Levels 3–5 Sample Companion

Level 4 Module 3

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.

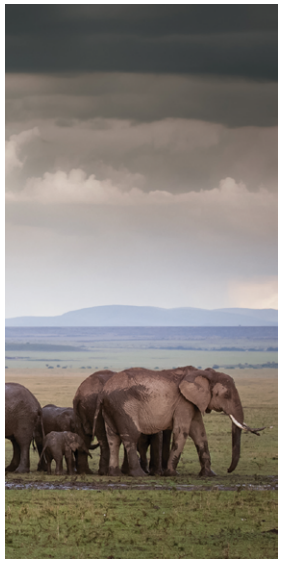
PhD SCIENCE®

Module Overview

MODULE OVERVIEW

DRIVING QUESTION 1

How do elephants sense rainstorms from more than 100 miles away?



INTRODUCTION

Background Information 2

Throughout this module, students study the anchor phenomenon—the elephant's ability to sense distant rainstorms—and work to answer the Driving Question: **How do elephants sense rainstorms from more than 100 miles away?** Students are introduced to the book *The Elephant Scientist* (O'Connell and Jackson 2011), which documents Dr. O'Connell's fieldwork studying the African elephants in Etosha National Park, Namibia. Students use this text throughout the module as they discover how elephants have the remarkable ability to sense and travel toward distant rainstorms.

This rich phenomenon drives students to seek how and what information travels across such great distances and how elephants can sense and respond to this information. Students begin to make sense of this phenomenon by comparing animals' sensory structures and the functions of those structures to humans' sensory structures and their functions. Next, students determine that energy from rainstorms travels through the ground in the form of waves over long distances to elephants. Students investigate sound waves and how elephants' sensory structures allow elephants to sense sound differently than humans. Students design, test, and analyze data for how they can use their sense of touch to differentiate between two surface vibration signals. Students return to the module text to read how Dr. O'Connell's research into elephant communication led to her discovery of specialized sensory receptors that allow elephants to detect ground vibrations with their feet and trunk. They then analyze different animal behaviors and research how elephants process, respond, learn, and remember how to respond to rainstorms.

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).

Near the end of the module, students build on their knowledge of specialized sensory structures in animals to uncover how plant structures and their functions help plants survive, grow, and reproduce.

Finally, students summarize their understanding of how elephants sense distant rainstorms and they apply their new knowledge to a new phenomenon.

Content Boundaries and Rationale 1

Why do students learn about structure and function through sense and response and information processing?

The anchor phenomenon of this module inspires students to wonder simultaneously about sensory structures and functions and sense and response in animals. Students apply different lenses to the anchor phenomenon, which includes looking at the structure and function of different sensory structures and sensory receptors. Later in the module, students build on their learning to understand how sensory structures are specialized and how animals use those specialized structures to respond to different types of information from their environment. Students analyze those responses to understand how those behaviors help the animal survive, grow, or reproduce.

Why do students learn about sound waves?

To make sense of the anchor phenomena, students use the Disciplinary Core Idea PS4.A, Wave Properties, to visualize and model how energy is transferred by waves on water. They then apply their understanding of water waves to make sense of how sound travels through the air and ground to elephants' sensory receptors.

Why don't students learn about matter or explain how sound travels through the vibration of particles?

To meet the Level 4 learning expectations of Disciplinary Core Idea PS4.A, Wave Properties, students are expected to understand that waves are regular patterns of motion caused by a disturbance and that waves transfer energy. Students learn the concept of matter in Level 2. To make content related to PS4.A accessible to Level 4 students, this module refers instead to objects and parts of objects that students can feel vibrate.

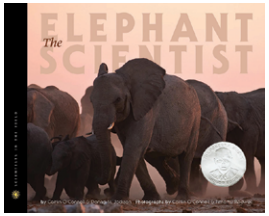
1 The Content Boundaries and Rationale subsection identifies boundaries of the Disciplinary Core Ideas and provides additional information about any content decisions made during development.

Students also discover in this module that sound travels away from vibrating objects and can cause other, nearby objects to vibrate. The module does not address the role of vibrating air or ground molecules in helping transmit sound. Students develop an understanding of air as matter in Level 5.

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 about how to support students with sensory disabilities. In addition, use the following resource to learn more about the science concepts featured in this module.

Sound: Stop Faking It! Finally Understanding Science So You Can Teach It by William C. Robertson



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 | **Use observations as evidence to explain (SEP.6)** that a **disturbance in water creates (CC.2) waves that transfer energy (PS4.A)**.

