room B.
Reflection off glass	How does a one-sided mirror work?	Work with the box but add light to Room B.
Reflection off whiteboard	How does it work?	Move the light to Room B.
See your reflection in someone else's eye	How does the person not see the other people but they see him/her?	Turn lights on in Room A and B.
Calm pool water	How does a two-way mirror work?	Take apart the one-way mirror box.
Water mirage	Why does the mirror work both ways?	Make our own one-way mirror.
Pool	Does the light matter?	Look at the mirror closer.
Houses with one-way mirrors	Can the student really see the adults?	Examine the mirror.
Old hotels with one-way mirrors	Does the student know the adults are watching them?	Learn about what it is made of.
Store windows	If someone stood close to the mirror, could they see through?	Test different mirrors in the box.
Library windows	What happens if you flip a mirror around?	Bring in mirrored sunglasses and tinted glass.
Sunglasses	How do you tell if it's a two-way mirror?	Learn how reflection works.
Magnifying glasses	Do the white walls in the video affect the mirror in any way?	Look into getting a one-way mirror.
Transparent cups	What if you turn off the student's lights and turn the adults' lights on?	Look into parts.
See yourself through glass	What would happen if both rooms were lit?	Investigate why transparent cups are transparent.
Plastic wrap	What if both lights are on in both of the rooms, what would happen?	Learn how glass is made.
Clear plastic	What would happen if you turn on both lights?	Learn how mirrors are made.
Mirror maze/circus mirrors	What would happen if both rooms were dark?	Investigate different lighting.
Mirrors	How/why did they create the mirror?	Investigate why two-way mirrors are made.
Shiny metal	What technology do you need to make a two-way mirror?	
Metal pole	Is it made of plastic?	
Swim goggles	How did they invent the mirror?	
Ski goggles	How do you make a two-way mirror?	
Tinted car windows	What do you need to make it work?	
Device screens	What is the difference between a mirror and a two-way mirror?	
Watch face	How is a double-sided mirror made?	
Stained glass	How do they make a one-way window?	
Bubbles	Is there any other way to make this mirror?	
Telescope or microscope		
Shiny counter		

Box Model Modification Instructions

Materials needed for each box model (multiply by 6 for a class set):

- box model with 1 toy in Room B and 1 toy in Room A
- 2 2"-x-2" pieces of cardboard or dark paper to cover the flashlight holes in Rooms A and B
- 1 box cutter
- packing or duct tape
- 1 cylindrical flashlight (with focusing and dimming capabilities)

1. **Cut a flashlight hole in the top of Room B (if you didn't do this in Lesson 1) and add the flashlight.**

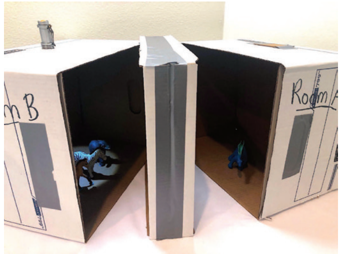
   The hole should be about 2/3 of the way toward the back of the box. Trace the flashlight's diameter and cut a hole a little smaller than that. Flip the box upside down and insert the flashlight partway through the hole. The end of the flashlight with the on/off switch should be sticking out the top of Room B.

2. **Cover the flashlight hole in Room A.**

   Cut a small piece of cardboard or dark paper that is large enough to cover Room A's flashlight hole. Tape it over the hole. Students may want to remove this piece of cardboard as an idea for an investigation. Tell them this is a great idea that they can add to the list.

3. Assemble the completed box model.

Insert Room A and Room B into the lids. Turn the flashlight on in Room B.



4. Check to make sure you're seeing the desired effect.

Dim the lights in the classroom. When you look through the viewing hole in Room B, you should see Room B's toy in the light and reflected in the one-way mirror.

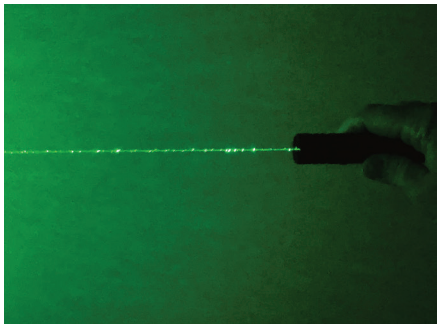
When you look through the viewing hole in Room A, you should see Room A's toy in the dark and see through the one-way mirror to the toy in Room B.

You will use the second piece of cardboard later in Lesson 2 to cover the flashlight holes in Rooms A and B.

Building Prerequisite Understanding Activities

Activity 1: Tracing the Path of Light with a Flashlight and Laser (25-30 minutes)

Key Ideas



Purpose of this activity: Build foundational understanding about how light travels from a light source and what happens when it reaches a solid object.

Listen for these key ideas:

- Light travels in straight lines, so our lines need to be straight.
- Light cannot bend around a solid object.
- An arrow can show the direction light moved.
- A shadow is made when light can't go through a solid object.

Materials needed:

- 1 laser pointer (optional, use laser eyewear)
- 1 flashlight (high powered, preferably zoomable)
- 1 sheet of paper or cardboard
- chalk dust or flour
- small mirror
- chart paper or whiteboard

SAFETY PRECAUTIONS

Lasers can be dangerous to the eye. If using the laser pointer, follow these safety measures:

1. Wear laser protective eye-wear during the setup, hands-on, and take down segments of the activity.
2. When using laser beams, put a caution sign at the door.
3. Remove all reflective items (watches, jewelry, etc.)
4. Before turning on the laser pointer, always be sure that it is pointed away from yourself and others.
5. Never look directly into a laser pointer.
6. Never direct a laser pointer at another person.
7. Remove all potential trip/slip fall hazards for darkened room movement.
8. Windows are covered with blinds, shades or other non-flammable barriers that reduce transmission of the beam.
9. Wash your hands with soap and water immediately after completing this activity.

1. **Demonstrate light traveling from the flashlight.** Suggest that in order to figure out what the lines/arrows represent, we should look at the light coming from a light source. Turn off the classroom lights and turn on a flashlight. Zoom the light if zoomable. Shine the light on a wall viewable by all students. Discuss what is happening by asking these questions:
   - *Where is the light coming from?*
   - *Where is the light going?*
   - *How did it get there?*
2. **Block the light coming from the flashlight with a piece of cardboard (or paper).** Ask:
   - *What changes do you notice?*
   - *Can the light curve around the cardboard?*
3. **Demonstrate light traveling from the laser pointer.** Turn off the flashlight and shine a laser pointer on the wall. Ask:
   - *Can you see the light traveling?*
   - *How do you know it's moving from the pointer to the wall?*
   - *When the laser pointer is blocked by cardboard, can the light curve around it?*
4. **Add chalk dust/flour to see the laser beam reflect off the wall.** Add chalk dust (or an equivalent material, such as flour) to the air by putting a small amount in your hand, rubbing it around, and then clapping in the air to disperse the dust. Point the laser pointer at the wall, running the beam through the dusty air. Ask:
   - *Can you see the light traveling?*
   - *Where does the light travel once it reaches the wall?*
5. **Trace the path of light.** Bounce the flashlight and/or laser beam off a mirror onto the ceiling. Ask students to describe the path light travels (1) from the laser to the mirror, (2) from the mirror to the ceiling, and (3) from the ceiling to the eye. Ask:
   - *If it's arriving at all our eyes, then is light just a single path?*
   - *Why is using one arrow helpful?*
   - *Why is using one arrow limited?*
6. **As a class, discuss and sketch how to represent the path of light.** The purpose of this discussion is to come to agreement about using straight lines and arrows to represent the path and direction that light travels from the source to an object and from an object to where it goes next.

Say, *We can't actually see light moving because it's really fast—so fast that we would need special equipment to see it move. So how could we represent how it moves from the flashlight or laser pointer to the wall? What are some things we need to show?*

As you facilitate this discussion, sketch a model of each material on chart paper or your whiteboard, and use arrows to show all the agreed-upon ideas.

