

LESSON 5: How do light and the one-way mirror interact to cause the one-way mirror phenomenon?

PREVIOUS LESSON *We thought the one-way mirror transmits and reflects light differently from mirrors and glass because of how it's made. We read about how the one-way mirror is made compared to a regular mirror. We found out that one-way mirrors have a thin layer of silver embedded in a plastic film on the glass. We modified a model to explain that light transmits through the transparent structures of the one-way mirror and reflects off the silver structures.*

THIS LESSON

PUTTING PIECES TOGETHER,
PROBLEMATIZING

1 day



In this lesson, we revisit the anchoring phenomenon and model interactions between light, the people, and the one-way mirror to explain why Mr. Bean and the men can see Mr. Bean. We wonder why Mr. Bean doesn't see the men even though they are lit up a little. We model what happens when light from Room A's light source shines directly on the one-way mirror toward the men. We figure out that the light that has reflected off the men also enters Mr. Bean's eyes and the men's eyes. Because light from the men enters Mr. Bean's eyes, we again wonder why Mr. Bean doesn't see the men.

NEXT LESSON *If different amounts of light enter Mr. Bean's eyes from each side of the one-way mirror, why can't Mr. Bean see the men? To figure this out, we will investigate what happens when light enters the eye and how the eye transforms light into signals sent to the brain. We will think about personal experiences to help us explain what happens when there are two inputs of light and why we only "see" one input or "see" one input better.*

BUILDING TOWARD NGSS

MS-PS4-2, MS-LS1-8



WHAT STUDENTS WILL DO

5.A *Revise a model to explain the observable one-way mirror phenomenon caused by unobservable interactions between light, Mr. Bean, the men, and the one-way mirror, which reflects and transmits about the same amount of light.*

WHAT STUDENTS WILL FIGURE OUT

- When light reflects off Mr. Bean and travels to the one-way mirror, about half of the light reflects off the silver structures back to his eyes and the other half transmits through the transparent parts to the men's eyes.
- The light that transmits through the one-way mirror reflects off the men and travels to the one-way mirror. About half of that light reflects off the silver structures back to the men's eyes and the other half transmits through the transparent parts to Mr. Bean's eyes.

Lesson 5 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	8 min	<p>PREPARE TO EXPLAIN THE ANCHORING PHENOMENON</p> <p>Revisit the Mr. Bean video and create a Gotta-Have-It checklist to help us model why Mr. Bean and the men both see Mr. Bean. Add the science term “model” to the Word Wall.</p>	A-C	Mr. Bean video, Science Ideas chart, chart paper, 6-x-8 sticky notes, 4 different color markers, tape
2	5 min	<p>CREATE INDIVIDUAL MODELS TO EXPLAIN WHY MR. BEAN AND THE MEN SEE MR. BEAN</p> <p>Individually model the path light travels to explain why Mr. Bean and the men can all see Mr. Bean.</p>	D	<i>Why do Mr. Bean and the men all see Mr. Bean?</i> , 4 different colored pencils, tape
3	7 min	<p>CREATE A CLASS CONSENSUS MODEL TO EXPLAIN WHY MR. BEAN AND THE MEN SEE MR. BEAN</p> <p>Through a class discussion, come to consensus about the path light travels to create a model to explain why Mr. Bean and the men can all see Mr. Bean.</p>	E-F	4 different colored pencils, large chart paper version of <i>Why do Mr. Bean and the men all see Mr. Bean?</i> , 4 different color markers
4	7 min	<p>PROBLEMATIZE WHY MR. BEAN CAN'T SEE THE MEN</p> <p>Rewatch the video as a class and prepare to model what happens when light from the Room A light source shines directly on the one-way mirror toward the men.</p>	G-H	Mr. Bean video, large chart paper version of <i>Why do Mr. Bean and the men all see Mr. Bean?</i>
5	15 min	<p>MODEL WHAT HAPPENS TO LIGHT THAT SHINES ON THE MEN</p> <p>In pairs and then in a class Consensus Discussion, model what happens to light as it reflects off the men in Room B and travels back to the one-way mirror.</p>		pencil, 4 different colored pencils, <i>Why do Mr. Bean and the men all see Mr. Bean?</i> , large chart paper version of <i>Why do Mr. Bean and the men all see Mr. Bean?</i> , 4 different color markers
6	3 min	<p>NAVIGATION</p> <p>Problematize that Mr. Bean only sees himself, but light that has reflected off the men also enters his eyes. Share initial ideas about why he cannot see them.</p>	I	

