IS5

Grade Four Instructional Segment 5: Animal Senses

The CA NGSS in grade four present a number of related performance expectations around how animals sense and process information. Students can develop a model that unifies external sensing organs, the internal brain structures that support them, the principles of information processing, and how all these processes work together to help organisms survive and thrive in the world. Because these ideas integrate so many concepts, this instructional segment represents a strong capstone to grade four.

GRADE FOUR INSTRUCTIONAL SEGMENT 5: ANIMAL SENSES

Guiding Questions

- How do the internal and external structures of animals help them sense and interpret their environment?
- How do senses help animals survive, grow, and reproduce?
- What role does light play in how we see?
- How do humans encode information and transmit it across the world?

Performance Expectations

Students who demonstrate understanding can do the following:

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. [Clarification Statement: **Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin. Each structure has specific functions within its associated system (CA).**] [*Assessment Boundary: Assessment is limited to macroscopic structures within plant and animal systems.*]

4-LS1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways. [Clarification Statement: Emphasis is on systems of information transfer.] [*Assessment Boundary: Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.*]

4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. [*Assessment Boundary: Assessment does not include quantitative measurements of energy.*]

4-PS4-2. Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. [*Assessment Boundary: Assessment does not include knowledge of specific colors reflected and seen, the cellular mechanisms of vision, or how the retina works.*]

4-PS4-3. Generate and compare multiple solutions that use patterns to transfer information.* [Clarification Statement: Examples of solutions could include drums sending coded information through sound waves, using a grid of 1s and 0s representing black and white to send information about a picture, and using Morse code to send text.]

**The performance expectations marked with an asterisk integrate traditional science content with engineering through a practice or disciplinary core idea.*

California clarification statements that are bolded and followed by **CA** *were incorporated by the California Science Expert Review Panel.*

GRADE FOUR INSTRUCTIONAL SEGMENT 5: ANIMAL SENSES

The bundle of performance expectations above focuses on the following elements from the NRC document *A Framework for K–12 Science Education*:

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-1] Asking Questions and Defining Problems [SEP-2] Developing and Using Models [SEP-3] Planning and Carrying Out Investigations [SEP-6] Constructing Explanations (for science) and Designing Solutions (for engineering) [SEP-7] Engaging in Argument from Evidence [SEP-8] Obtaining, Evaluating, and Communicating Information	LS1.A: Structure and Function LS1.D: Information Processing PS4.B: Electromagnetic Radiation PS4.C: Information Technologies and Instrumentation	[CCC-1] Patterns [CCC-2] Cause and Effect: Mechanism and Explanation [CCC-4] Systems and System Models [CCC-5] Energy and Matter: Flows, Cycles, and Conservation [CCC-6] Structure and Function [CCC-7] Stability and Change

Highlighted California Environmental Principles and Concepts:

Principle I The continuation and health of individual human lives and of human communities and societies depend on the health of the natural systems that provide essential goods and ecosystem services.

Principle II The long-term functioning and health of terrestrial, freshwater, coastal, and marine ecosystems are influenced by their relationships with human societies.

CA CCSS Math Connections: 4.OA.5; 4.MD.5, 6; 4.G.3; MP. 2, 4, 5, 6

CA CCSS for ELA/Literacy Connections: W.4.1; RI.4.3, 7

CA ELD Standards Connections: ELD.PI.4.10

This instructional segment is very broad and interconnects life sciences and physical sciences. This description of the instructional segment starts with a focus on the content connected to the internal and external structures of plants and animals and how these structures support their survival, growth, behavior, and reproduction. The remainder of the instructional segment description focuses on how various sensory receptors, a specific group of internal structures, are used to help organisms collect information, which they then process and use for survival and reproduction.

Students begin with observations to **construct explanations [SEP-6]** and **develop models [SEP-2]** for how plant and animal structures function to support survival, growth, behavior, and reproduction. They can begin their study by taking a walking field trip to a school or local garden, community park, or nature preserve. Each student chooses a plant or animal to carefully observe and sketch. The goal of drawing the organism is to identify different **structures [CCC-6]** and **ask questions [SEP-1]** about how they help the organism survive. These questions set the stage for gathering evidence. Based on further observations, research, and classroom and outdoor experiences, students **construct an argument [SEP-7]** about the importance of specific structures of an insect to its survival, growth, behavior, and reproduction. Together, student teams can use a "Questions, Claims, and Evidence" format to organize their argument that structures of their organism function to support survival, growth, behavior, and reproduction.

GRADE FOUR VIGNETTE 4.2: STRUCTURES FOR SURVIVAL IN A HEALTHY ECOSYSTEM

Performance Expectations

Students who demonstrate understanding can do the following:

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. [Clarification Statement: Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lung, brain, and skin. Each structure has specific functions within its associated system.] [*Assessment Boundary: Assessment is limited to macroscopic structures within from one of California's systems.*]

4-LS1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways. [Clarification Statement: Emphasis is on systems of information transfer.] [*Assessment Boundary: Assessment does not include the mechanisms by which the brain stores and recalls information or the mechanisms of how sensory receptors function.*]

Highlighted Science and Engineering Practices	Highlighted Disciplinary Core Ideas	Highlighted Crosscutting Concepts
[SEP-2] Developing and Using Models [SEP-7] Engaging in Argument from Evidence	LS1.A: Structure and Function LS1.D: Information Processing	[CCC-4] Systems and System Models [CCC-6] Structure and Function [CCC-7] Stability and Change

Highlighted California Environmental Principles and Concepts:

Principle II The long-term functioning and health of terrestrial, freshwater, coastal and marine ecosystems are influenced by their relationships with human societies.

