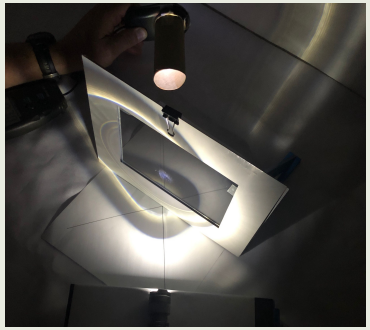
LESSON 3: What happens when light shines on the one-way mirror?

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
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*

Part	Duration	Summary	Slide	Materials
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

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	• 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)

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 box models 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 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 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.
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 8-×-8 piece of glass and 8-×-8 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 8-×-8 pieces of glass (or plexiglass) and the 8-×-8 pieces of regular mirror. 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* for more guidance.
- 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 *OpenSciEd 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 IN 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 prompt	Sample student response	Follow-up question
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.

✱ 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.

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.

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 prompt	Sample student response	Follow-up question
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.* *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 the thickness or flexibility plays a role in why the one-way mirror acts like a mirror and a window?* *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:

- 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.

If students need support in sharing their ideas, remind them to use their Communicating in Scientific Ways sentence frames. Use the following prompts to help students to dig deeper into their own thinking and the thinking of others:

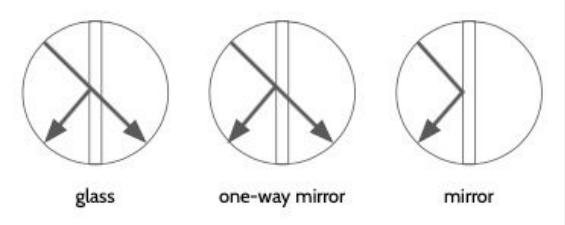
- *What's your evidence?*
- *Did it work that way for all three materials?*
- *Can you say more or give an example?*
- *Do you agree/disagree? Why?*
- *What can we conclude?*
- *What else do we need to find out?*

✱ 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.

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 for/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 prompt	Sample student response
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.

✱ 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.

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 for/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.

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.

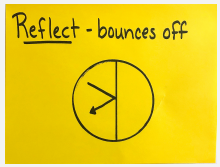
End of day 1

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 OUR 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 prompt	Sample student response
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.

✱ 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.

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.

Suggested prompt	Sample student response
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 for/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.*

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 prompt	Sample student response
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).*

✱ SUPPORTING STUDENTS IN ENGAGING IN PLANNING AND CARRYING OUT INVESTIGATIONS

The goal in this moment is to give students experience in collaboratively planning 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.

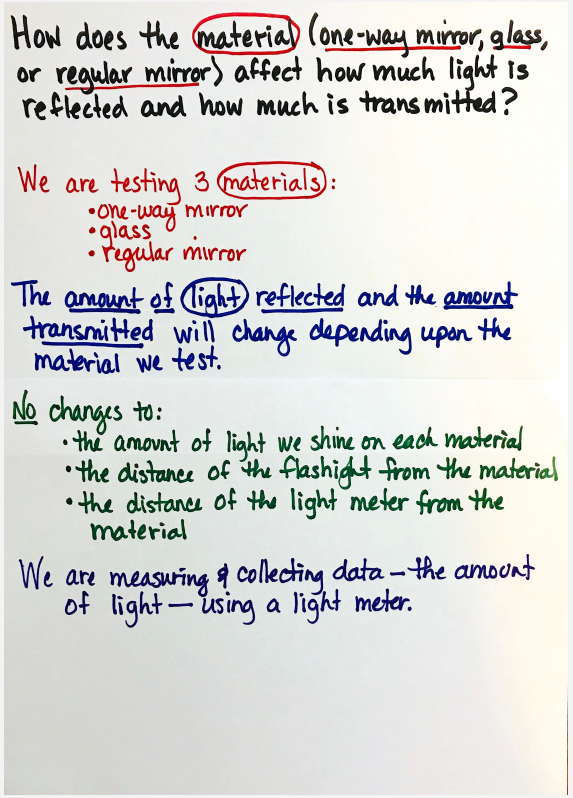
✱ SUPPORTING STUDENTS IN ENGAGING IN PLANNING AND CARRYING OUT INVESTIGATIONS

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.

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.

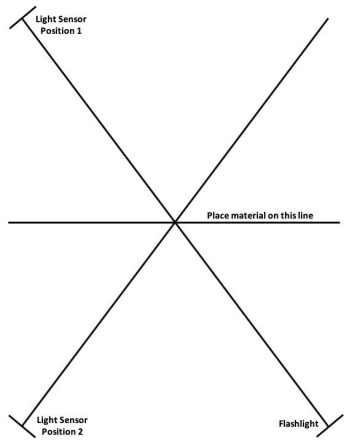
Demonstrate how to take a measurement of the ambient light in the classroom. Point out that the numbers on the light meter jump around, and tell students that holding the sensor very still for several seconds will make it easier to get a reliable reading. Then, tape a cardboard tube around the sensor, 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 prompt	Sample student response
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.



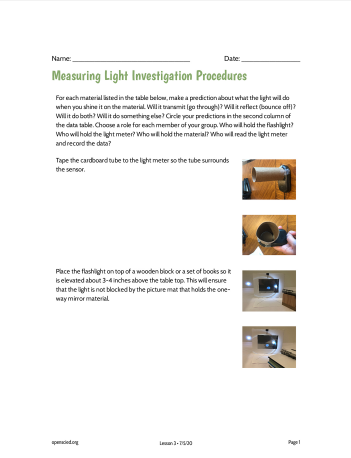
Introduce the investigation procedures and make predictions. Distribute the *Measuring Light Investigation Procedures* to students and tell students it is the procedure for the *Measuring Light Investigation*.