End of day 1

Lesson 5 • Materials List

	per student	per group	per class
Lesson materials	<ul style="list-style-type: none">• <i>Why do Mr. Bean and the men all see Mr. Bean?</i>• 4 different colored pencils• tape• pencil		<ul style="list-style-type: none">• Mr. Bean video• Science Ideas chart• chart paper• 6-x-8 sticky notes• 4 different color markers• tape• large chart paper version of <i>Why do Mr. Bean and the men all see Mr. Bean?</i>

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.

Check the Mr. Bean video clip from <https://www.youtube.com/watch?v=fkHlhiGOh70> to ensure that it plays on your device and can be viewed by the whole class. Make certain to start the video at 00:15 seconds and play it on silent.

If your class developed different modeling conventions for the amount of light (i.e., other than the dashed or dotted arrows) or ways to describe the materials, modify the key at the bottom of *Why do Mr. Bean and the men all see Mr. Bean?* and the diagram on **slide D** accordingly.

Make a large version of *Why do Mr. Bean and the men all see Mr. Bean?* on chart paper to use for class modeling. Include the two rooms, a light source, the one-way mirror, the people in both rooms, and your agreed-upon key with modeling conventions (your conventions may be different from those on *Why do Mr. Bean and the men all see Mr. Bean?*).

Have 4 different color markers ready for use throughout this lesson for the class modeling including the two colors you used previously for the microstructure of the one-way mirror and two new colors to trace light that reflected of Mr. Bean and light that reflected off the men.

Be sure you have the materials (e.g., markers, sticky note) ready to add the following word to the Word Wall: *Model*. Do not post this word on the wall until after your class has developed a shared understanding of its meaning.

Have the Science Ideas chart ready from the previous lessons.

Lesson 5 • Where We Are Going and NOT Going

Where We Are Going

In this lesson, students trace the path of light (1) as it leaves the light source in Room A and reflects off Mr. Bean toward the one-way mirror and (2) as it leaves the light source in Room A and travels directly toward the one-way mirror, transmitting through to reach the men. Through tracing the path of the light that reflects off Mr. Bean, they are able to explain why Mr. Bean and the men can see Mr. Bean. Through tracing the path of light that reflects off the men, they realize that their explanation is not quite complete because some of that light enters Mr. Bean's and the men's eyes. They leave this lesson wondering why Mr. Bean doesn't also see the men, because some light that has reflected off them enters his eyes.

This lesson focuses heavily on modeling with the purpose of progressing toward an explanation of the phenomenon. Students model the unseen path that light travels from the Room A light source and between the people and one-way mirror. They engage in argumentation about their models and make progress toward a full explanation of the phenomenon with their models.

Students have been engaging in the practice of modeling and using the language of models informally throughout the unit. At the start of this lesson, after reviewing the phenomenon and preparing to develop a model to explain what is happening, students earn the word "model" and add it to the Word Wall.

Where We Are NOT Going

Students will not yet unpack what happens when light enters the eye that causes us to see objects. That will happen in Lesson 6.

Lesson 7 focuses on developing an explanation using models. Students will use the model they develop in this lesson showing the path of light throughout the system, along with the model they develop in Lesson 6 showing what happens when light enters the eye, to develop a full explanation for the phenomenon in Lesson 7.