CA CCSS for ELA/Literacy Connections: W.4.1, SL.4.1, SL.4.4, SL.4.5

CA ELD Standards Connections: ELD.PI.1-3, 5, 9-11

GRADE FOUR VIGNETTE 4.2: STRUCTURES FOR SURVIVAL IN A HEALTHY ECOSYSTEM

Introduction

Mr. F thinks it is very important for students to explore natural **systems [CCC-4]** outside of their classroom rather than just reading about them in books. He plans ahead for a field trip outside of the classroom so students become active observers of the natural world and learn about the internal and external structures of plants and animals where they live. Mr. F's experience tells him that observing living organisms in nature would be the best strategy for teaching students about the functions of external structures in growth, survival, behavior, and reproduction.

Preparation for a Field Investigation

Students work with the art teacher to develop their skills for making plant and animal drawings in their science notebooks.

Day 1: Getting Ready for a Field Trip

Students brainstorm about the plants and animals they might observe during their field trip and discuss the types of external structures they might see.

Day 2: Observing External Structures in Nature

Students undertake a field investigation in the neighborhood and record the plants and animals they see in their science notebooks.

Day 3: Structures for Survival

Students identify external structures and add drawings to their science notebooks for the plants and animals they observe. They make claims about how they aid in survival.

Day 4: External Structures in California Habitats

Students investigate California's diverse habitats and investigate differences in the external structures of plants and animals that live there.

Day 5: Survival in Changing Habitats

Students develop pictorial models representing all of the information they have gathered about plants' and animals' external structures. They then use the models to test an interaction relating to the functioning of a natural system.

Preparation for a Field Investigation

Anchor phenomenon: Different animals and plants have different external parts.

The week before the field trip, Mr. F asked the art teacher to prepare the students by helping them learn how to draw various local plants and animals. He mentioned to her that the students would be focusing on the external structures of these organisms so it would be especially helpful if they learned how to draw items like beaks, wings, feet, tails, leaves, flowers, branches, roots, seeds, and nuts. At that time, Mr. F also enlisted three of his parent volunteers to work with the students during the field trip.

GRADE FOUR VIGNETTE 4.2: STRUCTURES FOR SURVIVAL IN A HEALTHY ECOSYSTEM

Day 1: Getting Ready for a Field Trip

The day before their field trip, Mr. F asked students what plants and animals they think they might see near the school and in the park. Since many of the students were very interested in nature, the class came up with a list of 10 different animals they had previously seen on campus; five birds and 10 plants they observed in the park; and several of the plants and animals that they were familiar with from visits to a local nature center. He divided the students into groups of four and asked them to choose one plant and one animal from the class list that they wanted to discuss as a group. Mr. F instructed them to write in their science notebooks the name of their chosen plant on one page and their animal on another page. Students then made a list of at least three external structures for each of their organisms. Mr. F's students were familiar with the idea of external structures from grade one (1-LS1-1), but most used the term *external parts*. Mr. F introduced the term *structure* and related the word to other uses in English. One member of each group went to the board and wrote the names of their group's plant and animal, and the external structures they identified. When all of the groups had shared their organisms and external structures on the board, Mr. F sent students on a "gallery walk" around the room during which they added suggestions to other teams' lists using a different color pen. When the lists had been completed, Mr. F asked the class, "What **patterns [CCC-1]** do you see in the types of external structures among the different animals?" and "What patterns do you see among the different plants?" Students recorded additional ideas about the external structures in their science notebooks. This process provided the students with lists of external structures they could look for during their outside exploration.

Mr. F reminded students that they were going on an off-campus field trip the next day and that they should bring along shoes that could get dirty or muddy.

Day 2: Observing External Structures in Nature

Investigative phenomenon: Different animals and plants live in different sections of their neighborhood.

On the day of their field trip, Mr. F briefly reminded the students how they need to behave while they are walking around the neighborhood: stay with the adults working with their groups; move and speak quietly so that they do not disturb the animals they are trying to observe; avoid littering; etc. He then explained the information they were going to collect during the **investigation [SEP 3]**, including observations of the plants and animals that live nearby—paying close attention to their external structures, such as beaks, wings, leaves, etc. Mr. F reminded students that as they were making their observations, they should pay special attention to the external structures of the organisms, making notes in their science notebooks.

Mr. F told students to put on their outside shoes and take along their pencils and science notebooks. An art teacher and/or a teacher or community volunteer with artistic expertise joined the class when they were ready to head out for their neighborhood exploration.

Students started with a 20-minute investigation of the schoolyard and a small park in the neighborhood. They observed some birds flying by, and he asked them to identify some of the

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external features of the birds, wings, beaks, and eyes. The students saw a squirrel running across the grass, so Mr. F asked them to identify some of the interesting features of the squirrel: long tail, big eyes, claws, and large ears. They had noticed the squirrel climbing up a big oak tree, so he asked them to identify some of the tree's external features: trunk, bark, branches, leaves, roots, and acorns.

When they return to the classroom, the class quickly compiled a list of the names of the plants and animals they observed during their field trip.

Day 3: Structures for Survival

Investigative phenomenon: Students only observed a few animals on their nature walk.

