Levels K–2 Sample Companion

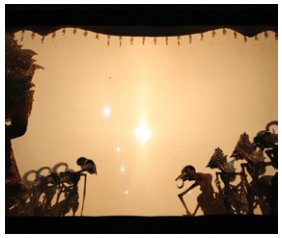
Level 1 Module 2

PhD Science® is a hands-on science program that sparks curiosity as students build enduring knowledge of how the scientific world works. Students think and act like real scientists as they ask questions, gather evidence, develop models, and construct explanations while investigating authentic phenomena.

This Sample Companion is a resource that will introduce you to the module and lesson structure that *PhD Science* follows. You will find detailed notes that will help familiarize you with our learning design and assist you in your review.

PhD SCIENCE®

Module Overview



MODULE OVERVIEW

DRIVING QUESTION 1

How do puppeteers use light to tell stories during wayang shows?

INTRODUCTION

Background Information 2

Throughout this module, students study the anchor phenomenon—wayang shadow puppetry—and work to answer the Driving Question: **How do puppeteers use light to tell stories during wayang shows?** Students engage with photographs, videos, and models of wayang shows as they seek to explain how light interacts with objects.

Students begin making sense of this phenomenon by observing that shadows can be found in places with light. Students learn that wayang shows traditionally occur at night, which makes students wonder where the light in a wayang show comes from. They identify light sources in the classroom and in wayang shows to determine that light sources are objects that give off their own light. They also learn that wayang shows often use a spotlight as a light source. Next, students investigate models to determine that objects can be seen only when light illuminates them or when they give off their own light. Students apply this understanding to wayang shows to explain that people can see the parts of a wayang show because light illuminates them.

Students then explore how shadows form in a wayang show. They identify the parts needed to form a shadow: a light source, an object, and a surface. They determine that in a wayang show, light from a spotlight (light source) is blocked by puppets (objects), which causes shadows to form on the screen (surface). Students deepen their understanding of how light interacts with objects as they investigate different materials to use as a screen in a wayang show. They learn that different amounts of light travel

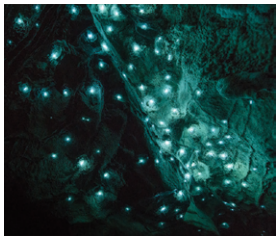
1 The Driving Question is a question developed at the beginning of a module that stimulates rich student discussion but may never be fully answered. It serves as motivation for student learning throughout the module. As students find satisfactory answers to Phenomenon Questions in each lesson, they make progress toward answering the module Driving Question. Over the course of the module, as students make sense of different aspects of the anchor phenomenon or related supporting phenomena and answer the Driving Question, they reflect on their progress by updating the anchor model and reviewing the questions on the Driving Question board. By the end of the module, students' public thinking about the anchor phenomenon, as captured on the anchor model and the Driving Question board, should demonstrate their incremental progress in explaining the anchor phenomenon and answering the Driving Question.

2 The Background Information subsection provides a deeper explanation of the anchor phenomenon and science topics covered in the module (including common misconceptions).

through different materials and determine that wayang screens are made of materials that allow some, but not all, light to travel through.

Near the end of the module, students extend their knowledge about how light interacts with materials as they explore a new phenomenon—a town that is covered by a shadow during the winter. Students use a model to figure out how engineers used mirrors to redirect sunlight to a part of the town where people gather often.

Finally, students summarize their understanding of how light allows people to see objects and how light interacts with different objects as they apply their knowledge in an End-of-Module Assessment.



Content Boundaries and Rationale 1

Why don't students learn that light entering the eye enables sight?

In Level 1 Module 2, students focus on the general relationship between light and sight. To meet the learning expectations for PS4.B: Electromagnetic Radiation for this grade level, students must articulate that people need light to see objects. This Disciplinary Core Idea progresses in Level 4 to include the understanding that people can see an object when light reflected from the object's surface enters their eyes.

Why isn't the term *reflection* used in this module to describe the interaction between light and mirrors?

Mirrors exhibit specular reflection, which causes them to reflect both light and images in a predictable way. To avoid confusion between the reflection of an image and the redirection of light as it travels to and from a mirror, this module uses the term *redirect* instead of *reflect* when discussing how light interacts with mirrors.

The term *reflection* is used in Level 4, when students gather evidence to learn that light travels in rays and that all objects reflect light. At that point, students can distinguish between diffuse reflection and specular reflection by using a ray model.

Why aren't the terms *transparent*, *translucent*, and *opaque* used in this module?

PhD Science® avoids these terms because the difference in the amount of light that travels through translucent and transparent materials is not always significant. For example, a translucent material such as wax paper can transmit nearly as much light as a transparent material such as acetate. A major

1 The Content Boundaries and Rationale subsection identifies the limits on the content explored in the Disciplinary Core Ideas and provides additional information about any content decisions made during development.

distinction between translucent and transparent materials is the way light travels as it passes through the materials. An object viewed through a translucent material cannot be seen clearly because light scatters when it travels through translucent materials. In contrast, an object viewed through a transparent material can be seen clearly because light does not scatter when it travels through transparent materials.

