Grade Three

Students in grade three demonstrate grade-appropriate proficiency in **asking questions and defining problems**; **developing and using models**, **planning and carrying out investigations**, **analyzing and interpreting data**, **constructing explanations and designing solutions**, **engaging in argument from evidence**, and **obtaining, evaluating, and communicating information**. They are expected to use these practices to demonstrate deep understanding of the core ideas. Students should also be expected to use and apply grade-level appropriate mathematics and computational thinking, for example as they display data with graphs or record and analyze patterns in measurement.

Table 1 summarizes the PEs included in each instructional segment and the crosscutting concepts that students may use as a tool to make sense of the disciplinary core ideas. These instructional segments are designed to be taught in this suggested sequence over the span of a school year, not taught individually. Where appropriate, PEs that integrate science ideas with engineering design are accompanied by one of the three PEs in grades 3-5 engineering design. The PEs marked with an asterisk integrate traditional science content with engineering through a practice or disciplinary core idea.

Table 1: Instructional Segments in Grade Three

GRADE THREE			
Instructional Segment 1: Forces and Interactions	**Performance Expectations Addressed**		
	3-PS2-1, 3-PS2-2, 3-PS2-3, 3-PS2-4*, 3-5-ETS1-1		
	Highlighted SEP	**Highlighted DCI**	**Highlighted CCC**
	• Asking Questions and Defining Problems • Planning and Carrying out Investigations	PS2.A: forces and motion PS2.B: types of interactions	• Patterns • Cause & Effect
	Brief Summary		

<table>
<tr><td></td><td colspan="3">Objects (moving or stationary) have many contact and non-contact forces acting on them at any given time. The sum of these forces explains an objects behavior. If forces are balanced, an object in motion will stay in motion and an object at rest will stay at rest. In contrast, it requires an imbalance of forces to make an object start or stop moving or to change its speed or direction.</td></tr>
<tr><td rowspan="6">Instructional Segment 2: Life Cycles and Inheritance of Traits</td><td colspan="3">Performance Expectations Addressed</td></tr>
<tr><td colspan="3">3-LS1-1, 3-LS3-1, 3-LS4-2</td></tr>
<tr><td>Highlighted SEP</td><td>Highlighted DCI</td><td>Highlighted CCC</td></tr>
<tr><td>• Developing and Using Models
• Analyzing and Interpreting Data</td><td>LS1.B: Growth and Development of Organisms
LS3.A: Inheritance of Traits
LS4.B: Natural Selection</td><td>• Patterns
• Cause & Effect</td></tr>
<tr><td colspan="3">Brief Summary</td></tr>
<tr><td colspan="3">Plants and animals have unique and diverse life styles. Their structure, function, and behavior change in predictable patterns thought their life cycle. Plants and animals inherit traits from their parents and can be influenced by the environment. Reproduction is essential for the continued existence of every organism.</td></tr>
<tr><td rowspan="6">Instructional Segment 3: Ecosystems and Interdependence</td><td colspan="3">Performance Expectations Addressed</td></tr>
<tr><td colspan="3">3-LS2-1, 3-LS3-2, 3-LS4-1, 3-LS4-3, 3-LS4-4*, 3-5-ETS1-3</td></tr>
<tr><td>Highlighted SEP</td><td>Highlighted DCI</td><td>Highlighted CCC</td></tr>
<tr><td>• Analyzing and Interpreting Data
• Engaging in Argument from Evidence.</td><td>LS2.D: Social Interactions and Group Behavior
LS3.B: Variation of Traits
LS4.A: Evidence of Common Ancestry and Diversity
LS4.C: Adaptation
LS4.D: Biodiversity and Humans</td><td>• Cause & Effect
• Scale, Proportion & Quantity
• Systems & System Models</td></tr>
<tr><td colspan="3">Brief Summary</td></tr>
<tr><td colspan="3">Environmental factors influence the growth, reproduction, and survival of organisms. For any environment, some kinds of organisms survive well, some not as well, and some cannot survive. Social interactions and group behavior influence animal's success in the environment. Fossils provide evidence for plants, animals, and the nature of environments from the past.</td></tr>
<tr><td rowspan="6">Instructional Segment 4: Weather, Climate and Impacts</td><td colspan="3">Performance Expectations addressed</td></tr>
<tr><td colspan="3">3-ESS2-1, 3-ESS2-2, 3-ESS3-1, 3-5-ETS1-1, 3-5-ETS1-2</td></tr>
<tr><td>Highlighted SEP</td><td>Highlighted DCI</td><td>Highlighted CCC</td></tr>
<tr><td>• Analyzing and Interpreting Data
• Obtaining and Evaluating and Communicating Information.</td><td>ESS2.D: weather and climate
ESS3.B: natural hazards</td><td>• Patterns,
• Cause & Effect</td></tr>
<tr><td colspan="3">Brief Summary</td></tr>
<tr><td colspan="3">Climate describes a range of an area's typical weather conditions and the variations of these conditions over time. Scientists make weather predictions based on past weather patterns. Humans cannot eliminate natural hazards from natural processes but can take steps to reduce their impacts.</td></tr>
</table>

Grade Three – Instructional Segment 1: Forces and Interactions

Third grade students **ask questions**, make observations and predictions, and **plan and carry out investigations** as they explore forces, interactions, and motion. Students engage in scientific experiences with explicit links to targeted core ideas, science and engineering practices, and crosscutting concepts, to help them answer questions such as: *What makes a block glide as I push it on a table? What makes it stop? How can we predict motion on a pendulum and why does it stop? What makes a toy car slide down a ramp and then stop? How are metallic objects attracted to magnets? How can magnets be used to solve a simple design problem?* These questions necessitate student experiences with different objects, as they lay static and move across a surface as well as looking at invisible forces: gravity and magnetism.

Grade Three-Instructional Segment 1: Forces and Interactions
How do forces affect an object at rest? *How do different contact and non-contact forces affect motion?* *How can we predict changes in motion and stability?* *How do equal and unequal forces affect an object?* *How can magnets be used to solve a simple design problem?**
Crosscutting concepts: *Patterns, Cause & Effects*
Science and Engineering Practices: Asking Questions and Defining Problems; Planning and Carrying out Investigations.
Students who demonstrate understanding can: **3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.** [Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving; and balanced forces pushing on a box from both sides will not produce any motion at all.] [*Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.*]

3-PS2-2 Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. [Clarification Statement: Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, and two children on a see-saw.] [*Assessment Boundary: Assessment does not include technical terms such as period and frequency.*]

3-PS2-3 Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. [Clarification Statement: Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paperclips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships could include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force.] [*Assessment Boundary: Assessment is limited to forces produced by objects that can be manipulated by students, and electrical interactions are limited to static electricity.*]

3-PS2-4 Define a simple design problem that can be solved by applying ideas about magnets.* [Clarification Statement: Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other.]

3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. [This performance expectation does not have a clarification statement or an assessment boundary.]

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. [This performance expectation does not have a clarification statement or an assessment boundary.]

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

> Math Connection
> During the investigation on forces, students may need to measure and weigh different objects. Some students will need experience using the measurement tools. For example, students need to know that the scale should be balanced or zeroed out before beginning the measurement; to use a ruler, the end of the object being measured must line up at the zero mark on the ruler, etc.

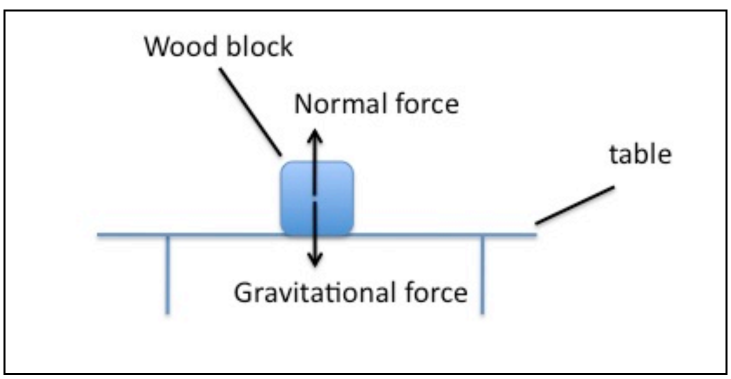
Background for Teachers

The general descriptive title of this instructional segment could be "Find the Hidden Forces." This instructional segment develops four critical ideas about forces, all of which require students to develop new ways of visualizing, **modeling**, and thinking about forces. The four critical ideas about forces are: (1) every object has many forces acting on it at every moment; (2) forces "add up," so that the overall result depends not just on one of them, but on the combination of them; (3) a force is required to make an object start or stop moving, or to change its speed or direction of motion, but that no force is needed to keep it moving at the same speed; and (4) certain properties of objects allow them to experience forces from other objects even when not touching them. It is essential as a teacher to ensure that students will engage in multiple experiences in order to recognize all forces acting on an object. This is an ideal place to discuss and offer student experiences exploring and describing ***cause and effect*** relationships and ***patterns***.

The first idea is that every object has many forces acting on it at every moment, whether or not it is moving. Helping students recognize and represent all of the multiple forces acting at the same time requires **modeling** of multiple situations for both moving and static objects. This requires students to make the forces visible such as friction or air-resistance that have no visible action. This will go against students' preconceptions that something or someone must actively create a force, or be a barrier.