Suggested prompts	Sample student responses	Follow-up questions
Where is the light coming from?	*It's coming from the flashlight/laser pointer.*	*Where does the light go?*
How does the light travel from the flashlight/laser pointer to the wall?	*It travels in a straight line.*	*How could we represent that in a drawing?* *How can we show which direction it is traveling?*
When the light shines on something solid, can it bend?	*No. Some light shines past the edges, but there is a shadow behind the object.*	*How can we show what light moves past the solid object and what light can't move past it?*
When light reaches a solid object like the cardboard, what happens to it?	*It bounces off the cardboard.*	*How could we represent that in a drawing?*

Activity 2: Conditions for Sight (15-20 minutes)

Key Ideas

Purpose of this activity: Build foundational understanding about how light travels that enables us to see objects.

Listen for these key ideas:

- For us to see an object, light must leave a light source, bounce off the object, and travel in a direct path to enter our eyes.
- Light cannot bend around a solid object.
- If there is no light source, we don't see anything.

Materials needed:

- 1 object in the room that some students can and some cannot see from their seats
- chart paper or whiteboard, markers

1. **Discuss the idea of vantage points and what is necessary to see an object.** Select an object in the classroom that half the class will be able to see from their seats and half the class won't be able to see. Discuss why some students can see the object while other students can't.

Suggested prompts	Sample student responses
What needs to be present for us to see an object?	*Light source, object that light can bounce off of, our eye*
When the classroom light is on, how does light travel that allows some of us to see the object?	*Light travels from the source to the object, bounces off the object, and goes into our eye.*
Why do some of us not see the object?	*There are other objects in the way.*
What happens when we block the path of light?	*We can't see the object anymore. Light can't bend around those objects.*

2. **Work as a class to discuss and represent where the light is going.** Emphasize that the arrows represent what is happening with the path that light travels.

   As you facilitate this discussion, sketch a model of each material on chart paper or your whiteboard, and use arrows to show all the agreed-upon ideas.

3. **Discuss what would happen if we turned off the light.** Ask:
   - *What if we turned off the light?*
   - *Why would we not see the object or have difficulty seeing the object?*
   - *How can we revise our model when the light is turned off?*

Activity 3: Representing the Path of Light in Different Scenarios (20 minutes)

Key Ideas

Purpose of this activity: Build foundational understanding about how we see objects and how to represent these ideas.

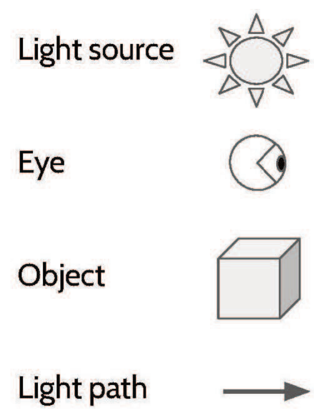
Look for/listen for these ideas:

- Light travels in straight lines, so our lines need to be straight.
- Light cannot bend around a solid object.
- An arrow can show the direction that light moved.
- For us to see an object, light must leave a light source, bounce off the object, and travel in a direct path to enter our eyes.

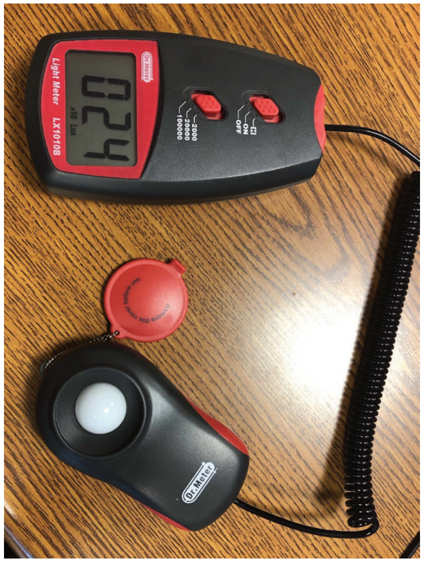
Materials needed:

- 1 *Representing the Path of Light in Different Scenarios* handout per student

1. **Introduce symbols to represent how light travels that allows us to see.** Pass out one copy of the *Representing the Path of Light in Different Scenarios* handout to each student and orient them to the symbols shown in the key.
2. **Work in small groups to map the path of light.** Give students time to think about the path that light travels in each of the four scenarios. Have them evaluate what the eyes in each scenario will be able to see and why.
3. **As a class, discuss what people in each scenario see and why.** Ask:
   - *What does this person see and why?*
   - *How did you represent this?*
   - *If the person cannot see the object, how could you move it so the person would be able to see it?*



Measuring Light Investigation Guidance

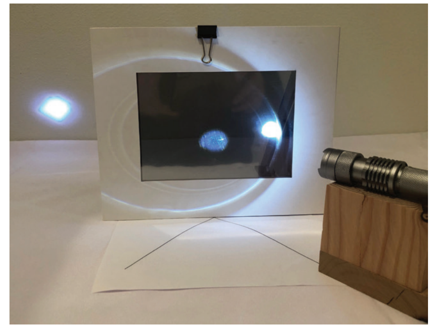


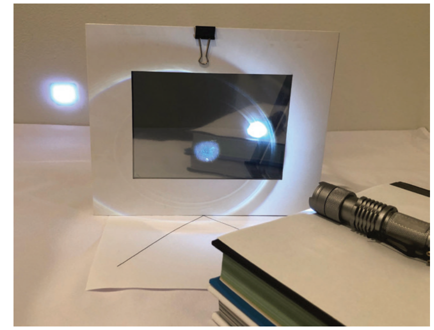
Check that students have removed the cover from the light meter and are using the right setting. The three settings (2,000; 20,000; 100,000) represent the sensitivity of the light meter. Students should choose the middle setting (20,000). This will set the sensitivity to x10 lux. Each reading will be in units of x 10 lux. For example, a reading of “024” represents 240 lux (24 x 10 lux).

Before making any observations, make sure students complete the following advance preparation steps:

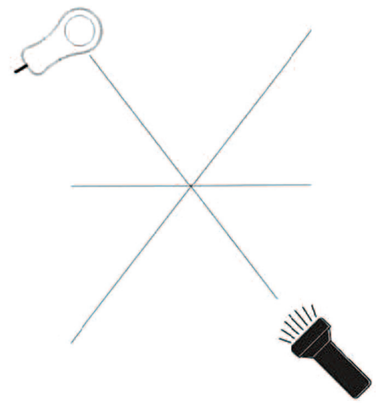
1. Tape a cardboard tube to the light meter so the tube surrounds the sensor.

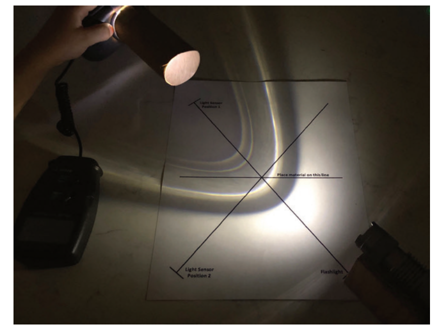
2. Place the flashlight on top of a wooden block or a set of books so it is elevated about 3-4 inches above the table top. This will ensure the light is not blocked by the picture mat that holds the one-way mirror material.



