Smithsonian

STC
Science and Technology Concepts™
MIDDLE SCHOOL

Structure and Function
Unit Sampler

Teacher Edition

CAROLINA®
www.carolina.com

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Introduction

Structure and Function Three-Dimensional Instruction Sampler

9 All-New Units for Middle School from the Smithsonian!

Smithsonian's STCMS Is Built to Meet the Next Generation Science Standards and Incorporate the 5 Innovations:

- **Three-dimensional learning** construction—every lesson, every unit
- Lessons that apply **science concepts** to NGSS* **engineering design**
- Hands-on investigations in which students build explanations for real-world **phenomena and design solutions—every day**
- **Coherent learning progression** that develops lesson by lesson, unit by unit—no "random acts of science"
- **Literacy and mathematics connections** that bridge science content and lead to deep understanding

STCMS Learning Framework

Physical Science	Life Science	Earth/Space Science
Energy, Forces, and Motion	Ecosystems and Their Interactions	Weather and Climate Systems
Matter and Its Interactions	Structure and Function	Earth's Dynamic Systems
Electricity, Waves, and Information Transfer	Genes and Molecular Machines	Space Systems Exploration

Hands Down, Research Tells Us that Inquiry-Based Instruction Is Best for Your Students

Choose instruction that has been proven to improve student performance and test scores not only in science, but also in reading and math. ◊

What students say about STC:
"In science you do hands-on activities instead of just writing and doing notes, and you get to work with people. For visual people in science that's a lot better because you get to see the experience and experiment."

What administrators say about STC:
"We saw instant results in our test scores—a double-digit increase in our end-of-grade state performance…"

◊ *Visit www.carolina.com/stc to download the LASER i3 Study Results*

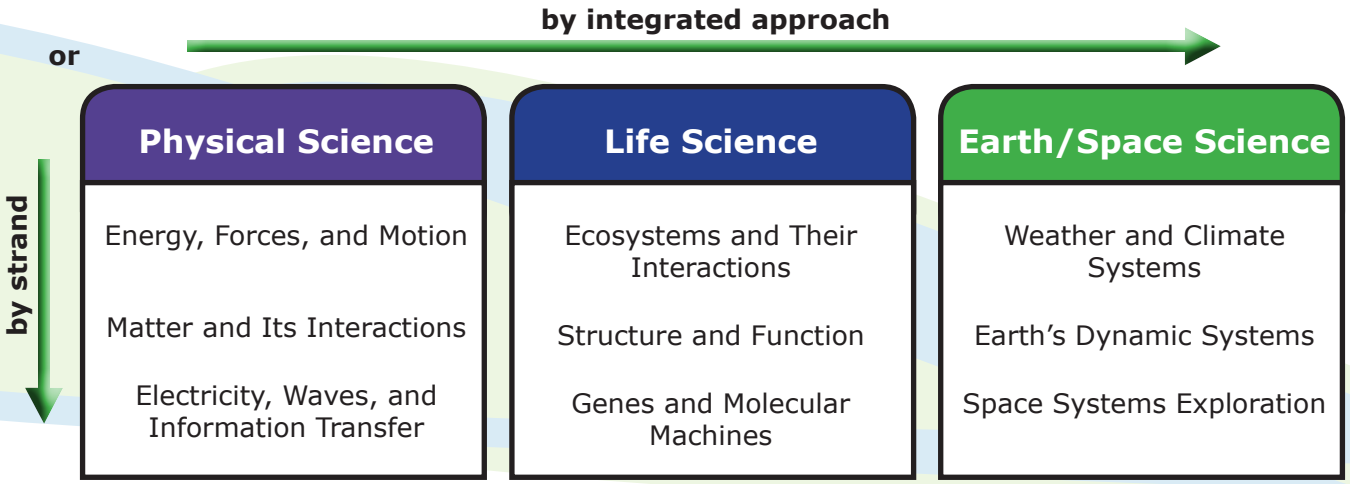
* Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

Coherent Learning Progressions—Lesson by Lesson, Unit by Unit

The NGSS provide students with continued opportunities to engage in and develop a deeper understanding of the three dimensions of science. The STCMS program follows this coherent learning progression, lesson by lesson, unit by unit.

The STCMS Learning Framework—Conceptual Progression by Unit

Three units in each strand of Physical, Life, and Earth/Space Science allows you to build your middle school program



An example of how concepts can grow across a strand within STCMS

Physical Science Concepts

Energy, Forces, and Motion develops the energy background on how visible objects move and collide resulting in energy transfer and ending with how energy can be transformed.

Matter and Its Interactions builds understanding of the relationship between energy and matter and transfer and transformation at the molecular level.

Electricity, Waves, and Information Transfer studies and builds an understanding of the transfer and transformation of energy, how specific energies are transmitted by waves, and the technology contributions to society that have resulted from this understanding.

Three-Dimensional Learning—The Signature Innovation of the Next Generation Science Standards

STCMS provides teacher support in weaving together Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts to address Performance Expectations over time.

STCMS meets the 5 Innovations of NGSS, deepening understanding of Performance Expectations

Alignment to Next Generation Science Standards

- MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
- MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

Students explore the nervous system as one system, composed of groups of cells, that interacts with other body systems, addressing **MS-LS1-3**. They also focus on sensory receptors responding to stimuli by sending messages to the brain, addressing **MS-LS1-8**.

In Getting Started, students focus on the sense of vision as an introduction to the nervous system and the sensory systems within it. During Investigation 7.1, students examine slides of nervous tissues under a microscope and determine their functions and how they aid in survival, addressing **MS-LS1-3**. The remaining investigations address **MS-LS1-8**. During Investigation 7.2, students measure reaction times, providing greater understanding of the nervous system and how sensory receptors respond to stimuli and lead to immediate behavioral response. In Investigation 7.3, students conduct activities that draw attention to several kinds of sensory receptors that respond to stimuli. In Investigation 7.4, students consider how sensory receptors can confuse the brain.

In Reflecting On What You've Done, students use the evidence obtained during their investigations to **illustrate a model** of how a living thing is able to sense and respond to various stimuli in its environment. Students also revisit the reaction-time activity, focusing on the effects of sensory impairment, and read about sensory receptors in other animals and how their own brain develops over time.

Throughout the investigations and readings, students' activities will highlight the causal nature of stimuli and the brain's response, addressing the **crosscutting concept** of **cause and effect.** Students will address the **science and engineering practices** of **obtaining, evaluating, and communicating information**. Throughout the lesson, students **observe and collect data**, evaluating it as they **discuss results, and communicating information** by working in groups as they write and discuss their results.

Complete Three-Dimensional Learning Support

Lessons in *Structure and Function*:

- Ignite learning through phenomena
- Explore phenomena through experiential learning
- Use models to represent systems, develop questions and explanations, generate data, and communicate ideas
- Integrate literacy and math
- Convert learning experiences into understanding of phenomena

Alignment to the Next Generation Science Standards

Alignment to Next Generation Science Standards

Alignment of *Structure and Function* to Next Generation Science Standards

PERFORMANCE EXPECTATIONS

- MS-LS1-1. Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells.
- MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
- MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
- MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
- MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
- MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
- MS-LS4-2. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.
- MS-LS4-3. Analyze displays of pictorial data to compare patterns of similarities in embryological development across multiple species to identify relationships not evident in the fully formed anatomy.

SCIENCE AND ENGINEERING PRACTICES

- Analyzing and interpreting data
- Engaging in argument from evidence
- Developing and using models
- Planning and carrying out investigations
- Constructing explanations and designing solutions
- Obtaining, evaluating, and communicating information

CROSSCUTTING CONCEPTS

- Structure and function
- Patterns
- Energy and matter
- Systems and system models
- Cause and effect

DISCIPLINARY CORE IDEAS

- LS1.A: Structure and function
- LS1.C: Organization for matter and energy flow in organisms
- LS1.D: Information processing
- LS4.A: Evidence of common ancestry and diversity
- PS3.D: Energy in chemical processes and everyday life

A Coherent Learning Progression within Each Unit

STCMS Program units develop logically and systematically to build a deep understanding of content and science and engineering practices.

From pre-assessment to summative performance assessment, students have multiple opportunities to build understanding by engaging in investigations. Within *Structure and Function*, students build understanding of how the structure and function of organisms contribute to their survival.

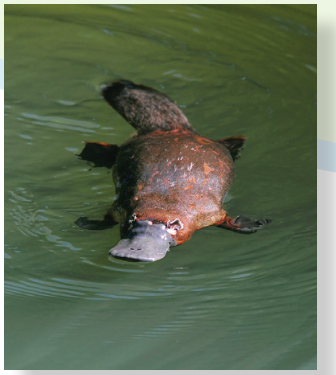
This sampler highlights a specific group of investigations from three lessons that directly support performance expectations:

MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. .

Three-dimensional understanding of this performance expectation builds throughout the unit. This sampler focuses on three specific opportunities: the Pre-Assessment, further investigation in Lesson 7, and the Performance Assessment in Lesson 8.

In the **Pre-Assessment**, students review what they already know about how living things survive in their environment. After an introduction to a compound microscope, students observe the body plans of different organisms and predict the functions of the different structures they observe. Students then compare plant and animal cells and begin to observe structural similarities and differences between the two groups of organisms. This prepares them for later lessons in which they look further into cells and the roles they play in the development and survival of organisms.



In **Lesson 7: The Nervous System**, students build on information they gained in Lesson 6 about the specialization of cells, each cell's specific function within an organism, and the specific levels of organization of cells in the production of organ tissues and organ systems as they investigate how the brain sends and receives information when exposed to stimuli. Investigation 7.3: Information Processing explores the role of sensory receptors in sending messages to the brain.

The information gathered in Lesson 7 directly prepares students for the **Performance Assessment in Lesson 8: Assessment: *Structure and Function,*** in which students conduct research on an animal with unique structures that allow it to better survive in its environment.

In STCMS:

- Units average 11 lessons
- Lessons average 5–6 investigations
- Investigations are based on 45- to 50-minute sessions
- Unit completion averages 12 weeks

Details on what is included in a unit can be found on the back cover of this sampler.

Coherent Learning Progression—Lesson by Lesson

Concept Storyline

A systematic approach builds deep three-dimensional understanding

Structure and Function
Concept Storyline

Unit Driving Question: How do the structure and function of organisms contribute to their survival?

Lesson 1: *Pre-Assessment: Structure and Function*
Focus Question: What do we already know about how living things survive in their environment, and how can we learn more?

Students perform short, simple investigations that evaluate their existing knowledge of one or more concepts related to structure and function. Students are introduced to a compound light microscope and practice their focusing skills. They observe the body plans of different organisms and predict the functions of different structures that they notice. Students also compare plant and animal cells and begin to observe structural similarities and differences between the two groups of organisms. Students are also introduced to the practice of scientific illustration and its significance in the scientific community.

Lesson 2: *Cells*
Focus Question: What roles can cells play in the development and survival of organisms?

Students carry out investigations relating to cells by creating wet-mount slides of various unicellular organisms, observing structures associated with these cells, and then predicting their functions. Next, students observe cell specialization in multicellular organisms by observing prepared slides of cells from different organisms. They attempt to determine the function of these cells based on their shape, structure, and other information provided. Students build on their foundation of cell specialization by observing images of embryos at different stages of development. During this investigation, they are introduced to the concept of cell differentiation in multicellular organisms and how this leads to cell specialization.