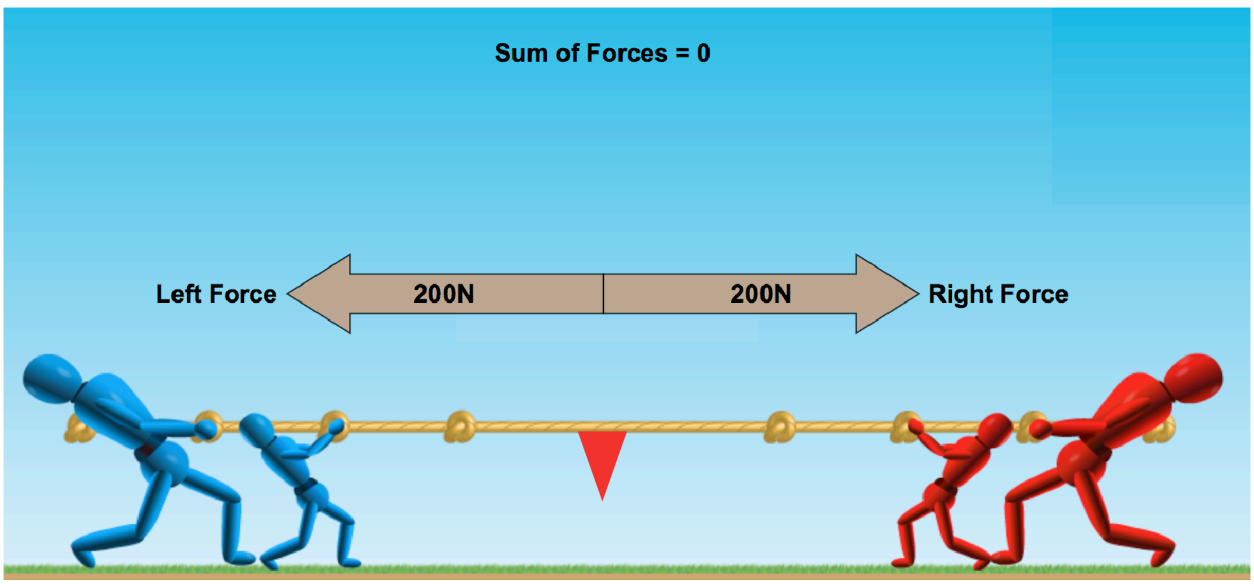
Any stationary object either on a surface (e.g. a wood block on a table), or moving across a surface, generally experiences two types of forces (see figure 1). One force is perpendicular to the surface (normal force). This is the force that holds an object above the surface, or in some cases allows it to sink in somewhat, as in the case of something sitting on foam. The other force is the gravitational force pointing towards the center of the Earth, or more simply “down”. If the object is moving across a surface and stops moving at some point, another force is present parallel to (along) the surface that opposes any motion across it. This is called a friction force. It is particularly hard for students to visualize a friction force in a static situation (such as an object sitting on a slope), so these ideas must be connected to their experiences. For instance, you might discuss with students how going down a concrete slide with just your clothes on causes you to stick to the slide. But, if you sit on a piece of cardboard you are able to move down the slide quite easily. Another example is when sandpaper pushes against wood to make the wood smooth. Having students analyze forces that they can feel or are aware (the chair holding you up, the surface stopping you on the slide) is an important way to help them notice the various types of forces that repeatedly occur in everyday situations. Once students learn to recognize the existence of these forces, they will need to develop ways of representing forces. These representations should recognize that each force on an object has both a direction and strength.

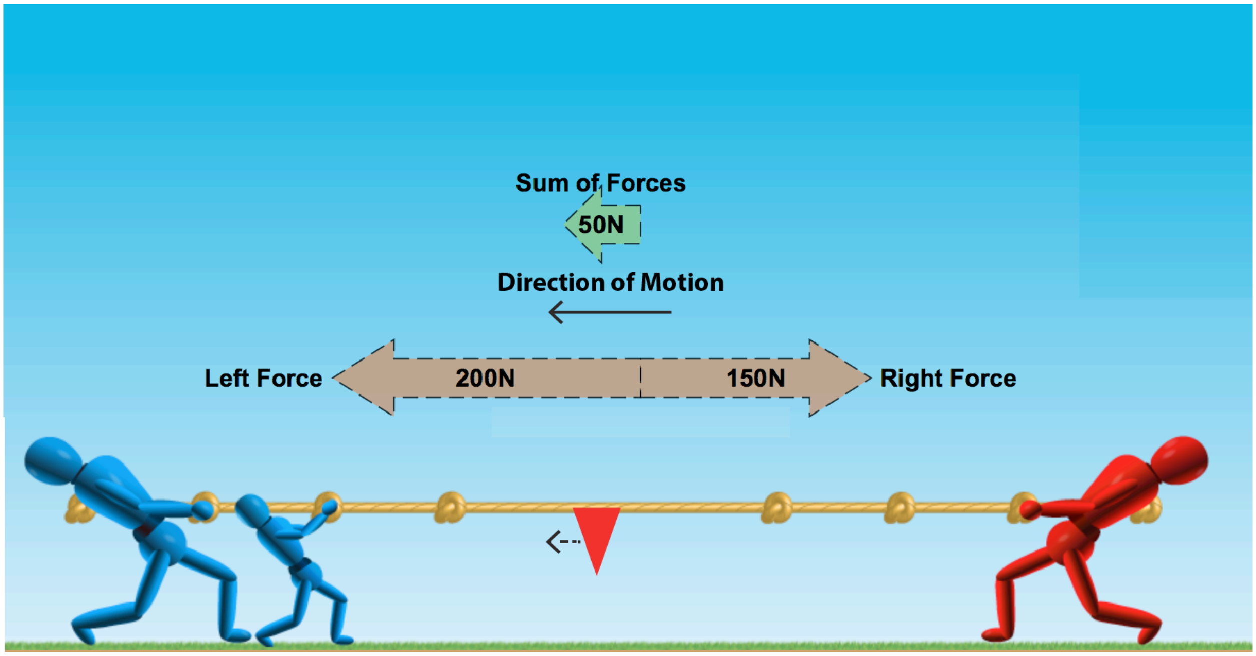
Figure 1: Diagram of the forces acting on a wooden block resting on a table.



The second big idea is that forces “add up,” so that the overall result depends not just on one of them, but on the combination of them. When something is not moving, this does not mean that there are no forces acting on it but that all the forces have balanced out so their combined effect is the same as if there were no force (net force zero). This idea needs to be developed first with forces that are being pushed or pulled in the same (or opposite) parallel directions. For example, discuss the forces on a rag tied to the center of a rope being pulled hard in opposite directions by two teams, both when the rag is held still by even pulls and when it starts to move in one or the other direction (see figure 2). Then with examples such as an object held up by three strings at different angles, where students can see that these non-aligned forces must balance out. Students can also predict and test how the object would begin to move if person cut one string. The mathematics of adding non-parallel forces is not appropriate at this grade level. The goal of the instructional segment is a conceptualization of forces and that they can balance one-another out, even when they are not all aligned.

Figure 2: Balancing forces in a tug of war in a parallel frame. (Adapted from PhET 2015a)





The third big idea is that it requires a force to make an object start or stop moving, or to change its speed or direction of motion, but that no force is needed to keep it moving at the same speed. This is counter-intuitive, because everything that can be observed seems to stop of its own accord. Students may want to visualize the invisible forces of friction to see why objects stop moving. A common pre-conception is that a force is required to keep an object in motion. In general, children think a moving object must always have some “motive force” acting on it. This instructional segment begins to develop the concept that an object with no forces (or no net force) on it (e.g., a rocket in space) continues to move at a steady speed. Part of the goal of this portion of the instructional segment is for students to develop the habit of looking for the force causing any change in motion of an object or system. In developing this part of the instructional segment, it is best to work with sliding blocks rather than wheeled cars because it is easier to correctly interpret the role of friction forces. The additional complexity of the rotational motion of the wheels and the fact that the point where the wheel is touching the ground is not moving (unless the car is skidding) is not appropriate for third grade.

The fourth idea in this instructional segment is that certain properties of objects allow them to experience forces from other objects even when not touching them. The first and most familiar example is gravity. Every object experiences a force pulling it towards the Earth, and the strength of that force is what we call the weight of the object. It is not appropriate at this grade level to try to develop a detailed understanding of the difference between mass and weight. However, teachers can introduce the term mass, and the concept that an object on the moon is pulled towards the moon by a gravitational force that is smaller [it weighs less] than it would experience on Earth. Students at this grade level can explore the effects of magnets on one another. For example, students can feel the force of two magnets attracting each other when opposite magnetic poles are facing each other. Also, students can investigate the relationship between electric currents and magnetic force by observing how an electric current moving through a wire behaves like a magnet and how a magnet moved in and out of a coil wire generates an electric current. This can be accomplished by exploring and analyzing a simple electromagnet, an electric motor, or an electric generator.

It is not immediately intuitive for students to analyze the phenomena of forces causing motion without direct contact. Not only are the forces invisible, but the electric currents are invisible as well. Hence, the activities explored in this part of the instructional segment require some way to make the current visible (a meter, a light bulb, or both). The idea that electric currents are a source of magnetic forces, and that a magnet moving in a wire loop exerts a force that can cause an electric current to flow, is the basic understanding needed to analyze how simple household devices such as an electric doorbell or can-opener work.

Engineering Connection

In order to tackle the type of design problem suggested by the last performance expectation for this instructional segment, students need to understand how to construct a simple electrical circuit with a switch and how to create an electromagnet as part of such a circuit. This requires multiple activities with building and analyzing simple electric circuits. For example, students can be challenged to design and build a circuit to turn an electromagnet on and off, so it can be used like a crane—to pick up paperclips from one pile and drop them in another pile. In activities such as this, the language of forces is not emphasized as much as using an electric circuit to create a force to achieve some effect. This reconnects this part of the instructional segment to the force-related activities that preceded it. Teachers can also add electrostatic forces as a further example of force at a distance, but it is not necessary for the development of the ideas in this instructional segment.

Description of Instructional Segment

In this instructional segment 1, students explore the concept of forces on objects as they move or are at rest. They see that an object's position is affected by a contact interaction, or a push or pull, friction, or elastic and tension forces in matter (e.g., springs or supporting structures or ropes) and non-contact interaction (electrostatic and magnetic) and that an object at rest has forces acting on it that balance each other. This is an excellent opportunity to highlight ***cause and effect relationships***. This instructional segment is divided in two parts: part 1**-** *Forces on Objects due to Contact Interactions* and part 2 **-** *Forces on Objects due to Non-Contact Interactions***.**

> ELA ELD Connection
> During the unit, age-appropriate definitions of domain-specific words and important academic vocabulary could be provided. In addition, a few words are selected critical to understanding the concept and for deeper explanation. These words can be further explained using a graphic organizer, such as the Frayer Model, that includes the definition, and students sharing specific characteristics of the word, examples, and non-examples. Selected words could include friction, gravity, forces, magnetic, interactions.

Forces on Objects due to Contact Interactions

Students **investigate** and **model** simple systems with the goal of defining and representing multiple forces that are occurring at a specific moment on a particular object within the ***system***. Students also discover the effect of an unbalanced net force on the object's motion. Students should also be encouraged to find ways to represent motion and determine if the motion is changing or not. Observations include both static situations and objects either sliding on a surface or flying through the air. (Rotational motion is avoided or not emphasized.)

Engineering Connection

Teachers might begin this instructional segment by asking their students to imagine what engineers need to know to improve the speed and steering in cars, boats, and airplanes. Students should be encouraged to use their own words to discuss the forces produced by engines and propellers that provide propulsion, as well as resisting forces (like friction and air resistance) that are needed for steering.