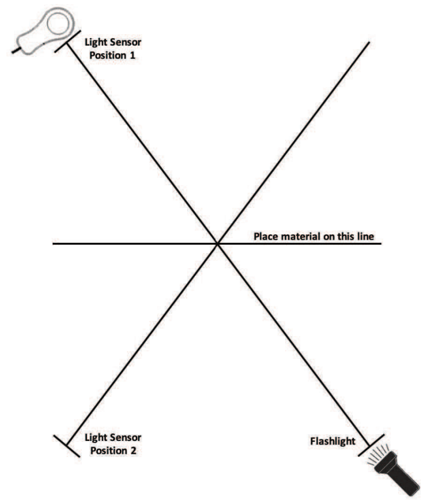


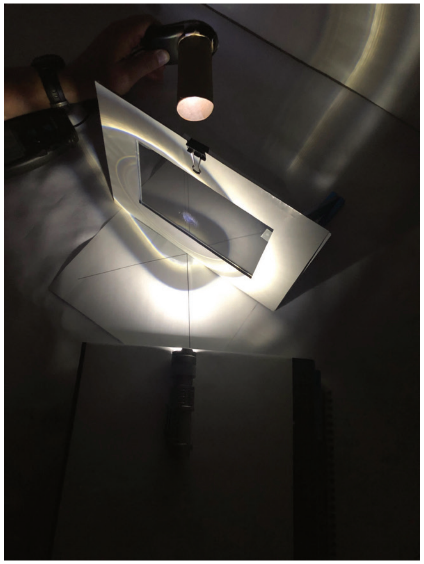
3. Take a baseline measurement of the light coming from the flashlight and record that number in the box at the top of their handout. The flashlight should be the same distance from the light meter that it will be for all the observations that follow, which corresponds to the distance across the long diagonal line on the template.



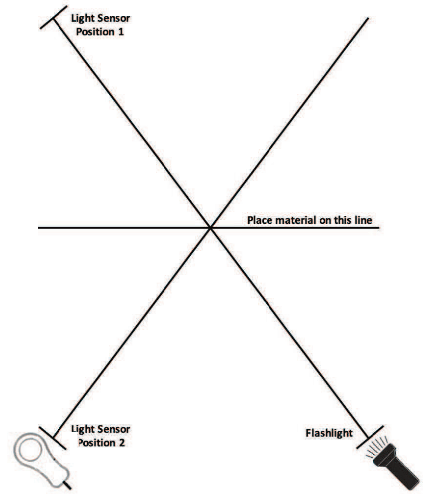


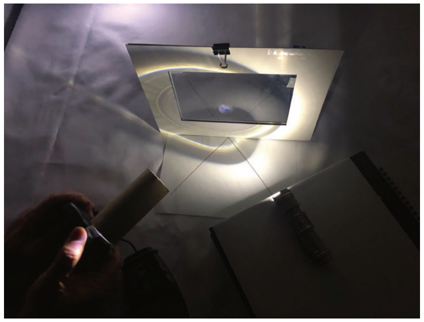
4. To test the amount of light a material transmits, students should hold the light meter at the opposite corner of the template from the flashlight, with the material in the middle dividing the template. Both the light meter and the flashlight should be centered along the lines of the template, toward the center of the material.



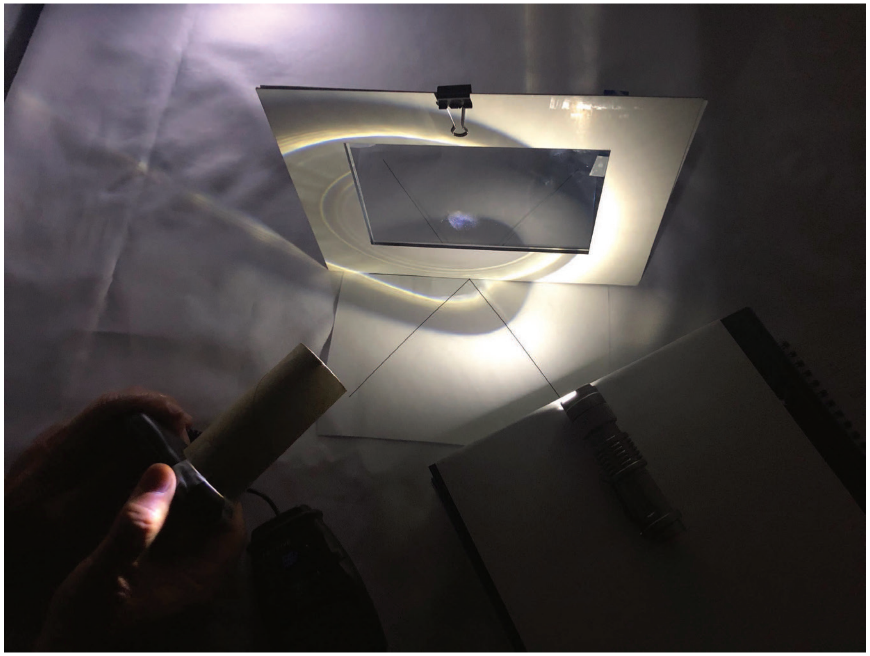


5. To test the amount of light a material reflects, students should hold the light meter at the corner of the template closest to the flashlight. Both the light meter and flashlight should be centered along the lines of the template, toward the center of the material.





6. If students are struggling to get a consistent reading on the light meter, make sure they are not sitting too close to a competing light source, like a window. Then, tell them to align the meter's sensor to the beam of light (either transmitted or reflected) from the flashlight and to keep the light meter as still as possible. They should record the highest number they see on the meter.



LESSON 3: ANSWER KEY 1

Name: ______________________________ Date: ______________________

Asking Questions Tool - Experimental Questions Key

Part A

1. What is the original question you want to investigate?

   How much light is reflected and how much is transmitted by each of the materials?

> Scientists develop experimental questions to identify what they want to test or change in an experiment (independent variable). They also include what they are going to observe or measure (dependent variable).
>
> **For example:**
>
> How does the amount of light a plant gets in a day affect how tail the plant grows?
>
> (independent variable) (dependent variable)
>
> **Example question frames for experimental questions:**
>
> How does ______________________affect _________________?
>
> (independent variable) (dependent variable)
>
> What is the effect of ___________________ on _______________?
>
> (independent variable) (dependent variable)

2. Look at your original question. What do you think will cause an effect? This is the variable you will change in your experiment (independent variable).

   Each of the materials—the one-way mirror, the glass, and the regular mirror—will cause different amounts of light to reflect and transmit (effect).

3. What will you measure to see if the change you made has an effect? This is the variable you will observe or measure (dependent variable).

   We will measure the amount of light that is reflected and the amount of light that is transmitted by each material.

4. Revise your question to include the variable you are changing (independent variable) and the variable you are measuring (dependent variable). Use the question frames shown above to help you revise your question.

Some examples:

- How does the material (one-way mirror, glass, or regular mirror) affect how much light is reflected and how much is transmitted?
- What is the effect of the material on the amount of light reflected and the amount transmitted?

5. If you collect this evidence in an experiment, what new thing about the phenomenon will it help you explain?

   Light affects how the one-way mirror behaves, so measuring the amount of light that it reflects and transmits, and comparing that to how much light the glass and the regular mirror reflect and transmit, might help us figure out what is happening at the point where the light hits the one-way mirror.

Part B

Peer or Teacher Feedback

Name: __________________

Name of person giving feedback: __________________

Provide feedback using the table below.

Criteria		Yes or no?	Feedback and/or suggested revision
Does the question include an independent and dependent variable?			
Is the question specific enough that you can design an investigation to answer it?			
Does the question help you figure out something new about the phenomenon?			

Extension Opportunity: Refraction of Light Activities

Activity 1: Assign Home Learning Opportunity - Refraction Reading

Time

2 min

Materials

1 *Reading: How do eyeglasses help people see better*? per student. There is a color copy of the reading in the Student Work Pages component. The Lexile Range for the reading is 810L–1000L.

Procedures

Assign home learning opportunity. At the end of day 1 of Lesson 6, distribute a copy of the reading *Reading: How do eyeglasses help people see better?* to each student. Tell students that during our next class period, we will further investigate refraction of light. To help prepare for the activities, they will need to read *Reading: How do eyeglasses help people see better?* as a home learning assignment. Let them know that it will not take long to complete the reading at home.