SCIENCE AND ENGINEERING PRACTICES	DISCIPLINARY CORE IDEAS	CROSSCUTTING CONCEPTS
SEP.6: Constructing Explanations and Designing Solutions • **Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation** or design a solution to a problem.	PS4.A: Wave Properties • **Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets the beach.**	CC.2: Cause and Effect • **Cause and effect relationships are routinely identified**, tested, **and used to explain change**.

MODULE OBJECTIVE | **Use patterns of different waves (CC.1)** to **develop a model that represents (SEP.2) features of a wave, including amplitude and wavelength (PS4.A)**.

SCIENCE AND ENGINEERING PRACTICES	DISCIPLINARY CORE IDEAS	CROSSCUTTING CONCEPTS
SEP.2: Developing and Using Models • **Develop a model using an analogy, example, or abstract representation to describe a scientific principle or design solution.**	PS4.A: Wave Properties • **Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).**	CC.1: Patterns • **Patterns can be used as evidence to support an explanation.**

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 | The elephant's ability to sense distant rainstorms

Driving Question | How do elephants sense rainstorms from more than 100 miles away?

Anchor Phenomenon Introduction

This lesson introduces students to the anchor phenomenon, the elephant's ability to sense distant rainstorms.

LESSON	ANCHOR PHENOMENON	DRIVING QUESTION	LESSON OBJECTIVE
1	The elephant's ability to sense distant rainstorms	How do elephants sense rainstorms from more than 100 miles away?	**Use patterns (CC.1)** to **develop initial models (SEP.2)** showing how **animals sense and interpret information from their environment (LS1.D)**. Part 1: **Develop initial models (SEP.2)** using **patterns (CC.1)** to represent **how animals sense information (LS1.D)**. Part 2: **Develop an anchor model (SEP.2)** using **patterns (CC.1)** in how **animals sense information from their environment (LS1.D)**.

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 | **Use observations as evidence to explain (SEP.6)** that a **disturbance in water creates (CC.2) waves that transfer energy (PS4.A)**.

ELEMENT	FORMATIVE ASSESSMENT	SUMMATIVE ASSESSMENT
SEP.6: Constructing Explanations and Designing Solutions • **Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation** or design a solution to a problem.	**Lesson 2** **Lesson 4** **Lesson 5** **Lesson 10**	**Lesson 13** **Lesson 14**
PS4.A: Wave Properties • **Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; there is no net motion in the direction of the wave except when the water meets the beach.**	**Lesson 4** **Lesson 6**	**Lesson 7**
CC.2: Cause and Effect • **Cause and effect relationships are routinely identified**, tested, **and used to explain change**.	**Lesson 4** **Lesson 5** **Lesson 10**	**Lesson 7** **Lesson 11** **Lesson 14**

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

Science and Engineering Practices

As students engage in sense-making, they develop and use models as tools to represent their ideas and explanations. In Kindergarten through Level 2, students learn to understand the utility of modeling as they begin to develop and use models that represent real-life events or engineering solutions. In this module, students expand their modeling skills to include developing a model that uses an analogy, example, or abstract representation to describe a scientific principle **(SEP.2)**. Students use different models to represent waves in this module as they use a wave tank to model waves, draw various models of waves and their properties, and use metal spring toys to represent how sound waves move through air. Students continue to build on these skills in middle school when they use models to describe, test, and predict more complex phenomena and engineering solutions.

Students routinely engage in using observations and collected data to construct explanations and to design solutions. In Kindergarten through Level 2, students learn to develop evidence-based accounts of phenomena from their observations. In this module, students explore waves and use observations and patterns to explain **(SEP.6)** what causes waves and what happens as the waves move across the water. In middle school, students build on this practice as they construct explanations supported by different types of evidence, applying scientific ideas and principles as reasoning to support their explanations.

In Kindergarten through Level 2, students learn to construct an argument and to obtain information from various sources, including texts and other media. Students use evidence, data, and models to construct and support different arguments **(SEP.7)** about how plants and animals use their structures to survive. Throughout the module, students obtain evidence from books and other media **(SEP.8)**, such as information about sensory structures and substructures of different plants and animals. In Levels 6 through 8, students build on this skill to construct and refute arguments and empirical evidence and to evaluate different sources of information.

Disciplinary Core Ideas

In Kindergarten through Level 2, students learn how animals and plants have different body parts that serve different functions and how some body parts are used to capture and convey different information.

In Level 4, students build on their knowledge of plant and animal body parts as they learn about the relationship between structures and substructures and how they function to contribute to an organism's behavior, growth, survival, or reproduction. Students begin the Sense and Response module by making observations and generating questions about elephants sensing and responding to information from their environment. Students wonder how elephants are able to sense rainstorms from over 100 miles away,

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

ADVANCE MATERIALS PREPARATION 1

An activity in this module requires advance preparation. See the lesson resources for more details on material preparation and instructions.