Since vehicles in the real world are complicated, engineers create simple **models** of the ***systems*** they need to improve. Students can do this as well, **investigating** and **modeling** the ***system*** of any vehicle with a block sliding across a variety of surfaces including some with very high friction, and others with much lower friction. At first, the teacher may tell the students to initiate the motion by giving the block a quick push. The teacher can challenge the students to devise a way to control the force that initiates the motion and to develop a way to include the unseen forces on the block in their model. The teacher may also ask the students to **model** what forces are acting on the block at the moment it is pushed and at a later moment when it is sliding and slowing down and finally when it is sitting still. Teachers may also encourage students to use ***cause and effect*** statements to explain their observations. Early student **models** may show the initiating push as the only force on the block. Teacher questions should focus on why the motion is different with the same push but different surfaces or with different directions for the initial push. This type of questioning is designed to elicit from students the idea that there is a force on the block due to friction between the block and the surface. It should also elicit that the size (or strength) of this force depends on the nature of the surface. Students revise their **model**s to include the friction force at various instants. Again, teacher questioning will be necessary to lead students to recognize that there is no pushing force when the block is freely sliding forward, only a friction force whose ***effect*** is to slow the block down. Teachers may also introduce hypothetical situations, such as the block sliding on smooth ice, or a surface with no friction at all, to build the idea that if there were no friction the block would just keep moving. The goal of these activities is to see that it takes a force to change a motion, but not to keep it going. Teacher questioning can help students make these explicit connections to ***cause and effect.***

Teachers then initiate a second round of revisions to the **model** to address questions about vertical forces. Here it is useful to add some activities that involve dropping, letting the block fall and discussing what force pulls it down. The most difficult force for students to see is the force from the table pushing up on the block. Teachers can ask questions about strategic hypothetical examples, such as a child standing on a trampoline, or a very heavy object breaking the table. Teachers can use these examples to help student visualize the counterbalancing forces of gravity and the force of the table on the block and include them in their **models** for all three situations. Again, teachers can use these experiences to help students make explicit connections to ***cause and effect*** relationships and ***patterns***.

Once the idea of balanced and unbalanced forces on an object has been developed, along with the idea that it takes an unbalanced force to change motion, students can be asked to **investigate** and/or **develop models** that include forces at particular instants for a variety of situations. A wide variety of questions can be asked such as "*What force pushes you forward when you start to walk*?" Or "*What are all the forces acting on a ladder leaning against a wall?*" Situations such as a weight suspended by three rubber bands at different angles can be used to initiate further **modeling** and analysis of forces.

Observations and/or measurements of an object's repetitive motion (e.g., a pendulum, a weight on a spring) reveals a ***pattern*** can be used to predict future motion. However, in such a motion, the forces involved are changing at each moment and thus one must **model** the ***system*** at particular moments to examine the forces at that instant and discuss how they are affecting the motion at that instant.

Students explore activities in which they change one variable of the ***system*** at a time and make observations. Students can explore variables that can cause a change in the ***system***, such as:

1) effect of the pull (angle) on a constant-weight object: students hang a weight on a string from a fixed support and look at what happens when the weight is pulled further and further from its resting position;

2) effect of varying the push on objects with the same weight: students use a simple catapult system where the object weight is constant, and they vary the amount that the catapult is drawn back;

3) effect of weight of object: students use a pulley system to lift objects of different weights;

4) effect of initial push by measuring the distance an object travels and predict and **investigate** how it changes: Students use a compressed spring to provide a push that can be systematically increased;

5) effect of opposing forces: students look at an object at rest that is experiencing different forces, such as a weight hanging from a spring, a flag in the center of a rope pulled by two teams, etc.

Figures 3, 4, and 5 below identify diagram representations of different forces on objects due to contact interactions.

Figure 3: Multiple representations of object at rest showing two forces acting on it: (1) force of gravity pulling down (weight) and (2) force of the surface it is resting on pushing up. The addition of the arrows shows balance of forces. [Images drawn by Seth Bush]

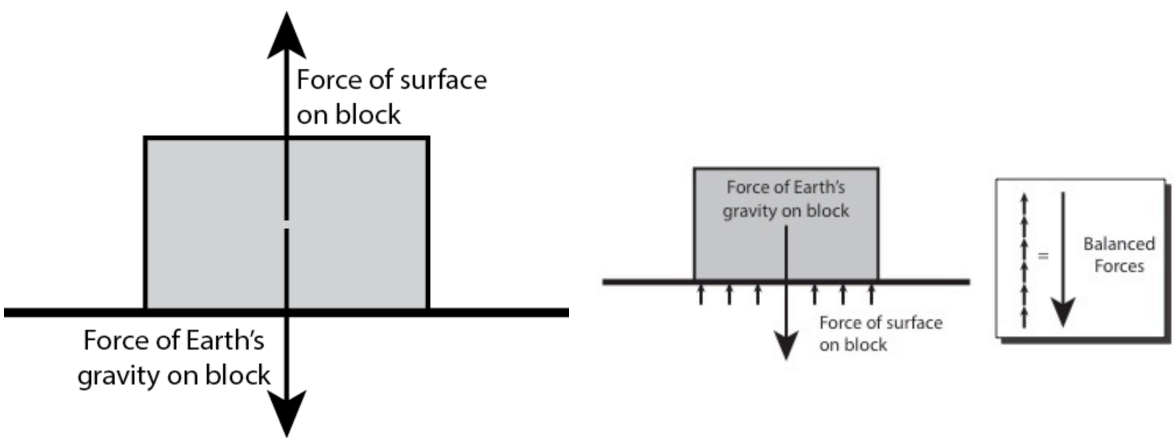


Figure 4: Student example showing forces acting on an object as it rests on a hand (Adapted from Cliparts 2015) [Original picture of hand from http://cliparts.co/cliparts/8i6/8Rx/8i68RxMKT.jpg with drawing by Emma Gragson.]

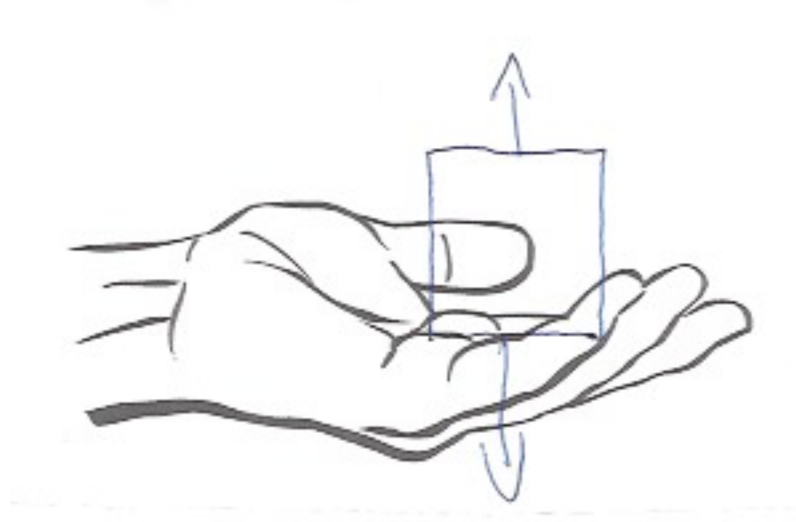
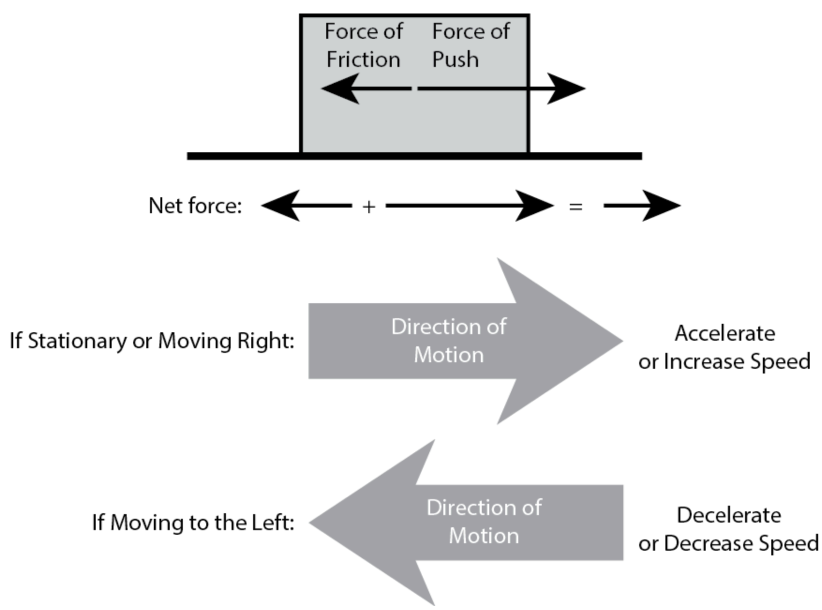


Figure 5: Diagram of an object being pulled [Image drawn by Seth Bush]



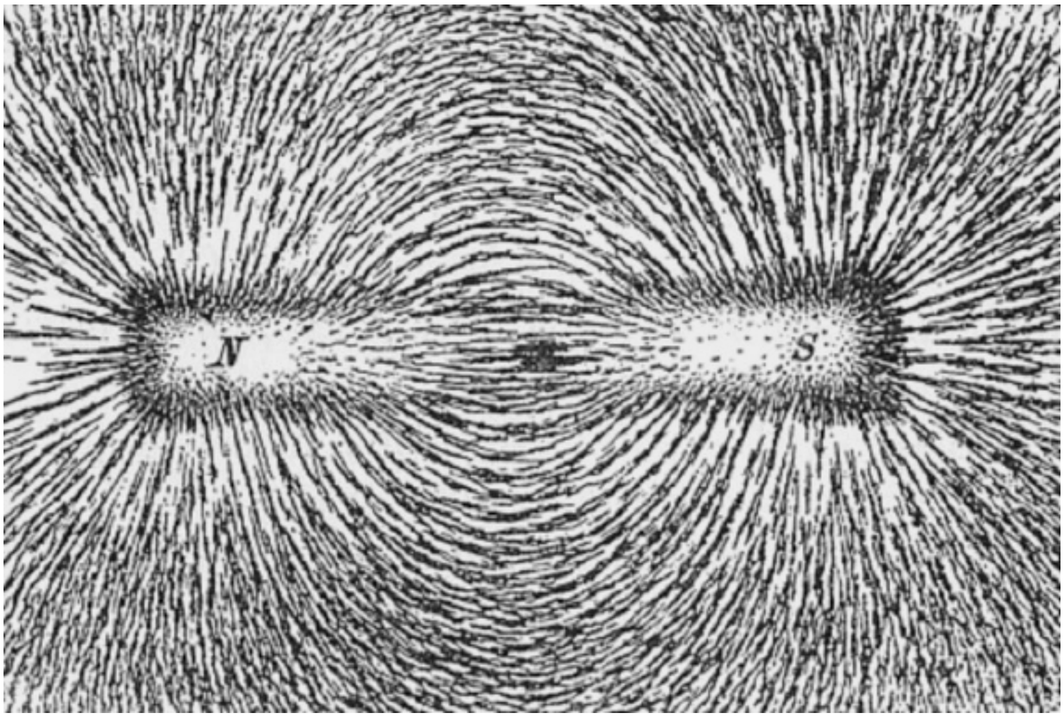
Teachers can wrap up this instructional segment by returning to some of the questions asked at the outset, about what engineers whose job it is to improve the speed and steering capabilities of cars, boats, and planes, need to know about forces.