Activity 2: Observing Refraction of Light

Time

25 min

Materials

For each group:

1 tall plastic cup

1 large plastic straw

1 sheet of white paper

1 marker, any color

For the class:

1 magnifying glass

1 flashlight

1 tall plastic cup

1 plastic ruler

Cooking oil

Rubbing alcohol

Water

1 sheet of white paper

Computer monitor

Slides S-V

Procedures

1. **Demonstrate light passing through a lens.** Darken the classroom, then shine a flashlight through the lens of a magnifying glass and say, *During our last class period, we explored how light interacts with the lens of a magnifying glass.*

Suggested prompts	Sample student responses
What happens as light passes through the lens of the magnifying glass?	*When light passes through the lens of the magnifying glass, it changes direction or refracts.* *All the light rays in the beam of light refract inward.*
What evidence do we have to support our thinking?	*When we traced the circle of light that passed through the lens, the circle of light was much smaller, which means the beam of light narrowed inward.*

2. **Discuss the home reading as a class.** Continue this discussion using the suggested prompts to surface important or key ideas that students learned from the reading assignment. Listen for these ideas:
   - Lenses can be made of different materials, but they are all transparent.
   - All lenses refract light, but not necessarily in the same exact way.
   - The shape of the lens, its thickness, and the material it is made of all affect how light is refracted by the lens.

Suggested prompts	Sample student responses
What did you read about in How do eyeglasses help people see better?*?*	*The reading was about lenses and how useful they are in helping people with vision problems see more clearly.*
Are all lenses exactly like the lens in the magnifying glass?	*Lenses come in different shapes and different thicknesses, and can be made of different materials.*
How are all lenses alike?	*They are all transparent.*
How do the differences—shape, thickness, and material—affect how a lens interacts with light?	*The differences cause light to refract or change direction differently. This means that objects might appear smaller or larger through the lens.*

3. **Conduct the small-group refraction investigations.** Each small group of students needs a bin of materials to conduct two quick investigations. The procedure for each is on the corresponding slide.
   - **What happened to the straw?** Show **slide S**, and have students quickly conduct this investigation and record their observations in their notebooks.
   - **Which way does the arrow point?** Show **slide T** and have students quickly conduct this investigation and record their observations in their notebooks.

4. **Conduct the whole-class refraction investigations.** Use the class materials to conduct two more quick investigations. The procedure for each is on the corresponding slide.
   - **What's wrong with my ruler?** Show **slide U**, and have students observe while you conduct this first demonstration. Give them a few minutes to record their observations in their science notebook.
   - **Can you see it?** Show **slide V** and have students observe while you conduct this second demonstration. Give them a few minutes to record their observations in their notebook.
5. Give students a few minutes to finish recording in their notebook, if they need extra time.

Additional Guidance

Keep in mind that you have only 25 minutes to complete all the investigations in Activity 2. If time is short, do not conduct the last demonstration. This will not negatively impact students' learning.

If you plan to conduct the last demonstration, it is highly recommended that you try the activity prior to using it in class. This will give you time to adjust the light and the image on your computer monitor and adjust the distance you stand from the monitor in order to get a good image projected onto the sheet of white paper.

Activity 3: Modeling Refraction of Light

Time

20 min

Materials

Chart paper

Markers

6-×-8 sticky note

Procedures

1. **Conduct a Building Understandings Discussion.** Use the suggested prompts and follow-up questions below to debrief the investigations from Activity 2. Have materials readily available to demonstrate one or more of the activities, if necessary. This will give students the opportunity to make additional observations and answer follow-up questions.

Key Ideas

Purpose of this discussion: Give students opportunities to

- share observations from the investigations in Activity 2, and
- connect what they observed to their previous observations of light refraction.

Listen for these ideas:

- When light moves from one transparent material to another, it refracts.
- When light refracts, the images and objects we see appear to change in a variety of ways, depending on the properties (thickness, material, shape) of the transparent materials that light passes through.

Suggested prompts	Sample student responses
What did you observe when we poured water into the glass with the straw?	*The straw looked like it was broken right at the surface of the water.* *The part of the straw below water also looked bigger than the part above water.* *The part of the straw below the water also looked like it was leaning at a slightly different angle than the part above water.*
What did you observe as you slid the arrow behind the glass of water?	*The arrow changed directions! Instead of pointing to the right, it was pointing to the left!* *It also looked bigger than the arrow above the water.* *I also noticed that when the person holding the paper moved it just a little bit, the arrow looked like it was curved.* *It looked out of shape or distorted!* *The arrow also appeared to get shorter or longer, depending on how the paper was moved.*
What did you see when we slid the ruler into the glass with the three liquids?	*The ruler did what the straw did, but each part of the ruler that was in a different liquid was slightly different sized.* *It looked like the ruler was broken into four different-sized pieces, but still part of the same ruler! It was cool!*
What do all the liquids have in common?	*They are all transparent.* *Oil is thicker than water.* *It flows a little slower, too.*
How are the liquids different?	*The oil also is slightly yellow. It's not colorless, like the water and rubbing alcohol.* *The rubbing alcohol feels a little thinner than water, but it's not easy to notice.* *The oil floats on the water, and the rubbing alcohol floats on the oil. We did floating and sinking investigations in elementary school.*

Suggested prompts	Sample student responses
What did you observe when we placed the lens in front of the computer monitor?	*There was a tiny image on the paper!* *It was the same as the image on the computer monitor, but it was upside down!*
What does the lens have in common with the liquids?	*It's also transparent.*

Additional Guidance

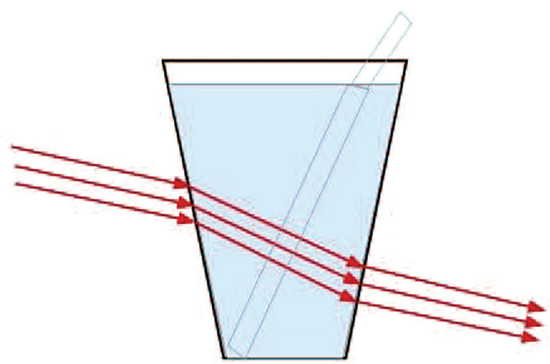
The concept of relative density as the relationship between the amount of matter (mass) in a sample and the amount of space it takes up (volume) is introduced in Lesson 5 of *Unit 6.3: Why does a lot of hail, rain, or snow fall at some times and not others? (Storms Unit)*. Students do not need to understand this concept for this lesson.

2. **Develop models to represent refraction of light.** Use chart paper and markers to develop a class model of the first activity. You will not have time to model all four, so it is recommended that you model the first activity to illustrate how light refracts as it passes from one transparent material (air) to another (water). You can use the suggested prompts and follow-up questions to guide students as they collaboratively develop the model and make connections to what they observe happening with the other liquids and the glass lens as light transmits through them. Use arrows to show the path of light as it moves from the air to the liquid or glass lens. Your model may look similar to the example below.

Suggested prompts	Sample student responses	Follow-up questions
If we develop a model of the first investigation, what components make up the system that we observed?	*The model should include the glass, the water in the glass, and the straw.* *We should also include light.*	*How would we represent each of these components?*
We know the water is transparent. Is there any other transparent material that the light is transmitting through?	*The light transmits through the air before it reaches the glass of water.* *It also transmits through the air again after it transmits through the glass of water.*	*What transparent materials does light transmit through in the other investigations?*
Does light refract when it transmits through water or other transparent materials like it does when it transmits through a lens?	*Light must be changing direction or refracting when it transmits through water or other transparent materials. The objects we see look different when we see them through water, oil, and rubbing alcohol.*	*In what ways do the objects appear to change when we observe them through water or other transparent materials?*

Suggested prompts	Sample student responses	Follow-up questions
Think about the lenses that you read about in How do eyeglasses help people see better?. *Do all lenses refract light in the same way?*	*All lenses refract light, but how much and the change in the direction of light depends on the shape, thickness, and material that the lens is made of.*	*Do you think this is true of different liquids?*
So how could we represent the light in our model?	*We could use arrows, like we did with the box model.* *The arrows should show the path that the light takes.* *The arrows should change direction, too.*	*Where should the arrows that represent light change direction?*

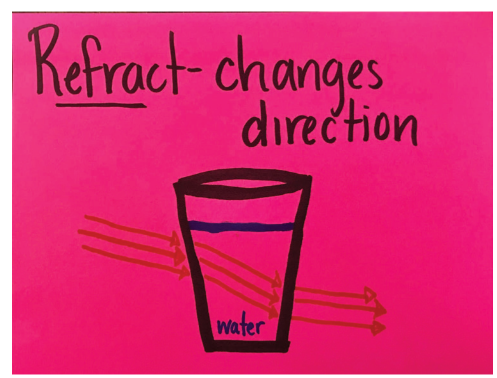
3. **Work together to draw conclusions.** Ask students, *What have we learned about refraction of light?* Listen for these key ideas in students' responses:
   - When light moves from one transparent material to another, it refracts.
   - When light refracts, the images and objects we see appear to change in a variety of ways, depending on the properties (thickness, material, shape) of the transparent materials that light passes through.