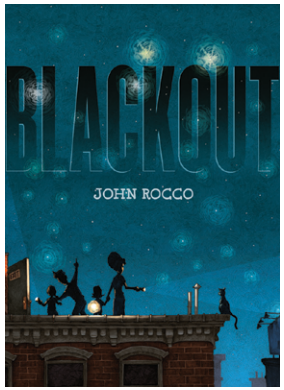
For this reason, instead of using the terms *transparent*, *translucent*, and *opaque*, this module describes materials as allowing no light, some light, or all light to travel through them. These distinctions help students directly consider how light interacts with different materials.

Additional Reading for Teachers 1

Many activities, investigations, and discussions throughout this module give students the opportunity to use their senses to explore phenomena. See the Supporting All Learners section of the Implementation Guide for information on how to support students with sensory disabilities. In addition, use the following resources to learn more about the phenomena and science concepts featured in this module.

- "Wayang Kulit: Indonesia's Extraordinary Shadow Puppetry Tradition" on the Asia Society website (http://phdsci.link/1608)
- *The Shadow Puppet Theatre of Malaysia: A Study of Wayang Kulit with Performance Scripts and Puppet Designs* by Beth Osnes

(Note: As indicated by the names of the resources above, wayang shadow puppetry is a tradition in Indonesia and several other Southeast Asian countries, including Malaysia.)



1 The Additional Reading for Teachers subsection provides resources to deepen teachers' knowledge of the phenomena and concepts featured in the module.

FOCUS STANDARDS 1

The Module Objectives describe what students should know and be able to do by the end of this module.

MODULE OBJECTIVE | **Make observations to construct an evidence-based account (SEP.6)** for how **light and objects can (PS4.B) interact as part of a system (CC.4), allowing the objects to be seen (PS4.B)**.

SCIENCE AND ENGINEERING PRACTICES	DISCIPLINARY CORE IDEAS	CROSSCUTTING CONCEPTS
SEP.6: Constructing Explanations and Designing Solutions • **Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.**	PS4.B: Electromagnetic Radiation • **Objects can be seen if light is available to illuminate them or if they give off their own light.**	CC.4: Systems and System Models • **Systems in the natural and designed world have parts that work together.**

MODULE OBJECTIVE | **Collect data to compare (SEP.3) the relative amount (CC.3) of light that travels through different materials and to identify that shadows form when light cannot travel through a material (PS4.B).**

SCIENCE AND ENGINEERING PRACTICES	DISCIPLINARY CORE IDEAS	CROSSCUTTING CONCEPTS
SEP.3: Planning and Carrying Out Investigations • **Make observations (firsthand or from media)** and/or measurements **to collect data that can be used to make comparisons**.	PS4.B: Electromagnetic Radiation • **Some materials allow light to pass through them, others allow only some light through, and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam.**	CC.3: Scale, Proportion, and Quantity • **Relative scales allow objects and events to be compared and described (e.g., bigger and smaller, hotter and colder, faster and slower).**

1 The Focus Standards section communicates Module Objectives and NGSS Performance Expectations that the module is building toward.

PhD Science is designed around Module Objectives, teacher-facing statements that describe what students should know and be able to do by the end of a module, rather than NGSS Performance Expectations (PEs). The purpose for this distinction is that PEs provide examples for what students should be able to do by the end of a grade or grade-band, while Module Objectives specifically describe the standards that students master in each module. Module Objectives support teachers in planning instruction and provide valid and actionable information to teachers about student proficiency with all three dimensions of the NGSS.

MODULE MAP 1

Anchor Phenomenon | Wayang Shadow Puppetry

Driving Question | How do puppeteers use light to tell stories during wayang shows?

Anchor Phenomenon Introduction

This lesson introduces students to the anchor phenomenon, wayang shadow puppetry.

LESSON	PHENOMENON	DRIVING QUESTION	LESSON OBJECTIVE
1	Wayang shadow puppetry	How do puppeteers use light to tell stories during wayang shows?	**Use observable patterns (CC.2)** to **develop a model (SEP.2)** that shows **how light is blocked to create a shadow on a surface (PS4.B)**. Part 1: **Use observable patterns (CC.2)** to **develop a model (SEP.2)** that shows that **shadows appear in places with light (PS4.B)**. Part 2: **Develop initial models (SEP.2)** that show **parts that work together (CC.4)** to **make shadows (PS4.B)**.

1 The Module Map provides a snapshot of what students are doing in each lesson. It includes the phenomenon students explore, the phenomenon question students seek to answer, the lesson objective, and the performance descriptors.