Forces on Objects Due to Non-Contact Interactions

Students extend their concept of forces and interactions through investigations using electrostatic electricity and magnets. Electric and magnetic forces between a pair of objects do not require that the objects be in contact. Students **investigate** electrostatically charged balloons or rods acting on different materials (e.g. salt, pepper or small pieces of paper). The sizes of the forces in each situation depend on the properties of the objects and their distances apart. Students' construct diagrams to illustrate the forces acting on each of the components of the system

When students examine the forces between two magnets, they can vary the distance between the magnets and their orientation relative to each other. Students start by looking at the affect of a bar magnet on the compass, as a context for introducing the North and South poles of magnets and the idea of forces acting at a distance (non-contact forces). They can use permanent magnets to explore how poles of magnets at varying distances interact with each other. Students can **investigate** and **model** the representation of forces from one magnet on various small objects (both magnetic and non-magnetic), as well as the forces on another magnet in a variety of situations. Students can use iron filings on a sheet of paper supported above a strong dipole magnet to map out the force pattern due to the magnet (See Figure 6). Again, teachers could use these student experiences as an opportunity to highlight the central nature of ***patterns*** and ***cause and effect*** relationships.

Figure 6: Iron filings on a sheet of paper supported above a strong dipole magnet. [Magnetic field of a bar magnet figure from Wikimedia commons]



Engineering Connection

3-PS2-4: Define a simple design problem that can be solved by applying scientific ideas about magnets.

Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. In this scenario the students will design a swing using magnetic force.

Performance Task

Design a swing for your playground using magnetic force to keep the swing moving.

Materials: String, magnets, pipe cleaners, egg cartons, rubber bands, foil, metal washers, tape, one classroom chair, magnets

Directions:

Students will work in small groups to create a swing that swings as a result of using magnetic force. Each group will use one classroom chair as the base that the swing will be attached to.

This activity highlights the three-dimensional nature of the *CA NG*SS standards. It gives students an opportunity to engage in **asking question and defining problems** to demonstrate (and reinforce) their core conceptual understanding. This activity also relies on the crosscutting concepts of ***patterns*** and ***cause and effect***.

http://www.eht.k12.nj.us/STEM/Gr.%203%20-%20T2%20UBD.docx

Snapshot Grade Three:

Probing for Students' Initial Ideas on Static Electricity

Introduction

Miss M's third-grade class has just finished a series of lessons investigating the influences of contact forces acting on objects in motion and at rest. So far, their classroom experiences and discussions have focused on contact forces only.

This next preparatory lesson about non-contact forces is designed to gauge student's pre-conceptions about non-contact forces and introduce to them this new idea. They will **ask questions** to determine **cause and effect** relationships of electric or magnetic interactions between two objects not in contact with each other).

Miss M begins, "Ok everyone, take out your lab notebooks because we are going to do a probe. Remember, with probes we want you to explain your thinking. I am going to read you a story and ask you to choose who you mostly agree with AND you must support you choice with evidence or examples from your experiences." Miss M. reads the prompt and she gives her students a few minutes to respond to the questions in the probe and record their initial thinking in their notebooks.

Probe: Does It Have to Touch?

Two friends are arguing about forces. They disagree about whether something has to be touched in order for a force to act. This is what they say:

> **Akiko:** "I think two things have to touch in order to have a force between them."
> **Fern:** "I don't think two things have to touch in order to have a force between them."

Which friend do agree with most?______________

Explain your thinking. Provide examples that support your ideas about forces. ______________

____

____

Keeley and Harrington 2010.

Miss M continues, "Now turn to your thinking partner and share your choice and your thinking... remember to listen respectfully to each other even if you do not agree. If after your discussion you want to change your choice or add more evidence, go for it." She lets the thinking partners share, while she walks around the room listening to discussions and helping students to remain on task.

After ten minutes of animated discussion, Miss M returns to the front of the class, "So, let's see where we are as a group. When I say GO you'll put one finger up if you agree most with Akiko and two fingers up if you agree most with Fern. Ready, set GO!” The group is evenly split. She prompts students to find a partner that disagrees with them and repeat their thinking partner discussion, reminding them that it is ok to change ideas and that it is ok to disagree.

After another ten minutes of discussion, Miss M begins asking students for their examples and evidence and records them on the board. Supporters of Akiko’s position pointed out evidence like “a soccer ball won’t move unless I kick it” and “my book has to touch the table to have the table push on it”. Supporters of Fern’s position point out other evidence, Clara says, “If I push a ball up in the air, it is going up but then it will fall down. Nothing is touching it, but it moves down. What is that? Gravity or something? The ball isn’t touching the Earth”. Aisha also explained excitedly, “Magnets push and pull even when they don’t touch objects. I always play with magnets and metal paperclips: I make the paperclip move on top of my grandma kitchen table moving a magnet below the table. It’s like magic. The magnet does not touch the paperclip”.

Miss M then uses her student’s initial ideas to introduce types of forces that include non-contact interactions. She will help students connect these ideas with those explored in the previous instructional segment about contact forces. Miss M. says, “In the next weeks we will be learning more about interactions such as gravity, magnetism and static electricity. At the end you will be able to explain phenomena between the magnet and paperclip”.

Miss M is planning to use this initial discussion to design experiences that explore properties of magnets, how to “see” a magnetic field and map it using a compass, how distance and orientation affects magnetic forces on objects. Throughout these activities, students will develop simple drawings representing **models** of how magnets work and will plan their own **investigations** to find out about properties of magnets.

(DCI PS2.A: Forces and Motion; 3-PS2-1: Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object; 3-PS2-2: Make observations and/or measurements of an object’s motion to provide evidence that a pattern can be used to predict future motion.) She is also planning to assess students by using freely available online simulation (http://phet.colorado.edu/en/simulation/balloons).

Mrs. M shares the objectives of the snapshot with the educational support personnel in the expanded learning program at her school and discussed with them how they can reinforce the key concepts by providing additional opportunities for students to explore and investigate.

Grade Three Instructional Segment 2: Life Cycles and Inheritance of Traits

In Instructional Segment 2, students engage in scientific experiences with explicit links to targeted core ideas, science and engineering practices, and crosscutting concepts, to help them answer questions such as: *How do animals/plants grow? Do animals/plants of the same type (species) show variation? How are animal traits passed to the young? What traits can be seen in plants? In what way can variation help or hurt the chance of an organism surviving? Can all traits be passed to offspring? In what way can variation help or hurt the chance of an organism surviving? Can all traits be passed to offspring*?

Grade Three - Instructional Segment 2: Life Cycles and Inheritance of Traits
Why do organisms grow and develop? *How do organisms vary in their traits?* *How are traits inherited?* *What traits influence the organism survival?* *In what ways do inherited traits affect survival?* *What characteristics do parents pass to their young?*
Crosscutting concepts: *Patterns, Cause & Effects; Systems & System Models*
Science and Engineering Practices: *Developing and Using Models; Analyzing and Interpreting Data.*
Students who demonstrate understanding can: **3-LS1-1 Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and**

death. [Clarification Statement: Changes organisms go through during their life form a pattern.] [*Assessment Boundary: Assessment of plant life cycles is limited to those of flowering plants. Assessment does not include details of human reproduction.*]

3-LS3-1 Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms. [Clarification Statement: Patterns are the similarities and differences in traits shared between offspring and their parents or among siblings. Emphasis is on organisms other than humans.] [*Assessment Boundary: Assessment does not include genetic mechanisms of inheritance and prediction of traits. Assessment is limited to non-human examples.*]

3-LS4-2 Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. [Clarification Statement: Examples of cause and effect relationships could be plants that have larger thorns than other plants may be less likely to be eaten by predators and animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to leave offspring.]

Background for Teachers

Life cycle and life span are different. The life span is the amount of time between birth and death. The life cycle is a set of events that happen to an individual as they grow and develop. Disciplinary core idea 3-LS1-1 identifies birth, growth, reproduction, and death as the key events of the life cycles of plants and animals. While it is true that all species of plants and animals undergo these events, the timing and details can be very different between species. Here are the life cycle stages for plants:

Germination →	leaf production →	flowering →	senescence
(birth)	(growth)	(reproduction)	(death)

Some weedy plants take only a few weeks to transition from germination to flowering while others, like fruit trees, take 10 years or more to begin reproduction. Why is there such big differences in the timing of life cycle events? The advantage for the weedy plant is that quick reproduction allows it to colonize bare or disturbed soil before other plants (after a fire, at the edge of a construction site, etc.). For a fruit tree, the long period of growth prior to flowering makes it possible for the plant to produce many offspring for many years. Plant death is called “senescence” and typically involves the yellowing and wilting of leaves. Senescence is important because seeds mature and fruits ripen during this part of the life cycle. Most of the calories consumed by people around the world are from seeds and fruits.

Two plants of the same species grown in different conditions (perhaps one in a greenhouse and one in the field) will undergo the same stages in the same order but the timing can differ by months. In other words, the environment can influence the timing of the life cycle in plants. By comparison, the environment has less influence on animal life cycles. For example, low nutrition diets cause the digestive tracts of some mammals and birds to grow larger. However, a casual observer would not discern much difference between these and individuals of the same species that have a high-quality diet.

The study of inheritance is old. Ever since the first plants and animals were domesticated, people have been studying inheritance and genetics. Farmers noticed small differences (variation) between individual plants and animals. They discovered that by allowing only individuals with favorable traits to reproduce they could preserve, or even enhance, those traits in subsequent generations. Over a period of 20,000 years, selective breeding by farmers produced most of the crops we rely on today: wheat, rice, corn, cabbage, and many others. All of these crops originated from wild plants. Of course, these early farmers could not always control which traits were inherited and they did not understand the mechanism of inheritance. Nevertheless, modern crops and livestock were created by people over the centuries by means of selective breeding. While it is easy to see how selective breeding by farmers can dramatically change organisms, it is important to remember that the same process of change happens in nature. In nature, organisms compete for limited resources (sunlight, nutrients, water, prey, shelter, etc.), but the competition is not fair. Small variation between organisms allows some to compete more successfully and improve their chances of reproducing. The offspring of these successful individuals often share the attributes that made the parents successful, thus increasing their own chance of success.