If necessary, use questions to guide students' thinking.

4. **Add "Refraction" to the Word Wall.** Tell students, *Over the last two class periods, we have used the phrase "changes directions" to describe what happens when light travels from one transparent material to another, and we have used evidence from our investigations to explain this phenomenon. For example, we know that light changes direction when it moves from air to the lens of a magnifying glass because we observed that light changed direction and focused inward to make a smaller circle of light on paper after transmitting through the lens. Because we can describe this behavior, we can use the science word, "refract," which means that light changes direction.*

As you share and define the new science vocabulary, write the word on a 6-×-8 sticky note, along with its definition and a simple diagram. Place the sticky note on the Word Wall in the classroom and say, *Whenever we talk about light changing direction as it transmits through one transparent material and into another, we can say that light refracts. I encourage you to use this term whenever we talk about what light is doing when it transmits through transparent materials.*



Name: ____________________ Date: ____________________

Final explanation: One-way mirror phenomenon

1. Why does the music student see themself but not the adults?

2. One change I made to my explanation based on the feedback I received was

I made this change because

3. One piece of feedback that I did not use was

I did not use that feedback because

Rubric Explaining the one-way mirror phenomenon

<table>
<tr><th rowspan="2">How or why account</th><th colspan="3">Category</th><th rowspan="2">Feedback</th></tr>
<tr><th>Missing</th><th>Developing</th><th>Mastered</th></tr>
<tr><td>Uses the following science ideas to explain why the music student sees themself and why the music student does not see the adults:
• When light shines on an object (the music student, the adults), it is reflected.
• About half the light reflects off the one-way mirror and half transmits through it.
• We see objects when light reflects off them and enters our eye.
• When a light input is detected by sense receptors in our eye, it is turned into a signal that travels to the brain.
• Less light enters the music student’s eyes that reflected off the adults than light that reflected off the music student.
• When there are multiple light inputs entering the eye, they are turned into signals, but the brain responds to the strongest signal.</td><td></td><td></td><td></td><td></td></tr>
<tr><th rowspan="2">Based on evidence</th><th colspan="3">Category</th><th rowspan="2">Feedback</th></tr>
<tr><th>Missing</th><th>Developing</th><th>Mastered</th></tr>
<tr><td>Evidence from classroom investigations (labs, readings, videos) supports the explanation.
• Measuring Light Lab from Lesson 3 shows about the same amount of light transmits through and reflects off the one-way mirror
• Half-silvered structure of the one-way mirror from Lesson 4 reading
• Video and reading from Lesson 6 about the eye and brain
• Observations using the box models from Lessons 1, 2, and 3</td><td></td><td></td><td></td><td></td></tr>
<tr><th rowspan="2">Revised explanation</th><th colspan="3">Category</th><th rowspan="2">Feedback</th></tr>
<tr><th>Missing</th><th>Developing</th><th>Mastered</th></tr>
<tr><td>Uses feedback from self and peer assessment to revise the explanation:
• Includes a revised explanation that is clearly improved
• Includes a reflection of why a change was made
• Includes a reflection on a piece of feedback they did not use, if applicable</td><td></td><td></td><td></td><td></td></tr>
</table>

*The ”Developing” section of the rubric represents students who may have several important ideas described in the rubric that indicate progress toward mastery but there is still something notably missing in their response. “Missing”, on the other hand, indicates their response is missing many important ideas described in the rubric.

Extension Opportunity: Surface Scattering and Everyday Phenomena

Activity 1: Disney Concert Hall Reading

Time

45 min

Materials per student

1 *Reading*: *Walt Disney Concert Hall Case Study* (There is a color copy of the reading in the *Student Edition*. The Lexile range for the reading is 810L–1000L.)

1 highlighter (optional)

slides U-X (optional)

Procedures

Cluster related phenomena that pertain to shiny and reflective surfaces. From the Related Phenomena list and Self-Documentation Collection, point out that many of students' ideas and experiences were about highly reflective surfaces like mirrors, smooth countertops or materials, and calm water. Pose the question, *Why are some materials "shiny" or "reflective"?* Elicit students' initial ideas.

Listen for students to suggest these ideas:

- The materials are really smooth.
- The materials are coated in something to make them this shiny.
- The materials are designed in a way to cause reflection.
- The light shines on the materials in a certain way because it only happens at certain times.

Introduce a real-world case study. Display **slide U.** Say, *I found a case where a famous building was really shiny. It was so shiny that it was blinding people and drivers when light reflected off of it. They had to modify the building to change how it reflected light so it wouldn't blind people anymore. This case may give us clues as to why shiny objects reflect light in certain ways and what they did to the surface to make it less shiny.*

Pass out 1 copy of the Reading: *Walt Disney Concert Hall Case Study* reading to each student. They can use this handout version to annotate.

Use the close reading strategies. Review the close reading strategy steps with students (**slide V**), pausing at each step.

1. Ask students what the main questions are that we are trying to answer using this reading. Students may suggest questions like the following:
    - Why do some materials make a “mirror reflection”?
    - What do shiny objects reflect so much light?
    - Cue students into the DQB questions related to mirrors and mirror reflections. If necessary, co-construct a question the class agrees encompasses the DQB questions in this category. Articulating a question reminds the students of the purpose for what they are trying to do and the type of information to look for within the reading. Explain that reading this case study will help them answer this question.
2. Give students 10 minutes to read the reading on their own.
3. Reread the first paragraph aloud together. As you read, pause and highlight a few ideas that could help answer the question(s).
4. Then, give students about five minutes to continue reading on their own, highlighting key ideas, and analyzing the images embedded in the text. Remind students to be selective about what they highlight and look for things that help answer their question(s).
5. Tell students to work with a small group (or with a partner) to summarize the key ideas from the reading that answer the question(s).

Discuss the reading as a class. Display **slide W.** Facilitate a brief class discussion. The purpose of this discussion is to summarize the idea that light reflects differently off smooth and rough surfaces and to make personal connections to this idea.

Suggested prompts	Sample student responses
What key ideas did you summarize that help us answer our questions?	*Light reflects in a V shape off any surface. When the surface is smooth, all the light goes in the same direction. When the surface is rough, all the light scatters.*

Share and explain related experiences of being “blinded” by light. Display **slide X**. Revisit the idea that people were “blinded” by light reflecting in a specific direction off the Walt Disney Concert Hall.

- Have students share experiences they have had where light reflected off smooth surfaces in a V shape and almost “blinded” them.
- If you believe your students are ready, you can introduce the term *specular reflection* as a way of describing when all the light reflecting on a surface reflects off at the same angle or in the same direction. Otherwise, use “reflects in the same direction”.

Share and explain related experiences of light scattering off rough surfaces.

- Have students share experiences they have had where light scattered in all directions off a rough surface.
- If students struggle to come up with ideas here, move straight to the next demonstration of light reflecting off different materials. After this experience, have them think about other objects in the classroom that have rough surfaces.