Lesson 3: *Cell Organelles*
Focus Question: What structures does a cell need in order to survive?

Students explore the phenomena of cellular structures, their functions, and their contribution to a cell's survival. Students start by creating a model of a eukaryotic cell to determine their prior knowledge. The remaining investigations address the organelles commonly found in both plant and animal cells, their functions, and the organelles' interdependence on one another. Students compare and contrast the organelles found in both types of cells and observe how structures vary based on an organism's needs. Students apply the information gained during this investigation to create a comic story line that personifies several organelles they have learned about.

Lesson 4: *Photosynthesis*
Focus Question: What roles do matter and energy play during photosynthesis?

Students plan and carry out an investigation to provide evidence of the matter and energy used by autotrophs during the process of photosynthesis. After determining the need for carbon dioxide, water, and light, students investigate the structures that enable a plant to access these resources in its environment.

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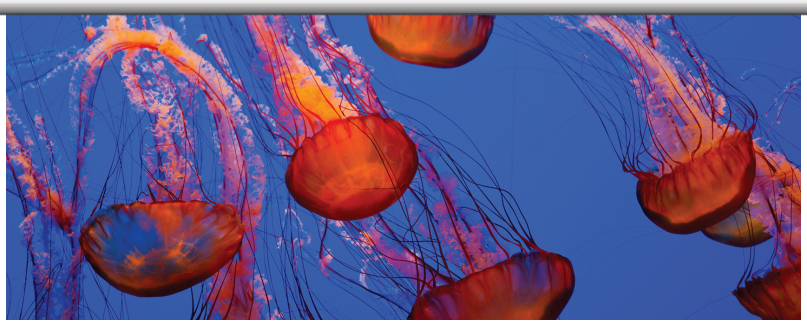

CREDIT: bierchen/Shutterstock.com

Lesson 5: *Cellular Respiration*

Focus Question: Where do cells get the resources they need to aid in an organism's survival?

Students explore cellular respiration by observing the impact of physical activity on the body. Students plan and carry out an investigation to provide evidence that humans release thermal energy. Students plan and carry out another investigation to provide evidence for whether or not autotrophs go through cellular respiration. Students also analyze data they collect on the energy value in different foods. Students compare and contrast the matter and energy used during cellular respiration to that of photosynthesis, realizing that both processes rely on one another.

Lesson 6: *Levels of Organization*

Focus Question: How does the organization of an organism's body aid in survival?

Students investigate a variety of tissues associated with different plants and animals and predict their functions. They explore different tissues, organs, and organ systems associated with plants and animals. Students research a particular organ system in the human body, compile a list of reliable sources of information, and present their findings to the class. They then make an evidence-based claim that a body is a system of interacting subsystems after they dissect a model organism, a frog. Students begin to explore evolutionary relationships by observing patterns in skeletal structures in different animals. They also create a cladogram to display evolutionary relationships between both present-day and fossilized organisms.

Lesson 7: *The Nervous System*

Focus Question: How does the brain send and receive information?

Students explore the structures associated with the nervous system and their functions. Students predict functions for various types of nervous tissue, test their reaction time, explore their sensory receptors, and confuse their brain with several sensory illusions. Students then revisit their reaction time after impairing their sense of balance. All of these investigations allow students to obtain, evaluate, and communicate information on how information is gathered by sensory receptors, is sent to the brain for processing, and results in an immediate reaction or in memory storage.

Lesson 8: *Assessment: Structure and Function*

Focus Question: How are different animals specially adapted to survive in their environment?

The unit concludes with a two-part assessment. The first part is the Performance Assessment in which students demonstrate their content knowledge and science and engineering skills by researching a particular animal and the structures that enable it to survive in its environment. Students then present their findings to the class with their partner. In the second part, students complete the Written Assessment that covers the performance expectations, disciplinary core ideas, crosscutting concepts, and science and engineering practices covered in this unit.

More resources for teachers and students found at:
www.carolinascienceonline.com
www.ssec.si.edu/STCMS

Non-Fiction Literacy Connected to Science Phenomena

Non-fiction literacy selections introduce students to phenomena and support their experiential learning, deepening their understanding.

Building Knowledge through Non-Fiction Literacy

Compound light microscopes usually have three to four objectives lenses. Most microscopes have a 4×, 10×, and 40× objective lens, also known as low, medium, and high power objectives lenses.

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Through the Compound Eye

For thousands of years, human beings have used tools. For a biologist, one of the most important tools is the microscope. Since its invention in the late 1500s, the microscope has been transformed into a relatively inexpensive yet efficient way for scientists such as yourself to view a world invisible to the naked eye.

Advances in microscope technology have led to the discovery of cells, cellular structures within cells, microorganisms such as bacteria, viruses, and more. Microscopes allow doctors to regularly analyze tissue samples from their patients to determine various illnesses, parasites, or other medical issues. Scanning electron microscopes are extremely powerful and can magnify an object up to several million times its normal size. These microscopes help scientists view tiny viruses and develop vaccines and cures for infectious diseases. Other electron microscopes can be used to create enlarged images of small structures such as silicon chips. Silicon chips are used in electronic devices to improve their performance. The enlarged images allow engineers to fit more circuits on the silicon chip, which, in turn, creates a more efficient electronic device, such as a new model of a cell phone. The many uses of microscope technology aid our understanding of the microscopic world and allow scientists to make further advances in the scientific community.

You will be using a compound light microscope during this unit. In this type of microscope, light is provided either by a mirror or a small, built-in lightbulb. The word "compound" refers to the two lenses—one in the eyepiece and one in an objective lens—that together magnify the image. You can calculate the total magnification by multiplying the magnification of the lens of the eyepiece by that of the lens on the objective.

The image on the facing page displays the parts of a compound microscope and explains the function of each part.

To use the microscope, you must follow eight steps in sequence. These are listed below. Review the steps and keep this list for reference when you look at microscope slides throughout this lesson.

Step 1: Turn on the light (or adjust the mirror) near the base so that you can see the field of view while looking through the eyepiece.

Step 2: Open the diaphragm found under the stage. The diaphragm regulates the amount of light and is perhaps the most misused, or unused, feature of the microscope. Yet it is one of the most important tools for the optimal viewing of an object. When viewing a specimen, too much or too little light will decrease the contrast or image quality.

Step 3: Turn the revolving nosepiece, and make sure the low power objective lens (the shortest lens, usually 4×) is clicked into place, perpendicular to the stage, as shown in the image above.

Step 4: Place the center of the microscope slide over the hole in the stage and secure it with the stage clips. Carefully move the stage clips over each end of the slide. Center the specimen in your field of view if needed.

Step 5: While looking from the side, use the large, coarse adjustment knob to fully raise the stage. Do not allow the objective lens to touch the slide.

Step 6: While looking into the eyepiece, use the coarse adjustment knob to focus the image as you slowly change the distance between the stage and the objective lens, as seen in the image at right.

Step 7: Stop moving the coarse adjustment knob when the object comes into focus. If necessary, use the fine adjustment knob to focus the object more clearly.

Step 8: Close the diaphragm slightly so that the image is still visible. This should increase the contrast of the image. ■

▲ Use the large, coarse adjustment knob to focus the object on your slide first.

CREDIT: Tetra Images/Shutterstock.com

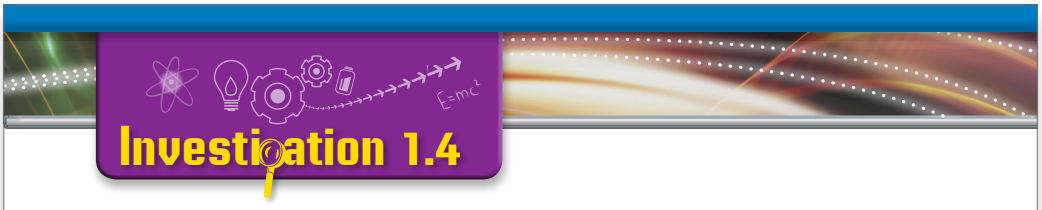
The Compound Light Microscope

1. **Arm**–Supports the stage and upper part of the microscope; contains the focus adjustment knobs
2. **Base**–Supports the microscope
3. **Coarse Adjustment Knob**–Raises and lowers the stage or objective lenses
4. **Diaphragm**–Wheel or lever that adjusts the amount of light that passes through the hole in the stage and into the specimen
5. **Eyepiece**–The part of the microscope through which you look; usually contains a 10× lens
6. **Fine Adjustment Knob**–Raises and lowers the stage or objective lenses a tiny distance for exact focusing
7. **Light**–Sends light through the hole in the stage to illuminate the specimen on the slide
8. **Nosepiece**–Holds objective lenses; rotates to enable changing magnification
9. **Objective Lenses**–Used in combination with the eyepiece; provide a range of magnifications, usually from 4× to 40×
10. **On/Off Switch**–Turns the light source on and off
11. **Stage**–Supports the slides
12. **Stage Clip**–Usually one on each side of the hole in the stage; helps hold the slides in place

What Do They Already Know?

Pre-assessment investigations help teachers gain insight into students' prior knowledge and misconceptions. Pre-assessments introduce students to science phenomena they will investigate throughout the unit, beginning the construction of deep understanding and the ability to explain phenomena.

Investigation 1.4: Plant Versus Animal asks students to compare plant and animal cells and begin to observe structural similarities and differences between the two groups of organisms. This prepares students for later lessons in which they look further into cells and the roles they play in the development and survival of organisms.



Plant Versus Animal

Materials

For you

- Science notebook

For your group

- 2 microscopes
- 1 Microscope slide A
- 1 Microscope slide B

Procedure

1. During this investigation, you and your group will investigate two microscope slides of cells. During your observations, focus on the shape and structures found within the cells to determine if they belong to a plant or animal.

Safety Warning

- **Never handle broken glass. If a slide breaks, notify your teacher immediately.**

2. Split your group into pairs. Each pair should select a microscope. Next, each pair should choose either microscope slide A or slide B. Focus the slide you and your partner picked, working your way up the magnifications until you are able to observe the cells on high power (40×). These cells, like most of the cells you will view in this unit, have been stained to make it easier to view them because most cells are transparent in nature.
3. Observe the shape and structure of the cells on your slide. In your science notebook, sketch what you observe in your field of vision. Record the name of the slide under your sketch.
4. Answer the following question in your science notebook: Do you think these cells belonged to a plant or an animal? Explain your reasoning.
5. When finished with your observations, remove the microscope slide from the stage. Trade slides with your other group members.
6. Repeat Steps 2–4.
7. Look at the cell diagrams in Figure 1.4 on the next page with your group members. Answer the following questions in your science notebook:
   a. Observe all the structures that are commonly found in plant and animal cells. Notice that some structures are the same in each cell, while others are different. Your microscope does not have a strong enough magnification to see every single structure, but some should look familiar. Which structures did you see in the slides you observed?
   b. Why do you think that cells need all these structures?
   c. Choose five structures from the diagrams on the next page. In your science notebook, record the five structures you chose and make a claim as to the function, or job, of each structure. Explain the reasoning behind your claim.
8. Be prepared to share your group's answers and ideas with your class.

continued

Lesson 1

Pre-Assessment: Structure and Function

Use pre-assessments to introduce phenomena and identify misconceptions early on

Investigation 1.4: Plant Versus Animal *continued*

7. Have students work in their groups to answer the remaining questions. The students should write their answers in their science notebooks. Sample answers follow:

a. Depending on their prior knowledge, students may just describe the structures that they observed. Other students may state that they were able to observe the cell membrane, cytoplasm, and nucleus in the animal cells and the cell wall, cytoplasm, and nucleus in the plant cells.

b. Each structure helps the cell do different tasks, which help the cell survive.

c. Answers will vary based on prior knowledge. The cell membrane regulates what materials can enter and exit a cell. Cell walls provide a rigid structure to plants. The nucleus contains the DNA, which can control cellular activity. Chloroplasts contain chlorophyll and all the structures needed for photosynthesis to occur. Mitochondria harvest energy for cellular activities. The makeup of each of these cellular components uniquely fits each of these tasks.