ASSESSMENT MAPS 1

Each *PhD Science* module includes a system of assessments designed to provide students with multiple and varied opportunities to demonstrate proficiency with the elements identified in the Module Objectives. The assessment maps in this section identify the lessons in which the elements that make up each Module Objective are assessed. For more information on the *PhD Science* approach to formative and summative assessment, see the Implementation Guide.

MODULE OBJECTIVE | **Make observations to construct an evidence-based account (SEP.6)** for how **light and objects can (PS4.B) interact as part of a system (CC.4), allowing the objects to be seen (PS4.B)**.

ELEMENT	FORMATIVE ASSESSMENT	SUMMATIVE ASSESSMENT
SEP.6: Constructing Explanations and Designing Solutions • **Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.**	**Lesson 3** **Lesson 4** **Lesson 6** **Lesson 7**	**Lesson 5** **Lesson 10**
PS4.B: Electromagnetic Radiation • **Objects can be seen if light is available to illuminate them or if they give off their own light.**	**Lesson 2** **Lesson 3** **Lesson 4**	**Lesson 5** **Lesson 9** **Lesson 10**
CC.4: Systems and System Models • **Systems in the natural and designed world have parts that work together.**	**Lesson 1** **Lesson 6**	**Lesson 9** **Lesson 10**

1 The Assessment Maps show the lessons in which the NGSS elements of the Module Objectives are formatively or summatively assessed.

BUILDING KNOWLEDGE AND SKILLS ACROSS LEVELS 1

Throughout Level 1, students build knowledge and skills associated with the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts.

Science and Engineering Practices

In this module, students plan and conduct investigations to produce data that they can use to describe how light interacts with different objects **(SEP.3)**. Students also use collected data to make comparisons **(SEP.3)**. For example, in the Science Challenge, students plan and conduct an investigation to collect data about the relative amount of light that travels through different materials. Students use the data to compare the materials and then to select a material to use as a wayang screen. In Levels 3 through 5, students build on this skill by using observations and measurements to produce data that serve as evidence to explain phenomena and test solutions.

Throughout this module, students also use their observations of light and shadows as evidence to construct an evidence-based account for the anchor phenomenon **(SEP.6)**. In Levels 3 through 5, students use observed patterns and relationships to construct and support explanations of phenomena and to generate and compare solutions.

Disciplinary Core Ideas

In this module, students make observations to learn that objects are visible when light illuminates the objects or when the objects give off their own light **(PS4.B)**. Students then consider how light interacts with objects **(PS4.B)** as they observe and compare different shadows to determine that a shadow forms when an object blocks light from reaching a surface. In the Science Challenge, students determine that different materials allow no light, some light, or all light to travel through them. Students then wonder about other ways light interacts with objects as they investigate a town in Norway to learn that mirrors can redirect light. In Levels 3 through 5, students learn that light reflects off the surface of an object and enters the eye, allowing the object to be seen.

Crosscutting Concepts

In this module, students study cause and effect relationships **(CC.2)** as they investigate how light interacts with different materials. In the Science Challenge, students identify a pattern in the amount of light certain materials allow to travel through them. Students then observe models to determine that mirrors can cause light to be redirected. In Levels 3 through 5, students learn to identify, test, and use cause and effect relationships to explain change. Students recognize that events that regularly occur together may or may not signify a cause and effect relationship.

In the Science Challenge, students use relative scales **(CC.3)** as they use a light meter and a penlight to collect data about the relative amount of light various materials allow to travel through them. In Levels 3 through 5, students will recognize that objects vary immensely in size and that events vary immensely in duration. To help comprehend these scales, students will measure physical quantities, such as volume, weight, and time, by using standard units.

1 The Building Knowledge and Skills Across Levels section describes the progression of student learning in each of the three NGSS dimensions.

Lesson 6

Concept 2 | Interactions with Light

LESSON 6 SHADOWS

Lesson Phenomenon | Shadow formation in a wayang show

Phenomenon Question | How do shadows form in a wayang show?

OVERVIEW

Previously we learned that we can see parts of a wayang show because light illuminates them.

In this lesson we investigate how light interacts with objects and identify the parts needed to form a shadow: a light source, an object, and a surface. We then figure out that in a wayang show, light from a spotlight (light source) is blocked by puppets (objects), which causes shadows to form on the screen (surface).

Later we apply our understanding of how light interacts with objects in a Science Challenge to select a screen material that could be used in a wayang show.

Lesson Objective

Develop a model to represent (SEP.2) how **the parts of a system work together (CC.4)** to **form a shadow (PS4.B)**.

Performance Descriptors

Part 1: **Identify the parts that work together (CC.4)** to **form a shadow (PS4.B)**.

Part 2: **Use observations as evidence (SEP.6)** to describe that **an object blocking light (PS4.B)** can **cause (CC.2)** **a shadow to form on a surface (PS4.B)**.

Part 3: **Develop a model to represent (SEP.2)** how **the parts of a system work together (CC.4)** to **form a shadow (PS4.B)**.