Mr. F had students return to their small groups and called their attention to the list of plants and animals they observed the previous day. Students were surprised at how they only observed a few of the animals they listed in their science notebooks on day 1. Some students suggested it might have been too hot during the field trip for the animals to be out. Others proposed that their original lists were different because they were visiting the area during a different season. Yet others said that the differences were a result of the drought in their area over the past year (**stability and change [CCC-7]**). A few mentioned that they thought that recent construction activities in the area disturbed the plants and animals (EP&C II).

Investigative phenomenon: Different plants and animals have different external structures and also different behaviors.

Mr. F asked groups to select a plant and an animal that they observed during the field trip, explaining that they must choose organisms different from those they had previously written about in their science notebooks. Following what they did on day 1, students wrote the name of their chosen plant on one page of their science notebook and their animal on another page. Below the organisms' names, students drew simple **pictorial models [SEP-2]** of each organism, including the external structures with labels. Mr. F mentioned that as they made these drawings they should think about how each of the structures may be helping the plant or animal survive.

Mr. F put a sample chart on the board which students copied in their science notebooks, making as many rows as there were student groups. To initiate the class discussion, he asked one group to name its organism and identify some of the external structures the group observed.

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Name of Plant or Animal	External Structures Observed	blank	blank
Gray squirrel	Claws	blank	blank
(add more rows as needed)		blank	blank

Mr. F deepened the discussion by having students explore the importance of these **structures and functions [CCC-6]** by giving them two written prompts: Describe how the plants and animals use the external structures you observed. and Explain how the structures aid the plants and animals in survival. They added labels to the blank columns of their charts for each of these prompts.

Name of Plant or Animal	External Structures Observed	Use of the External Structures	How the Structures Aid in Survival
Gray squirrel	Claws	Climbing trees and gathering acorns	Escaping predators and supplying the food they need to survive

After all groups responded in their science notebooks, Mr. F had each group approach the board and enter its information in the chart. As one group entered its information, the group described and explained its claims about the survival value of the external structures they identified. Mr. F asked, “What do others think about this claim? Is there anything that you would like to add or change?” As others contributed, some of the groups made additional notes in the chart, modifying their claims or adding other evidence. All students recorded information from the final chart in their science notebooks.

Day 4: External Structures in Changing California Habitats

Investigative phenomenon: Different plants and animals grow in different parts of California.

In an effort to help students discover the natural diversity of habitats, plants, and animals in California, Mr. F called their attention to a habitats wall map (https://www.cde.ca.gov/ci/sc/cf/ch4.asp#link8). He also saw this as an opportunity for integration between standards in science and History–Social Science (3.1.1) where they learned about geographical features in their local region including deserts, mountains, valleys, hills, coastal areas, oceans, and lakes. After looking closely at the map, students shared their observations mentioning that there are many different habitats in California: several students said that they have never visited the desert or the mountains; others mentioned that they have never seen the coast or ocean. Mr. F prompted the students to discuss the plants and animals that live in each of California’s

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habitats (the poster has pictures of the plants and animals grouped with each habitat). Several of the students expressed great interest in learning about the different habitats, so Mr. F mentioned that he had included the book *California's Natural Regions* (https://www.cde.ca.gov/ci/sc/cf/ch4.asp#link9) in the class backpack of "habitat tools"—students get one week to take the backpack home and engage in the activities in the backpack with their family.

Mr. F pointed out their local region and, using the map and their local knowledge, asked students to write the names of some plants and animals that live near their community. He then prompted them by asking, "Do you think that the plants and animals that live in other habitats will have different external structures than the organisms that live near them?" Several students raised their hands rapidly to point out that the external structures of the organisms that live in coastal and marine ecosystems will be very different; many will have fins, gills, large tails for swimming, and tentacles for gathering food and moving. Mr. F encouraged students to identify different external structures they might see in freshwater and streams.

Investigative phenomenon: The Merriam's kangaroo rat has specific external structures.

Mr. F distributed copies of a photograph of a common animal in California's deserts, the Merriam's kangaroo rat (see Structures for Survival in a Healthy Ecosystem at https://www.cde.ca.gov/ci/sc/cf/ch4.asp#link10). He asked them to use the blank spaces to label the animal's major external structures including its eyes, nose, feet, tail, and cheeks. Turning over the paper, students responded to each of the writing prompts by explaining how the structures help kangaroo rats grow, reproduce, and survive. Several of the students were surprised that there was an arrow pointing to the animal's cheek and asked Mr. F why. He told them that kangaroo rats use cheek pouches to store seeds collected from the desert floor until the rats can bury the seeds near their burrows. He asked students to share their arguments about the function of one of the kangaroo rat's external structures. The class worked together to decide the top three arguments for the function and role in survival of each of the kangaroo rat's external structures.

Day 5: Survival in Changing Habitats

Investigative phenomenon: Different plants and animals have different external structures and also different behaviors. (Students return to this phenomenon from day 3.)

As a formative evaluation activity, Mr. F asked students to **analyze and interpret [SEP-4]** their data from day 4 as the basis for developing **pictorial models [SEP-2]** which would help them identify interconnections and **cause and effect [CCC-2]** relationships between the external structures of animals and plants, and their survival. Their initial models (figure 4.13) identified the plant or animal, their major external features, and the role of each structure in survival.