LEARNING PLAN for LESSON 5

1 · PREPARE TO EXPLAIN THE ANCHORING PHENOMENON

8 min

MATERIALS: Mr. Bean video, Science Ideas chart, chart paper, 6-x-8 sticky notes, 4 different color markers, tape

Rewatch the Mr. Bean video, focusing on what is seen and not seen. Display slide A and watch the Mr. Bean video located at <https://www.youtube.com/watch?v=fkHlhiGOh70>. Focus students with these prompts:

- What is seen? Why does Mr. Bean see himself? Why do the men see Mr. Bean?
- What is not seen? Why can't Mr. Bean see the men?

Create a Gotta-Have-It Checklist to help model what is seen. Display slide B. Prompt students to share aloud what we need to include in our models to explain why Mr. Bean can see himself and the men can also see Mr. Bean. Remind students of the resources they can use to generate ideas for the checklist, such as the Science Ideas chart.*

Listen for and publicly record ideas such as these:

- light source in Room A and no light source in Room B
- light leaving the light source
- light reflecting off Mr. Bean
- one-way mirror between the rooms
- the structure of the one-way mirror material (e.g., half-silvered, silver structures, transparent structures)
- light reflecting off and transmitting through the one-way mirror material
- Mr. Bean's and the men's eyes
- light from Mr. Bean entering Mr. Bean's and the men's eyes

Add “model” as a word we earn to the Word Wall. Tell students, *Over the last few class periods, we have been trying to explain the one-way mirror phenomenon. We've been using the language “model” regularly, but we've never specifically defined models. We've used two types of models to help us with our explanations:*

- Our box models are a physical representation that we've used to test different aspects of the phenomenon.
- Our diagrammatic models have helped us visualize and explain what is happening with light and the structure and function of objects like the one-way mirror, things that we can't see.

Both types of models, or representations, help us explain the one-way mirror phenomenon. When we engage in representing for the purpose of explaining, we are modeling the world.

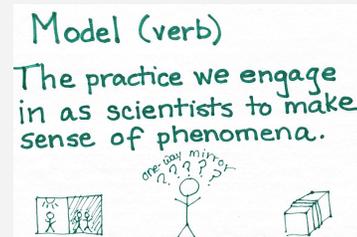
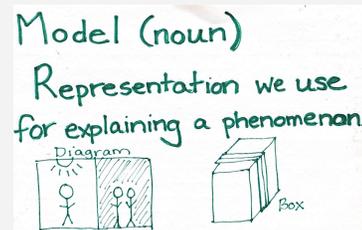
Show slide C and share and define the new science vocabulary for model as a verb and model as a noun. Write the word “model” on a 6-x-8 sticky note, along with its definition and a simple diagram. (See images below.) Place the two sticky notes on the Word Wall in the classroom and say, *I encourage you to use the word “model” whenever we are developing a representation of our thinking to explain the one-way mirror phenomenon or when we engage in the practice of modeling to explain the phenomenon.**

* SUPPORTING STUDENTS IN DEVELOPING AND USING SYSTEMS AND SYSTEM MODELS

As students create the Gotta-Have-It Checklist, use a systems lens to help them include the parts of the system (e.g., light source, Mr. Bean, the men, the one-way mirror and its structure) and the unseen interactions between those parts (e.g., the interaction between light and Mr. Bean, the interaction between light and the one-way mirror).

* SUPPORTING STUDENTS IN ENGAGING IN DEVELOPING AND USING MODELS

“Models” as a noun are representations of the world. “Modeling” as a verb involves students using a representation for a purpose: to explain a real-world phenomenon. A helpful heuristic is developing a “model for” making sense of a phenomenon, rather than developing a “model of” a phenomenon. If you find yourself asking students to make a representation or “model of” a phenomenon, but they aren't using those models for sensemaking, you may not be engaging them in the reasoning practice of modeling. For example, a common science activity is asking students to make a model of all the parts of a cell. This representation is often not used to explain any real-world phenomenon, so they are simply developing a “model of” that system. However, if they developed that “model for” explaining how and why we get energy from food, they would be using their model to explain a real-world phenomenon. OpenSciEd units are designed to support students in developing models for making sense of phenomena.