Description of the Instructional Segment

In this instructional segment, Life Styles and Inheritance of Traits, students **investigate** that plants and animals have unique and diverse life cycles. The characteristic structures, functions, and behaviors of organisms change in predictable ways as they progress from birth to old age. Students are expected to develop an understanding of the similarities and differences of organisms' life cycles and that reproduction is essential to the continued existence of every kind of organism. The segment is divided into three parts: Part 1**-** Comparative Life Cycles; Part 2- Inheriting Traits: A Chip off the Block and Part 3- Variations within Species: Survival of the Fittest

Comparative Life Cycles

One way to help students engage with this material is to have them observe classroom organisms with interesting life cycles. Some organisms include the hornworm (*Mandaluca sexta*), an insect with a complete life cycle (from egg to larva to pupa to adult) or milkweed bugs (*Oncopeltus fasciatus*), an insect with an incomplete life cycle (from egg to nymph to adult). Other classroom organisms are crayfish, painted ladies, frogs and classroom plants. Students begin to **develop models** of unique and diverse life cycles, and share their own understanding. Living organisms have structures for living and moving, as well as interaction with their environment. Plants and animals kept in the classroom provide a close and personal experience for the students. Students can also record everyday observations and comparisons in a living environment like a school garden or aquarium.

As an extension of their observations and comparisons, students can conduct an **investigation** on a life cycle of a particular organism in an environment. Students can recall experiences or gather information from printed and digital sources. With the latter approach, the teacher can divide the students into groups and give them a text about a flowering plant (e.g., peas, pumpkin, orange tree, etc.) or animal (e.g., bird, horse, frog, moth, butterfly, etc.). Using information gained from the illustrations (e.g., photographs) and the text, students answer questions and refer explicitly to the text to support their answers to help them demonstrate understanding of the life cycle (e.g., where, when, why, and how development occurs). Each group of students should study material about at least one plant and at least one animal. Students then share their findings through a verbal presentation that includes diagrams with development **models** of the plant and animal. In their presentations, students describe the relationship between the development of the organisms using language that pertains to time, sequence, and ***effect***. By looking across life cycles and comparing the examples from different groups, students learn about common features and ***pattern*** of development. This can lead to a discussion about the variability of life cycles within a species and across species. This is an excellent place for teachers to again call attention to the crosscutting nature of ***patterns*** and pattern recognition. By the end of this part of the instructional segment, students demonstrate an understanding that plants and animals have unique and diverse life cycles that include being born (sprouting in plants), growing, developing into adults, reproducing, and eventually dying.

> ELA/ELD Connection
> The verbal informational presentations can be in the format of a news show, which can be recorded or videotaped. The class can be divided into pairs or triads, one student is the interviewer who interviews the other student(s) who take on the persona of the plant or animal. The roles of each student can be rotated, so all experience asking questions as well as answering them. The questions are designed to demonstrate an understanding of the life cycle (e.g., where, when, why, and how development occurs). The news report can be supported using diagrams or illustrations, either created by the students or from digital resources.

Inheriting Traits: A Chip off the Block.

Students work on activities that include information on families of common animals and plants, presented in pictures (e.g., appearance of multiple individuals) and in tables or graphs (e.g., height of seedlings at a given age). They can start by looking at one or two features that are the same or different in the family. Students can observe that families of guinea pigs have coats with different colors and patterns; that dog or cat families vary in the shape and size of ears; and the variation of color on maize samples (corn on the cob) by looking at the number of kernels and color. These activities give students the opportunity to look at inheritance of traits with an emphasis on organisms other than humans. This can provide an opportunity to highlight ***cause and effect*** in a life science context. Students analyze and report on the variation of these traits in the organism studied, distinguishing ***patterns*** of similarities and differences in the traits shared between offspring and their parents or among siblings. Students should look at examples of at least one animal and one plant.

Students in third grade acquire an understanding that organisms have different inherited traits. Offspring acquire a mix of traits from their biological parents. Different organisms vary in how they look and function because they have different inherited information. In each kind of organism, there is variation in the traits themselves, and different kinds of organisms may have different versions of the trait. Teachers must recognize and be sensitive to the fact that many of their students may not live with both biological parents or may not even know who both biological parents are. While only the biological parents contribute physical traits to a child, the adults who chose to be part of that child's life will heavily influence that child's personality and dispositions.

Variations within Species: Survival of the Fittest.

Third grade students construct an argument using **evidence** on how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. Organisms have differences depending on where they grow, or the food they consume. This causes organisms that are related to end up looking or behaving differently. Animals engage in behaviors that increase their chances for reproduction, and over generations, plants may develop specialized structures and/or depend on animal behavior to accomplish reproduction.

Students engage in activities that show how a selective factor (e.g., food supply, predation, humans) determines the survival of species. Students explore one species at a time and the lifetime of one generation. For example, students might conduct a "Battle of the Beak" activity mimicking different beaks on a type of bird (e.g., finches).They will learn about the adaptive advantage, based on beak function, by simulating birds competing for various foods (selective force). Teachers need to emphasize that even while this activity may be exaggerating some features; it is a simulation of the same species. This is another opportunity to highlight the crosscutting concept of ***cause and effect*** relationships and of ***system models***. Students begin to make the link that a particular feature can be an advantage. Over time and many generations, these advantages may produce the differences in these species that we see today. Teachers can provide students with texts (RI.3.2, 4) to investigate how animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to produce offspring. For example, albinism in rabbits may be a disadvantage when living in a forest but an asset in the artic. Other examples include polar and brown bears' survival in different environments. There are many examples of "evolution in action" such as lizard-like skinks gradually losing their legs over many generations as their habitat became drier and sandier (presumably, being snake-like provides advantages in dry sandy environments.) Examples of ***cause and effect*** relationships on survival can be highlighted and explored, for example with plants that have larger flowers than other plants may be more desirable for cultivation (selective force: humans). Students support their findings, referring explicitly to the text as the basis for the answers. Students develop the idea that "fitness" is not an absolute quality, but rather it is defined with respect to survival in a particular environment. Some insects increase their chance of survival through social behavior in which all individuals contribute but only a few reproduce. Students' explorations lead to examples of ***patterns***, ***cause and effect*** and transition to ***system and system models***.

Grade Three Instructional Segment 3: Ecosytems and Interdependence

In this instructional segment students focus on how the environment and organisms are linked together and how the organisms in the environment have changed over time using evidence that we have from the present and the past. Students engage in scientific experiences with explicit links to targeted core ideas, science and engineering practices, and crosscutting concepts, to help them answer questions such as: *How do changes in the environment affect living organisms? What do fossils tell us* *about an environment in the past? How can organisms interact in groups to benefit individuals? What happens to a plant or animal as the environment changes?*

Grade Three-Instructional Segment 3: Ecosystems and Interdependence
How does the environment affect living organisms? *How are plants, animals and environments of the past similar or different from current plants, animals and environments?* *What do the characteristics of extinct animals tell us about environment in the past?* *How do organisms interact in groups to benefit individuals?* *What happens to organisms when the environment changes?*
Crosscutting concepts: *Cause & Effect; Scale, Proportion & Quantity; Systems & System Models*
Science and Engineering Practices: *Analyzing and Interpreting Data; Engaging in Argument from Evidence.*
Students who demonstrate understanding can: **3-LS3-2 Use evidence to support the explanation that traits can be influenced by the environment.** [Clarification Statement: Examples of the environment affecting a trait could include normally tall plants grown with insufficient water are stunted, and a pet dog that is given too much food and little exercise may become overweight.] **3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.** [Clarification Statement: Examples of evidence could include needs and characteristics of the organisms and habitats involved. The organisms and their habitat make up a system in which the parts depend on each other.] 3**-LS4-1 Analyze and interpret data from fossils to provide evidence of the organism and the environments in which they lived long ago.** [Clarification Statement: Examples of data could include type, size, and distributions of fossil organisms. Examples of fossils and environments could include marine fossils found on dry land, tropical plant fossils found in

Arctic areas, and fossils of extinct organisms.] [*Assessment Boundary: Assessment does not include identification of specific fossils or present plants and animals. Assessment is limited to major fossil types and relative ages.*]

3-LS2-1 Construct an argument that some animals form groups that help members survive. [This performance expectation does not have a clarification statement or an assessment boundary.]

3-LS4-4 Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.* [Clarification Statement: Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms.] [*Assessment Boundary: Assessment is limited to a single environmental change. Assessment does not include the greenhouse effect or climate change.*]

3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost. [This performance expectation does not have a clarification statement or an assessment boundary.]

3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem. [This performance expectation does not have a clarification statement or an assessment boundary.]

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

Background for Teachers

From the previous instructional segment, it might be easy to come away with the idea that the appearance, health, and behavior of an organism are entirely a function of genes and inheritance. But of course, the environment plays a major role in determining an organism's characteristics. Plants are especially responsive to the environment. This makes sense since, unlike animals, plants cannot move to find water or escape an attack. Plants are literally *rooted* in one place. Thus, they have to change the shape of their bodies to respond to conditions. Some plants have defense mechanisms to help ensure their survival. Seedlings grown in the shade must grow very tall to reach the light. If you have ever grown plants on a classroom windowsill, where light tends to be poor, you might have seen these tall, spindly seedlings. When an insect attacks a plant, the plant may produce chemicals throughout its body parts that make it taste bad and help repel further attacks. The differences in leaf size are adaptations that have evolved to help plants maximize photosynthesis and save water. Plants take up water from the soil and most of that water travels up the plant to the leaves and then is lost to the air. Larger leaves lose water faster. In environments where there is plenty of water, leaves can be large to provide maximum surface area for photosynthesis. In dry environments, leaves tend to be small to limit water loss. The needles of pine trees are thought to have evolved both as a way to save water and help the leaves survive cold temperatures.

The environment also influences animals. Skin tans in response to ultraviolet light exposure. As salmon swim from the ocean to freshwater, their gills change. One of the most important concepts in biology is that changes in response to the environment ("acquired traits") are not passed on to offspring. Only traits encoded in genes are passed on to offspring. It is interesting to note that discoveries about genes in the last decade have begun to challenge this concept. The new science of *epigenetics* examines how the environment can induce changes to the genes of organism that in some cases have been shown to be inherited from one generation to the next.

There are limits to the effect of the environment on organisms. For example, an animal grown in low-light conditions will not develop extra eyes to help it see in the dark. Some changes that may seem to be induced by the environment are actually a result of genetics. For example, animals that live in snowy places grow white fur in the winter and brown fur in the summer for camouflage. This change is NOT induced by the environment, but is a genetic adaptation that evolved because it helps the animals survive.

Childhood obesity, a major concern today, is an extension of this topic (and could be a topic for a classroom interdisciplinary discussion of health and science). Obesity is typically a result of both genetics and environment. High-calorie and high-sugar diets have the potential to lead to weight gain and obesity. However some children, due to genetics, will gain weight more readily and have a greater chance to develop obesity than peers.

Disciplinary core idea 3-LS4-4 is closely related to 3-LS4-2 and sets the stage for understanding the concept of natural selection. In almost every ecosystem we know of, more plants and animals are born than can ultimately survive. Limitations on energy (food or light) and space (including water, nutrients, and shelter) means that plants and animals must compete to survive and reproduce. But no two organisms (even of the same species) are exactly alike. Variation between organisms is created by small differences in genes. These small differences tip the scales in favor of one organism or another, allowing that successful organism to survive and reproduce, passing on its traits onto the next generation.