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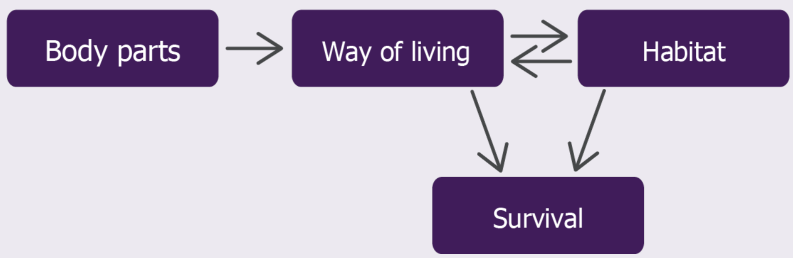
Mr. F explained that they would be making **arguments supported by observational evidence [SEP-7]** regarding the role of external structures in the survival of organisms in different habitats. He reminded students that their arguments must include evidence they gathered in support of their point of view and include their reasoning to support the structure's role in survival, growth, behavior, and/or reproduction. They posted their models around the class and used the evidence summarized in their models to make an evidence-based argument for the importance of the external structures they investigated to their organism's survival. Mr. F asked other students if they could add any more information or suggestions that would allow each presenter to strengthen their evidence or argument. Students then had the opportunity to adjust their models to clarify the interactions among the components of the model.

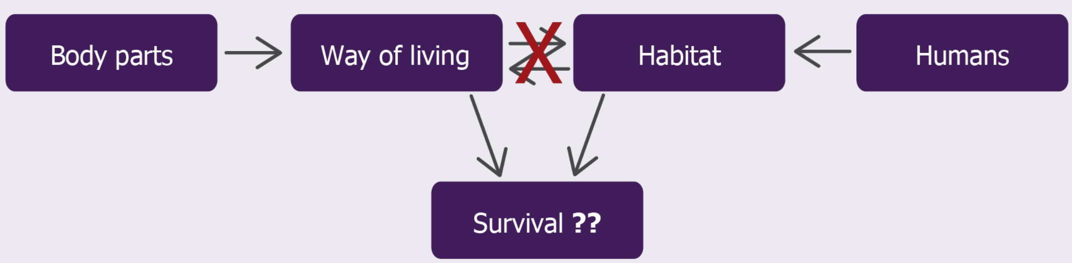
Figure 4.13. Initial Survival Model



Students use the phrases "body parts" and "way of living" to describe **structure and function [CCC-6]** relationships (LS1.A). The two arrows in grey indicate that organisms function well in a specific habitat (LS4.C). Resources in the habitat and the organism's abilities and behaviors allow it to survive. Diagram by G. Lieberman and M. d'Alessio.
Long description of Figure 4.13.

Mr. F asked the students to recall their many conversations about how human activities can influence the environment (EP&C II). Which components and interactions in the model can humans affect? Students agreed that people have the most influence on habitats (figure 4.14).

Figure 4.14. Survival Model Highlighting Human Influence



Students identify how humans **affect [CCC-2]** habitats such that their existing way of living is changed. This puts survival into question (LS2.C, LS4.D). Diagram by G. Lieberman and M. d'Alessio.
Long description of Figure 4.14.

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Mr. F asked students, “How might human activities that damage a habitat affect your plant’s or animal’s survival, growth, behavior, and/or reproduction.” They used their models to develop a claim about the effects of habitat loss on their organism’s survival.

Vignette Debrief

The major theme of these lessons was the interplay between the external **structures and functions [CCC-6]** of plants and animals, their habitats, and their role in survival growth, and reproduction. Notice how the investigative phenomena were all very similar to one another as Mr. F revisited several related examples. In fact, these phenomena are very similar to snapshot 3.1 from kindergarten (“Rivers have a wide variety of plants and animals that live near them”) and snapshot 4.4 from grade 3 (“Some places on the school yard have lots of plants and animals while other places have fewer”). In earlier grades, they focused on describing **patterns [CCC-1]** in diversity, and this is the first time they really included these **causes [CCC-2]** in their rudimentary models. Students will revisit this same observation over and over again in the middle grades and high school, and each time they will be able to **explain [SEP-6]** the observed diversity with a deeper understanding of the **causes and mechanisms [CCC-2]**.

SEPs. Students had an opportunity to undertake a field **investigation [SEP-3]** where they could observe local plants and animals in their natural environment. Students created **pictorial models [SEP-2]** that represented the results of their investigations by identifying the plants or animals they had chosen. Their models showed the interconnections between major external features of their organisms, the role of each structure in survival, and the relationships between the external features and the ecosystem where each organism lives.

DCIs. Students mastered the fundamental connections illustrated in figures 4.13 and 4.14, including how organisms’ structures help them to survive (LS1.A), how different organisms survive in different habitats (LS4.C), and how humans influence habitats and can jeopardize survival (LS2.C, LS4.D).

CCCs. On day 2, students observed structures. On day 3, they linked these **structures to specific functions [CCC-6]** within a habitat. At the elementary level, students focused on structures that they could directly observe. They identified **patterns [CCC-1]** where certain structures recurred in specific habitats, but they didn’t yet examine what caused these patterns. (An ideal student might say, “Lots of plants in deserts have sharp spines. Spines must help the plants survive in that habitat. I wonder how they all got spines.”) In the middle grades, they will expand their understanding to microscopic structure/function relationships as well as look at how natural selection explains structure/function relationships in terms of **cause and effect [CCC-2]**.

EP&Cs. Students delved into the question of how environmental changes caused by humans might affect the usefulness of the external structures and their organism’s survival (EP&C II).