Activity 2: Observations of Scattering and Discussion

Time

25 min

Materials per group

18″ × 8″ piece of aluminum foil

18″ × 11″ piece of paper

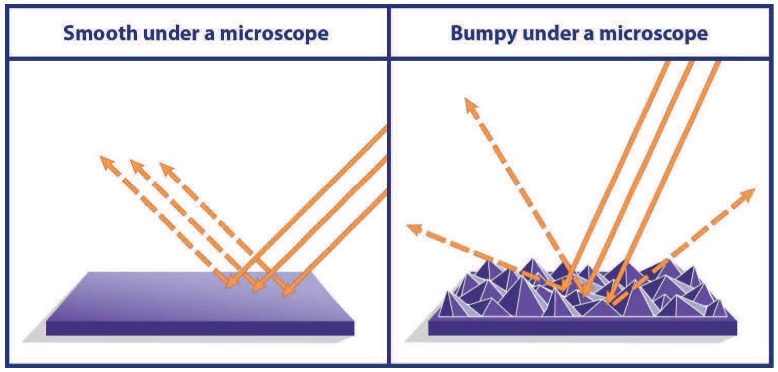
18″ × 8″ piece of cardboard

18″ × 8″ mirror (edges taped)

18″ × 8″ glass (edges taped)

1 flashlight

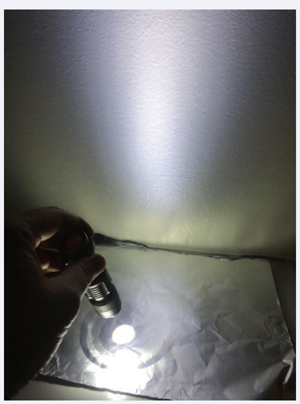
slides Y-AB (optional)



Procedures

Use the model from the reading to explain "blinded" and "scattering" experiences.

- Demonstrate how you can shine a flashlight on a mirror and it will reflect a focused beam of light onto the ceiling or nearby wall. Explain that students will test how well a material focuses the reflected light or scatters it in all directions.
- Arrange students in small groups, each with a bin of investigation materials.
- Darken the classroom.
- Have students work together to test different materials in terms of how much they focus or scatter reflected light (as shown in the images below)

Scattered beam off aluminum foil	Focused beam off a mirror
	

Facilitate a Consensus Discussion. Bring the class together for a Consensus Discussion to agree on what we've figured out. During the discussion, display **slides Y-AA**, which include microscope images of the materials students tested as well as the model for specular reflection and scattering. Have students use the microscope images and model to share why the microscale surfaces of each material would reflect light in different ways.

Return to students' Related Phenomena. Display **slide AB** and construct an explanation for why some surfaces are "shiny" and can "blind" us when light reflects off them. Transition to using the ideas about light interacting with smooth surfaces to explain why such surfaces can cause mirror reflections. Prompt students to consider how light reflecting off a mirror or really smooth surface could cause a mirror reflection, but light off a rough surface does not. Project the model on **slide Z** to help facilitate the discussion.

As the class comes to consensus, consider having your students add an entry to their Progress Trackers in their science notebooks. While students update their Progress Trackers, update the class's Science Ideas chart with the new ideas the class agreed upon.

Key Ideas

Purpose of the discussion: The purpose of this discussion is to come to consensus on how light behaves differently depending on whether the material has a smooth or rough surface at the microscale.

Listen for these student ideas:

- When light shines on surfaces that are *rough* at the micro scale, it scatters in all directions.
- When light shines on surfaces that are *smooth* at the micro scale, it reflects in the same direction.

Activity 3: Using Models to Explain Everyday Phenomena

Time

20 min

Materials per student

1 *Explaining New Phenomena*

slide AC (optional)

Procedures

Use the model to explain a related phenomenon. Tell students that you have two related phenomena where the same object reflected light in different ways. Pass out 1 copy of *Explaining New Phenomena* to each student and display **slide AC**. Give students time to read the two options. Answer any questions students have to understand the context. Then, give students time to choose one option and record their explanation. Encourage them to choose which modality to share their thinking—written and pictorial on the handout, or oral form. Encourage them to use the model for specular reflection and scattering of light. If you have time, when everyone is done, have a few students share their explanations.

Open and Closed Questions (Asking Questions Tool)

1. What is the question you are working on?
2. What is the purpose of your question? Circle one of the reasons below or write in your reason.

Here are some reasons why people ask questions in science:

- *We don't understand how the phenomenon (or a part of the phenomenon) works.*
- *We have a disagreement (in our model or with someone's explanation or argument).*
- *We need to test an idea we have.*
- *Other reason:*______________________________

Close-ended and open-ended questions: Questions that can be answered with "yes" or "no" or with a single word are closed-ended questions. Asking open-ended questions gives you space to figure out more things. Scientific questions are open-ended questions.

3. Is your question close-ended or open-ended? Circle one.
   - close-ended (Complete step 4.)
   - open-ended (Skip to step 5.)
4. Revise your question to make it an open-ended question. Think about what you want to explain about the phenomenon. *Try using one of these question stems*:
   - *How does... ?*
   - *Why does... ?*
   - *What happens when... ?*
   - *What happens if... ?*
   - *What is the difference between* _____________ *and* _____________?

Write your revised question:

5. What information or data do you need to answer your question?

6. How would this information or data help you achieve the purpose you circled in step 2?

Peer or Teacher Feedback

Name: ______________________ **Name of person giving feedback:** ______________________

Provide feedback to another student using the table below.

Criteria	Yes or no?	Feedback and/or suggested revision
Is the question open-ended?		
Does the information or data in step 5 help answer the question?		
Does the question help the student achieve their purpose for asking the question?		

LESSON 8: TEACHER REFERENCE 3

Testable Questions (Asking Questions Tool)

1. What is the original question you want to investigate?

Testable questions: Scientists develop testable questions when they want to collect evidence about a phenomenon or problem. To do this, they need to know what to observe or measure to answer their question. Here are some examples:

Question	What will be observed or measured to answer the question
Where does a jaguar roam in a single day?	Use a GPS tracker to observe the area a jaguar travels in a 24-hour period.
How does the amount of rain in a forest affect plant growth?	Measure the amount of plant growth over time and collect the amount of rain over time.
Is a dog's speed related to the length of its legs?	Measure the length of different dogs' legs and measure how fast they run the same 100-meter course.
How many minutes per day do teenagers use social media apps to communicate with their friends?	Measure the amount of time teenagers (ages 13-19) use social media apps to communicate with friends every day for a week.

2. What do you need to observe or measure to answer your question? (for example: an amount, a length, an amount of time, speed, an area)

3. What additional information do you need in your question about the phenomenon you are studying? (for example: the age of the teenagers in your study, the dog breeds you are testing, or which population of jaguars you are focusing on)

4. Revise your question to include what you wrote in steps 2 and 3.

5. Once you gather this evidence, what new thing do you think you will be able to explain about the phenomenon?

Peer or Teacher Feedback

Name: ______________________ **Name of person giving feedback:** ______________________

Provide feedback to another student using the table below.

Criteria	Yes or no?	Feedback and/or suggested revision
Does the question include something observable or measurable?		
Is the question specific enough that you could design an investigation to answer it?		
Does the question help figure out something new about the phenomenon?		

Experimental Questions (Asking Questions Tool)

Experimental questions are one type of testable question.

1. What is the original question you want to investigate?

Experimental questions: Scientists develop experimental questions to identify what they want to test or change in an experiment. This is called the *independent variable*. They also include how they are going to measure their results, which is the *dependent variable*.

For example:

How does the <u>amount of light</u> a plant gets in a day affect <u>how tall the plant grows</u>?
(independent variable) (dependent variable)

Here are some example question frames for experimental questions:

How does ______________________ affect ______________________?
(independent variable) (dependent variable)

What is the effect of ______________________ on ______________________?
(independent variable) (dependent variable)

2. Look at your original question. What do you think will cause an effect? This is the variable you will change in your experiment (independent variable).