2 · CREATE INDIVIDUAL MODELS TO EXPLAIN WHY MR. BEAN AND THE MEN SEE MR. BEAN

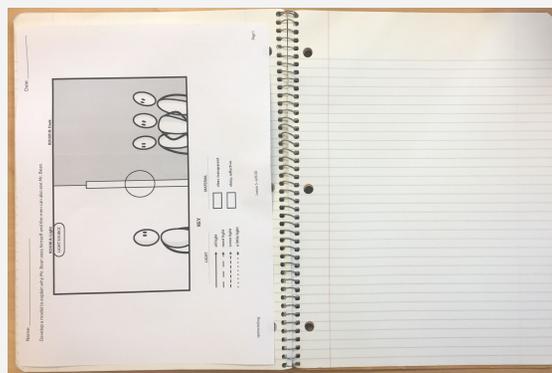
5 min

MATERIALS: *Why do Mr. Bean and the men all see Mr. Bean?*, 4 different colored pencils, tape



Individually model why all the people can see Mr. Bean. Display slide D. Remind students of the agreed-upon modeling conventions from Lessons 3 and 4. Distribute a copy of *Why do Mr. Bean and the men all see Mr. Bean?* to each student. Give students time to individually model on the handout what happens to light as it leaves the light source, to explain why Mr. Bean and the men can see Mr. Bean.*

Have students tape the *Why do Mr. Bean and the men all see Mr. Bean?* handout into their science notebook on a left-side page, leaving the right-side page blank. They will add another model to the right-side page in Lesson 6.



* SUPPORTING STUDENTS IN ENGAGING IN DEVELOPING AND USING MODELS

To emphasize the iterative process of modeling and revision, revisit the class consensus model from the end of Lesson 2 to frame this modeling task as an opportunity to revise our models to account for the new ideas we figured out in Lessons 3 and 4 about the structure and function of the one-way mirror.

ASSESSMENT OPPORTUNITY

Building towards: 5.A Revise a model to explain the observable one-way mirror phenomenon caused by unobservable interactions between light, Mr. Bean, the men, and the one-way mirror, which reflects and transmits about the same amount of light.

What to look for/listen for:

- Ideas from Lesson 2: The model represents how light travels from the light source in Room A and reflects off Mr. Bean.
- Ideas from Lessons 3 and 4: About half of the light transmits through the one-way mirror and the other half reflects back to Mr. Bean.
- Ideas from Lesson 4: The structure of the one-way mirror is half-silvered, which allows about the half of light to reflect off the silvered structures and the other half to transmit through the transparent structures.
- Ideas from Lessons 2, 3 and 4: Light rays enter both Mr. Bean's and the men's eyes from objects that are seen.

What to do: Cue students to use their Progress Tracker and other resources from their science notebook or class consensus models to develop their individual model. If students struggle, help them break down the task into smaller components. Start with what happens when light leaves the light source and reaches Mr. Bean. Next, have them model what happens when light reaches the one-way mirror. You can also have students turn and talk with a partner or small group prior to the individual modeling to help them generate ideas.