CA CCSS Connections to English Language Arts and Mathematics. These lessons offer several opportunities for teachers to make interdisciplinary connections. In

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preparation for their field investigation, students worked with an art teacher to strengthen their skills in drawing local plants and animals, as well as their external structures so they could **communicate their findings [SEP-8]**.

On day 1, the students brainstormed about the plants and animals they might see during their field trip. They then held a class discussion about the types of external structures they might see among the plants and animals in their local community, preparing them for what they would be observing during their field trip.

On day 2, with assistance from the art teacher and parent volunteers, Mr. F gave students an opportunity to participate in a field trip so that they could observe plants and animals in their local settings. They made notes in their science notebooks, gathering evidence they would use through all the remaining lessons.

On day 3, students began to summarize their data in both drawings and charts (SL.4.5) when they identified a plant or animal and described the use of the external structures. They then considered where their organism lived and described their initial thoughts about how each external structure aided the plant or animal in survival. The groups described and explained their **claims supported by observational evidence [SEP-7]** about the survival value of the external structures and engaged in discourse with other students to gain their advice and additional ideas.

Day 4 expanded students' knowledge about the natural diversity of habitats, plants, and animals in California. Using a natural habitats map, students identified California's major ecosystems and the plants and animals that lived in each. They **investigated [SEP-3]** the organisms and compared the external structures of plants and animals in different habitats. Using writing prompts, Mr. F asked students to share their arguments about the function of a kangaroo rat's external structures.

On day 5 students develop a **pictorial model [SEP-2]** that identified interconnections and **cause and effect [CCC-2]** relationships between external structures and the survival of plants and animals. They shared their models and then tested the effects of human-caused changes to habitats on the survival of the organisms they were studying. As a formative assessment, students engaged in **argument using evidence [SEP-7]** making a case about the effects of human-caused habitat damage on the survival of the plants and animals that live there (W.4.1).

Vignette prepared by the State Education and Environmental Roundtable.

Resources:

California Education and the Environment Initiative. 2013. *California's Natural Regions*. Sacramento: Office of Education and the Environment. https://www.cde.ca.gov/ci/sc/cf/ch4.asp#link11.

———. 2013. *Habitats Map*. Sacramento: Office of Education and the Environment. https://www.cde.ca.gov/ci/sc/cf/ch4.asp#link12.

———. 2013. *Structures for Survival in a Healthy Ecosystem*. Sacramento: Office of Education and the Environment. https://www.cde.ca.gov/ci/sc/cf/ch4.asp#link13

Structure and Function in Vision

According to the evidence statement for 4-LS1-1, students should be able to make a claim about a single structures/function relationship, emphasizing the relationship between external structures and the internal systems related to them. This section uses the phenomenon of animal vision because it connects to other performance expectations at this grade level to create an integrated theme within the instructional segment. Students observe pictures of different animal heads and eyes (figure 4.15). How many eyes does the animal have? How big are they? Where on the head are they located? Many spiders and insects have multiple eyes, but every big animal (vertebrate) that they look at has two eyes. The eyes differ in size, color, shape, and where they are located on the animal's head, but there are always two. This commonality is related in large part to common evolutionary history, but the differences have big effects on what and how animals see.

Figure 4.15. Animal Eyes

Sources: David~O 2008; Cattoir 2011; Haen 2012; Hume 2009; Art G. 2007; Haggblom 2013
Long description of Figure 4.15.

Students need to **develop a model [SEP-2]** of how these different eye **structures allow different functions [CCC-6]**. Students can begin by using a camera as a physical model. When students point a camera in a particular direction, there are objects that appear in the frame and objects that they cannot see. Human and animal eyes have a similar *field of view*. Students measure their own personal field of view as an angle by drawing a protractor on the ground and then having friends try to sneak up from behind, recording the angle at which they are first detected (CA CCSSM 4.MD.5, 6). Students **construct an argument [SEP-7]** that animals with eyes on the side of their head will survive better because they can see predators sneaking up on them from more directions. The camera model also demonstrates another function of eyes. A camera has only one "eye," making certain optical illusions possible (figure 4.16). Students explore how their two eyes provide them depth perception through games and challenges where they operate with only one eye open (such as trying to catch a falling object or drop a penny into a bucket). Students **develop a conceptual model [SEP-2]** of depth perception that describes how both eyes need to see the same object from slightly different angles. Having two eyes near one another looking in the same direction helps accomplish this function. Students sort through the pictures of animal eyes along with information about what they eat and how they live. Students identify the animals they think might have the best depth perception. What do they have in common? Why would some animals benefit from better field of view versus better depth perception? Students **obtain information [SEP-8]** from an article that describes how animals use vision to survive and find food. This activity expands on their understanding of the predator-prey relations that they learned about in kindergarten, (including labeling these relationships with the terms predator and prey, which may not have been done in kindergarten). Students **construct an argument [SEP-7]** that animals with eyes close together will be better predators because their superior depth perception allows them to see and then capture moving objects such as prey that is trying to escape. Given information about a fictional animal's eating and living habits, students can creatively draw a picture of the animal, including **applying their model [SEP-2]** of the relationship between eye position and survival needs.

Figure 4.16. Cameras with One Lens Lack Depth Perception

Source: Lock 2008
Long description of Figure 4.16.