1 Each lesson is organized around a specific aspect of the anchor phenomenon or a supporting phenomenon that students explore.

Lesson parts in Kindergarten through Level 2 are designed to take from 20 to 45 minutes. In Levels 3 through 5, lesson parts should take from 30 to 60 minutes to implement.

2 The module anchor phenomenon is a rich, multilayered scientific phenomenon that can motivate instruction throughout an entire module or a large portion of a module. This phenomenon drives the module because students need to uncover targeted Disciplinary Core Ideas to develop a satisfactory explanation for how the phenomenon works. The Lesson Phenomenon is an aspect of the anchor or a related supporting phenomenon that students explore throughout a lesson.

3 A Driving Question guides the learning throughout a module. A Phenomenon Question guides student learning throughout a lesson.

4 The Overview section of a lesson provides teachers with a snapshot of the lesson to come. It includes

-Lesson Navigation—a short description of how the lesson coherently fits in the overall module storyline.

-Lesson Objective and Performance Descriptors

-Standards Addressed table

-Summary Box—a snapshot of the phenomenon and the Phenomenon Question for the module.

5 Every lesson in *PhD Science* includes a three-dimensional Lesson Objective. Lesson Objectives describe the student actions over the course of a lesson and include NGSS elements, the pieces of the NGSS that we combine to describe what students will do and come to know by the end of the lesson.

6 Performance Descriptors are included for each lesson part and describe the elements developed in each of those parts.

Performance Descriptors communicate how the learning goals of each lesson part build towards the Lesson Objective.

Formative assessments (or Checks for Understanding) that appear in each lesson evaluate the elements claimed in the Lesson Objectives and Performance Descriptors.

STANDARDS ADDRESSED 1

SCIENCE AND ENGINEERING PRACTICES	DISCIPLINARY CORE IDEAS	CROSSCUTTING CONCEPTS
SEP.2: Developing and Using Models • **Develop** and/or **use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s)**. SEP.6: Constructing Explanations and Designing Solutions • **Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.**	PS4.B: Electromagnetic Radiation • **Some materials allow light to pass through them, others allow only some light through, and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam.**	CC.2: Cause and Effect • **Events have causes that generate observable patterns.** CC.4: Systems and System Models • **Systems in the natural and designed world have parts that work together.**

1 Standards Addressed provides a summary of the Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts addressed within the lesson. Bold text indicates the part of the element addressed in the lesson.

PART 1 of 3

PREPARE 1

Complete the following preparation before this lesson part. Find the full materials list and preparation instructions in the Lesson 6 Preparation Resource.

Copies of *Blackout* (Rocco 2011) (5 to 10 minutes)

Class shadows chart (5 to 10 minutes)

Preparation Notes

1 Each lesson has a Preparation Resource that contains instructions for all necessary preparation the teacher must complete before teaching each part of the lesson.

MATERIALS 1

The table lists materials needed for each section of Part 1.

SECTION	STUDENT MATERIALS	CLASS MATERIALS
Launch	None	None
Learn: Compare Shadows	None	☐ Lesson 6 Resource A: Wayang Shadow Photographs
Learn: Identify How Shadows Form	☐ Prepared copy of *Blackout* (Rocco 2011) (1 per group) ☐ Sticky note arrows (12 per group)	☐ Prepared copy of *Blackout* (1, from prepared group materials) ☐ Prepared class shadows chart (1) ☐ Marker (1)
Land	None	☐ Wayang Knowledge Deck poster (1) ☐ Prepared class shadows chart (1)

MATERIALS REUSE
No disposable or prepared materials from Part 1 are reused in the module.

1 The Materials table provides a list of student and teacher materials needed in each section of each lesson part.

LAUNCH 5 to 10 minutes

Students review their learning from Concept 1 and discuss questions they have about shadows in a wayang show.

1. **Identify gaps in students' explanations of the anchor phenomenon to develop the Phenomenon Question.**

   Display the anchor model. Remind students that they have learned that light illuminates parts of a wayang show, but point out that they do not yet know how shadows form on the screen. Use the following questions to help students identify gaps in their understanding.

   What have we learned about shadows?

   What questions do you have about the shadows in a wayang show?

2 Build on student questions to develop the Phenomenon Question **How do shadows form in a wayang show?** Record additional student questions on the Driving Question board.

   Language Support

   Students will encounter the term *form* throughout the module. Providing the Spanish cognate *formar* may be helpful. Consider using a synonym such as *make*. Explain that students' bodies make, or form, shadows when students are in sunny places.

   Tell students that in this lesson, they will continue investigating shadows to answer their questions about how shadows form.

Performance Descriptor

Identify the parts that work together (CC.4) to **form a shadow (PS4.B)**.