This core idea focuses on constructing an **argument based on evidence**. In every ecosystem around the world, scientists are trying to find evidence that support environmental influences. There are many factors to consider, living and non-living, that determine the number of species and the number of individuals that can survive in any given ecosystem. Understanding ecosystem dynamics helps us predict how species can be affected by natural and human-made changes to an area. Changes can be physical (drought, destruction of the habitat like road construction or housing developments, etc.) or biological (introduction of a new species, reintroduction of predators, etc.).

Fossils of huge dragonflies (with bodies as long as your arm) have been discovered which date back millions of years to approximately when the dinosaurs were alive. Today, we understand how insects take in oxygen and get rid of carbon dioxide during respiration. The insect respiration system, especially the ability to deliver oxygen to muscles, is a major factor that limits how big an insect can get. Rather than having a series of blood vessels to carry oxygen, the oxygen just diffuses through the insect's tissues in what is referred to as an "open" circulatory system. We now know that the giant insects of the past evolved during a period when oxygen levels in the atmosphere were higher than today's level. As oxygen levels dropped to current levels, the largest insects became extinct and smaller species persisted.

Description of the Instructional Segment

This instructional segment on ecosystems and interdependence is divided into four parts: Part 1**-** Effects of the Environment on Organisms; Part 2**-** Evidence of Past Organisms and Environments: Fossils; Part 3- Changes to the Ecosystem and Effects; and Part 4- Group Behaviors

> ELA ELD Connection
> The Achieve the Core Web site has a link to a collection of science texts with text-dependent questions that could be used as reading materials, see http://www.readwords.org/spotlight-on-science#520. Possible related texts include "On Shaky Ground," "Back from the Brink," "Blue Bloods of the Sea," and Coral Reef Goes Digital."

Effects of the Environment on Organisms

Students start by looking at samples of local animals and/or plants and describe their observed features. They propose ideas of local areas where they came from. Engage the students by asking "*Where else can we find these organisms today?"* Students then explore using digital media that simulates current environments and organisms. Students match organisms with environments and indicate what environmental features help these organisms adapt well there. This is an opportunity to highlight the crosscutting nature of ***cause and effect*** relationships. Environments may include: tropical rainforests, salt marshes, deserts, prairies, and arctic. It would be helpful to provide realia in the classroom setting and pictures of the different types of environments. Organisms may include examples of various plants and animals, such as insects, amphibians, reptiles, birds, and mammals. This helps students start to look for evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all**.** Students could do a matching game with a partner and have them explain what type of organism live in what type of environment. This matching game could also provide photos of organisms that live in various environments to reiterate the fact that there are possibly more than one correct answer. The key to this activity is not if the answer is right or wrong but for the students to engage in arguments from the evidence in the photos.

A closer look at an environment can help students classify living and non-living factors that affect survival. The organisms and their habitat make up a ***system*** in which the parts depend on each other. The living factors include animals, plants, and molds. The non-living factors include soil, temperature, water, and light. A classroom terrarium or fish tank could help students **investigate** these factors and **model** how to measure changes over time.

The environment also affects the probability of survival of traits in a population and the way individual organisms grow and develop. Some plant and animal characteristics result from individuals' interactions with the environment, which can range from amount of water, to diet, to learned behaviors. Students look at one type of organism and feature (for example, a willow tree and its height) and search for information on how the same tree can be smaller closer to the artic than the equator (reasons: less light, and poor soil). Competition for the same resources in an environment (e.g., food, space or shelter) may favor a dominant animal, while other factors (e.g., other competitors, predators or disease) may not. Plants rely mostly on non-living environmental factors (e.g., soil, temperature, water, light) and sometimes living organisms (dispersion of seeds). Different plant features are adapted to different environments (e.g., shape and type of leaves of desert plants differ from those of river valley plants). Some organisms depend on each other for survival (e.g., clownfish and sea anemone, acacia and ants, or insects and flowers). These experiences highlight the importance of ***cause and effect*** in understanding how the environment impacts organisms.

Third graders are expected to develop an understanding of the idea that when the environment changes some organisms survive and reproduce, some move to new locations, or some die. Examples of evidence could include needs and characteristics of the organisms and habitats involved. For example, amphibians would need a moist environment. Amphibians start their life cycle in water with gills and as they age they develop lungs allowing them to survive on land.

When scientists look at plant leaves, they notice some common patterns in plant leaf shape and size that are related to the physical environment. Desert plants have smaller leaves, while rain forest plants can host leaves bigger than a child. Forests in some areas have trees with broad leaves that fall off in the winter, while trees in other areas have thin needles. Why? At the third grade, students should be able to recognize the ***patterns*** and begin to **ask questions** about why they have developed.

Evidence of past organisms and environments: fossils

Fossils are evidence of ancient life existence and they are found in layers of rock. Fossils preserve the shape of a part of an ancient organism's body that lived (or died) in this exact spot. From the previous instructional segment, students know that the shape and size of different parts of an organism can depend upon the environmental conditions. Even if the organism is long extinct and we cannot find it on Earth today, it may show evidence of the same adaptations of modern plants or animals. When students observe a fossil at one location that looks very different from the organisms that live in that spot today, they know that the environment must have changed since the ancient organism was alive (3-LS4-1).

An urban example of a fossil is where imprints of a leaf or footprints of a dog are trapped in the concrete. If available, investigate using examples of imprints left in concrete surrounding the school, a local fossil, or pictures of imprints and derive from evidence (i.e., type of animal or plant it was) and what the local community may have been like. In this case, you will probably determine that the environment has not changed much since the sidewalk concrete dried because dogs still roam the neighborhood and the same tree may still be growing beside the sidewalk. In California, scientists have discovered some fossils that are very different from the organisms that live here today. (Here is a set of images of fossils: http://education.usgs.gov/lessons/schoolyard/fossils.html). For example, the fossils of giant sea creatures are found in the hills and mountains around California, telling us that these pieces of land were once under water (e.g., a Plesiosaur fossil found near Fresno)

The UC Museum of Paleontology (http://ucmpdb.berkeley.edu/) provides a searchable database of fossils found in California counties. Other online resources include:

- http://www.fossilmuseum.net/Education.htm
- http://www.sciencekids.co.nz/pictures/dinosaurs/bones.html

Students can also cast fossils or handle fossil models to help them distinguish some features.

Changes to the Ecosystem and Effects

By this time, third graders will have examined how the environment can effect an organism and the rich history fossils provide. There are two main concepts that are the foundation for this next section: environmental conditions can effect the shape and size of organisms and fossils are a record of organisms that no longer exist but demonstrate the possible adaptations of modern plants or animals. The next concept student will examine is what happens when there are changes to the ecosystem.

To support the students in planning and carrying out investigations based on this this question of what happens when there are changes to the ecosystem. Students can visit a local garden, school-yard, or take a field trip to an aquatic environment (stream, lake, river or beach). They can look at the elements present in it and try to answer questions such as: *Where is the water coming from? What kind of plants live there? Where are man-made additions? What are elements native to the systems?* Students share their notes and place elements into a chart with man-made or natural elements. Students then read informational texts and gather evidence about how a natural habitat has changed as a result of one or more human activities (RI.3.1; W.3.7). This is an important science and engineering practice for this instructional segment: **analyzing and interpreting data**. Through a teacher led class discussion, students identify the types of environmental changes that are described in the text, such as changes in land characteristics, water distribution, temperature, soil, and plant and animal life. This helps them determine the main idea of the text—human activities have resulted in changes to the natural habitat. Students select one of the described environmental changes and make a list of the series of events they think might have caused these changes, using language that pertains to time, sequence, and ***cause and effect*** (RI.3.3.).

The teacher takes the class outside of the building to look for environmental changes on campus, in a nearby park, at a nature center, or in the local neighborhood. In these areas, students might find places where plants have been removed and replaced by pavement or bare patches of dirt, soil has been disturbed as the result of erosion by water, or litter has been piled up. Students generate measurement data by measuring disturbed and undisturbed areas using rulers. They also make a simple map of the area they studied showing the sizes of different disturbed areas. If it is not possible to take students outside, the teacher can show them before and after photographs of natural habitats where humans have disturbed the area. It may be necessary to help students identify comparable areas that show recognizable environmental changes. For example, comparing a paved playground and a nearby grassy or wooded area would allow them to observe changes in land characteristics or plant and animal life.

This instructional segment is a particularly good opportunity for helping students develop understandings of the crosscutting concepts cause ***and effect*** and ***systems and system models***. Specifically, an informative reading about environmental changes, such as those that have taken place in California's coastal wetlands, gives teachers an opportunity to lead focused discussions with students about the changes that occur as a result of human activities, and the causes and effects of those environmental changes.

Through these activities, students can continue developing their understanding of California's Environmental Principles and Concepts. In particular, this instructional segment gives them an opportunity to investigate examples related to Principle II and discover that: direct and indirect changes to natural systems due to the growth of human populations and their consumption rates; methods used to extract, harvest, transport and consume natural resources; and the expansion and operation of human communities influence the geographic extent, composition, biological diversity, and viability of natural systems.

The following vignette is an example of how teaching and learning focused on the disciplinary core ideas LS4.C Adaptation and LS4.D Biodiversity and Humans and PEs 3-LS4-3&4 Biological Evolution: Unity and Diversity might look in a third-grade classroom.

Grade Three Vignette
Living Things in Changing Environments

Introduction

The vignette presents an example of how teaching and learning may look in a third-grade classroom when the *CA NGSS* are implemented. The purpose is to illustrate how a teacher engages students in three-dimensional learning by providing them with experiences and opportunities to develop and use the science and engineering practices and the crosscutting concepts to understand the disciplinary core ideas associated with the topic in the instructional segment.

It is important to note that the vignette focuses on only a limited number of performance expectations. It should not be viewed as showing all instruction necessary to prepare students to fully achieve these performance expectations or complete the instructional segment. Neither does it indicate that the performance expectations should be taught one at a time.

The vignette uses specific classroom contexts and themes, but it is not meant to imply that this is the only way or the best way in which students are able to achieve the indicated performance expectations. Rather, the vignette highlights examples of teaching strategies, organization of the lesson structure, and possible students' responses. Also, science instruction should take into account that student understanding builds over time and that some topics or ideas require activating prior knowledge and extend that knowledge by revisiting it throughout the course of a year.

Days 1-4 – Organisms Responding to Environmental Change.

Ms. J decides to use several elements of the California EEI unit, *Living Things in Changing Environments*, as the foundation for part three of her Ecosystems and Interdependence unit. She uses the first two chapters of the leveled reader, *Sweetwater Marsh National Wildlife Refuge*, to introduce students to the marsh and the plants and animals that live there, as an example of where humans have changed the habitat. For example:

"Belding's savannah sparrows are endangered in California. They use pickleweed and other plants to make their nests. Putting their nests in tall, thick pickleweed, keeps the eggs safe from water, even at high tide."