Opportunities for Mathematics Connections

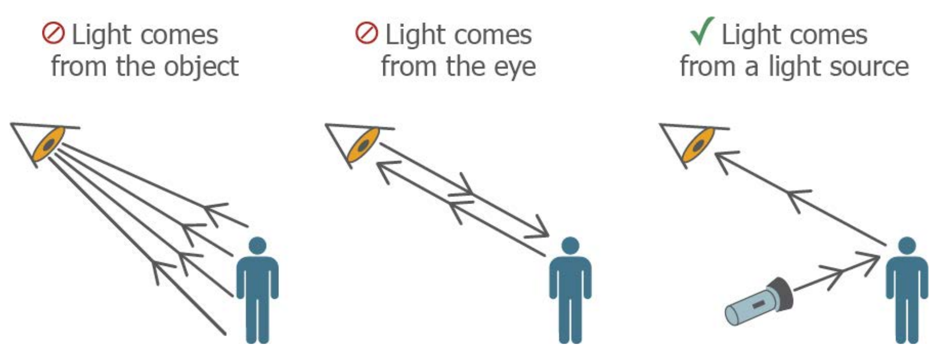
Draw lines of symmetry on different animals' faces, including humans. Discuss how the placement, size, and shape of eyes and ears on the head of each animal facilitate survival for prey species and for predator species in terms of sensing images and sounds. For example, predator species (cats) usually have eyes that are closer together for stereoscopic vision, while prey animals (horses) have eyes placed on the sides of their head to allow for a wider field of vision.

CA CCSSM: 4.G.3; MP. 2, 6

Models of How We See

Some observations of animal eyes can reinforce incorrect preconceptions about how sight works. A cat moving around in the night appears to have eyes that "glow." Is that how cats can see so well in the dark? In grade one, students made an argument that people require light to see (1-PS4-2). But what is the relationship between light and sight? Students can draw an initial **pictorial model [SEP-2]** that explains how they think we see objects (figure 4.17). To help students reassess their preconceptions, teachers can use science assessment probes such as "Apple in the Dark" and "Seeing the Light" (Keeley, Eberle, and Farrin 2005; Keeley 2012). "Apple in the Dark" asks, Would you be able to see a red apple in a totally dark room? "Seeing the Light" asks students to identify types of objects and materials that reflect light. Each probe asks students to identify what they know and to detail their thinking behind their choices. The student feedback from these formative assessments can help to direct the series of experiments and observations that follow.

Figure 4.17. Possible Student Models of How Light Enables Animals to See Objects



The model on the left is incomplete while the model in the center is largely incorrect. The model on the right shows light leaving a light source and reflecting off the person before it enters the eye. Diagram by M. d'Alessio

Long description of Figure 4.17.

Collaborative student teams begin to investigate reflection with flashlights and mirrors. They conduct an **investigation [SEP-3]** by holding the flashlight at different angles and drawing diagrams representing their observations showing the trajectory of the light and indicating the source and the receiver of the light. They observe that light travels in a straight line away from the source and is then reflected. They investigate what happens when the light hits different surfaces including shiny surfaces (Mylar, glass, glossy paint) or objects (glass, crystal, leaves) and nonshiny surfaces (wood, dirt, eraser). Students performed similar investigations in grade one (1-PS4-3), but now they represent their results using **pictorial models [SEP-2]** showing the paths of light rays and using the language of angles to describe the reflections (4.MD.5). Students also relate the path of light to the movement of **energy [CCC-5]** (4-PS3-2). Students can draw a model of how light travels from the Sun and bounces off mirrors to the central tower of a concentrated solar power plant (linking back to renewable energy in IS2). Students may need to **obtain and evaluate additional information [SEP-8]** from articles and media to deepen their understanding of how light reflecting from objects and entering the eye allows objects to be seen. Students can develop posters that communicate their different models and explanations about vision. By conducting a gallery walk around all the posters, individuals can review and respond to the models developed by other students. Students can then apply their models to the original formative assessment probes about seeing in the dark (we cannot see without a light source) and what materials reflect light (all materials reflect some light or we would not be able to see them at all, but some materials reflect more light than others). They can gather additional information about why cats' eyes appear to glow (cat eyes have a unique internal structure like a curved mirror at the back of their eyes that causes light to reflect off the inside of their large eyes towards the eyes of a human observer). Students should then be able to **support the claim [SEP-7]** that one reason a cat can see well at night is because its eyes are large and therefore capture more of the light reflecting off of the objects they are viewing.

Sample Integration of Science and ELD Standards in the Classroom

Students notice that a car light shining on an animal at night reveals the animal's glowing eyes. To explain this phenomenon, students observe the structure and function of the human eye, and compare it to those of other organisms (4-LS1-1, 4-PS4-2). They create tables with brief descriptions that characterize the placement of each organism's eyes and the rationale for such placement (e.g., eyes located on the sides of their heads allow animals to see in front, to their sides, and behind them, helping them to be aware of predators).

CA ELD Standards: ELD.PI.4.10

Source: Lagunoff et al. 2015, 264–265

Internal Body Systems for Processing Information

Animals and plants have specialized structures that allow them to sense their environment. Animals collect information about environmental conditions (movement, temperature, color, sound) from the signals they receive through internal and **external structures [CCC-6]** or sense receptors (eyes, skin, ears, hairs, tongue, antennae). This information moves from the sensory receptors into the brain, where it is processed and used to guide the animal's actions, increasing its chances of survival. Every animal's brain is continuously receiving and responding to this sensory input from the environment.