Agenda | 30 to 45 minutes

LAUNCH | 5 to 10 minutes

LEARN | 20 to 30 minutes

- Compare Shadows (5 to 10 minutes)
- Identify How Shadows Form (15 to 20 minutes)

1

LAND | 5 minutes or less

Spotlight on Nature of Science

In this lesson, students develop an understanding of the following NGSS Nature of Science element.

Scientific Knowledge Is Based on Empirical Evidence

- Scientists look for patterns and order when making observations about the world.

Students look for patterns in their observations of various shadows. They then explore how the arrangement of the light source, object, and surface determines whether a shadow will form.

1 Each lesson part contains an Agenda and is organized into these sections:

Launch—the lesson part opening, which engages students as they begin thinking about the lesson phenomenon

Learn—the heart of the lesson part, during which students develop new knowledge and apply prior knowledge to explore phenomena

Land—the lesson part closing, in which students reflect on what they have learned

2 The Driving Question board allows students to capture and organize their questions about the anchor phenomenon and related phenomena. These questions help drive students' explorations throughout a module.

What would you need to form a shadow that looks like a cat?

Use student responses to summarize that students would need a cat, or an object that looks like a cat, and light from a light source to form a shadow that looks like a cat. Then suggest that students return to *Blackout* (Rocco 2011) to see whether objects and light sources also form the shadows in the book.

Identify How Shadows Form | 15 to 20 minutes

Students explore *Blackout* and build understanding about how the shadows in the book are formed.

3. **Develop a class chart showing light sources and objects that form shadows in *Blackout*.** 2

Display a prepared copy of *Blackout*, and show students the four shadows on the marked pages. Place students in groups, and distribute a prepared copy of *Blackout* and 12 sticky note arrows to each group. Then tell students to work together in their groups to find the light source and object that form each shadow on the marked pages. Instruct students to place a sticky note arrow on each light source and object they identify.

Look for *students to place sticky note arrows on the following light sources and objects:*

- *The candle and the father's hands on page 20*
- *The flashlight and the boy's hands on page 24*
- *The flashlight on page 26 and the cat on page 27*
- *The spotlight and the cat on page 28*

When students finish, display the prepared class shadows chart. Tell students that the illustrations at the top of the columns represent the shadows they just looked at in *Blackout*. If needed, identify the illustration in the book that matches each shadow on the chart. Then invite groups to share the light source and the object they identified for each shadow. Record student responses on the class shadows chart.

Teacher Note 1

If students do not mention needing light or a light source, ask the following questions: Do you think you would need a light source to form a shadow that looks like a cat? Why do you think that?

Teacher Note

The illustrations on the class shadows chart are in the same order as the shadows in the book. For example, the illustration in the first column represents the shadow of the father's hands on page 20 of *Blackout*.

Teacher Note

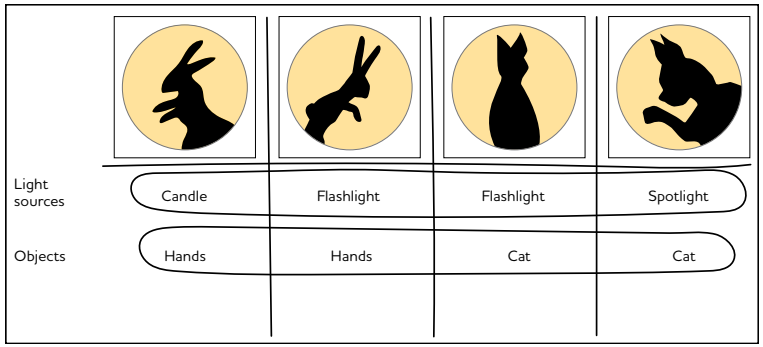
List the light sources in one row and the objects in another row. The rows will be labeled later in the lesson.

Leave space on the chart for a third row to list surfaces, which will be added later in this lesson part.

1 Sidebar Teacher Notes are used throughout the curriculum to provide teachers with guidance related to science content knowledge, pedagogy, progression of student learning, and usage of anchor visuals throughout the module.

2 Each module includes one or more core texts that students interact with to support their learning. Core texts are used throughout the program to introduce scientific information or to help frame students' thinking about science concepts and phenomena. The *Teach* book also provides strategies for teachers to make the core text accessible to all students.

Sample class shadows chart:



4. Update the class chart by adding the surfaces on which the shadows appear.

Remind students that at the beginning of the module they observed their own shadows. Point out that students' shadows appeared on the ground. Ask groups to revisit the shadows on the marked pages in *Blackout* and to use the remaining sticky note arrows to identify the places where the shadows appear.

Look for *groups to place sticky note arrows on the following surfaces:*

- *The kitchen wall on page 20*
- *The stairway wall on page 24*
- *The water tower on page 27*
- *The board on page 28*

Next, ask students to share with the class where each shadow appears. Record student responses in a final row on the class shadows chart. Circle the row, and label the row Surfaces. Explain that shadows form on surfaces such as walls, sidewalks, or the ground. Clarify that the walls, the water tower, and the board in *Blackout* are all surfaces.