3. What will you measure to see if the change you made has an effect? This is the variable you will observe or measure (dependent variable).

4. Revise your question to include the variable you are changing (independent variable) and the variable you are measuring (dependent variable). Use the questions frames above to help you revise your question.

5. If you collect this evidence in an experiment, what new thing about the phenomenon will it help you explain?

Peer or Teacher Feedback

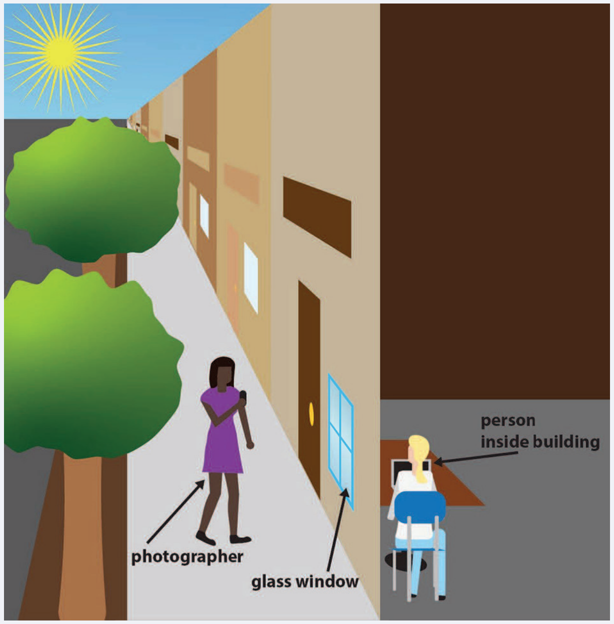
Name: ______________________ **Name of person giving feedback:**______________________

Provide feedback to another student using the table below.

Criteria	Yes or no?	Feedback and/or suggested revision
Does the question include an independent variable and a dependent variable?		
Is the question specific enough that you could design an investigation to answer it?		
Does the question help figure out something new about the phenomenon?		

Name: ______________________ Date: ______________

Portraits Through Glass: Individual Assessment

Side view	Front view
	

1. Imagine you are standing outside the glass window next to the photographer. It is the middle of a sunny day. You look into the glass window of the building with no lights on inside. The “front view” is what you see.

a. Use words or pictures (or a combination) to explain where light travels that causes you to see <u>the trees</u> in this image.

b. Use words or pictures (or a combination) to explain where light travels that causes you to see the person in this image.

2. Some objects in the image stand out more than other objects.

a. Circle one object that stands out the most in this image to you. Put a square around another object that stands out the least to you.

b. Explain in words or pictures why you see one object more than the other object.

3. What could you change in the system to make the person stand out more? Include why you think your change will help you to see the person better.

Portraits Through Glass: Scoring Guidance

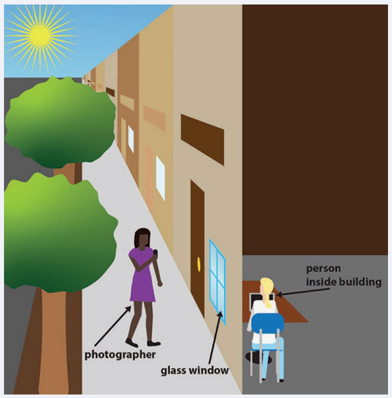
Allow your students to choose the modality for communicating their thinking. They can explain the phenomenon through written explanation or using a diagrammatic explanatory model. Guidance is provided depending on the modality students choose to use.

This assessment can be used to assess student progress on the LLPE. This LLPE is an integration of elements from the three dimensions.

8.B Apply science ideas and evidence from classroom investigations to explain a common, real-world phenomenon in which a material designed for light transmission and to look transparent to the eye and brain functions as a one-way mirror due to the relationship the material has to other parts in the system.		
SEPs	**DCIs**	**CCCs**
Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events. Students started to engage with this element in Lesson 6 and then throughout Lesson 7 and the first day of this Lesson. Students can engage in the application of science ideas for the purpose of explanation using two forms. These explanations can take the form of written explanation and/or an explanatory model. Either choice should give you the opportunity to assess progress on SEPs. Look for how students apply science ideas to support their explanations. Are there patterns in science ideas present or missing from all students' explanations? Students may also bring evidence from the classroom or their experiences to bolster their explanations.	When light shines on an object, it is reflected, ~~absorbed~~, or transmitted through the object, depending on the object's material ~~and the frequency (color) of the light~~. (MS-PS4-2) The path that light travels can be traced as straight lines, ~~except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.~~ (MS-PS4-2) Each sense receptor responds to different inputs (electromagnetic, ~~mechanical, chemical~~), transmitting them as signals that travel along nerve ~~cells~~ to the brain. The signals are then processed in the brain~~, resulting in immediate behaviors or memories.~~ (MS-LS1-8) Students should use their understanding of light interactions with materials (reflection, transmission) to trace the path light takes from the source to and from different objects in the system. To explain what is seen by the viewer, students need to leverage their understanding of the eye as a sense detector of light inputs which are transformed into signals sent to and processed by the brain.	Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function. Structure and function is the focal CCC for this assessment. Students may bring their understanding of system and system models to support their thinking too. Either should be evidence that students are using CCC to guide their explanations. For structure and function, pay attention to how students describe the way light interacts with the glass material. Glass is designed to transmit most light, so students may show this in their models or written explanation (indicated by drawing that most light goes through the glass or saying this in words). Importantly, look for how students use the light that reflects off the glass to explain what is seen. If students use systems and system models, pay attention to their explanation of the important components and important interactions, which include light interacting with the glass, and reflected light interacting with the eye and brain.

The scoring guidance provided below uses a + and ++ notation that can help you identify different ideas that students should (or could) include in their responses.

- If several of the ideas marked with a + are missing from a student's response, this may indicate the student has not mastered the science ideas or that the student may be struggling to bring those ideas together in a written explanation or model. Additional probing of their thinking can provide insight about whether the student is struggling with a science practice or science idea, or both.
- If all or almost all of the ideas marked with a + are present in a student's response, this may indicate the student has mastered the science ideas and is able to use them in a written explanation or explanatory model.
- If the ideas marked with a ++ are present in a student's response, this indicates that the student is bringing a deeper understanding of the science ideas or a deeper engagement with the practice to their response. Students should not be marked off if ideas marked with a ++ are not present in their response.

<table>
<tr><th>Side View</th><th>Front View</th></tr>
<tr><td>
</td><td></td></tr>
</table>

1. Imagine you are standing outside the glass window next to the photographer. It is the middle of a sunny day. You look into the glass window of the building with no lights on inside. The "front view" is what you see.

a. Use words or pictures (or a combination) to explain where light travels that causes you to see the trees in this image.

Students may choose to respond with a written description or diagrammatic representation, or a combination of the two. In either type of response look for students to engage in explanation, using written explanation or an explanatory mode.

Look for the following ideas represented in written or pictorial form. Encourage students to use a key if pictorial form is chosen.

+ Light from the Sun reflects off the trees to the glass (in a model: this will be indicated by an arrow away from the sun to the tree and an arrow away from the tree)

+ Light reflects off the glass (in the model: arrow from the tree to the glass and an arrow away from the glass)

+ The light that reflects off the glass enters the viewer's eyes (in the model: an arrow away from the glass and pointing into the eye).

+ Overall response indicates they are tracing a path away from the source (Sun) toward objects (trees, glass) and into the eye. This indicates a path of light model where written explanations and arrows indicate that light is traveling between the source and objects, and reflection off objects into the eye is required for sight.