8. Lead a class discussion about the investigation. First, ask the class whether they all agree which slide displayed animal cells and which displayed plant cells. Ask them how they answered this question originally and how their understanding of the difference between these cells changed after examining Figure 1.4. Remind students that structural differences in cells go along with functional differences. Ask students to share the function descriptions they recorded for the structures they chose. Do not be concerned with correcting student misconceptions at this point. They will explore all of these cellular structures later, in Lesson 3.

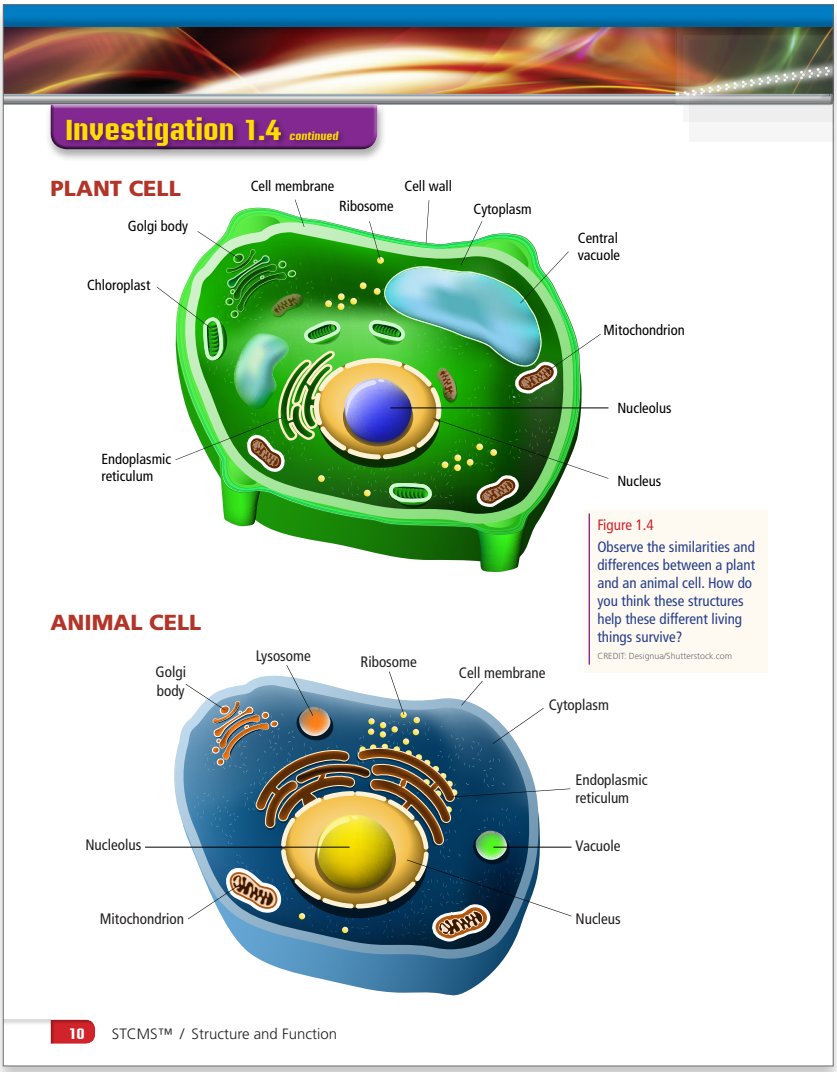


Figure 1.4
Observe the similarities and differences between a plant and an animal cell. How do you think these structures help these different living things survive?
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NGSS, English Language Arts, and Math Standards

Lesson at a Glance provides an overview of each lesson, including lesson-specific correlations to the NGSS and connections to English Language Arts and Math Standards.

Lesson 7 The Nervous System

	GETTING STARTED	INVESTIGATION 7.1: Analyzing and Interpreting Nervous System Tissue	INVESTIGATION 7.2: Stop, Drop, and React!	INVESTIGATION 7.3: Information Processing	
Overview	• Students discuss the nervous system and try a few visual exercises to learn about the sense of vision.	• Students examine a variety of nervous system tissues under a microscope and predict their functions. • Students read Building Your Knowledge: *The Nervous System* to better understand how the brain receives, processes, and reacts to various stimuli in an organism's environment.	• Students measure reaction time for both hands and compare data between their own hands and those of their classmates.	• Students investigate their sensory receptors at various stations and attempt to explain how they are able to use and react to their senses. • Students read Building Your Knowledge: *Information Processing* to further build on their understanding of the brain's role in the nervous system.	
Objectives	• Complete some activities that test a student's own nervous system.	• Analyze the structure and function of different tissues and cells that work together in the nervous system.	• Identify the cause-and-effect relationship between stimuli and response.	• Explore different senses to determine how the brain gathers and synthesizes information, resulting in an immediate response or behavior.	
Concepts	• Vision is one of the senses controlled by the nervous system.	• The nervous system allows animals to sense and respond to stimuli both externally and internally. • The nervous system must work closely with other parts of the body in order to react to various stimuli.	• Our motor abilities can be asymmetric, favoring one hand over the other.	• Sensory receptors send messages to the brain to be processed, resulting in an immediate response.	
Assessment	Self-Assessment Formative	Formative	Formative	Formative	
Key Terms	Stimulus	Axon Central nervous system Dendrite Homeostasis Interneuron Motor neuron Neuron Neurotransmitter Peripheral nervous system Sensory neuron Synapse	Stimulus	Memory Olfactory receptor Photoreceptor Reflex Reflex arc Sensory receptor	
Time	0.5 period	1 period	1 period	2 periods	
Standards	**ALIGNMENT TO NEXT GENERATION SCIENCE STANDARDS** **Performance Expectations** • MS-LS1-3 • MS-LS1-8 **Science and Engineering Practices** • Obtaining, communicating, and evaluating information **Crosscutting Concepts** • Cause and effect **Disciplinary Core Ideas** • LS1.A: Structure and function • LS1.D: Information processing				

Daily NGSS Support

LESSON AT A GLANCE

	INVESTIGATION 7.4: Confusing the Brain	REFLECTING ON WHAT YOU'VE DONE	*EXTENDING YOUR KNOWLEDGE* READING SELECTIONS
	• Students complete a series of activities that confuse various sensory systems, resulting in a misinterpretation of information from the brain.	• Students use evidence gathered during their investigations to illustrate a model that displays how the brain receives and sends messages around the body. • Students retest their reaction time after impairing their sensory system. • Students read Extending Your Knowledge: *Receptors: Your Body's Connection to the World Around You, The Adolescent Brain: How Did We Get Here?* and the Organism Profile: *Common Octopus*.	• In *Receptors: Your Body's Connection to the World Around You*, students learn about the variety of human sensory receptors. • In *The Adolescent Brain: How Did We Get Here?* students learn about the development of cognitive abilities. • In the Organism Profile: *Common Octopus*, students learn about a unique way of sensing aquatic surroundings.
	• Explore some limitations of sensory receptors and how information is gathered and processed by the brain.	• Test whether impaired sensory systems react to visual stimuli as quickly as unimpaired sensory systems. • Revisit and update the KWL chart titled "Body Systems."	• ***Receptors: Your Body's Connection to the World Around You*** Recognize the diversity of human sensory receptors other than the five basic senses. • ***The Adolescent Brain: How Did We Get Here?*** Understand how cognition develops in humans. • **Organism Profile: *Common Octopus*** Recognize the diversity of sensory systems in the animal kingdom.
	• Our sensory receptors send information to the brain for processing, but this information can sometimes confuse the brain, resulting in a misinterpretation of the information.	• Sensory systems can become impaired with real measurable effects.	• Humans have more than five kinds of sensory receptors. • People develop specific cognitive abilities at different ages. • The common octopus is an invertebrate with a complex nervous system.
	Formative	Self-Assessment Formative	
	Sensory receptor		Cognition Neuroscientist Proprioception Synaptic pruning
	1 period	2 periods	

Daily ELA and Math Support

CONNECTIONS

English Language Arts

- SL.7.1 Comprehension and collaboration
- RST.6-8.1 Key idea and details
- RST.6-8.2 Key idea and details
- RST.6-8.3 Key idea and details
- RST.6-8.4 Craft and structure
- RST.6-8.7 Integration of knowledge and ideas
- RST.6-8.8 Integration of knowledge and ideas
- RST.6-8.9 Integration of knowledge and ideas
- WHST.6-8.1 Text types and purposes
- WHST.6-8.4 Production and distribution of writing

Mathematics

- MP5 Use appropriate tools strategically.
- MP6 Attend to precision.

Support for Teachers During the Transition to NGSS

Lesson-specific alignment to NGSS makes it clear how each part of the standards is tackled, ensuring true three-dimensional learning.

Lesson 7 The Nervous System

Lesson-specific correlations tell you the what and how of NGSS—in every lesson

Alignment to Next Generation Science Standards

- MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
- MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.

Students explore the nervous system as one system, composed of groups of cells, that interacts with other body systems, addressing **MS-LS1-3**. They also focus on sensory receptors responding to stimuli by sending messages to the brain, addressing **MS-LS1-8**.

In Getting Started, students focus on the sense of vision as an introduction to the nervous system and the sensory systems within it. During Investigation 7.1, students examine slides of nervous tissues under a microscope and determine their functions and how they aid in survival, addressing **MS-LS1-3**. The remaining investigations address **MS-LS1-8**. During Investigation 7.2, students measure reaction times, providing greater understanding of the nervous system and how sensory receptors respond to stimuli and lead to immediate behavioral response. In Investigation 7.3, students conduct activities that draw attention to several kinds of sensory receptors that respond to stimuli. In Investigation 7.4, students consider how sensory receptors can confuse the brain.

In Reflecting On What You've Done, students use the evidence obtained during their investigations to **illustrate a model** of how a living thing is able to sense and respond to various stimuli in its environment. Students also revisit the reaction-time activity, focusing on the effects of sensory impairment, and read about sensory receptors in other animals and how their own brain develops over time.

Throughout the investigations and readings, students' activities will highlight the causal nature of stimuli and the brain's response, addressing the **crosscutting concept** of **cause and effect.** Students will address the **science and engineering practices** of **obtaining, evaluating, and communicating information**. Throughout the lesson, students **observe and collect data**, evaluating it as they **discuss results, and communicating information** by working in groups as they write and discuss their results.

between humans and other animals, much can be learned by studying nonhuman nervous systems. For example, by studying rats, scientists determined that exercise actually increases levels of molecules that stimulate growth and plasticity in the brain, leading to improved health and learning.