Teacher Note
If needed, tell students that a water tower is a tank that stores water for people to use.

Language Support 1
Students will encounter the term *surface* throughout the module. Explain that a surface is the top or outer layer of something. Invite students to find different surfaces around the classroom.

1 Language Supports can be found throughout the modules. In-line and sidebar Language Supports provide guidance for teachers, including Spanish cognates and best practices for supporting English language development.

Check for Understanding 1

Identify the parts that work together (CC.4) to **form a shadow (PS4.B)**.

EVIDENCE	NEXT STEPS
During this discussion, be sure to check in with each student. Listen for the following in students' responses: • Students identify the three parts (CC.4) that form a shadow (PS4.B): an object, a surface, and a light source.	If students need support to identify the parts that form a shadow, have students think about the parts that were needed to form their shadow outside. Consider adding this example to the class shadows chart.

6. **Have students consider how shadows form in wayang shows.**

Revisit the class shadows chart, and point out that each shadow in *Blackout* needed a light source, an object, and a surface.

What else do we need to know to explain how shadows form in a wayang show?

Invite students to share their ideas, and add students' questions to the Driving Question board. Tell students they will next explore how an object and light from a light source form a shadow on a surface.

1 Checks for Understanding are formative assessments that occur throughout modules and provide teachers with the opportunity to monitor students' learning. They include evidence statements to help teachers gauge students' understanding as well as next steps to monitor students' progress towards lesson objectives and provide teachers with remediation for clear support on needed remediation.

LEARN 15 to 30 minutes

Investigate Shadow Systems | 20 to 25 minutes

Students investigate the order of parts that create a shadow.

2. Introduce the order of parts stations.

Tell students they will visit six prepared order of parts stations. Direct students' attention to one of the stations. Work with students to identify the parts at the station: The cat figurine is the object, the box lid is the surface, and the penlight is the light source. Explain that each station has the same parts but that the parts are in a different order at each station.

Next, draw students' attention to the prepared order of parts procedure sheet at the station. Tell students that each station's procedure sheet shows the order of the cat, the box lid, and the penlight that students will observe.

2

Safety Note

This activity poses potential hazards. Review these safety guidelines with students to minimize the risks:

- Do not look directly into the light from the penlights.
- Do not shine the penlights into or toward anyone's eyes.
- Do not move the penlights at the stations.

3. Support students as they conduct shadow investigations.

LESSON 6 ACTIVITY GUIDE A

Divide the class into six groups, and assign each group to their first station. Turn on the penlight at each station, and turn off overhead classroom lights if necessary. Then instruct students to observe the order of the cat, the box lid, and the penlight at their station and to determine whether a cat shadow forms.

Provide time for groups to record in their Science Logbook whether they see a cat shadow at their station before instructing groups to rotate to the next station. As students work, circulate to remind them of the directions and to ensure that the order of the cat, the box lid, and the penlight matches

Content Area Connection: English 1

As students visit the order of parts stations, encourage them to use important terms they have learned throughout the module (e.g., *object*, *surface*, *light source*, *shadow*). Using this language helps students form precise responses and deepens their understanding of how shadows form.

Spotlight on Three-Dimensional Integration 3

In this activity, students use models (SEP.2) to investigate the effects of changing the order of the parts needed to form a shadow (PS4.B, CC.2).

1 Content Area Connection notes describe instructional strategies or optional activities for connecting science learning to any of the following content areas: mathematics, English, history, geography, and visual art. The Implementation Guide includes information about where *PhD Science* connects to Math and ELA achievement descriptors and Common Core State Standards.

2 Safety notes describe safety hazards and/or procedures related to an activity as well as suggestions for minimizing risks.

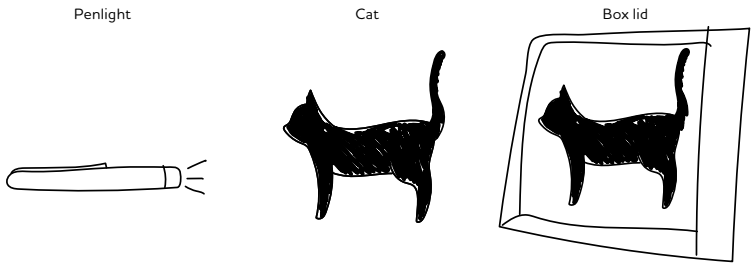
3 Spotlight Notes explain how a lesson activity relates to one or more specific Disciplinary Core Ideas; Science and Engineering Practices; Crosscutting Concepts; Nature of Science; and/or Engineering, Technology, and Applications of Science elements. These notes can also include educative information about instructional supports related to the identified elements.

How are the Shadow stations similar to the No Shadow stations? How are these stations different?

Do the cat, the box lid, and the penlight need to be in a certain order to form a shadow? Why do you think that?