"Belding's savannah sparrows depend on the salt marsh as their habitat. Where buildings, roads, or levees have replaced pickleweed, these sparrows have fewer places to nest. The more people and pets that disturb their habitat the fewer pairs will build nests."

After reading *Sweetwater Marsh National Wildlife Refuge*, students discussed the different species that live in this Southern California salt marsh habitat. Based on the information they gathered from the reading, the class made a mural with "before" and "after" sections where some students drew the original habitat and others showed the habitat after human activity. The students' drawings also showed plants and animals, specifically illustrating some of the organisms' needs and adaptations, for example, the plants were birds nested. They also illustrated some of the changes, for example, the addition of buildings, roads, and levees and changes to the amount of pickleweed at the marsh. This reading and mural were the basis for a discussion of how organisms respond to different environmental changes and introduced students to the idea that changes to an ecosystem can significantly affect the plants and animals that live there.

In order to reinforce the crosscutting concept about ***systems and system models***, Ms. J reminds the students that ecosystems are an example of a system. She asks them to identify the salt marsh ecosystem components on their mural. Several students also point out the birds nesting in the plants as an example of an interaction among the components of the ecosystem.

After completing their mural, Ms. J asked the students several questions about the marsh, its plants and animals, and how the habitat might change if more human-activity occurs there. She focuses the students on environmental changes by asking students to predict answers to questions like, "Which plants or animals will be affected if the water becomes saltier?" and "If the water in all of the San Diego Bay becomes muddier, what might happen?" (Eelgrass could disappear from the area.) The students make brief notes about the changes discussed during the class meeting, and based on their notes and the discussion, students identify the main idea of the reader—human activities have resulted in changes to the natural habitat.

As a formative assessment, Ms. J distributes a set of *Altering the Salt Marsh* cards to groups of students and asks them to find the card that starts with "Power plants make the temperature of the water…" She then has the groups discuss the effects of power plants on the temperature of water. Ms. J invites a student volunteer to share their groups answer to the question, "How do power plants affect the temperature of water?"

After discussing the other environmental changes described on the *Altering the Salt Marsh* cards, Ms. J creates a class list of the environmental changes on the whiteboard. This list describes the changes that have occurred at Sweetwater Marsh, including changes to the land from dredging and building of dams, changes to the temperature and salinity of the water. It also describes the resulting changes to the many plants and animals that live there, such as pickleweed, and the endangered light-footed clapper rail, California least tern, and Western snowy plover. She then asks the students to make a list of the series of events they think might have caused these environmental changes. Finally, she asks the children to re-engineer the solutions. The children generate more environmentally friendly solutions while considering what the technologies need to do (criteria) and reasonable assumptions about constraints, such as available time, materials, and money.

Day 5 – Surviving in a Changing Environment.

The day after the classroom analysis of environmental changes at Sweetwater Marsh, Ms. J took her students on a field trip to visit the campus and local neighborhood. (Note: In preparation for this activity, Ms. J identified three "comparable" areas near the school where her students could see plants and animals, and observe the effects of human activities.) Before going outside, Ms. J explained to the students that they would be going on the local field trip to make observations and collect evidence about environmental changes on campus and in the local neighborhood.

One of the things that the students observed was that there were only a few plants and animals on their school grounds. Ms. J had the students make notes about their observations in their science journals. The class then began walking down the street, making observations and taking notes as they went by the houses and apartment buildings in the neighborhood. They soon observed that some areas had green spaces with different kinds of plants and animals, and saw many birds sitting on the branches of the bushes and squirrels running through the yards. The last place they visited was a local park where they saw even more plants and animals.

As they walked back to the school and then into their classroom, Ms. J guided a student discussion of similarities and differences among the areas they visited during their “field trip.” She made a four-column list on the board labeled “Place,” “Description of Area,” “Plants We Saw,” and “Animals We Saw.” With their data recorded, Ms. J asked the students to contribute to a list of the differences in the plants, animals, and “habitat” among the campus, neighborhood, and park. The class then began a teacher-guided discussion to **analyze** the data and what might have caused these differences and the students identified a variety of human activities, such as, removing trees, making streets, paving the campus, and building houses. Once they completed their list, she asked the students to identify the **evidence** they saw during their field trip that, in a particular habitat, some organisms can survive well, some survive less well, and some cannot survive at all. Ms. J recorded the students’ **evidence** on the board.

Days 6-7 – Solving an Environmental Problem.

This field trip gave Ms. J an opportunity to call students’ attention to the crosscutting concept related to ***cause and effect***. She also leads the students through a discussion about California’s Environmental Principles and Concepts, specifically Principle II Concept c “the expansion and operation of human communities influence the geographic extent, composition, biological diversity, and viability of natural systems.”

Ms. J called the students’ attention to the class list of the environmental changes that have occurred at Sweetwater Marsh. They then read, “Restoring the Marsh,” the third chapter of the reader, to learn about some of the solutions to the problems caused by the environmental changes that occurred at Sweetwater Marsh. When they completed their reading, Ms. J led a discussion that had the students identify the solutions to the environmental changes discussed in the text and make claims about the merits of the different solutions to use as **evidence** in their arguments.

Based on what they discussed about the design solutions used at Sweetwater Marsh, the teacher asked students to select one of the environmental changes they observed during their field trip. The students were most interested in what they observed on campus, very few plants and animals. Therefore, Ms. J instructed them to write a brief informative text that **identified this problem** and described possible **solutions**, making claims about the merits of their individual ideas. Students made brief presentations about their ideas and **argued** for their proposed solutions. As a class, they decided that they wanted to implement a plan to make a small garden of native plants in an open area of the playground. Working in teams of three, students created and presented alternative designs for their native plant gardens. As a whole class, they chose the three designs they liked most. Later in the week, they went out onto the campus and used their rulers to measure the possible garden plots. They returned to the classroom and Ms. J instructed them how to use the measurements they had made to reinforce what they had learned about area and perimeter during their recent math lessons.

So that they could continue planning their gardens and refining their designs, students went to the Internet to research information about establishing a native plant garden including the cost of the plants, soil, and other supplies. With this information available, Ms. J help them estimate the number of plants they would need and calculate the cost of each of the designs they were comparing. Based on their calculations and the amount of money that Ms. J had in her garden fund, the students refined their designs to fit the space and budget they had available. The students invited their principal to visit the classroom and presented their ideas about creating a native plant garden on campus. She was so impressed with their work that she gave them permission to build the garden.

Performance Expectations		
3-LS4-3 Biological Evolution: Unity and Diversity *Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.* **3-LS4-4 Biological Evolution: Unity and Diversity** *Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.*		
Science and engineering practices	**Disciplinary core ideas**	**Cross cutting concepts**
Analyzing and Interpreting Data *Analyze and interpret data to make sense of phenomena using logical reasoning.* **Constructing Explanations and Designing Solutions** *Use evidence (e.g., observations, patterns) to construct an explanation.* **Engaging in Argument from Evidence** *Construct an argument with evidence.* *Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.*	**LS4.C Adaptation** *For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all.* **LS4.D Biodiversity and Humans** *Populations live in a variety of habitats, and change in those habitats affects the organisms living there.*	**Cause and Effect** *Cause and effect relationships are routinely identified and used to explain change.* **Systems and System Models** *A system can be described in terms of its components and their interactions.*
California's 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.* **Concept a.** *Direct and indirect changes to natural systems due to the growth of human populations and their consumption rates influence the geographic extent, composition, biological diversity, and viability of natural systems.*		

Concept b. *Methods used to extract, harvest, transport and consume natural resources influence the geographic extent, composition, biological diversity, and viability of natural systems.*

Concept c. *The expansion and operation of human communities influences the geographic extent, composition, biological diversity, and viability of natural systems.*

Connections to the CA CCSS for ELA/Literacy: RI.3.1, RI.3.2, RI.3.3, W.3.2, W.3.3

Connections to the CA CCSSM: MP.5, MP.6

Vignette Debrief

The *CA NGSS* require that students engage in science and engineering practices to develop deeper understanding of the disciplinary core ideas and crosscutting concepts. The lessons give students multiple opportunities to engage with the core ideas in life sciences (biological evolution and environmental changes), helping them to move towards mastery of the three components described in the *CA NGSS* performance expectation.

In this vignette, the teacher selected two performance expectations but in the lessons described above she only engaged students in selected portions of these PEs. Full mastery of these PEs will be achieved throughout subsequent instructional segments.

Students were engaged in a number of science practices with a focus on **analyzing and interpreting data**, **constructing explanations and designing solutions**, and **engaging in argument from evidence**.

Based on their firsthand observations in the local area, they discovered the types of plants and animals that lived near the school, collected evidence about environmental changes, and the effects of those changes on organisms. Having developed their basic knowledge about environmental changes and their effects on plants and animals, students identified an environmental change they wanted to investigate further. This ultimately led them to design, propose, and compare several possible solutions to what they had observed.

The field trip and subsequent class discussions provided a context within which the students could begin framing their developing knowledge about components and interactions in natural systems, and how what they observed related to California Environmental Principle II Concept c, regarding how “the expansion and operation of human communities influences the geographic extent, composition, biological diversity, and viability of natural systems.” In addition, these experiences offered an opportunity for students to begin developing their understanding of the crosscutting concept of ***cause and effect***.

CCSS Connections to English Language Arts and Mathematics

Students used the text in *Sweetwater Marsh National Wildlife Refuge* as the basis for describing the relationships between a series of historical events, scientific ideas, and concepts associated with the effects of human activities on the plants and animals that live in the marsh. They then identified the main ideas within the reader based on their notes, and questions and answers during a class discussion. These activities correspond to the *CA CCSS for ELA/Literacy* Reading Informational Text Standard 3 (RI.3.1, RI.3.2, RI.3.3). In addition, they reinforced their writing skills by taking brief notes from print sources and writing an informative text that identified problems in the marsh and possible solutions, corresponding to Writing Standard 3 (W.3.2, W.3.3).

While developing the designs for their native plant gardens, students were challenged to use rulers to measure possible garden plots with precision, applying the CA CCSSM Standards for Mathematical Practice 5 and 6 (MP.5, MP.6). They also calculated the costs of the alternative designs and used this information, and other considerations, to refine their designs to fit the available space and budget. Additionally, this activity reinforces what students had learned about area and perimeter during previous lessons.

MP.5 Use appropriate tools strategically.
MP.6 Attend to precision.