LESSON PART	TIME IN ADVANCE	PREPARATION TIME	INVESTIGATION	DESCRIPTION
Lesson 12 Part 1	1 day	5 to 10 minutes	Investigate Plant Structures	Purchase and prepare celery stalks for investigation. See Lesson 11 Preparation Resource for more information.

1 The Advance Materials Preparation section identifies and briefly describes module activities and investigations that require advance preparation. The intent is to give teachers a snapshot of activities and investigations that will require them to take special steps to prepare in advance of a lesson.

Lesson 2

Concept 1 | Sensory Structures

LESSON 2 ANIMAL SENSES 1

2 **Lesson Phenomenon** | Comparing different animal senses

Phenomenon Question | How do other animals sense information differently than humans? 3

OVERVIEW 4

Previously we developed initial models to explain how elephants sense distant rainstorms. We wondered how elephants sense information that humans cannot sense.

In this lesson we investigate how different animals' sensory structures and their functions compare with human senses. Through our investigation, we identify the possible specialized sensory receptors in elephants that can sense distant rainstorms. We wonder how information travels from a rainstorm to the elephants' sensory receptors.

Later we will apply our learning to a new context in a Conceptual Checkpoint.

Lesson Objective 5

Combine information to explain (SEP.8) how **sensory structures and substructures (CC.6) function in animals to sense information about their environments (LS1.D)**.

Performance Descriptors 6

Part 1: **Obtain and combine information to explain (SEP.8)** the variety in **structure and function of sensory receptors (CC.6)** and **external sensory structures (LS1.A) that are specialized for different information in animals and humans (LS1.D)**.

Part 2: **Use evidence to construct an explanation (SEP.6)** for how **sensory substructures relate to specialized functions (CC.6),** allowing **animals to sense each type of information (LS1.D)**.

Part 3: **Obtain and combine information to explain (SEP.8)** how **external and internal sensory structures (LS1.A) have shapes and functions (CC.6) to receive different types of information (LS1.D)**.

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.6: Constructing Explanations and Designing Solutions • **Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation** or design a solution to a problem. SEP.8: Obtaining, Evaluating, and Communicating Information • **Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.**	LS1.A: Structure and Function • Plants and **animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction**. LS1.D: Information Processing • **Different sense receptors are specialized for particular kinds of information, which may then be processed by an animal's brain. Animals are able to use their perceptions and memories to guide their actions.**	CC.6: Structure and Function • **Substructures have shapes and parts that serve functions.**

1 Standards Addressed provides a summary of the Disciplinary Core Ideas (DCIs), Science and Engineering Practices (SEPs), and Crosscutting Concepts (CCs) 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 2 Preparation Resource.

Video (5 minutes or less)

Station resources (10 minutes or less)

Touch Station (5 minutes or less)

Smell Station (15 to 20 minutes)

Sight Station (5 to 10 minutes)

Hearing Station (5 minutes or less)

Taste Station (5 minutes or less)

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: Introduce Sense Stations	☐ Science Logbook (1 per student)	None
Learn: Visit Sense Stations	☐ Science Logbook (1 per student)	☐ Prepared sense stations (1 set)
Land	☐ Science Logbook (1 per student)	None

MATERIALS REUSE

The list identifies disposable and prepared materials to save for reuse in the module.

☐ Sense stations

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 consider the relationship between sensory structures and their functions.

1. **Identify gaps in the current explanation of the anchor phenomenon.**

   Tell students they will rewatch the elephants at a watering hole video from the previous lesson. Ask students to observe how the elephants use their body parts to interact with the environment. Then play the video (http://phdsci.link/2952). 2

   How do the elephants use their body parts to interact with the environment?

   Listen for *student responses that mention elephants using body parts such as legs, ears, or trunk to interact with the environment.*

   Explain to students that all animals, including humans, have **structures**, or body parts that serve specific functions or purposes. Tell students that structures can be made up of smaller parts, called **substructures**, that support the function of the structure. Hold up one hand and tell students that the hand is a structure. Then point to each finger and identify the fingers as substructures of the hand that help support the hand's function.

   Language Support
   Introduce the terms *structure* and *substructure* explicitly by using a process such as this:

   - *Pronounce the word* structure *and have students repeat it. Say struc-ture in syllables, and then repeat the full word.*
   - *Provide the Spanish cognates for structure (estructura) and substructure (subestructura).*
   - *Provide a student-friendly explanation, such as "a body part with a specific purpose."*
   - *Consider explaining the meaning of the prefix sub-: underneath or lower.*

   After introducing *structure*, *substructure*, and other important terms, provide scaffolds to support multilingual learners' use of the terms as those students speak, write, and investigate. For more information, see the Language Support section of the Implementation Guide.