One interesting area of animal research is in sensory systems that humans do not possess. The nervous system of each species evolves to include sensory receptors that help that species survive and reproduce. As a result, an animal's environment has an impact on what its nervous system includes. For example, fish that live in dark, muddy streams where vision is unreliable have evolved electroreceptors that perceive electric signals that the fish produce in pulses. Electric fish use these sensory receptors to navigate and to communicate. Sea turtles can detect variation in Earth's magnetic field, but the sensory receptors used still remain a mystery to scientists. These variations help them navigate long distances in the featureless open sea, where vision is not helpful. Some snakes have thermoreceptors that help them detect infrared thermal radiation from living things that serve as their potential prey.

Even the sensory systems with which we are familiar, such as vision and olfaction (smell), take different forms in other animals. Many animals have far more developed olfactory systems that can detect and identify a broader variety of odorants. Several insects and marine invertebrates have visual systems that detect features of light that humans cannot see, such as light's polarization properties. And the range

Building Coherent Learning Progressions within a Lesson

Through a series of investigations in Lesson 7: The Nervous System, students explore the structures associated with the nervous system and their functions. Students predict functions of various types of nervous tissue, test their own reaction time, explore their sensory receptors, and confuse their brain with several sensory illusions. Students then retest their reaction time after impairing their sense of balance. These investigations allow students to obtain, evaluate, and communicate information about how information that is gathered by sensory receptors is sent to the brain for processing, and how this processing results in an immediate reaction or in memory storage.

CONNECTIONS

English Language Arts

Getting Started
Investigation 7.1
Investigation 7.2
Investigation 7.3
Investigation 7.4
Reflecting On What You've Done

Science Notebook

Getting Started
Investigation 7.1
Investigation 7.2
Investigation 7.3
Investigation 7.4
Reflecting On What You've Done

Mathematics

Investigation 7.2
Investigation 7.3
Reflecting On What You've Done

FOCUS QUESTION How does the brain send and receive information?

Figure 7.1
Every day, you encounter numerous stimuli that cause you to react certain ways. What other stimuli would you encounter at the beach?
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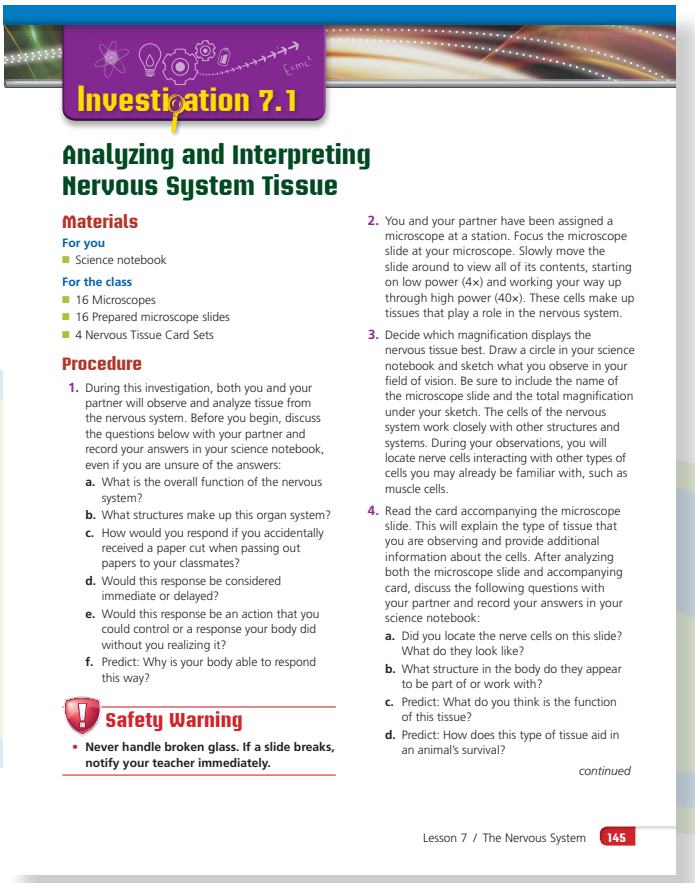
A Systematic Approach to Building Understanding of Content and Science and Engineering Practices



Investigation 7.1

Analyzing and Interpreting Nervous System Tissue

Materials

For you
- Science notebook

For the class
- 16 Microscopes
- 16 Prepared microscope slides
- 4 Nervous Tissue Card Sets

Procedure

1. During this investigation, both you and your partner will observe and analyze tissue from the nervous system. Before you begin, discuss the questions below with your partner and record your answers in your science notebook, even if you are unsure of the answers:
   - **a.** What is the overall function of the nervous system?
   - **b.** What structures make up this organ system?
   - **c.** How would you respond if you accidentally received a paper cut when passing out papers to your classmates?
   - **d.** Would this response be considered immediate or delayed?
   - **e.** Would this response be an action that you could control or a response your body did without you realizing it?
   - **f.** Predict: Why is your body able to respond this way?

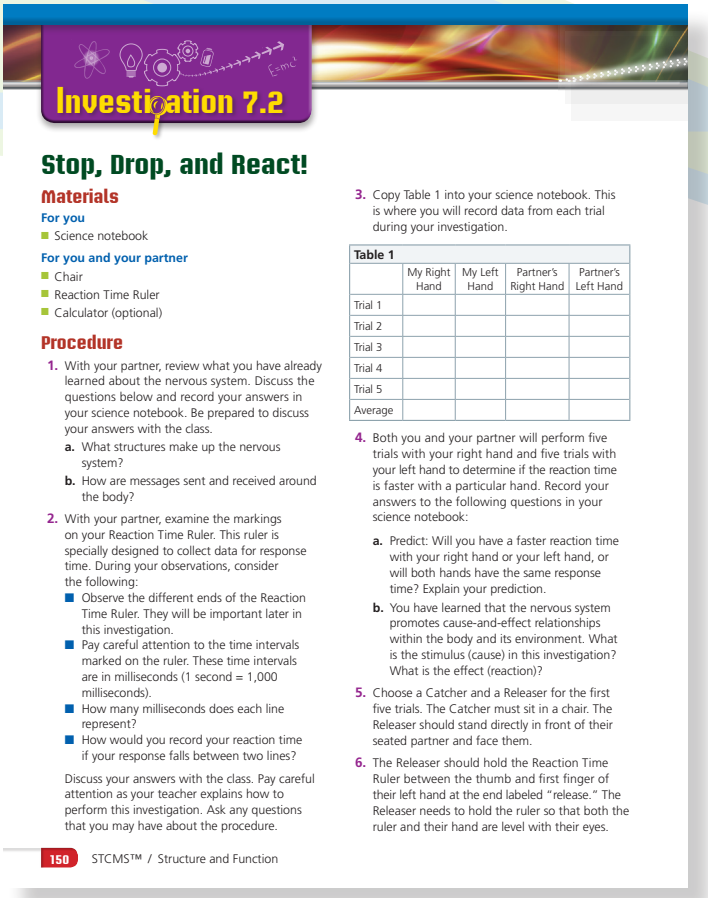
Safety Warning

- **Never handle broken glass. If a slide breaks, notify your teacher immediately.**

2. You and your partner have been assigned a microscope at a station. Focus the microscope slide at your microscope. Slowly move the slide around to view all of its contents, starting on low power (4×) and working your way up through high power (40×). These cells make up tissues that play a role in the nervous system.
3. Decide which magnification displays the nervous tissue best. Draw a circle in your science notebook and sketch what you observe in your field of vision. Be sure to include the name of the microscope slide and the total magnification under your sketch. The cells of the nervous system work closely with other structures and systems. During your observations, you will locate nerve cells interacting with other types of cells you may already be familiar with, such as muscle cells.
4. Read the card accompanying the microscope slide. This will explain the type of tissue that you are observing and provide additional information about the cells. After analyzing both the microscope slide and accompanying card, discuss the following questions with your partner and record your answers in your science notebook:
   - **a.** Did you locate the nerve cells on this slide? What do they look like?
   - **b.** What structure in the body do they appear to be part of or work with?
   - **c.** Predict: What do you think is the function of this tissue?
   - **d.** Predict: How does this type of tissue aid in an animal's survival?

continued

Investigation 7.1: Students examine a variety of nervous system tissues under a microscope, analyze the structure of the different tissues, and predict their functions. Through the investigation and a Building Your Knowledge reading selection, students begin to better understand how the brain receives, processes, and reacts to various stimuli in an organism's environment.



Investigation 7.2

Stop, Drop, and React!

Materials

For you
- Science notebook

For you and your partner
- Chair
- Reaction Time Ruler
- Calculator (optional)

Procedure

1. With your partner, review what you have already learned about the nervous system. Discuss the questions below and record your answers in your science notebook. Be prepared to discuss your answers with the class.
   - **a.** What structures make up the nervous system?
   - **b.** How are messages sent and received around the body?
2. With your partner, examine the markings on your Reaction Time Ruler. This ruler is specially designed to collect data for response time. During your observations, consider the following:
   - Observe the different ends of the Reaction Time Ruler. They will be important later in this investigation.
   - Pay careful attention to the time intervals marked on the ruler. These time intervals are in milliseconds (1 second = 1,000 milliseconds).
   - How many milliseconds does each line represent?
   - How would you record your reaction time if your response falls between two lines?

   Discuss your answers with the class. Pay careful attention as your teacher explains how to perform this investigation. Ask any questions that you may have about the procedure.
3. Copy Table 1 into your science notebook. This is where you will record data from each trial during your investigation.

Table 1

	My Right Hand	My Left Hand	Partner's Right Hand	Partner's Left Hand
Trial 1				
Trial 2				
Trial 3				
Trial 4				
Trial 5				
Average				

4. Both you and your partner will perform five trials with your right hand and five trials with your left hand to determine if the reaction time is faster with a particular hand. Record your answers to the following questions in your science notebook:
   - **a.** Predict: Will you have a faster reaction time with your right hand or your left hand, or will both hands have the same response time? Explain your prediction.
   - **b.** You have learned that the nervous system promotes cause-and-effect relationships within the body and its environment. What is the stimulus (cause) in this investigation? What is the effect (reaction)?
5. Choose a Catcher and a Releaser for the first five trials. The Catcher must sit in a chair. The Releaser should stand directly in front of their seated partner and face them.
6. The Releaser should hold the Reaction Time Ruler between the thumb and first finger of their left hand at the end labeled "release." The Releaser needs to hold the ruler so that both the ruler and their hand are level with their eyes.

Investigation 7.2: Students measure the reaction time of both of their hands, and then compare data between their own hands and those of their classmates to investigate the cause-and-effect relationship between stimuli and response.

Connecting non-fiction literacy to hands-on investigation to build content knowledge.

BUILDING YOUR KNOWLEDGE

READING SELECTION

A message is sent between neurons by releasing neurotransmitters across the synapse. These neurotransmitters are released by the axon terminals in one neuron, which induce an electrical charge when they attach to the dendrite of the following neuron.

CREDIT: Andrii Vodolazhskyi/ Shutterstock.com

Have you ever touched a hot pan accidently? Apart from shouting, "Ouch!" you probably pulled your hand away. Both the speedy reaction and the resulting sensation of pain indicate your nervous system was at work.

In this scenario, the heat of the pan is considered a stimulus. A stimulus is anything that can cause an organism to react. Stimuli and an organism's response are an example of a cause-and-effect relationship. For example, a human hears a loud noise (cause) and they jump (effect). The doorbell chimes (cause) and your dog barks (effect). Sunlight causes a tree to begin photosynthesis and a stoplight causes your dad to stop the car. Each day, you are exposed to countless stimuli and you respond accordingly. In fact, all living things have the ability to sense and respond to various stimuli in their environment. Responding to stimuli aids in the survival of all living things. In many complex animals, the nervous system is responsible for reactions to stimuli.