3 · CREATE A CLASS CONSENSUS MODEL TO EXPLAIN WHY MR. BEAN AND THE MEN SEE MR. BEAN

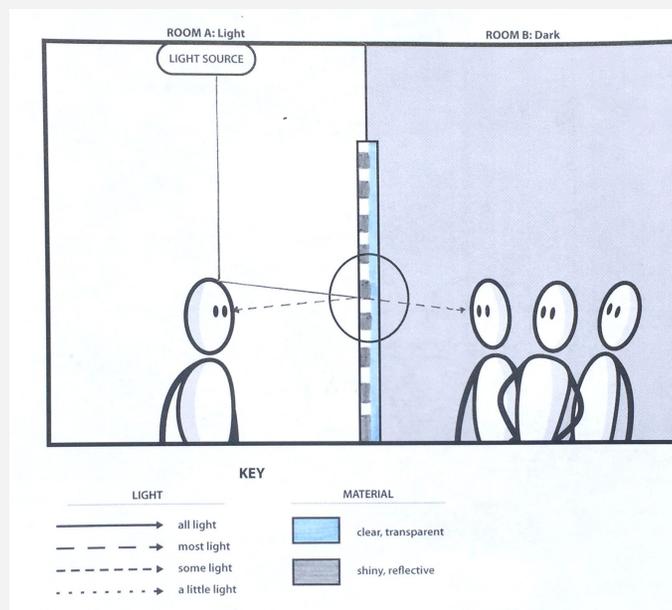
7 min

MATERIALS: 4 different colored pencils, large chart paper version of *Why do Mr. Bean and the men all see Mr. Bean?*, 4 different color markers

Have a Consensus Discussion to model why all the people can see Mr. Bean. Display slide E. Facilitate a class discussion to reach consensus about the path that light travels starting with the light source. * Once students come to consensus, use the large chart paper version of *Why do Mr. Bean and the men all see Mr. Bean?* to record their consensus ideas. Use two colors in this class consensus model to represent the microstructure of the one-way mirror material as agreed upon at the end of Lesson 4.

Here are suggested prompts for the discussion:

- How did you represent the path light takes when it shines on Mr. Bean?
- How did you represent the path light takes when it reflects off Mr. Bean and reaches the one-way mirror?
- Why does the light interact with the one-way mirror in this way?
- How did you represent the path that light takes as it enters Mr. Bean's eyes and the men's eyes?
- Based on the arrows that you drew entering Mr. Bean's and the men's eyes, what can they see?



* SUPPORTING STUDENTS IN ENGAGING IN ARGUMENT FROM EVIDENCE

In this discussion, students are arguing for a model or parts of a model. While many students may be in agreement about what to include in the model, use this opportunity to push them to use evidence to support their ideas. Uncertainty or alternative ideas may still exist for some students, so talking through evidence can surface student thinking and facilitate coming to consensus. Here are example prompts:

- What evidence do we have to support that idea?
- Do you agree with the points being made? Why?
- How is that idea related to what we previously discussed?

* ATTENDING TO EQUITY

Universal Design for Learning: Use *representations* like color coding the objects that the light reflects off to foreground the connection between the path light travels and what people see. This becomes important later in this lesson when students add another set of arrows showing the light that reflects off the men. If color coding is used, consider a color palette of orange, blue, black, grey, and dark brown so it can be seen by students who may be color blind (see example images).

KEY IDEAS

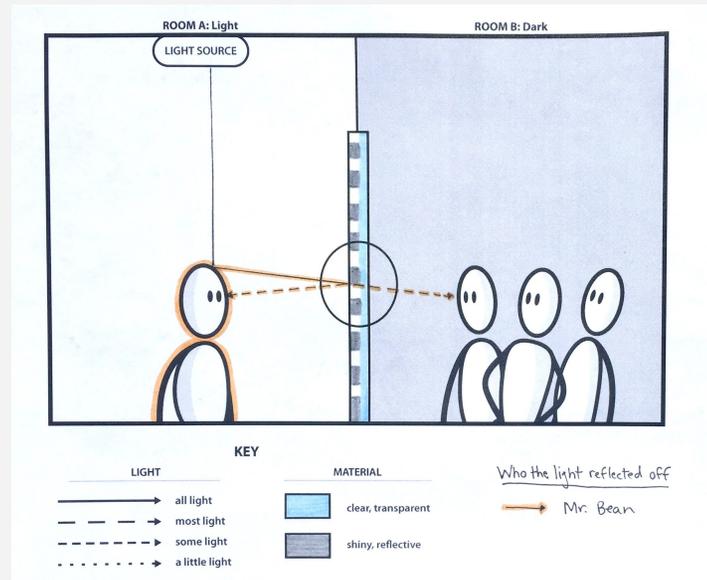
Purpose of the discussion: To make claims supported by some evidence about why Mr. Bean and the men all see Mr. Bean.