Confirm that the cat must be between the penlight and the box lid to form a shadow. Record this understanding for the class by drawing a cat between a penlight and a box lid, ensuring that the penlight faces toward the cat.

Sample class shadow parts drawing:



6. **Revisit Blackout, and encourage students to draw conclusions about the order of the parts needed to form a shadow.**

Display the illustration on pages 26 and 27 of *Blackout*. Ask students to compare the illustration with the class shadow parts drawing.

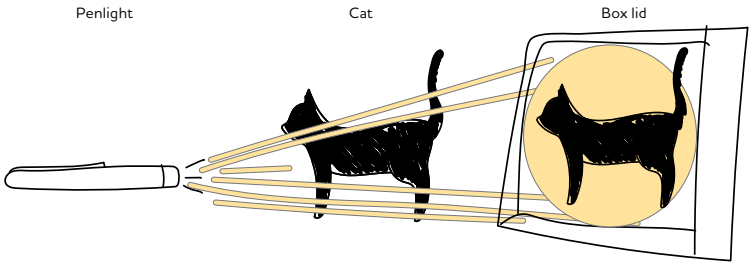
What do you notice about the order of the object, the surface, and the light source in these pictures?

Confirm that a shadow forms when an object is between a light source and a surface.

Extension 1
Consider asking students to look for shadows in the classroom and to identify the order of the parts that form each shadow.

1 Extension notes describe natural and grade level–appropriate activities that extend the lesson's learning for some or all students. Extension activities are always new activities that extend beyond the time allotted for the lesson. They may be activities that students perform or that teachers demonstrate.

Sample class shadow parts drawing:



9. Define *shadow* by having students compare shadows and how they form.

Revisit the illustration from pages 26 and 27 of *Blackout*. Ask students to again compare the parts that form a shadow in the illustration with the parts that form a shadow in the class shadow parts drawing. Have students Think–Pair–Share in response to the following questions.

How is this shadow in *Blackout* similar to the shadow we formed on the box lid?

How does this shadow in *Blackout* form?

Circulate and listen as students explain their thinking. Encourage each pair to use a nonverbal signal to agree or disagree with their partner's observations.

Differentiation 1

Incorporate multiple modalities of learning by providing students with the option to act out the order of the parts of the shadow as they discuss their observations.

1 Sidebar Differentiation notes are included throughout *PhD Science*. These notes provide teachers with strategies to support students as they engage with lesson content and work to meet lesson learning objectives. Differentiation notes provide examples of how teachers may scaffold instruction to support specific learning needs.

LAUNCH 5 to 10 minutes

Students reflect on their current understanding of interactions that form shadows and share examples of these interactions with the class.

1. **Have students consider their experiences with shadows so far in the module.**

   Ask students to Think–Pair–Share in response to the following question.

   What examples have we seen in which objects, surfaces, and light sources interact to form shadows?

   Listen for *students to provide examples from classroom experiences,* Blackout *(Rocco 2011), and wayang shows. If students do not mention shadows formed in wayang shows, consider asking them how puppeteers tell stories in wayang shows.*

   Distribute a sheet of paper to each student pair. Tell students to work with their partner to choose one example of an interaction that forms a shadow and to draw a picture of the interaction on their paper. Use a collaborative conversation routine such as a Whip Around to allow students to share the example they chose. 1

   Tell students that in this lesson part, they will continue to observe the parts that interact to form shadows as they further explore the Phenomenon Question **How do shadows form in a wayang show?**

Performance Descriptor

Develop a model to represent (SEP.2) how **the parts of a system work together (CC.4)** to **form a shadow (PS4.B)**.

Agenda | 30 to 45 minutes

LAUNCH | 5 to 10 minutes

LEARN | 15 to 20 minutes

- Observe Shade (15 to 20 minutes)

LAND | 10 to 15 minutes

1 Whip Around is a common instructional routine found throughout *PhD Science*. An instructional routine is a classroom procedure that supports the development of content knowledge and academic skills in an engaging and active way. Notes in the *Teach* book introduce new instructional routines and establish guidelines for students. The routines suggested help students think about science in different ways to build content knowledge, deepen understanding, and develop critical-thinking skills. The Implementation Guide has more information about the instructional routines used in *PhD Science*.

1 ✓ Ensure that students understand that shade is a kind of a shadow, as they will use this knowledge in a later lesson. If students need support to make the connection that shade is a kind of shadow, consider asking them whether the definition of *shadow* from the previous lesson part also applies to *shade*.

LAND 10 to 15 minutes

Students apply their new knowledge to explain how shadows form in a wayang show.

2 **4. Have students watch a video and apply their new knowledge to a wayang show.**

Tell students they will watch a video of a puppeteer and use what they have learned about shadows to figure out how shadows form during wayang shows. Play the wayang puppeteer video (http://phdsci.link/1603), and ask the following question.