The nervous system coordinates voluntary and involuntary actions by communicating through a network of nerve cells called **neurons**. As animals have evolved to become more complex, so have their nervous systems. Simple animals, like jellyfish, have a nerve net, which is made up of neurons spread throughout the body that control movement and sense stimuli, or events that alert one or more of their senses. More complex animals, such as mammals, have neurons with similar appearances but different functions. A neuron has three main parts: a dendrite, a cell body, and an axon. The **dendrite** receives information from a stimulus and transmits it through the cell body to the axon as an electrical impulse. The **axon** is a long structure that carries the impulse to the axon terminals. In each terminal are chemicals called **neurotransmitters** that are released into a region called the **synapse**, which is a very small space between the neuron and the structure with which it is communicating, for example, a muscle, gland, organ, or another neuron.

The nervous system has two main branches: the **central nervous system** (CNS) and the **peripheral nervous system** (PNS). The CNS is made up of the brain and the spinal cord and acts as the control center. It contains a type of neuron called an **interneuron**, which functions to relay information. The PNS is made

continued

Lesson 7 The Nervous System

Investigation 7.3: Information Processing

Procedure

1. Have students work with their groups to answer the questions from the Student Guide in their science notebooks. Then, lead a class discussion about our senses and how they allow us to respond to our environment. Sample answers follow:

a. A stimulus is anything that can cause a reaction.

b. Examples of a stimulus a human might respond to include thunder, a pin poking the skin, a doorbell, a stoplight, an alarm clock, and the smell of freshly baked cookies.

c. The brain

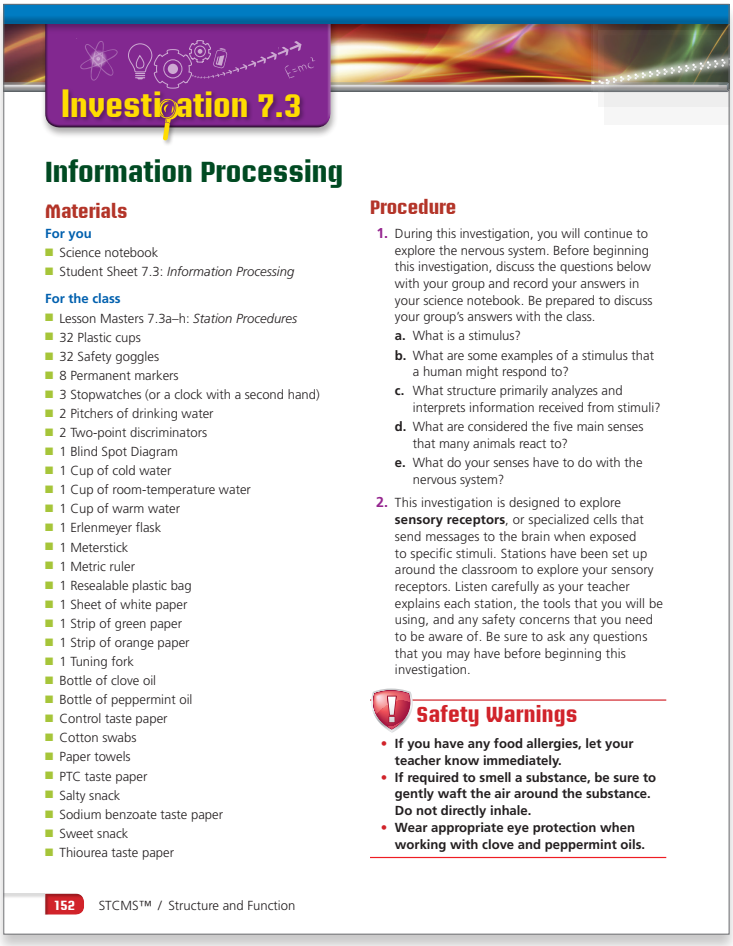
d. Vision, hearing, touch, taste, smell

e. Each sense has sensory receptors that act as first responders to stimuli. The brain interprets these responses and determines the needed behavior or reaction.

Safety Warnings

- **Ask students if they have any food allergies.**
- **Demonstrate how to gently waft the air around a substance. Remind students to not directly inhale an aroma.**
- **Remind students that they will need to wear appropriate eye protection when working with clove and peppermint oils at Station 5.**

2. Distribute Student Sheet 7.3: *Information Processing* to each student and explain that all data and observations they make during the investigation will be recorded on this sheet. Point out the eight stations you have set up around the room. Explain to students that they will test a different stimulus and response at each station. After you briefly describe each station's intent, point out the instruction card at each station and assure students that all instructions they will need are on these cards. Emphasize that they should record their observations on their student sheet after performing each trial rather than waiting until they have completed the activity at each station. Encourage students to



Investigation 7.3

Information Processing

Materials

For you
- Science notebook
- Student Sheet 7.3: *Information Processing*

For the class
- Lesson Masters 7.3a–h: *Station Procedures*
- 32 Plastic cups
- 32 Safety goggles
- 8 Permanent markers
- 3 Stopwatches (or a clock with a second hand)
- 2 Pitchers of drinking water
- 2 Two-point discriminators
- 1 Blind Spot Diagram
- 1 Cup of cold water
- 1 Cup of room-temperature water
- 1 Cup of warm water
- 1 Erlenmeyer flask
- 1 Meterstick
- 1 Metric ruler
- 1 Resealable plastic bag
- 1 Sheet of white paper
- 1 Strip of green paper
- 1 Strip of orange paper
- 1 Tuning fork
- Bottle of clove oil
- Bottle of peppermint oil
- Control taste paper
- Cotton swabs
- Paper towels
- PTC taste paper
- Salty snack
- Sodium benzoate taste paper
- Sweet snack
- Thiourea taste paper

Procedure

1. During this investigation, you will continue to explore the nervous system. Before beginning this investigation, discuss the questions below with your group and record your answers in your science notebook. Be prepared to discuss your group's answers with the class.
   - **a.** What is a stimulus?
   - **b.** What are some examples of a stimulus that a human might respond to?
   - **c.** What structure primarily analyzes and interprets information received from stimuli?
   - **d.** What are considered the five main senses that many animals react to?
   - **e.** What do your senses have to do with the nervous system?
2. This investigation is designed to explore **sensory receptors**, or specialized cells that send messages to the brain when exposed to specific stimuli. Stations have been set up around the classroom to explore your sensory receptors. Listen carefully as your teacher explains each station, the tools that you will be using, and any safety concerns that you need to be aware of. Be sure to ask any questions that you may have before beginning this investigation.

Safety Warnings
- **If you have any food allergies, let your teacher know immediately.**
- **If required to smell a substance, be sure to gently waft the air around the substance. Do not directly inhale.**
- **Wear appropriate eye protection when working with clove and peppermint oils.**

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Investigation 7.3: Students explore the role of sensory receptors that send messages to the brain. By engaging in eight different stimulus stations, students collect data on the reactions of their own sensory receptors when they are exposed to different stimuli.

ask questions at any point before or during the investigation.

- **Station 1: Temperature Receptors**. At this station, students will test their skin's reaction to warm, cold, and room-temperature water.
- **Station 2: How Sensitive Are You?** At this station, groups of four will work in pairs to test the skin's response to pressure, using two-point discriminators. Demonstrate how to adjust the tool and hold it against a volunteer's fingertip, back of the neck, and mid-calf. Emphasize that students should touch their partner's body gently with the tool because the ends are sharp. Model how to properly use the two-point discriminator.
- **Station 3: Locating Your Blind Spot**. Explain that each eye has a spot at which the optic nerve leaves the eye to carry messages to the brain. At this spot, known as the blind spot, the eye has no photoreceptors. Students will use a card and a ruler to locate their blind spot in each eye.
- **Station 4: Taste Receptors**. At this station, students will taste four different taste papers in an attempt to activate different taste receptors (bitter, sweet, salty, sour, and umami [savory]). Explain that some students may not be able to taste some of the chemicals on the paper. Point out that during this activity, students will need to rinse their mouth after each taste paper. Explain that they will have their own cup to obtain water from the pitcher at the station. Emphasize that students should swallow the water after each rinse.

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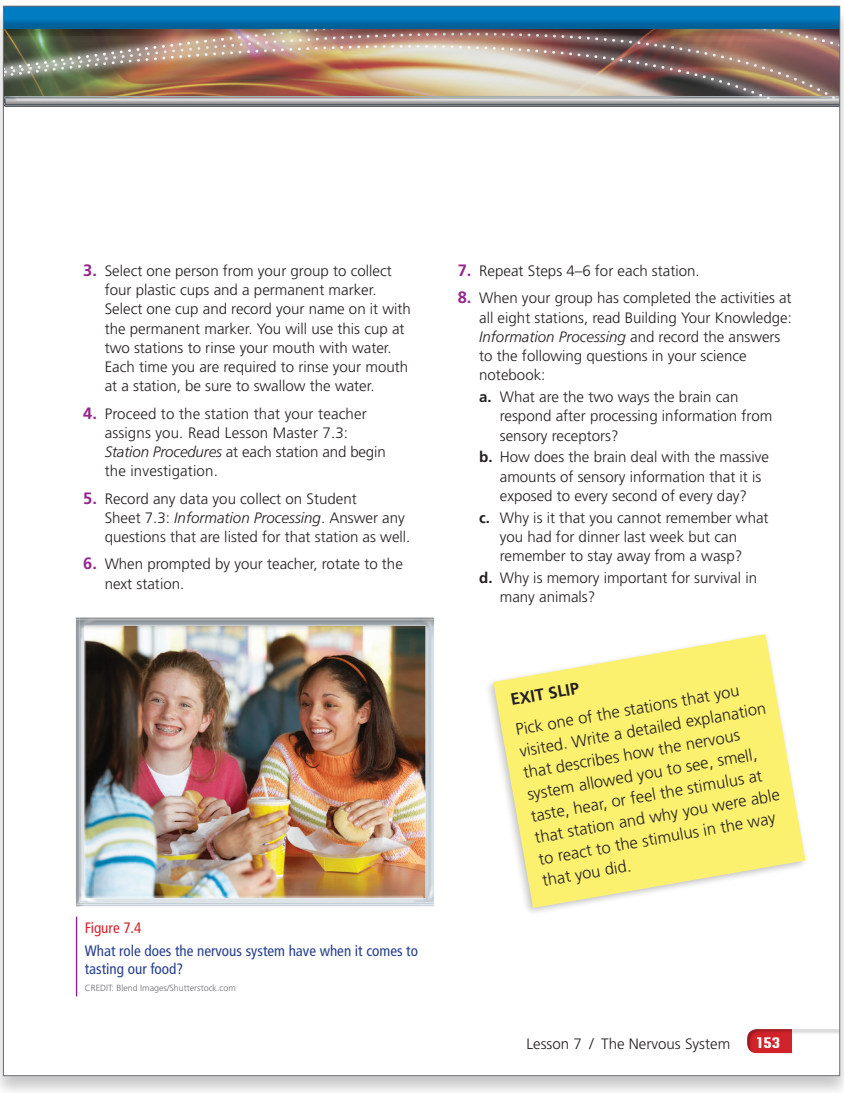

3. Select one person from your group to collect four plastic cups and a permanent marker. Select one cup and record your name on it with the permanent marker. You will use this cup at two stations to rinse your mouth with water. Each time you are required to rinse your mouth at a station, be sure to swallow the water.
4. Proceed to the station that your teacher assigns you. Read Lesson Master 7.3: *Station Procedures* at each station and begin the investigation.
5. Record any data you collect on Student Sheet 7.3: *Information Processing*. Answer any questions that are listed for that station as well.
6. When prompted by your teacher, rotate to the next station.
7. Repeat Steps 4–6 for each station.
8. When your group has completed the activities at all eight stations, read Building Your Knowledge: *Information Processing* and record the answers to the following questions in your science notebook:
   a. What are the two ways the brain can respond after processing information from sensory receptors?
   b. How does the brain deal with the massive amounts of sensory information that it is exposed to every second of every day?
   c. Why is it that you cannot remember what you had for dinner last week but can remember to stay away from a wasp?
   d. Why is memory important for survival in many animals?