Listen for agreement about the following ideas:

- Some of the light that reflects off Mr. Bean travels back to Mr. Bean's eyes, and some transmits through the one-way mirror to the men's eyes.
- About half of the light reflects off the silver structures back to Mr. Bean's eyes and the other half transmits through the transparent parts of the one-way mirror to the men's eyes.
- Light that has reflected off Mr. Bean enters both Mr. Bean's and the men's eyes. This is why they all see Mr. Bean.

Motivate a need to color code arrows to keep track of the light. Display slide F. Say, *Our model shows that light from the light source reaches Mr. Bean and then reflects off him, so he and the men both can see him. But light from that source is reflecting off a lot of other objects too. Let's consider what happens to the light when it reflects off other objects. To keep things easy to follow, I suggest we color the arrows after they reflect off an object or person. Let's use a third color to color our arrows reflecting off of Mr. Bean together.*

Add color to Mr. Bean and the arrows once light reflects off him. Say, *Let's also use that same color for Mr. Bean to help us keep track of what the light allows us to see.* As a class, add the third color to the arrows reflecting off Mr. Bean. Update the key with the new color. Have students add color to their own models on *Why do Mr. Bean and the men all see Mr. Bean?* using colored pencils.*



4 · PROBLEMATIZE WHY MR. BEAN CAN'T SEE THE MEN

7 min

MATERIALS: Mr. Bean video, large chart paper version of *Why do Mr. Bean and the men all see Mr. Bean?*

Problematize that the men are lit up, but Mr. Bean doesn't see them. Display slide G. Rewatch the Mr. Bean video from <https://www.youtube.com/watch?v=fkHlhiGOh7O>, to notice that there is some light entering the dark room and that the men are actually lit up.

Suggested prompt

Where is the light coming from that lights up the men?

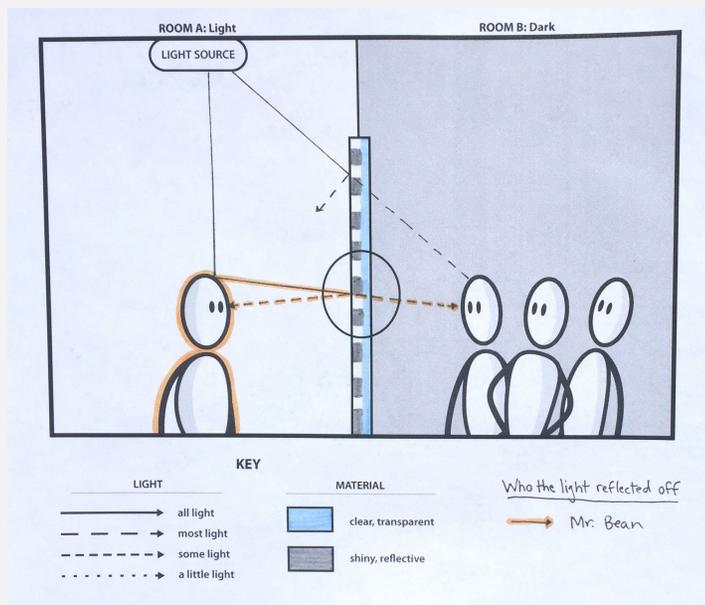
What happens when light from the Room A light source reaches the one-way mirror on its way to the men?

Sample student response

It's coming from the light source in Room A and transmitting through the one-way mirror.

Some of it reflects back into Room A and some of it transmits through to the men.

Model what happens when Room A's light source shines directly on the one-way mirror toward the men. Display slide H. Ask for volunteers to add arrows to the class consensus model to represent what happens when light shines on the one-way mirror and transmits through to the men. These arrows should not yet be colored because they are coming directly from the light source and haven't yet reached and reflected off the men.