Performance Descriptor

Obtain and combine information to explain (SEP.8) the variety in **structure and function of sensory receptors (CC.6)** and **external sensory structures (LS1.A) that are specialized for different information in animals and humans (LS1.D)**.

Agenda | 45 to 60 minutes 1

LAUNCH | 5 to 10 minutes

LEARN | 35 to 45 minutes

- Introduce Sense Stations (5 to 10 minutes)
- Visit Sense Stations (30 to 35 minutes)

LAND | 5 minutes or less

Language Support
Students will encounter the term *function* throughout the module. Providing the Spanish cognate *función* may be helpful.

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

Explain to students that animals have internal and external structures. Tell students that an internal structure, such as the brain, is on the inside of the body and is not seen and that an external structure, such as the nose, is on the outside of the body and is easily seen. Use the following prompts to lead a class discussion about how elephants sense information from their environment.

What do you think the elephants can sense about the watering hole?

What structures do you think elephants use to sense information from their environment?

As students answer, point out on the anchor model the structures they mention. Tell students that the structures that sense information from the environment are called **sensory structures**. Clarify that sensory structures are external structures, such as the ears, nose, and eyes.

1 **Language Support**

Introduce the term *sensory structure* explicitly. Providing the Spanish cognate *estructura sensorial* may be helpful. Discuss the term in parts (*sensory* and *structure*) to help students understand each separately. Explain to students that the word *sensory* refers to the senses (e.g., sight, smell, taste, hearing, touch) and the word *structure* refers to a part of the body that serves a specific purpose.

2. Develop the Phenomenon Question and have students record it in the Knowledge Tracker in their Science Logbook.

Build on students' new understanding of sensory structures. Prompt students with the following questions.

How are your sensory structures different from an elephant's sensory structures?

Listen for *student responses that mention differences in the size or shape of elephant sensory structures, such as the ears or trunk.*

How might those differences help elephants at the watering hole?

Listen for *student responses that describe how differences in structure may allow elephants to have different abilities than humans to sense information from their environment.*

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 English language development.

Remind students that in the previous lesson, they discussed how some animals sense information differently than humans do. Review with students some examples of related phenomena. Then invite students to add more examples to the Driving Question board.

Build on student responses to develop the Phenomenon Question **How do other animals sense information differently than humans?** Ask students to record this question in the appropriate section of their Knowledge Tracker.

3. **Navigate to the investigation.**

Pose the following question to students.

What could we do in the classroom to help us understand how other animals sense information?

Listen for *student responses that suggest researching, investigating, or modeling how other animals sense information.*

Agree that investigating more about how other animals sense information will help answer the Phenomenon Question.

LEARN 35 to 45 minutes

Introduce Sense Stations | 5 to 10 minutes

Students are introduced to the sense stations.

4. **Describe the sense stations.**

LESSON 2 ACTIVITY GUIDE A

Tell students that they will visit five sense stations. Explain that each sense station provides background information about a sensory structure and a sensory receptor. Then explain to students that sensory receptors are substructures that support the function of the sensory structure. Clarify that sensory receptors are internal structures.

Teacher Note 1

If students completed the Lesson 1 Suggested Homework, ask them to share examples of animals sensing information that humans cannot. This discussion will create a natural bridge from the previous lesson's learning to the next.

Content Area Connection: Mathematics 2

Use the Taste Station informational text to reinforce place value understanding and multiplicative comparison with students by determining the number of taste buds in other animals. Use pictorial models, such as a place value chart, and equations to model understanding. Some examples follow:

- A catfish has _____ times as many taste buds as a cow.
- If an average human has 10,000 taste buds, and a cow has twice as many taste buds as a human, how many taste buds does a cow have?

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. In-line Teacher Notes provide information relevant to all students or explain something that teachers need in real time to effectively facilitate the lesson.

2 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.

Language Support

Students will encounter the term *sensory receptor* throughout the module. Explain that sensory receptors are internal structures that are specialized to receive information about an environment. Emphasize to students that sensory receptors (e.g., odor receptors) are a type of substructure that supports the function of a sensory structure (e.g., nose).

Tell students that at each station, they will read the information and then investigate to compare a human's and an animal's ability to sense information using that sense. Tell students that they will visit three stations the first day and the remaining two stations the next day. Inform students that they should respond to the questions in their Science Logbook before moving to the next station.

Visit Sense Stations | 30 to 35 minutes

Students explore a variety of ways animals sense information. Students compare how they sense information to the sensing abilities of other animals.