Figure 7.4
What role does the nervous system have when it comes to tasting our food?
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Investigation 7.4: Confusing the Brain

Procedure

1–2. Ask students if they have ever had a strange feeling that their senses were playing tricks on them. Then explain how an interesting area of research studies how our sensory receptors can confuse our brains. As volunteers collect the materials for their groups, remind students that they can ask questions about the investigation at any point.

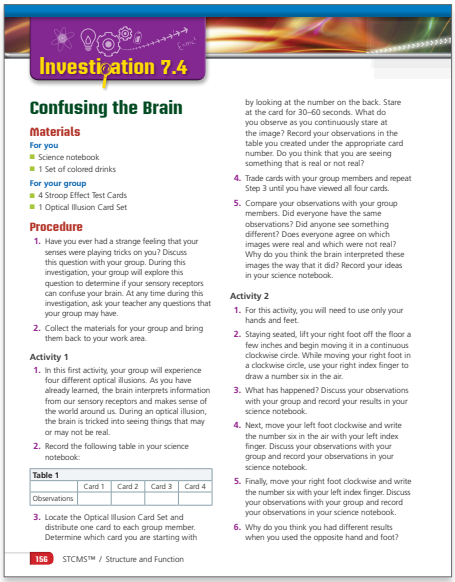
Depending on the needs of your class, you may wish to have each group work at its own pace and facilitate a class discussion at the end of the class in which students can discuss their observations and results. If this option is used, be sure to briefly explain each activity before groups begin. Alternatively, you might stop the groups after each activity, discuss their results, and then explain the next activity before they begin.

Activity 1

1–2. Explain that optical illusions occur when the brain is tricked into seeing things that may or may not be real. Ask students why they think this happens. Make sure students understand that these perceptions are a result of the brain trying to make sense of deceptive or misleading information it has gathered, in this case, through the eyes. Make sure students have made a copy of Table 1 in their science notebooks before moving on to Step 3.

Safety Warning

- **Ask students if they have any food allergies.**



Investigation 7.4

Confusing the Brain

Materials

For you
- Science notebook
- 1 Set of colored drinks

For your group
- 4 Stroop Effect Test Cards
- 1 Optical Illusion Card Set

Procedure

1. Have you ever had a strange feeling that your senses were playing tricks on you? Discuss this question with your group. During this investigation, your group will explore this question to determine if your sensory receptors can confuse your brain. At any time during this investigation, ask your teacher any questions that your group may have.
2. Collect the materials for your group and bring them back to your work area.

Activity 1

1. In this first activity, your group will experience four different optical illusions. As you have already learned, the brain interprets information from our sensory receptors and makes sense of the world around us. During an optical illusion, the brain is tricked into seeing things that may or may not be real.
2. Record the following table in your science notebook:

Table 1

	Card 1	Card 2	Card 3	Card 4
Observations				

3. Locate the Optical Illusion Card Set and distribute one card to each group member. Determine which card you are starting with by looking at the number on the back. Stare at the card for 30–60 seconds. What do you observe as you continuously stare at the image? Record your observations in the table you created under the appropriate card number. Do you think that you are seeing something that is real or not real?
4. Trade cards with your group members and repeat Step 3 until you have viewed all four cards.
5. Compare your observations with your group members. Did everyone have the same observations? Did anyone see something different? Does everyone agree on which images were real and which were not real? Why do you think the brain interpreted these images the way that it did? Record your ideas in your science notebook.

Activity 2

1. For this activity, you will need to use only your hands and feet.
2. Staying seated, lift your right foot off the floor a few inches and begin moving it in a continuous clockwise circle. While moving your right foot in a clockwise circle, use your right index finger to draw a number six in the air.
3. What has happened? Discuss your observations with your group and record your results in your science notebook.
4. Next, move your left foot clockwise and write the number six in the air with your left index finger. Discuss your observations with your group and record your observations in your science notebook.
5. Finally, move your right foot clockwise and write the number six with your left index finger. Discuss your observations with your group and record your observations in your science notebook.
6. Why do you think you had different results when you used the opposite hand and foot?

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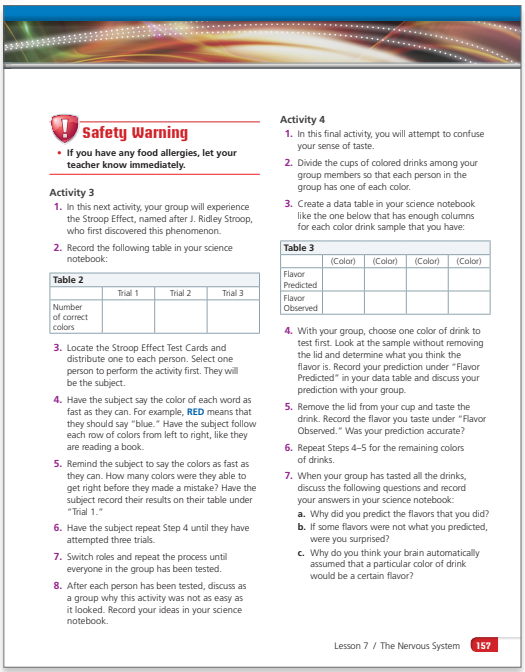
Investigation 7.4: Students test the limits of sensory receptors by completing a series of activates that confuse various sensory systems, resulting in a misinterpretation of information from the brain.



Safety Warning

- **If you have any food allergies, let your teacher know immediately.**

Activity 3

1. In this next activity, your group will experience the Stroop Effect, named after J. Ridley Stroop, who first discovered this phenomenon.
2. Record the following table in your science notebook:

Table 2

	Trial 1	Trial 2	Trial 3
Number of correct colors			

3. Locate the Stroop Effect Test Cards and distribute one to each person. Select one person to perform the activity first. They will be the subject.
4. Have the subject say the color of each word as fast as they can. For example, **RED** means that they should say "blue." Have the subject follow each row of colors from left to right, like they are reading a book.
5. Remind the subject to say the colors as fast as they can. How many colors were they able to get right before they made a mistake? Have the subject record their results on their table under "Trial 1."
6. Have the subject repeat Step 4 until they have attempted three trials.
7. Switch roles and repeat the process until everyone in the group has been tested.
8. After each person has been tested, discuss as a group why this activity was not as easy as it looked. Record your ideas in your science notebook.

Activity 4

1. In this final activity, you will attempt to confuse your sense of taste.
2. Divide the cups of colored drinks among your group members so that each person in the group has one of each color.
3. Create a data table in your science notebook like the one below that has enough columns for each color drink sample that you have:

Table 3

	(Color)	(Color)	(Color)	(Color)
Flavor Predicted				
Flavor Observed				

4. With your group, choose one color of drink to test first. Look at the sample without removing the lid and determine what you think the flavor is. Record your prediction under "Flavor Predicted" in your data table and discuss your prediction with your group.
5. Remove the lid from your cup and taste the drink. Record the flavor you taste under "Flavor Observed." Was your prediction accurate?
6. Repeat Steps 4–5 for the remaining colors of drinks.
7. When your group has tasted all the drinks, discuss the following questions and record your answers in your science notebook:
   a. Why did you predict the flavors that you did?
   b. If some flavors were not what you predicted, were you surprised?
   c. Why do you think your brain automatically assumed that a particular color of drink would be a certain flavor?

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Three-Dimensional Application

Reflecting on What You've Done: Using the evidence collected during their investigations, readings, and discussions, student illustrate a model that displays how an animal's nervous system is able to send and respond to a stimulus in its environment. Students extend the concepts of Investigations 7.2 and 7.4 by repeating the reaction time investigation after confusing their brain by spinning. They consider how this may apply to the effects of medications and the warnings about activities they may carry out while taking certain medications.

Reflecting On What You've Done

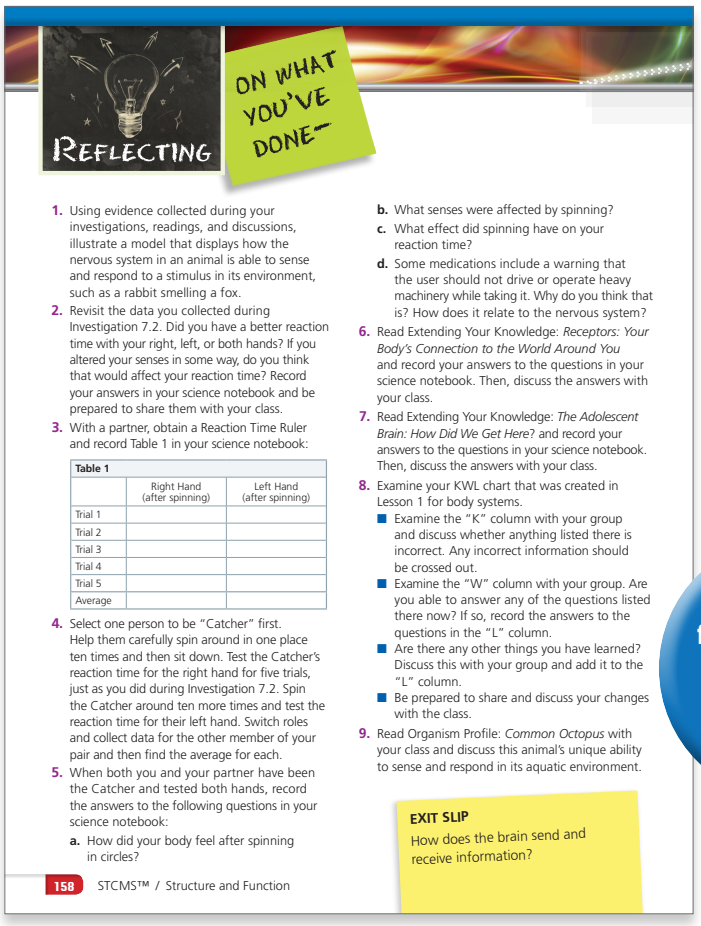
1. Ask students to think about all they have learned through the investigations, readings, and discussions. Tell them to draw a model that shows how a complex animal can sense and respond to a stimulus in its environment. Suggest they first pick a stimulus and animal that interest them and then consider sensory receptors, nerve cells, and the brain. They should show a stimulus being sensed, that information traveling to the brain, the brain processing that information, and then sending a response.

2. Have students find the data they collected in their science notebooks during Investigation 7.2: Stop, Drop, and React! and review the data to see with which hand they had the faster reaction time. Then ask them to consider what would happen to their reaction time if they altered their senses in some way and to record a prediction in their science notebooks. Lead a class discussion about students' ideas, as well as ways they think senses can be altered.