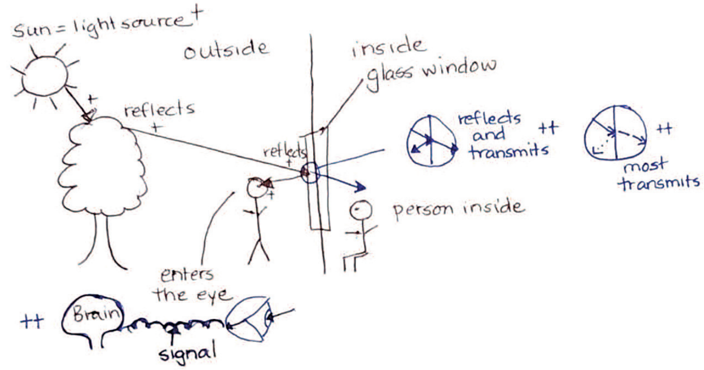
++ Light goes through the glass (in the model: arrow continues through the glass)

++ A little light reflects off the glass and a lot of it also goes through the glass and bounces off the person (emphasis here would be on understanding properties of glass as a material).

++ Light entering the eye through the lens and to the retina (in the model: A zoomed in bubble showing light entering the eye)

++ Light inputs transformed to electrical signals to the brains (in the model: the light arrow transforming to another representation)

In this case, the ideas marked with ++ indicate that the student is bringing more of the science ideas from the unit to give a more complete explanation, which is not necessarily required by the prompt itself, but could be used to answer it.



Guidance on arrows: Encourage students to use solid arrows to document where light travels. It is not necessary for students to use the dashed and dotted arrows in their representations. This is also true for 1b. Note that if students want to show "a little light" or "a lot" of light the dashed and dotted arrows can be used to conceptually communicate their thinking, but it is not necessary for this response, and may lead to confusion if students try to mathematically account for amounts of light.

b. Use words or pictures (or a combination) to explain where light travels that causes you to see the person in this image.

+ Light from the Sun transmits through the glass (in the model: an arrow pointing away from the Sun and to the glass and an arrow moving through the glass in a straight line).

+ Light reflects off the person (in the model: an arrow transmitted through the glass to the person and then an arrow pointing away from the person).

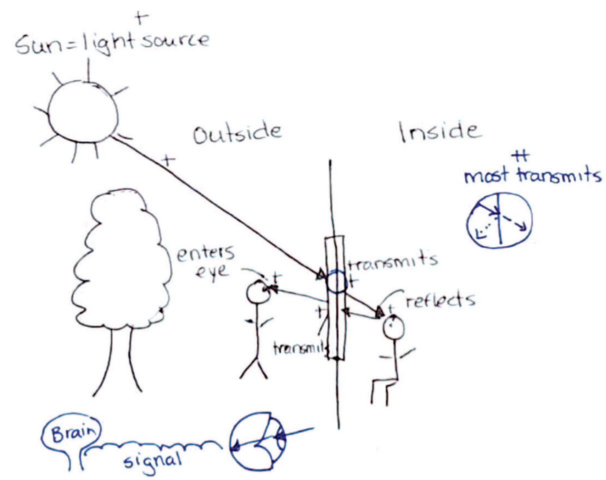
+ Light reflecting off the person transmits back through the glass (in the model: arrow moving away from the person and back through the glass).

+ The light that transmits back through the glass enters the eye (in the model: arrow pointing into the eye).

++ Most of the light from the Sun transmits through the glass. Some light reflects off the glass (in the model: arrows indicate different amounts of light doing different things).

++ Light entering the eye through the lens and to the retina (in the model: A zoomed in bubble showing light entering the eye)

++ Light inputs transformed to electrical signals to the brains (in the model: the light arrow transforming to another representation)



In this case, the ideas marked with ++ indicate that the student is bringing more of the science ideas from the unit to give a more complete explanation, which is not necessarily required by the prompt itself, but could be used to answer it.

2. Some objects in the image stand out more than other objects.

a. Circle one object that stands out the most in this image to you. Put a square around another object that stands out the least to you.

+ one object circled.

+ one object with a square around it.

As long as their 2b explanations are consistent with the objects they selected, students can choose any objects that stand out the most and the least to them. This is their choice and their opportunity to share their thinking about how they can see any objects in the scene.

b. Explain in words or pictures why you see one object more than the other object.

+ If outside objects stand out more, expect an explanation such as this: More light is entering my eye from the [outside object] than from the [inside object].

+ My eye detects more light from the object and processes that light into a stronger signal.

+ My brain makes me see the [outside object] more because it was a stronger signal.

+ If the person inside stands out more, expect an explanation such as this: More light is entering my eye from the person [or other inside object] than from the [outside object].

+ My eye detects more light from the person/inside object and processes that light into a stronger signal.

+ My brain makes me see the person/inside object more because it was a stronger signal.

++ Students may include more details of the eye-brain system, such as light entering the lens, the retina, or the optic nerve. This could indicate a deeper understanding of the system if the explanation clearly explains how the components interact with each other. If it is just a listing of parts, this would not indicate a deeper understanding, necessarily.

If students choose to use a diagrammatic model, look for students to use the same conventions described in questions 1a and 1b. Their models would also need to indicate more and less light inputs into the eye, and weaker or stronger signals to the brain. Students may adopt the class's conventions for their representation, or choose their own representation. Credit should be given if their representation clearly communicates that more prominent objects are the result of more light input to the eye and a stronger signal to the brain, and less prominent objects are the reverse.

3. What could you change in the system to make the person stand out more? Include why you think your change will help you to see the person better.

Students should provide one idea for a change they can make to the system. Below is a list of possible ideas, but students may share other ideas not on this list and those ideas should be accepted, too.

Example Idea 1

+ Turn on a bright light inside the building that shines on the person.

Reasoning 1 + The Sun's light is the main light source in the photo, but if there is another, brighter light source shining on the person from inside the building, more light would reflect off the person and transmit through the glass into my eyes outside. This would make light reflecting off the person a stronger input into my eyes.

Example Idea 2

+ Turn on a bright light inside AND wait until it's dark out.

Reasoning 2 + This would make the person stand out more because the light from inside the building would be the main (or only) source of light. It would shine on the person, reflect off the person, and transmit through the glass and into my eyes. The light from inside reflecting off the person would be the stronger input into my eyes.

Example Idea 3

+ Get closer to the window and block the outside light with hands.

Reasoning 3 + If I cup my hands next to my face and am closer to the glass, it cuts down on the light reflected off the glass and into my eyes. This would make the light reflecting off the person the stronger input into my eyes.

Other ideas may include using your shadow to block some of the sunlight, waiting until the Sun goes behind a tree or cloud to block the sunlight, or other options that reduce the sunlight reflected off the glass into the eyes in order to make the light reflecting off the person and transmitted through the glass a stronger signal.

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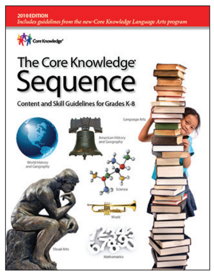

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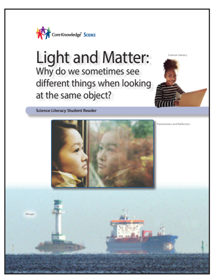
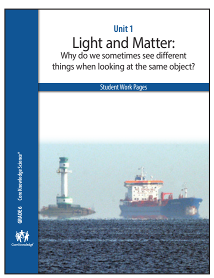
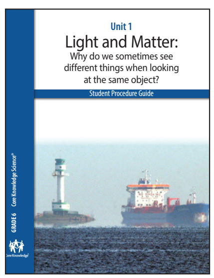
The *Core Knowledge Sequence* is a detailed guide to specific content and skills to be taught in Grades K–8 in language arts, history, geography, mathematics, science, and the fine arts. In the domains of science, including Earth and space, physical, and life sciences, the *Core Knowledge Sequence* outlines topics that build systematically grade by grade to support student learning progressions coherently and comprehensively over time.







For which grade levels are these books intended?

In general, the content and presentation are appropriate for students in middle school, Grades 6–8. For teachers and schools following the *Core Knowledge Sequence*, these books are intended for Grade 6 and are part of a series of **Core Knowledge SCIENCE** units of study.

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