5. Provide time for students to rotate through the sense stations and record their responses.

LESSON 2 ACTIVITY GUIDE A

Divide the class into groups, and assign each group to their first station. Instruct students to read the text and then the procedure sheet before they begin the investigation at each station. The text introduces students to the sense they will explore, and the procedure sheet explains how they will explore that sense. Remind students to respond to the questions in their Science Logbook before moving to the next station.

Allow students 10 minutes to work at each station. As students work, circulate to support teamwork and to encourage students to record detailed responses.

Sample student response:

Question	Response	Touch Station
What sensory structure senses this information?	*Tongue*	*Skin*
What sensory receptor senses this information?	*Taste buds*	*Touch receptors*

Teacher Note
Review group work expectations with students. Highlight the importance of working quietly so as not to interfere with students using their sense of hearing at the Hearing Station.

Teacher Note
Before students begin working at the sense stations, check that they understand the teacher-determined protocol for rotating stations and how to respond to the questions in their Science Logbook.

Differentiation 1
Some students may benefit from hearing other ways to think about the questions. Consider reframing the questions as follows:

- Do you have a sensory structure like this animal's? How is your structure different or the same?
- Why is it important for the animal to sense this information?
- Does the animal sense the same information you sense? Does the animal sense the information in a different way? If so, how?

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.

2 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.

2

Spotlight on Science and Engineering Practices
As students share their ideas with their group, encourage them to cite relevant evidence from the sense stations in their explanations (SEP.6).

Teacher Note
Elsewhere in Level 4, students develop a ray model for light that explains why humans need light to see objects.

Check for Understanding 1

Obtain and combine information to explain (SEP.8) the variety in **structure and function of sensory receptors (CC.6)** and **external sensory structures (LS1.A) that are specialized for different information in animals and humans (LS1.D)**.

EVIDENCE	NEXT STEPS
Look and listen for the following ideas in students' discussions and written responses: • Identify that the shapes and functions of sensory structures and sensory receptors (CC.6) vary between humans and other animals and are specialized (LS1.D). • Use text and investigations to explain (SEP.8) why sensing certain information helps the animal (LS1.A). • Use text and investigations to explain (SEP.8) differences in the ability of humans and other animals to sense information (LS1.D).	If students need support, revisit the informational texts at the stations, and ask questions such as the following: • How does this animal use its sensory structures? • How does this animal use its sensory receptors? • How is this similar to or different from how a human uses their sensory structures?

LAND 5 minutes or less

Students finalize their work for the stations they have visited so far and prepare to visit the remaining stations in Part 2.

6. **Have students prepare to complete the sense stations investigation during Part 2.**

   Give students time to reset and clean up all stations. Have students review their Science Logbook to ensure that they have answered the questions for each station they visited.

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 direction for clear support on needed remediation.

LAUNCH 5 minutes or less

Students state the purpose of the sense stations investigation.

1. **Revisit the purpose of the sense stations.**

   Ask students to share what they are trying to figure out through their investigation.

   Remind students that they will complete their investigations at the sense stations and gather evidence to answer the Phenomenon Question **How do other animals sense information differently than humans?**

LEARN 30 to 40 minutes

Visit Sense Stations | 20 to 25 minutes

Students complete their investigation to describe each animal and sense and compare each animal's ability to sense information with their own.

2. **Provide time for students to rotate through the sense stations and record their responses.**

   LESSON 2 ACTIVITY GUIDE A

   Have students rejoin their groups from Part 1 and visit the remaining two sense stations.

   Allow students 10 minutes to work at each station and to record their responses in their Science Logbook. As students work, circulate to support teamwork and to encourage students to record detailed responses.

Performance Descriptor

Use evidence to construct an explanation (SEP.6) for how **sensory substructures relate to specialized functions (CC.6),** allowing **animals to sense each type of information (LS1.D)**.

Agenda | 40 to 55 minutes

LAUNCH | 5 minutes or less

LEARN | 30 to 40 minutes

- Visit Sense Stations (20 to 25 minutes)
- Develop an Explanation (10 to 15 minutes)

LAND | 5 to 10 minutes

Extension 1

Students can research other animal senses. Consider providing time for students to research and develop additional sense stations related to animal sensory structures they are interested in learning more about.

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.

Develop an Explanation | 10 to 15 minutes

Students use their investigation data to explain the supporting phenomenon. They build a conceptual understanding of how external sensory structures and internal sensory receptors (substructures) relate to function.

3. Discuss the results of the investigation.

Ask questions such as the following to elicit student thinking.