5 · MODEL WHAT HAPPENS TO LIGHT THAT SHINES ON THE MEN

15 min

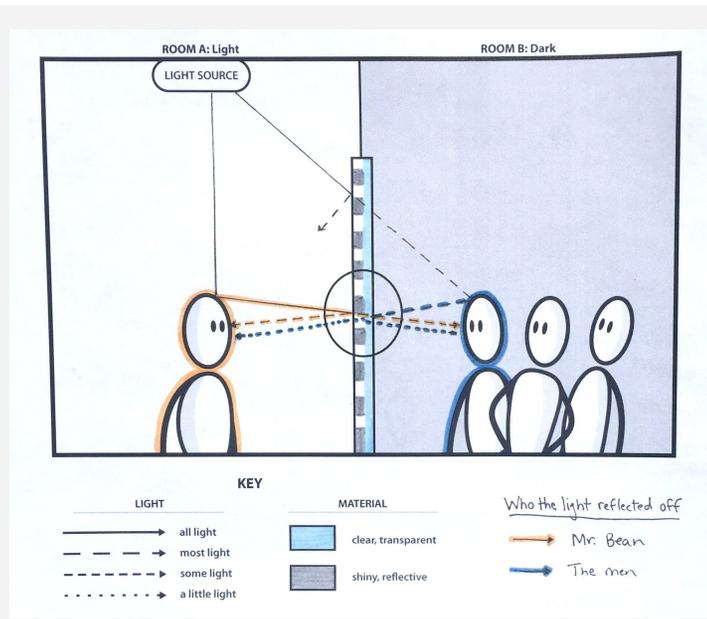
MATERIALS: pencil, 4 different colored pencils, *Why do Mr. Bean and the men all see Mr. Bean?*, large chart paper version of *Why do Mr. Bean and the men all see Mr. Bean?*, 4 different color markers

Discuss in pairs where the light goes after it shines on the men. Have students turn and talk with a partner to work out their initial ideas about what happens to the light *after* it shines on the men. Encourage students to draft their ideas on their handout using pencil so they can easily revise their ideas later during the class discussion if needed.

ADDITIONAL GUIDANCE

If it is difficult for students to trace both (1) the light going directly to Mr. Bean and (2) the light going directly to the one-way mirror on the same sheet, give students an extra copy of *Why do Mr. Bean and the men all see Mr. Bean?*. Have them model separately what happens to light that shines directly on the one-way mirror. After the discussion, they can add their ideas onto their original model explaining what happens when light shines directly on Mr. Bean.

Lead a Consensus Discussion on what happens to the light after it shines on the men. As a class, discuss ideas and add a new set of arrows to the class consensus model to explain what happens when light shines on the men. Add a fourth color for this new set of arrows to keep track of what happens to the light once it reflects off the men.



KEY IDEAS

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

1. Some of the light that reflects off the men transmits back through the one-way mirror to Mr. Bean's eyes, and some of it travels back to the men's eyes.
2. When light reflects off the men to the one-way mirror, about half of that light reflects off the silver structures back to the men's eyes and the other half transmits through the transparent parts of the one-way mirror to Mr. Bean's eyes.
3. Light that has reflected off the men enters Mr. Bean's and the men's eyes.
4. There is more light that reflects off Mr. Bean than light that reflects off the men entering Mr. Bean's eyes.

Listen for agreement about the following ideas:

- Whenever light shines on the one-way mirror, about the half transmits and half reflects.
- More light enters Mr. Bean's eyes that has reflected off Mr. Bean than light that has reflected off the men.

Suggested prompt	Sample student response	Follow-up question
<i>Where does the light go that shines on the men?</i>	<i>It reflects off them in all directions.</i>	
<i>How can we represent that the light has reflected off the men?</i>	<i>Use a different color.</i>	<i>About how much light is reflecting off the men? (some light)</i>
<i>What happens when that light reaches the one-way mirror?</i>	<i>Some reflects back at the men and some transmits.</i>	<i>About how much light is reflecting off and transmitting through the one-way mirror at this point? (a little)</i> <i>About how much of the light that has reflected off the men enters Mr. Bean's and the men's eyes? (a little)</i>

