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 men see Mr. Bean? and (2) Why does Mr. Bean see himself but not the men? 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

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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 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 phenomena 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
8	10 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	
				End of day 3

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	• 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)

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 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 addition 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 one-way 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 *OpenSciEd 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 segway 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 prompt	Sample student response
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.*
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.

✱ 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 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
		

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.

✱ 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.

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 prompt	Sample student response
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.* *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 interpret these as about the same light which changes what we see.*

✱ 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.

✱ 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 Emergent Multilingual Students: 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.

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 for/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. Establishing 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.

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 Mr. Bean phenomenon, 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?

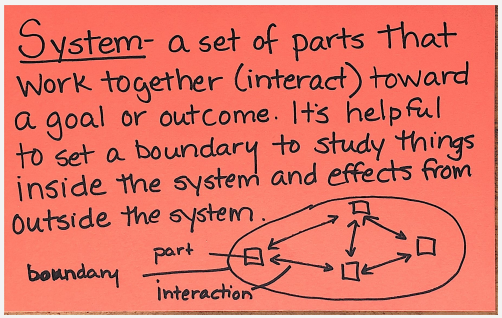
✱ SUPPORTING STUDENTS IN DEVELOPING AND USING SYSTEMS AND SYSTEM MODELS

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 systems model 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.

- 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.

✱ 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.

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.

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' 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.*

✱ 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

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.

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 phenomena 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 for/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.

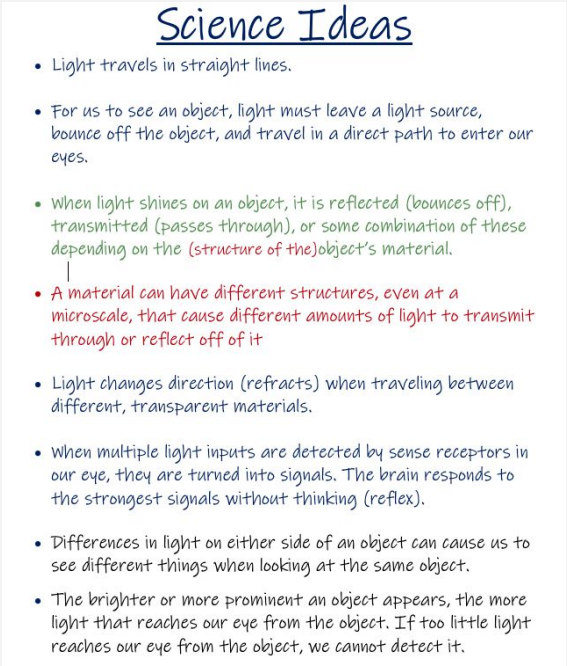
Suggested prompt	Sample student response
What do we notice is different in each scenario?	*The classroom is lit up in one image and dark in the other image.*
How do we think the classroom light compares to the hallway light?	*In the one image, the classroom light is really bright, probably brighter than the hallway. In the other image the hallway is probably brighter than the classroom.*

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.

Suggested prompt	Sample student response
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.*
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 phenomena 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 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 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 *OpenSciEd 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 OpenSciEd 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?

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 *OpenSciEd 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.

✱ 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.

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.