- **What did you discover during your investigation at the sense stations?**
- **How did the animals' noses, eyes, ears, tongue, or skin compare with those of humans?**
- **Why are some senses stronger in certain animals than in humans?**

Listen for *student responses that include the following ideas:*

- *All animals, including humans, have sensory structures and sensory receptors to sense information from the environment.*
- *Each structure has a specific function.*
- *Differences in structures and substructures can result in differences in function.*

1 *Ensure that students understand the connection between the structure and function of sensory structures. If needed, highlight one sensory structure from the sense stations and compare the sensory structure of the animal to the similar structure in humans. Reiterate that a sensory receptor is a substructure of the sensory structure. Ensure that students understand the following concepts about sensory structures and sensory receptors:*

- Sensory structures are external structures.
- Sensory receptors are internal structures.
- Sensory receptors communicate information to an animal's brain.
- There are many types of sensory receptors, and each one is specialized to receive a specific type of information: odor, light, touch, sound, or taste.

Teacher Note

Throughout the module, students explore the senses of animals that have a brain. Many invertebrate animals, however, do not have a brain. Consider clarifying this fact to students to avoid misconceptions. Students do not need to understand sensory processes in animals that do not have a central nervous system.

Teacher Note

To maintain the focus of this module, only the five basic senses are discussed. However, research has identified over twenty human senses. Examples of these additional senses include the following:

- Equilibrioception—the sense of balance
- Proprioception—the sense of body position and movement in space
- Thermoception—the sense of temperature changes

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.

4. Elicit and evaluate student explanations.

To solidify deeper understanding, provide each group with a sheet of chart paper, and assign the group an animal, a sensory structure, and a substructure as follows.

- Crocodile: skin and touch receptors
- Dog: nose and odor receptors
- Cat: eye and light receptors, pupils
- Rabbit: ear and sound receptors, inner ear
- Cow: tongue and taste buds

Instruct students to create a poster that shows how the sensory structure of the animal receives information from the environment. Encourage students to provide an explanation that describes the external sensory structure, the sensory receptor, and the type of information sensed.

Sample student response:

When the cow's tongue and taste buds touch food, such as grass, the cow tastes the food and can tell if it's safe to eat.

Display student work around the classroom. Then have students complete a Gallery Walk. One person from each group should remain at their poster to answer questions or to describe the group's work. After a few minutes, have all students return to their original group. Ask students to revise their poster to include new ideas.

Teacher Note

Consider providing groups with copies of the informational texts from each station for students to refer to as they develop their posters.

Differentiation

For students who are ready to include an additional example, suggest they develop their own model and explanation on a separate paper to explain a different sensory structure.

1 Gallery Walk 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*.

Build on student ideas to conclude that differences in sensory structures result in improved function for sensing that type of information.

6. **Elicit new questions about the anchor phenomenon.**

Display the Driving Question board and remind students of the Driving Question: **How do elephants sense rainstorms from more than 100 miles away? Ask students to apply their new learning to begin developing an answer to this question.**

- **How do you think elephants' senses compare with humans' senses?**
- **What should we explore next about how elephants can sense distant rainstorms?**
- **What new questions should we add to the Driving Question board?**

Through discussion, conclude that learning about elephants' sensory structures and the information elephants can sense might help answer the Driving Question.

HW Suggested Homework 1

Briefly draw attention to how students have identified that differences in a structure can affect the function of that structure. Ask students to find and record examples of how something's structure is important for the structure to perform a specific function. Have students consider different objects including human-designed objects and natural objects.

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

LAUNCH 5 minutes or less

Students identify how they can apply new understanding of the supporting phenomenon to the anchor phenomenon.

1. **Have students gather information about elephants.**

   Ask students the following questions.

   How do you think elephants can sense information differently than other animals?

   Listen for *student responses that describe differences between the sensory structures of elephants and other animals and their possible functions.*

   How could we find out more about elephant sensory structures?

   Tell students they will continue to explore sensory structures to help answer the Driving Question: **How do elephants sense rainstorms from more than 100 miles away?**

LEARN 35 to 45 minutes

Read About Elephants | 20 to 25 minutes

Students listen to the text to identify elephants' potential external sensory structures and internal sensory receptors responsible for detecting information from rainstorms.

2. **Introduce Dr. O'Connell's research and ask students to gather evidence as they listen to the text.**

   LESSON 2 ACTIVITY GUIDE B

   Explain that scientists often build on the ideas and work of others when exploring questions. Tell students that they will listen to a text about elephants. Introduce *The Elephant Scientist* [1] itlin O'Connell and Donna M. Jackson (2011), and tell students that Dr. O'Connell is a scientist who has been studying elephants for decades.