3. Organize students into pairs and give each a Reaction Time Ruler. Have students re-create Table 1 in their science notebooks.

4. Demonstrate with a volunteer how to carefully spin a partner without endangering them. Then have the Releaser from each pair spin the Catcher around in place 10 times and then help him/her sit down. Make sure they test the Catcher's reaction time for the right hand for five trials immediately upon sitting. Let students know that except for the spinning, they are following the same procedure as they did in Investigation 7.2. Direct pairs to conduct five trials to test the reaction time for the Catcher's left hand. After collecting data and calculating an average, tell partners to switch roles and do the same steps for each hand for the second Catcher.

EXIT SLIP
The brain sends and receives information through neurons that connect throughout the body. The brain processes information coming in from sensory stimuli and then immediately sends a response message to the motor neurons or other parts of the body, which then react. Sometimes, the brain stores the information it processes in the form of memories that aid in survival as well.



Exit slips check for understanding and the ability to explain phenomena.

Non-Fiction Literacy with Real-World Applications

Non-fiction literacy features real-world phenomena and applications connected to students' investigative learning experiences.

EXTENDING YOUR KNOWLEDGE — READING SELECTION

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RECEPTORS: Your Body's Connection to the World Around You

Do you remember when you were a little kid and science was so much simpler? Maybe you watched chicks hatch or maybe you built drums. You probably also learned about your five senses: touch, taste, hearing, sight, and smell. These senses come to us from a variety of receptors found throughout our bodies. Receptors are nerve endings that respond to stimuli outside or inside an organism. The nerve endings then send a message to your central nervous system where the messages are interpreted into meaningful concepts such as "sour," "green," "smooth," "cookies being baked," or "annoying pop song from last summer." We then are able to act in response.

Humans use some of the basic five senses when they pet a cat. They see the cat, feel the softness of its fur, and hear it purr. The cat uses the same basic senses to respond to being petted.

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It turns out that you have more senses than just those five. Your body has a variety of sensory receptors designed to respond to the world and keep you safe and healthy. For instance, pain was once thought to be an overload on touch receptors. Now we know that painful sensations have their own receptors. Many other receptors are being discovered and debated.

Balance is also a sense. This is an important one for all animals because it keeps us from falling over. Several systems have to work together to let your body know that it is balanced. You have receptors in your eyes, in your ears, and throughout your body that tell your brain that you are upright and safe. Medical conditions such as vertigo can disrupt your sense

continued

Athletes need to have a strong sense of proprioception.

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of balance. The sense of balance is closely tied to another sense called **proprioception**. This sense lets you know where all of your body parts are located. That might seem obvious until you try a new dance move or start learning a sport for the first time and you realize how tricky it sometimes is to know and control multiple body parts at once!

Another set of receptors are stretch receptors. These receptors can feel when organs and muscles are being stretched. Stretch receptors tell you when your bladder is full. Stretch receptors are also responsible for certain types of headaches.

Though you cannot feel it, your body can detect when certain chemicals are moving through your body. These are called chemoreceptors. They detect hormones, medications, and drugs that might be moving through someone's system. For example, you have receptors in your nose that can detect gaseous chemicals. That includes everything from pleasant aromas such as peppermint oil to less pleasant or potentially dangerous gaseous chemicals. Other receptors can detect potential poisons in your body and trigger vomiting in an attempt to keep those poisons from circulating throughout your body. ■

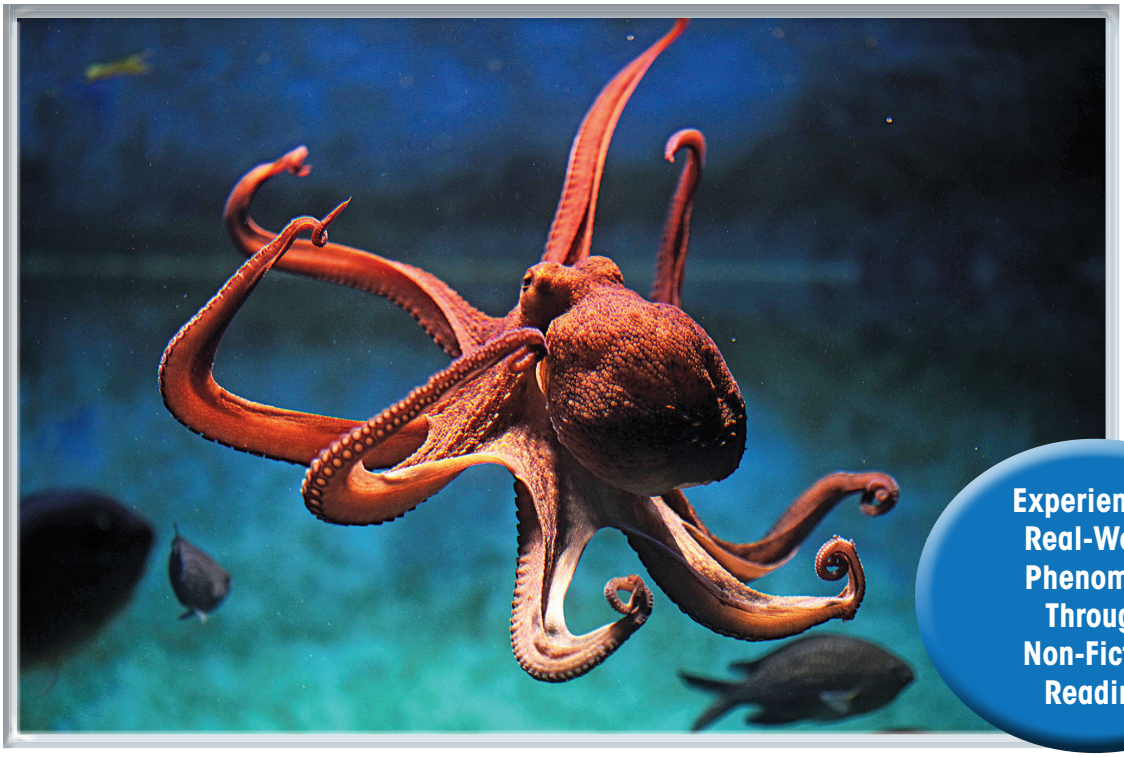
Can you recall times in your life when you really needed to focus on your sense of balance?

CREDIT: Jupiterimages/Creatas/Thinkstock

Discussion Question

1. Receptors perform a variety of functions within the bodies of animals. Could humans survive without some of these receptors? Explain your reasoning.

ORGANISM PROFILE Common Octopus



CREDIT: Vladimir Wrangel/Shutterstock.com

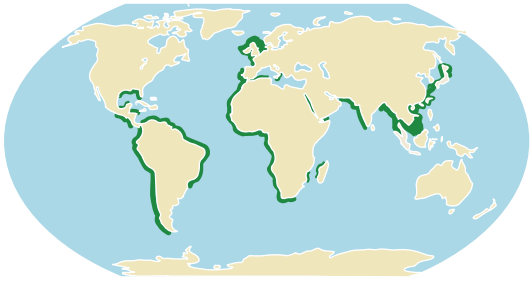
Experiencing Real-World Phenomena Through Non-Fiction Reading

Organism Common Name: Common octopus

Organism Scientific Name: *Octopus vulgaris*

Conservation Status: Not evaluated

How big is the organism? The common octopus ranges between 2.7–10 kilograms (6–22 pounds) and between 61–91 centimeters (24–35.8 inches) in length.



Where is the organism found? The common octopus can be found in temperate marine waters all over the world, including the Atlantic, Indian, and Pacific Oceans and the Mediterranean Sea. The octopus stays in shallow water on the ocean floor where it walks amongst coral looking for prey.

How does the organism get its energy? Octopuses are carnivores and will eat crabs, clams, snails, and small fish. They prefer live prey, which they identify by smell and feel. Octopuses use different methods to catch prey. They may use their limbs to feel around coral and under rocks, or they may pounce on their prey, covering it with their body. The octopus uses its toothed tongue, which is called a radula, and its limbs as tools to help it eat prey that may have a shell or hard exterior. For example, an octopus

will use its limbs to pull apart clams or use its radula to drill a hole into hard mollusk shells.

Content Connection

Octopuses are invertebrates, meaning that, unlike humans, they have no skeletal structure or spinal cord, but they do have a skull made of cartilage to protect their brain. The octopus also has a hard, pointed beak and a radula to help it eat. With no skeleton, octopuses are able to squeeze in and out of tight places. In fact, an octopus can fit through any opening that is large enough for its beak. An octopus has eight "arms" coming from its head. Scientists recently discovered that the two front arms act as legs, which help the octopus walk along the ocean floor. The octopus's arms are lined with two rows of round suckers, which can detect taste and also work as suction cups. In addition to walking on the ocean floor, the octopus gets around using jet propulsion. To use jet propulsion, an octopus will draw water through a cavity in its body and then quickly siphon the water out, propelling itself forward, head first.

One of the many fascinating things about the octopus is its skillful use of camouflage. Used both as a way to hide from enemies and also for hunting prey, octopuses can change both the color and texture of their skin to blend into their surroundings. Just under their skin are thousands of color-changing cells called chromatophores. These chromatophores are filled with different-colored pigments, materials that change color based on reflected or transmitted light. These pigments are released when an octopus wants to be covert.

If their amazing camouflage skills do not work, octopuses can also use ink to distract predators and escape. The octopus has an ink sac filled with a dark liquid, which is made of melanin, the same pigment that colors human hair and skin. When an octopus is threatened, it will shoot out ink, which distracts the predator and allows the octopus to quickly swim away.

Octopuses can change their color and texture to blend into almost any environment. Can you spot the octopus in this photograph?

CREDIT: magnusdeepbelow/Shutterstock.com

Other Interesting Facts

Octopuses are extremely intelligent and have the largest brain of any invertebrate. Scientists who study octopuses in captivity have had trouble keeping octopuses in aquariums because of how easily they find ways to escape. In scientific experiments, octopuses have shown that they can navigate mazes, solve problems, and retain short-term memory of the solutions. In recent studies, octopuses have also been observed playing, something only intelligent animals will do.

Octopuses keep gardens. They use the discarded shells from their prey along with rocks and other objects scattered around their dens to keep them hidden. ■

Summative Assessment

STCMS summative assessments target the full range of unit concepts and practices through a performance assessment and a written assessment.

Lesson 12: Assessment: *Structure and Function:* Students apply the knowledge and skills they have developed over the course of the unit to research an animal with a unique structure that aids in its survival.

Lesson 8 Assessment: Structure and Function

FOCUS QUESTION How are different animals specially adapted to survive in their environment?

Introduction

In this unit, you have explored the diversity of organisms' structures and their functions while developing an understanding of how those structures aid in survival. Some key topics have included cells, organelles within cells, photosynthesis, cellular respiration, levels of organization, and the nervous system.

During the first part of the assessment, you will conduct research to obtain information about how specific structures ensure the survival of a particular animal. You will synthesize information from multiple sources and then communicate the information to your classmates in a presentation. In the second part of this lesson, you will answer questions about cells, organelles, photosynthesis, cellular respiration, levels of organization, and the nervous system in a written assessment. Your teacher will use the results of these assessments to determine how well you can apply the concepts, knowledge, and skills you have learned in this unit. You will also evaluate your own learning by assessing your ability to understand concepts related to structure and function.