Many of these sensory responses seem automatic. When a person suddenly pulls away from a hot object, what happens inside them to make this happen? Students record an initial model of what they think happens and then explore their own reactions to sensory input by experiencing hot or cold objects, the smell of perfume, or a special taste-testing paper called PTC. Students describe the sequence of events they observe in themselves and in other organisms. With the aid of informational media, they refine their **model [SEP-2]** of the systems that allow animals to sense and respond to their environment.

Grade Four Snapshot 4.5: Investigating Termite Sensory Systems

Anchoring phenomenon: Termites and other insects share many external body parts in common with one another.

Mr. S eagerly opened class with a question to activate his students' prior knowledge. He asked, "Have you ever seen termites before?" Anthony responds, "Last spring my parents had to call the termite people to clean the house. I didn't know we had termites. The whole house was covered in plastic for days." Mr. S responded, "Yes, termites sometimes make their homes in wooden houses. While it's a good place for the termites, it can weaken the house." He asked students what termites look like and some described them as "ants with wings" while others said they have seen termites without wings crawling out of rotting wood. He then asked, "What kind of animal is a termite?" Many students knew that termites are insects, so Mr. S asked them to draw as many pictures of insects as they could from their memory with as much detail as possible. Grouping students together in their usual teams with designated roles (facilitator, reporter, materials manager, and recorder), he asked students to compare their drawings and look for patterns in insect external **structures [CCC-6]**. "What body parts do insects have in common?" Students identified six legs, segmented bodies, wings, eyes, and antennae as common, though not universal, features of insect bodies. Mr. S asked, "Which of these body parts do you think a termite uses to sense its environment?" After some discussion, Mr. S told students that they would try to figure that out, and he pulled out a tray with several small containers. Something was moving in those containers!

Mr. S opened one container and projected a few termites on the screen with his document camera. He demonstrated how to be gentle with the termites and invited students to **ask questions [SEP-1]** about them, though he only answered background questions about them and deflected all questions that they might be able to investigate on their own. Then he said, "I am going to give each group a container with a few termites. Please, be gentle with them as I showed you earlier." The materials manager from each group quickly came to pick up a small container of termites, a pen, and a piece of paper.[2] He directed the recorder to draw a simple squiggle line on a piece of paper. The team facilitator then carefully poured the termites onto the paper while the remaining two students had small paintbrushes in hand to gently keep the termites on the paper. To the amazement of the students, the termites began to follow the pen design! Students recorded their observations and questions in their science notebooks.

2. If the teacher and/or school has concerns about students using live termites, the lesson can be adapted so only the teacher is responsible for handling the termites.

Grade Four Snapshot 4.5: Investigating Termite Sensory Systems

Investigative phenomenon: Termites follow a line drawn by a pen.

After several minutes of observations, groups generated a list of questions about what **caused [CCC-2]** the termites to follow the pen mark. Each reporter for the group shared in a whole-class discussion the list of questions and possible ideas that explained what **caused [CCC-2]** the termites to follow the pen mark: "We think the cause may be that termites follow a specific color, so I wonder if changing the color would make a difference in behavior." "Team four thinks the brand of pen determines the cause for the termites to follow the lines." "Can the termites follow different angle turns?" Other thoughts included placement of termites on the paper, the width of the pen, the odor of the pen, the texture that the pen made on the paper. Mr. S asked students to link each possible idea with a different sense organ on the termite and the **structures [CCC-6]** on the termite's body.

Investigative phenomenon: Termites follow lines drawn by some pens in certain shapes but not others.

Each team chose one variable or cause to test and examined and reported the result (effect) to the class. Mr. S helped each team create a table to record the data for its investigation; the table included the variable or cause the team was testing and the number of termites that followed the line drawn. They also recorded observations in their science notebooks. After careful **investigation [SEP-3]** and data recording, the groups carefully placed the termites back into their containers and prepared to share their experimental results with the rest of the class. Students found that termites followed the lines drawn by certain brands of pens. Ballpoint pens caused the most termites to follow the lines, and it did not matter if the design was curved or straight.

Color of writing implement	Trial 1-Curved Line # of termites following line	Trial 2-Curved Line # of termites following line
Blue sharpie		
Blue pencil		
Blue ballpoint		
Blue gel pen		

Mr. S. asked students to explain in their notebooks how they think the termites were processing the sensory information that allowed them to follow the trail. They were to include **evidence [SEP-7]** from their **investigations [SEP-3]** and describe a **cause and effect [CCC-2]** relationship. For several minutes the groups shared ideas and drawings.

Grade Four Snapshot 4.5: Investigating Termite Sensory Systems

Next, he provided students with background reading about how worker termites communicate with special chemicals called pheromones. Students **obtained information [SEP-8]** about how termites lay down these pheromones to communicate location of food or nesting locations. Termites' antennae are able to sense these pheromones and process this information in their brains, enabling them to travel to specific locations. Mr. S asked students to draw a concept map relating the ink in the pens to the termites' brains. These **pictorial models [SEP-2]** included components representing the termites' antennae, brains, and legs; the ink; and the connections between each of these concepts (4-LS1-2).

Mr. S asked students to review their concept maps and think about environmental changes they could make that would disrupt the movements of the termites. Several of the groups mentioned that using their finger to spread the ink might confuse the termites; others suggested that drawing many more lines of ink on the paper could also confuse them since they would not know which path to follow. Mr. S then related this mini activity on paper to human activities that change the environment in ways that disrupt the senses of the animals that live there, decreasing their chances for survival and reproduction (EP&C II). He asked the students to share ideas about how loud noises in a forest might affect songbirds. The groups developed and discussed their ideas, which they then shared with the class. Some of their ideas included the following: loud noises make it so that the birds could not hear each other's songs, and loud noises scare birds away from the area.