Performance Descriptor

Obtain and combine information to explain (SEP.8) how **external and internal sensory structures (LS1.A) have shapes and functions (CC.6) to receive different types of information (LS1.D)**.

Agenda | 45 to 55 minutes

LAUNCH | 5 minutes or less

LEARN | 35 to 45 minutes

- Read About Elephants (20 to 25 minutes)
- Develop an Explanation (10 to 15 minutes)
- Update Anchor Model (5 minutes or less)

LAND | 5 minutes or less

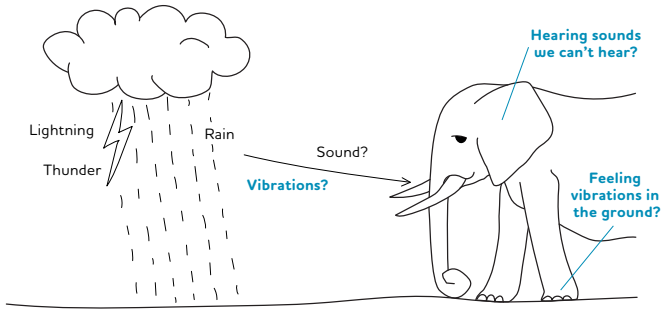
Language Support

Throughout the module, students will encounter challenging terms from *The Elephant Scientist*. To support multilingual learners engaging with this text, refer to the strategies described in the Language Support section of the Implementation Guide.

[1] 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 anchor model: 1

How do elephants sense rainstorms from more than 100 miles away?



We think there is something special about an elephant's ears and feet that help it hear sounds and feel vibrations in the ground that humans cannot sense. Maybe these sensory structures have sensory receptors that are specialized to sense rainstorms from more than 100 miles away.

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

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

Differentiation

As students connect what they learned in this lesson back to the Driving Question, they may benefit from questions such as the following:

- What new information did you learn in this lesson? How does that information remind you of the anchor phenomenon?
- How is the phenomenon we explored in this lesson similar to the anchor phenomenon?

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.

2 Students record each lesson's Phenomenon Question in their Knowledge Tracker. This practice supports students 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.

LAND 5 minutes or less

Students summarize and reflect on their new learning.

6. **Work with students to summarize their new knowledge and create an anchor chart.**

   Display the anchor model. Create an anchor chart to summarize what students know about sensory structures. Use learning from the sense stations and the class models to guide the discussion.

   Sample anchor chart 1

   Sense and Response

   Sensory Structures

   - Animals have sensory structures (e.g., eyes, ears, nose) that help them gather information about their environments.
   - These sensory structures contain smaller substructures called sensory receptors. Different sensory receptors receive different information (i.e., light, sound, taste, touch, odor) about the same environment and send it to the animal's brain.

7. **Have students reflect on new learning and navigate to the Conceptual Checkpoint.**

   Draw students' attention to the anchor model and anchor chart. Emphasize that students have figured out a lot about how elephants might sense distant rainstorms. Tell students that in the next lesson they will update the Driving Question board and apply what they know in a Conceptual Checkpoint.

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).

Concept 1 | Sensory Structures

LESSON 3 CONCEPTUAL CHECKPOINT 1

2 **Lesson Phenomenon** | Desert chameleon structures and functions

Phenomenon Question | How does the desert chameleon use its structures to survive?

OVERVIEW 3

Previously we investigated how animals' sensory structures allow them to sense information differently than humans. We wondered what information travels from rainstorms to elephants and what specialized sensory receptors elephants use to sense this information.

In this lesson we apply our learning about animal sensory structures and their functions as we complete a Conceptual Checkpoint.

Later we will explore how information travels from rainstorms to elephants' sensory receptors.

1 Conceptual Checkpoints are three-dimensional assessments where students make sense of an unfamiliar but compelling assessment phenomenon. Through this task, students are able to demonstrate achievement of certain elements of Module Objectives developed within previous lessons of the module. Conceptual Checkpoints are integrated within each End-of-Concept lesson to provide teachers with information on how students are progressing at consistent points throughout the module before the End-of-Module Assessment.

2 Conceptual Checkpoint tasks require students to transfer knowledge and skills built throughout the module to make sense of a new phenomenon and demonstrate their understanding of the targeted elements of the Module Objectives. Typically, Conceptual Checkpoints within a single module focus on a running phenomenon context.

3 The Overview section of a Conceptual Checkpoint 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.

LAUNCH 5 to 10 minutes

Students summarize how their learning from this concept helps them make sense of the anchor phenomenon.

1. **Discuss how students have acquired new knowledge throughout the concept.**

   Display the anchor model and ask students to review the Knowledge Tracker in their Science Logbook. Ask questions such as the following to facilitate a discussion about what students have learned so far.