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.


Name: _____ Date: _____

Measuring Light Investigation Procedures

For each material listed in the table below, 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.

openscied.org Lesson 3 - 7/1/20 Page 1

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.

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 prompt	Sample student response
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.

✱ 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*

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.

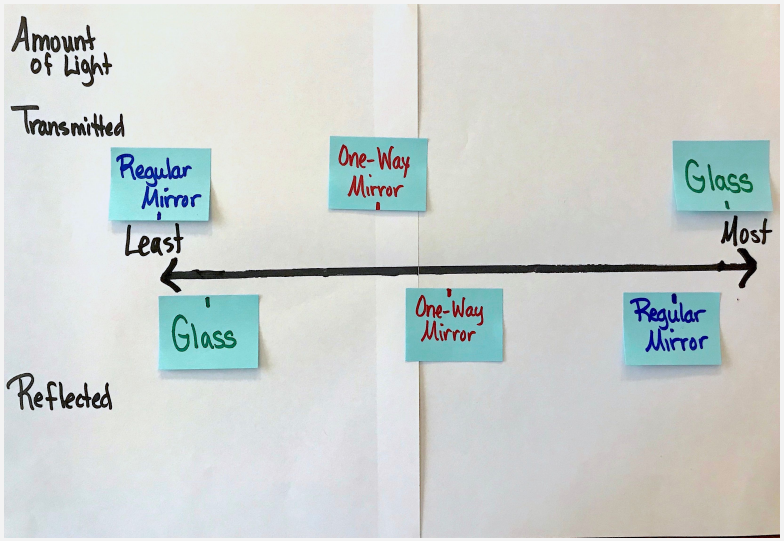
Listen for the following ideas to surface:

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. It reflected even more light than the glass transmitted. • The one-way mirror reflected just a bit more light than it transmitted. • The glass reflected a very small amount of light.

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.



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.

ADDITIONAL GUIDANCE

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

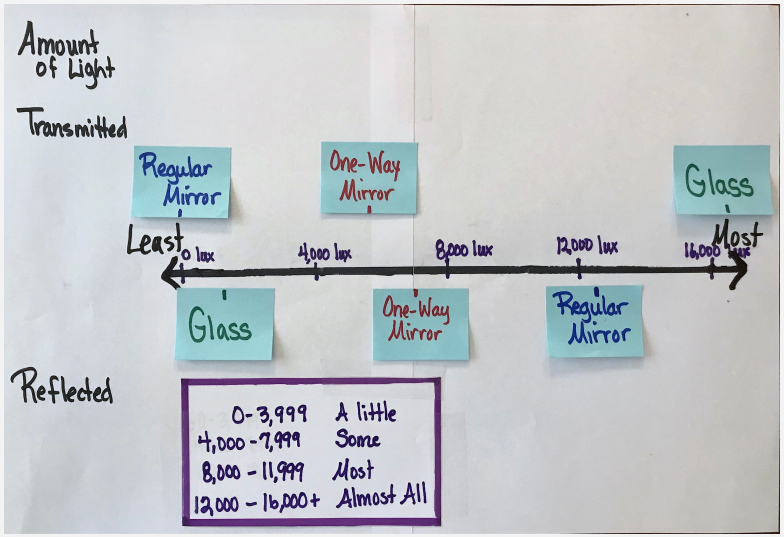
Material	Light transmitted	Light reflected
Glass	16,400 lux	1,300 lux
One-way mirror	5,300 lux	7,000 lux
Regular mirror	0 lux	12,500 lux

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:

Material	What have we figured out about each material	What we have figured out about all materials
One-way mirror	• 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.	• 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.
Glass	• The glass reflects and transmits light, too. • The glass reflects much less light than it transmits.	
Regular mirror	• 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.	

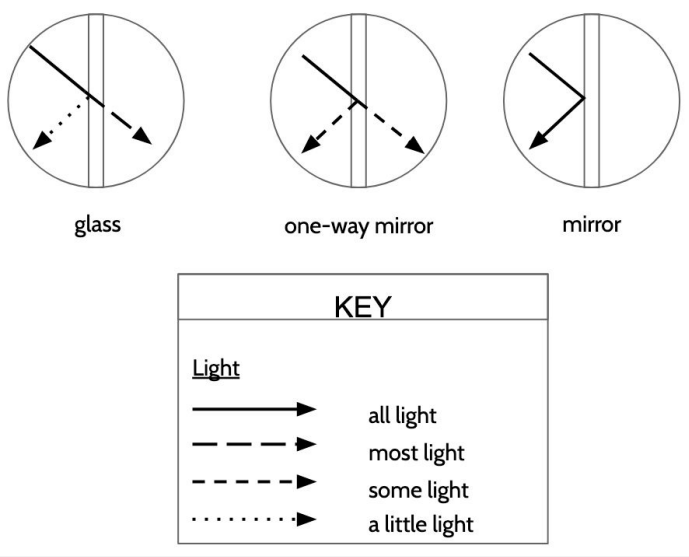
Update the class consensus model. Ask students to share their ideas about how to represent what the class just figured out.

Suggested prompt	Sample student response	Follow-up question
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 this.

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

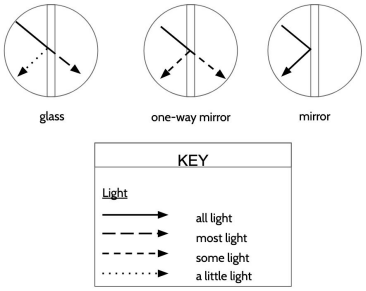
- Light travels in straight lines.
- For us to see an object, light must leave a light source, bounce off the object, and travel in a direct path to enter our eyes.
- When light shines on an object, it is reflected (bounces off), transmitted (passes through), or some combination of these depending on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