Advanced Information Processing

Sensory input also provides the basis for much more systematic communication. Humans use sound and sight to encode messages in language and music. Our ear receives the sound and our brain decodes it. We are not unique—many animals use sound to communicate with one another to warn of predators, to attract mates, to defend their territory, and more. Animal brains, like human ones, must learn to decode complicated messages in sound and sight.

Students used cameras as a model for vision because many probably have experience with how technology used in cameras collects and stores images. The digital screen itself is a light source that sends different colors of light directly to the eyes. But how does the device store the picture inside or transmit it across the world? Most of these devices use digitized signals (i.e., information encoded as series of 0s and 1s) as a reliable way to store and transmit information. Students can simulate the information-encoding process by developing their own Morse-code system to digitize short words and transmit them to another group of students using a flashlight or a drum.

Students could even develop a system to send an image across the room. They would start by drawing simple shapes on paper with grids and then convert that image into a digitized one by darkening only the squares that contain part of the original image (figure 4.18). Students can then agree upon a system for transmitting and communicating whether or not a square is filled or empty. The digitized image is rougher and "more edgy" than the original, but it is also easier for friends across the room to perfectly reproduce the exact same image. Students also recognize that if they use smaller squares, they can send a more detailed image, but it will also take longer to transmit. This activity is also a surprising manifestation of the CCC of **structure and function [CCC-6]** in engineering where the structured pattern of signals helps convey a message.

Figure 4.18. Practice Sample of Recreating Digitized Images

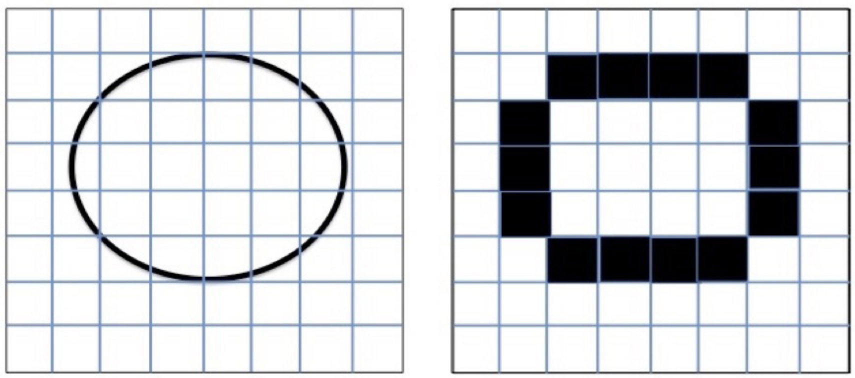


Diagram by M. d'Alessio
Long description of Figure 4.18.

Engineering Connection: Use Patterns to Communicate Information

Students can generate and compare multiple solutions that use **patterns [CCC 1]** to communicate information (4-PS4-3). For example, students can participate in a message-sending contest where each team must divide in two and send a message from one part of the team to the other part of the team around the corner of the building. An added challenge is that the message should not be recognized by any other team. Teachers remind students that they are going to use the engineering design cycle of defining the problem; identifying constraints; brainstorming to generate and compare multiple solutions that use patterns to transfer information; develop a prototype; test and refine. Teachers give them a variety of sound or light producing devices and materials to work with (e.g., mirrors). They then work in groups to develop **solutions [SEP-6]** for the problem and share their results with the class.

Opportunities for Mathematics Connections

Students encode messages using mathematical patterns as background knowledge, then relate these encoded messages to patterns in mathematics.

CA CCSSM: 4.OA.5, MP. 2, 4, 5

Sample Integration of Science and ELD Standards in the Classroom

When students are observing and explaining the phenomenon of energy transformations, they might begin by categorizing the varying forms of energy (light, sound, heat, electric current, mechanical, and chemical) and creating a list of existing examples for each, accessing experiential knowledge and language reservoirs (4-PS3-2). Ultimately, to emphasize energy transference from one place to another for the purposes of communication, students work in small groups to first construct a pictorial chart with the different forms of energy and then prepare a written report to generate, analyze, interpret, and describe multiple solutions that use patterns to transfer information (e.g., coded information through sound of drumming, Morse code, binary number encoding such as DVD and pricing tags, or simplified computer programming software/gaming) (4-PS4-3). The teacher leads students through analyzing a model for the written report, including examining key language features used in analysis and description. To support students at the Emerging and early Expanding level of English proficiency, the teacher pulls a small group and leads the students through jointly constructing the report, concentrating on the science content and vocabulary as well as the key language features studied in the model text.

CA ELD Standards: ELD.PI.4.10

Source: Lagunoff et al. 2015, 264–265

Grade Five

As the culminating grade in elementary school, the entire year draws upon patterns and understandings developed in prior grades. Students look at phenomena from previous grades from the central theme of the exchange of **energy and matter [CCC-5]** within **systems [CCC-4]**. Table 4.4 shows a possible example of how instruction can be divided into instructional segments during grade five. The year progresses through systems of different **scales [CCC-3]** from tangible systems with chemicals in plastic zip bags in IS1 up to the scale of ecosystems in IS2 and then to the interacting subsystems of the entire planet in IS3. IS4 continues along this progression in terms of scale, but instead of tracking