   - **What are examples of animal sensory structures and sensory receptors?**
   - **What are some ways that animals use their sensory structures to help them survive?**
   - **What information do elephants sense from their environment?**
   - **How did we figure out how animals use their sensory structures?**

     Listen for *students to mention the following:*

     - *Sensory structures such as eyes and sensory receptors such as light receptors*
     - *Animals detecting predators to survive*
     - *Elephants sensing information from distant rainstorms*
     - *Investigations or activities that helped students develop this knowledge*

2. **Transition the class to the Conceptual Checkpoint.**

   Explain that students can use what they know about animals using their structures to survive to make sense of other, similar phenomena. Tell students that they will now apply their knowledge of animals' structures and sensory receptors to a new context as they complete a Conceptual Checkpoint.

Agenda | 30 to 50 minutes

LAUNCH | 5 to 10 minutes

LEARN | 20 to 30 minutes

- Conceptual Checkpoint (20 to 30 minutes) 1

LAND | 5 to 10 minutes

1 In Conceptual Checkpoint lessons, students apply their learning to a new phenomenon as they complete the Conceptual Checkpoint.

Provide each student with a copy of the desert chameleon information sheet and a Conceptual Checkpoint. Review the information sheet with students and tell students that they will use the information to help them complete the Conceptual Checkpoint.

Teacher Note
The information sheet contains Namib Desert weather data sourced from Weather Underground (2023). If necessary, clarify to students that the Namib Desert is in the Southern Hemisphere where summer occurs from December through February.

4. **Read each assessment item aloud to students, and give them time to complete the Conceptual Checkpoint.**

Conceptual Checkpoint 1

This Conceptual Checkpoint assesses students' understanding of the knowledge and skills they developed throughout Concept 1. Use the Lesson 3 Conceptual Checkpoint Scoring Guide to score each student's assessment. The scoring guide also lists the NGSS elements assessed by each item and identifies next steps for students who need additional support.

Teacher Note
Debriefing the Conceptual Checkpoint provides an opportunity to identify each student's strengths and growth areas and to respond flexibly to students' needs before moving to the next concept. This practice also helps students develop their metacognition skills as they identify the knowledge they applied to respond to assessment items and notice where they might have made mistakes.

To debrief the Conceptual Checkpoint, use the scoring guide to score each student's assessment. (See the scoring guide and sample responses in Appendix A: Summative Assessments and Scoring Guides.) Identify at least one assessment item to debrief with the class. Select an exemplar response to this item either from the Teacher Edition or from a student assessment. If selecting a response from a student assessment, remember to remove identifying information. Be sure to select responses from a variety of students over time.

When providing students with individual feedback on the assessment, guide them to focus on specific areas for improvement to deepen their understanding of the concept. Offer students who need additional support the opportunity to revisit portions of the module.

1 Summative assessments, such as Conceptual Checkpoints, have a Scoring Guide that provides the teacher with the following information:

- The Scoring Guidance identifies the correct response or provides support in evaluating student's constructed responses for each item. It also includes information about how to determine a student's score—the maximum points available for each item with a space for the teacher to record the points earned by the student.

- An Alignment Map provides the SEP, DCI, and CC Element parts that are being assessed in each item. The alignment also indicates which elements appear in Module Objectives.

- Next Steps are provided for Conceptual Checkpoints to inform teachers of strategies that can be implemented after the assessment is implemented to support students who did not meet expectations on a given item.

Sample Driving Question board: 1

PHDK5-61-65%

Driving Question: **How do elephants sense rainstorms from more than 100 miles away?**

Questions about how elephants sense and respond to information from their environment

- How do elephants sense rainstorms?
- What senses are the elephants using to detect distant rainstorms?
- Do elephants have special senses?
- What do elephants do when they sense a rainstorm far away?
- How do the elephants know the right direction to go?
- How do elephants know what to do when they sense a rainstorm?
- Do elephants have special structures to detect rainstorms?

Questions about how information travels across a distance

- Can sound travel 150 miles?
- How do the elephants know that it is a rainstorm that is coming?
- Can elephants see or hear a storm when it's so far away?
- Can elephants smell the rain from the storm from that far away?

Related Phenomena:

- Service animals like dogs that help people who are blind
- A dog going to the door before the doorbell rings
- A bird sensing there is a worm underground
- Animals that sense danger and run away
- A cat seeing in the dark
- Chameleon eyes move in almost all directions

1 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.

In Conceptual Checkpoint lessons, students reflect on the Driving Question board to consider which questions they have answered and add new questions.