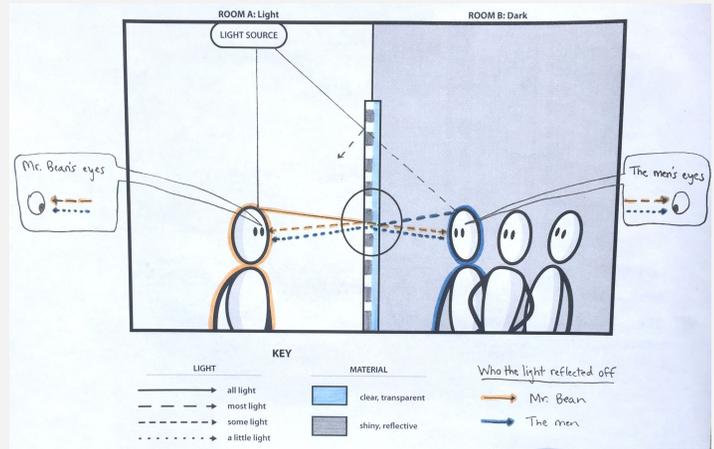
ADDITIONAL GUIDANCE

Be sure to emphasize that whatever amount of light reaches the one-way mirror, about half of that light will reflect and about half will transmit. So if there's a smaller amount of light hitting the one-way mirror, only about half of that light will reflect and transmit.

Zoom in on the eyes and consider the two light inputs. Discuss the following questions about light inputs entering Mr. Bean's eyes and the men's eyes, and then add zoomed-in eyes to the class consensus model.

Suggested prompt	Sample student response	Follow-up question
<i>What light is entering Mr. Bean's eyes?</i>	<i>Light that reflected off Mr. Bean and light that reflected off the men.</i>	<i>How much of the light that has reflected off each person enters his eyes?</i>
<i>If we zoomed in on just Mr. Bean's eyes, how could we represent these different amounts?</i>	<i>Use our different arrows.</i>	
<i>What light is entering the men's eyes?</i>	<i>Light that reflected off Mr. Bean and light that reflected off the men.</i>	<i>How much of the light that has reflected off each person enters their eyes?</i> <i>How could we zoom in and represent that?</i>

Update individual models based on the Consensus Discussion.
 Once the class comes to consensus, give students time to update their *Why do Mr. Bean and the men all see Mr. Bean?* with the revised class consensus model showing the light that shines directly on the one-way mirror and transmits through to the men. Students will use this model in Lesson 7 to write explanations for the one-way mirror phenomenon.



6 · NAVIGATION

3 min

MATERIALS: None

Problematize that Mr. Bean only sees himself. Display slide I. Note that even though light that has reflected off the men enters Mr. Bean's eyes, he still does not see the men. If time allows, have students talk with a partner first before sharing their ideas with the class.

Suggested prompt	Sample student response	Follow-up question
<i>What would we expect Mr. Bean to see, based on the light inputs to his eyes?</i>	<i>If light from Mr. Bean and the men is entering Mr. Bean's eyes, we'd expect him to see himself and the men.</i>	<i>What does Mr. Bean actually see?</i>
<i>What do you think could be happening that Mr. Bean is not seeing both light inputs?</i>	<i>Maybe there's not enough light from the men? Maybe the eye does something with the light? Maybe his brain is doing something?</i>	

ADDITIONAL GUIDANCE

Lesson 6 will only focus on “Why doesn't Mr. Bean see the men?” for the sake of simplicity. However, students might recognize that light that has reflected off the men also enters the men's eyes, raising the question, “Why don't the men see their reflection?” If students are curious about this, you can bring it into the discussion with additional questions:

- What would we expect the men to see, based on the light inputs to their eyes?
- What do the men actually see?

Additional Lesson 5 Teacher Guidance

SUPPORTING STUDENTS IN MAKING CONNECTIONS IN ELA

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

When students are discussing models during the class discussions, encourage them to share the ideas they prepared during their individual or pair modeling work. Press students to share their rationale for their representations by asking for evidence from Lessons 2, 3, and 4 about light and the one-way mirror's structure and function.