Figure 8.1
Many cacti have spines, which are modified leaves that reduce water loss and offer protection from many animals. Cacti also produce flowers that aid in reproduction. They have many other structures that enable them to survive in their desert environment.
CREDIT: Pheniti Prasomphethiran/Shutterstock.com

Objectives for This Lesson

- Review and reinforce concepts from the *Structure and Function* unit.
- Complete a performance assessment by carrying out an investigation through research and analysis.
- Apply knowledge and skills to answer questions in a written assessment about concepts related to structure and function.

ng Started

son, you will demonstrate what you ned by working with a partner to a performance assessment. Then, work independently to complete a ssessment. During the Performance nt, you will research an animal to e the different internal and external that aid in its survival. You will then our findings to the class. During the ssessment, you will answer questions e predictions about various structures and their functions. Follow your teacher's instructions carefully and complete your work neatly and accurately.

Figure 8.2
Can you apply each concept you learned about in this unit to this lemur?
CREDIT: Apple1966/Shutterstock.com

2. Observe the ring-tailed lemur (*Lemur catta*) in Figure 8.2. Using knowledge gained throughout the unit, discuss the following questions with a partner and record your answers in your science notebook:
   - **a.** Is this lemur considered a unicellular or a multicellular organism? What evidence do you have to support your claim?
   - **b.** Does this organism go through the process of photosynthesis, cellular respiration, or both? What evidence do you have to support your claim?
   - **c.** What are some external structures found on this lemur? How do you think they aid in the lemur's survival?
   - **d.** Predict: What are some organs and organ systems you would expect to find in this animal? How could you determine if your prediction is accurate?
   - **e.** Provide an example of a stimulus that the lemur might react to. What response would you expect it to have?
   - **f.** Using your stimulus as the starting point, explain how the nervous system allows the lemur to obtain, process, and respond to the stimulus it encounters.
3. Your teacher will facilitate a class discussion about the concepts you learned about in each lesson in this unit. Be prepared to ask any questions you still have about structure and function.

How Are They Progressing Against the Next Generation Science Standards?

Unit-specific rubrics to assess three-dimensional learning guide evaluation of student proficiency with the Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas addressed in the specific unit.

Appendix D: Assessing Three-Dimensional Learning

Science and Engineering Practices

Criterion	1. Beginning	2. Developing	3. Proficient
Developing and Using Models	Student cannot develop a model to predict phenomena.	Student can partially develop a model to predict phenomena.	Student can develop a model to predict phenomena.
	Student cannot develop a model to descril mechanisms.	Student can partially develop a	Student can develop a model
	Student cannot and use a mode phenomena.		
	Student cannot model to gener ideas about des including those inputs and outp		
Planning and Carrying Out Investigations	Student cannot investigation inc collaboratively a independent an variables and co		
	Student cannot investigation inc collaboratively a what tools are r the gathering o measurements v and the amount to support a cla		
	Student cannot investigation an experimental de data to serve as evidence that ca goals of the inv		
	Student cannot serve as the bas to answer scien or test design sc a range of cond		

Crosscutting Concepts

Criterion	1. Beginning	2. Developing	3. Proficient
Patterns	Student rarely observes how patterns of forms and events guide organization and classification while prompting questions about relationships and the factors that influence them.	Student occasionally observes how patterns of forms and events guide organization and classification while prompting questions about relationships and the factors that influence them.	Student frequently observes how patterns of forms and events guide organization and classification while prompting questions about relationships and the factors that influence them.
	Student rarely recognizes that macroscopic patterns are related to the nature of microscopic and atomic-level structure.	Student occasionally recognizes that macroscopic patterns are related to the nature of microscopic and atomic-level structure.	Student frequently recognizes that macroscopic patterns are related to the nature of microscopic and atomic-level structure.
	Stud chart data.		
	Stud to id relati		
Cause and Effect	Stud relati corre		
	Stud corre imply		
	Stud effec phen desig		
	Stud phen than		
Systems and System Models	Stud syste speci maki that		
	Stud that repre inter		
	Stud that repre and i syste		

Disciplinary Core Ideas

Criterion	1. Beginning	2. Developing	3. Proficient
Structure and Function	Student cannot explain that all living things are made of cells and that an organism may consist of one single cell or many different numbers and types of cells.	Student can partially explain that all living things are made of cells and that an organism may consist of one single cell or many different numbers and types of cells.	Student can explain that that all living things are made of cells and that an organism may consist of one single cell or many different numbers and types of cells.
	Student cannot explain that within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.	Student can partially explain that within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.	Student can explain that within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.
	Student cannot explain that the body of a multicellular organism is a system of multiple interacting subsystems that work together to form tissues and organs that are specialized for particular body functions.	Student can partially explain that the body of a multicellular organism is a system of multiple interacting subsystems that work together to form tissues and organs that are specialized for particular body functions.	Student can explain that the body of a multicellular organism is a system of multiple interacting subsystems that work together to form tissues and organs that are specialized for particular body functions.
Information Processing	Student cannot explain that each sense receptor responds to different inputs, transmitting them as signals that travel along the nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.	Student can partially explain that each sense receptor responds to different inputs, transmitting them as signals that travel along the nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.	Student can explain that each sense receptor responds to different inputs, transmitting them as signals that travel along the nerve cells to the brain. The signals are then processed in the brain, resulting in immediate behaviors or memories.
Organization for Matter and Energy Flow in Organisms	Student cannot explain that plants, algae, and many microorganisms use the energy from light to make sugars from carbon dioxide and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.	Student can partially explain that plants, algae, and many microorganisms use the energy from light to make sugars from carbon dioxide and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.	Student can explain that plants, algae, and many microorganisms use the energy from light to make sugars from carbon dioxide and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.
	Student cannot explain that within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, support growth, or release energy.	Student can partially explain that within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, support growth, or release energy.	Student can explain that within individual organisms, food moves through a series of chemical reactions in which it is broken down and rearranged to form new molecules, support growth, or release energy.

Is It Really an NGSS Program?

7-Point NGSS Program Checklist—A Quick-Start Guide

Five Innovations of NGSS	Questions
Three-Dimensional Construction	• Does the curriculum explicitly reflect and integrate all three dimensions of the NGSS and build to the Performance Expectations? • Are there multiple opportunities for students to master each dimension?
Focus on Engaging Phenomena	• Are students observing, investigating, modeling, and explaining phenomena? • Are they conducting inquiry science investigations and designing solutions? • Are they engaging?
Engineering Design and the Nature of Science	• Are engineering standards and science standards taught with equal importance? • Do learning experiences include Disciplinary Core Ideas of engineering design as well as the Science and Engineering Practices and Crosscutting Concepts of both engineering and the nature of science? • Are engineering design and the nature of science integrated throughout the science content and not separate lessons at the unit's end?
Coherent Learning Progression	• Is it clear that there is a coherent learning progression within each unit as well as across grade levels? • Is there a convincing concept storyline or other coherent framework? • Do units build on and extend knowledge and understanding gained in prior grades?
Connections to Math and ELA	• Are connections to the Mathematics and ELA Standards explicit?
Key Support Materials	
Materials	• Do students have the materials to carry out scientific investigations and engineering design projects?
Assessment	• Are there multiple assessments capable of evaluating student progress and the performance expectations, including the science and engineering practices?

So many programs claim to meet the NGSS, but how can you be sure? Use this 7-point NGSS program checklist as a guide.

	STCMS™	Where Is It in STCMS?
	✓ Yes	• Unit Overview lesson summaries show how Performance Expectations build over time • Alignment to Next Generation Science Standards before each lesson explicitly describes the integration of the Disciplinary Core Ideas, Crosscutting Concepts, and Science and Engineering Practices • Lessons that integrate real-world situations with scientific principles, leading to engaging and relevant instruction

	✓ Yes	• Focus Questions for each lesson that look at phenomena from a science perspective
		• Introductions that provide students with examples of phenomena that they can relate to
		• Investigations that:
		  • give students multiple opportunities to study, model, and explain phenomena
		  • provoke questions and call for the design of solutions

	✓ Yes	• Lesson at a Glance Alignment to Next Generation Science Standards • Lessons build an understanding of science and the world while incorporating meaningful engineering design opportunities • Lessons build an understanding of science content and develop use of evidence to revise design solutions
	✓ Yes	• Unit Concept Storylines show at a glance the conceptual progression over the course of the unit • Unit Table of Contents shows the focus on investigations and phenomena and on nonfiction support • STCMS Learning Framework illustrates the progression of concepts across grade levels and strands • Lessons that provide multiple opportunities for students to engage prior knowledge and experience investigative phenomena to deepen understanding and provide explanations
	✓ Yes	• Lesson at a Glance correlates ELA and Mathematics Standards for each lesson • Reading Selections that include discussion questions intentionally constructed to support ELA Standards • Teacher Edition includes explicit guidance on the importance of and the "how to" of connecting science and the Mathematics and ELA standards (Tab 3)
	✓ Yes	• Unit purchase includes the Teacher Edition, Student Editions—both with digital access—and all the materials to complete the investigations that are not commonly found in middle school science labs/classrooms.

	✓ Yes	• A coherent system of classroom-based assessments that provide powerful information to inform teaching and learning, for not only the teacher, but the student as well. STCMS units include:
		  • pre-assessment lesson
		  • formative assessment including Exit Slips to monitor student progress
		  • self-assessment for students
		  • summative assessment—performance and written components
		  • unit-specific NGSS rubrics to assess three-dimensional learning

STC

SCIENCE AND TECHNOLOGY CONCEPTS™

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Physical Science

Energy, Forces, and Motion

MS-PS2-1, MS-PS2-2, MS-PS2-3, MS-PS2-5, MS-PS3-1, MS-PS3-2, MS-PS3-5, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4

Matter and Its Interactions

MS-PS1-1, MS-PS1-2, MS-PS1-3, MS-PS1-4, MS-PS1-5, MS-PS1-6, MS-PS3-4, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4

Electricity, Waves, and Information Transfer

MS-LS1-8, MS-PS2-3, MS-PS3-3, MS-PS3-5, MS-PS4-1, MS-PS4-2, MS-PS4-3, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4

Life Science

Ecosystems and Their Interactions

MS-LS1-5, MS-LS1-6, MS-LS2-1, MS-LS2-2, MS-LS2-3, MS-LS2-4, MS-LS2-5, MS-LS4-4, MS-LS4-6, MS-ESS3-3, MS-ETS1-1, MS-ETS1-2

Structure and Function

MS-LS1-1, MS-LS1-2, MS-LS1-3, MS-LS1-6, MS-LS1-7, MS-LS1-8, MS-LS4-2, MS-LS4-3

Genes and Molecular Machines

MS-LS1-1, MS-LS1-4, MS-LS3-1, MS-LS3-2, MS-LS4-4, MS-LS4-5

Earth/Space Science

Weather and Climate Systems

MS-ESS2-4, MS-ESS2-5, MS-ESS2-6, MS-ESS3-2, MS-ESS3-4, MS-ESS3-5, MS-PS3-4, MS-ETS1-1, MS-ETS1-2

Earth's Dynamic Systems

MS-LS4-1, MS-ESS1-4, MS-ESS2-1, MS-ESS2-2, MS-ESS2-3, MS-ESS3-1, MS-ESS3-2, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4

Space Systems Exploration

MS-PS2-4, MS-ESS1-1, MS-ESS1-2, MS-ESS1-3, MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, MS-ETS1-4

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  - Student Guide eBook Access
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