💬 **What object, surface, and light source interact to form shadows in a wayang show?**

Confirm that the puppets (objects) block the light from a spotlight (light source) from reaching the screen (surface). Next, display the anchor model as well as the photograph on the back of the Wayang Knowledge Deck poster. Ask students to observe the photograph as they Think–Pair–Share in response to the following question.

💬 **What have we learned about shadows that helps us understand how shadows form in a wayang show?**

Listen for *students to mention the following ideas:*

- *Light from a spotlight (light source) interacts with puppets (objects) to form shadows on the screen (surface).*
- *Shadows form on the screen when the puppets block light from reaching the screen.*
- *The puppeteer uses the puppets to form the shadows that the audience sees.*

5. Update the anchor model.

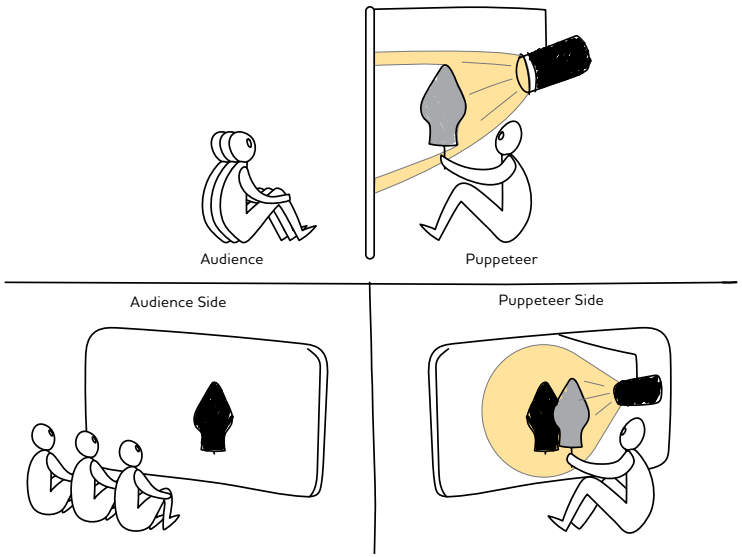
Use student responses to update the anchor model by drawing light from the spotlight interacting with the puppet.

1 The Look/Listen for Checkpoint indicates a critical moment of student sense-making in the module. The checkpoint tells teachers that they should not transition to the next activity in the lesson until they can identify evidence of student understanding.

2 Videos are used strategically throughout the curriculum as a way for students to access and understand complex phenomena and concepts.

Sample anchor model: 1

How do puppeteers use light to tell stories during wayang shows?



A wayang show is a system that has many parts. The puppeteer tells a story with shadows by using puppets, a screen, and a light source. The audience watches shadows on the screen as the puppeteer tells the story. Light from a light source illuminates parts of the show. The puppeteer and the audience can see these parts. **The puppets block some of the light from the light source from reaching the screen. This interaction forms shadows.**

1 The anchor model is a visual representation of students' explanation of the anchor phenomenon. This explanation grows and changes throughout a module as students apply new learning. Building this explanation and reflecting on unexplained processes or events reinforces the motivation for students' explorations.

The *Teach* book includes sample anchor models that are intended for guidance, not exact replication.

After updating the anchor model, ask the following question.

What would happen if light from the spotlight was not blocked by the puppets in a wayang show?

Build on student responses to explain that without the interaction between the light, the puppets, and the screen, the puppeteer would not be able to tell a story with shadows.

6. **Update the anchor chart.** 1

Display the anchor chart. Work with students to record their new learning about shadows on a sentence strip, and add the sentence strip to the anchor chart.

Sample anchor chart:

Light

Sight

- Light sources give off their own light.
- We can see objects when light illuminates them.
- We can see light sources because they give off their own light.

Interactions with Light

- **Shadows form when objects block light from reaching surfaces.**

7. **Have students update the Knowledge Tracker in their Science Logbook to reflect on what they learned in this lesson.** 2

Ask students to think about what they figured out during this lesson. Then tell students to consider how that new knowledge may help them answer the Driving Question. Have students record their ideas in the appropriate section of their Knowledge Tracker.

Tell students they will continue to explore how light interacts with surfaces during a Science Challenge in the next lesson.

1 The anchor chart is a record of transferable science knowledge that students develop throughout a module. Statements of transferable knowledge recorded on the anchor chart are clearly articulated, are grounded in evidence from students' explorations, and can be applied to multiple phenomena (including the anchor phenomenon, supporting phenomena, and assessment phenomena).

2 Students record each lesson's Phenomenon Question in their Knowledge Tracker. This practice supports in recognizing and making connections between the lesson-level phenomena they explore throughout the module. At natural points in each lesson, students reflect on what they have learned and how that information may help them answer the Driving Question.

HW Suggested Homework 1

Encourage students to use what they have learned to identify objects, surfaces, and light sources that interact to form shadows inside and outside their homes.

1 Suggested Homework provides optional opportunities for applying and extending science learning outside of school or in their communities.