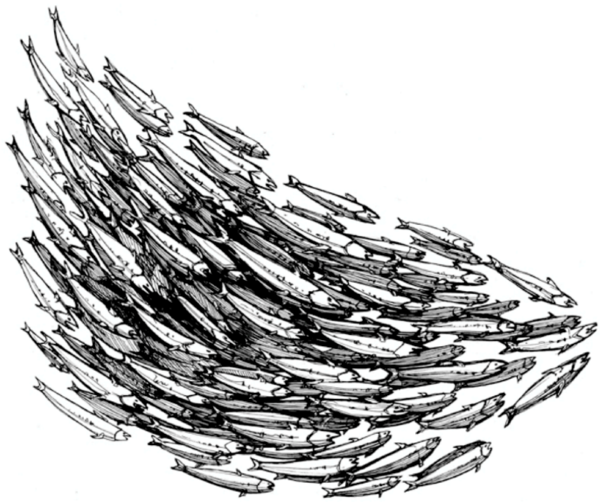
Resources for the Vignette

- California Education and the Environment Initiative. 2011. *Living Things in Changing Environments.* Sacramento: Office of Education and the Environment.

Group Behaviors and Ecosystems

Why do bees form a hive? How do penguins keep their eggs from freezing? Students in third grade collect observational data on how organisms interact in groups to benefit individuals within the group. Science experiences for third graders can include activities and games where teams complete tasks that highlight the potential individual benefits of cooperative behavior. Examples of animals in the wild, such as groups of penguins in the artic, zebras in Africa, schools of fish (see figure 7), or migrating birds, demonstrate group behaviors that benefit group interdependence. Group behaviors are found in organisms ranging from unicellular molds to ants to primates, including humans. Many species with a strong drive for social affiliation live in groups formed based on genetic relatedness, physical proximity, or other recognition mechanisms (which may be species specific). Group behavior can increase the chances of survival for individuals and their relatives. While some groups are stable over long periods of time, others are fluid, with members moving in and out. Groups change over time, for example, they may break up if their size or operation becomes counterproductive, if dominant members lose their place, or if other key members are removed from the group. Group interdependence is so strong a trait that animals that usually live in groups suffer behaviorally as well as physiologically when reared in isolation, even if all of their physical needs are met.

Figure 7: Some animals like fish may school or form aggregations for many reasons, including foraging, reproduction, and defense from predators. (Boatt Press 2015)



While examining group behaviors of animals, students can explore computer simulations. This provides a good opportunity to have students investigate **models** of a phenomena with computer simulations to help students visualize a system that shows group behaviors in ecosystems. Craig Reynolds (1987) published a paper where he explored computer simulations of flocks, herds, and schools. He was able to create a computer simulation. This computer model examined animal motion such as bird flocks and fish schools (figure 8.). Another good example is the ants and pheromones simulation from NetLogo (Figure 9 below). NetLogo is a multi-agent programmable modeling environment used by tens of thousands of students, teachers, and researchers worldwide and found at https://ccl.northwestern.edu/netlogo/.

Figure 8: This is a depiction of the simulated bird-oid object (BOID) flock avoiding cylindrical obstacles (1986)

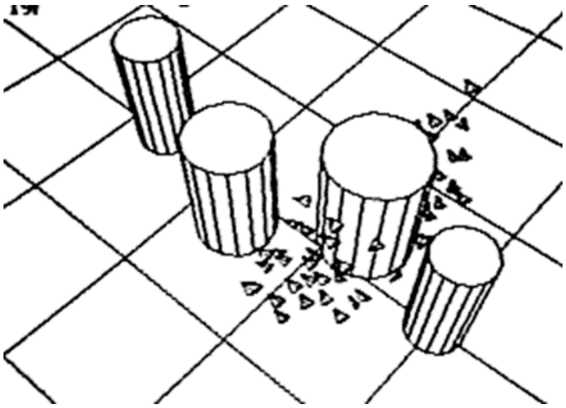
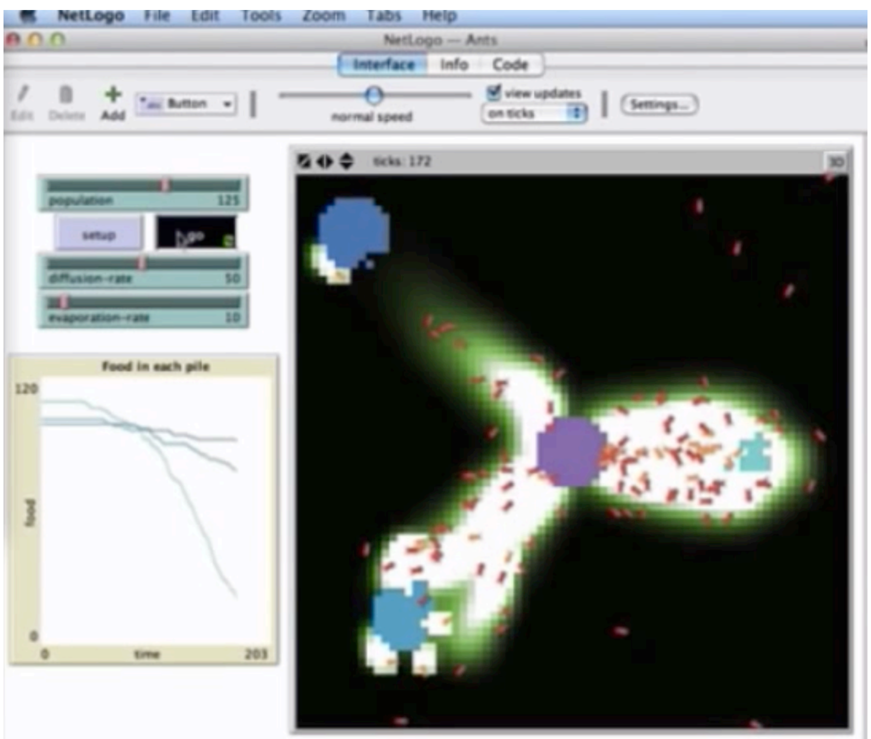


Figure 9: In this NetLogo ants computer simulation, ants (red) leave a trail of pheromones (white) that helps other ants find food (blue) around their nest (purple). This is a model of biological phenomena that helps students construct explanations using a model. (NetLogo 2015)



Grade Three – Instructional Segment 4: Weather, Climate and Impacts

Students experience weather every day of their life and have a large body of prior knowledge even in the early elementary grades. They can often describe the weather at different times of year and in different parts of the world using rich descriptions, but this instructional segment will push them to describing these conditions using numbers (***scale, proportion, and quantity***).

Grade Three-Instructional Segment 4: Weather, Climate and Impacts
What is typical weather in different parts of the world? *What is typical weather in different times of the year?* *What weather patterns are common for different seasons?* *How can the impact of weather-related hazards be reduced?**
Crosscutting concepts: *Patterns, Cause & Effects*
Science and Engineering Practices: *Analyzing and Interpreting Data; Obtaining and Evaluating and Communicating Information.*
Students who demonstrate understanding can: **3-ESS2-1 Represent data in tables and graphical displays to describe typical weather conditions during a particular season.** [Clarification Statement: Examples of data could include average temperature, precipitation, and wind direction.] [*Assessment Boundary: Assessment of graphical displays is limited to pictographs and bar graphs. Assessment does not include climate change.*] **3-ESS2-2 Obtain and combine information to describe climates in different regions of the world.** [This performance expectation does not have a clarification statement or an assessment boundary.] **3- ESS3-1 Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.** *[Clarification Statement: Examples of design solutions to weather-related hazards could include barriers to prevent flooding, wind resistant roofs, and lightning rods.]

3-5-ETS-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

[This performance expectation does not have a clarification statement or an assessment boundary.]

3-5-ETS-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

[This performance expectation does not have a clarification statement or an assessment boundary.]

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

Background for Teachers

In this instructional segment, students analyze and interpret data to describe typical weather conditions expected during a particular season and in different regions of the world. By applying their understanding of weather-related hazards, students are able to argue from evidence about the merit of a design solution that reduces the impacts of such hazards. Students are **asking questions** like: *What is typical weather in my local region? How does it compare to other areas of California? Does it change during the year? What weather patterns are common for different seasons? What weather-related hazards are in my region? How can we reduce weather-related hazards?*

Through exploration of multiple examples, students develop an understanding of the distinction between weather and climate. Weather, which varies from day to day and seasonally throughout the year, is the condition of the atmosphere at a given place and time. Even though the weather changes all the time, there are certain weather patterns that repeat each year at each spot on Earth. For example, it almost never snows in San Francisco or Los Angeles, but it does snow every year in the mountains near Lake Tahoe or Big Bear, a short drive from those cities. Snow only comes during the winter season in California's mountains, but other places on Earth like Antarctica receive snow year-round. Climate is longer term and location sensitive; it is the range of a region's weather over one year or many years. Because it depends on latitude and geography, climate varies from place to place. Weather and climate are shaped by complex interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions can drive changes that occur over multiple time ***scales***—from hours, days, weeks, and months for weather to years, decades, centuries, and beyond for climate.

Description of Instructional Segment

As part of this instructional segment on weather, climate and impacts, students can collect weather data such as temperature, precipitation, humidity, barometric pressure, and wind direction at their school site over the course of a season from publically available sources (e.g. http://www.weather.gov). Alternatively, under the SEP of **asking questions and defining problems**: (3–5-ETS1-1) Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. (3–5-ETS1-1) as an engineering extension, students could design and build a weather station to collect weather data about their school site (an example of a publically available lesson plan offered by NOAA is available at: http://oceanservice.noaa.gov/education/for_fun/BuildyourownWeatherStation.pdf). Weather data is an excellent platform to have students look for ***patterns*** and make ***cause and effect* arguments**. Further, it provides ample opportunity for students to

ELA ELD Connection
For additional background information from different sources, students can investigate the Climate Kids, NASA's Eye on the Earth, Web site at http://climatekids.nasa.gov/climate-change-meaning/ that addresses weather and climate issues. Students can also compare important points and details from different informational texts, such as *Climates* by Theresa Alberti, *The Magic School Bus and the Climate Challenge* by Joanna Cole, and *Climate Maps* by Ian F. Mahaney.

obtain, evaluate, and communicate information through graphic displays, including pictographs and bar graphs.

Moving beyond their school site, student can make further use of publicly available sources to plan and carry out investigations based on a region of the world and presents the same types of data. Students can present their findings to the group with a culminating activity including collecting and sharing students’ work across a variety of regional climates to generate a global picture of the variety of climates thus supporting the SEP of **obtaining, evaluating, and communicating information.**

From instructional segment 2, students know that the physical environment plays a major role in determining the types of plants and animals that live in a region, and climate is an excellent example of such a physical factor. As students study major climate zones, they can relate them to the types of plant life that thrives in different parts of the world (analyzing and interpreting data). Students might notice important ***patterns*** such as the banding of specific biomes at different latitudes and differences between the biomes along the coast versus the interior of some continents (including distinct bands along the coast). Each of these ***patterns*** is evidence of specific phenomenon that students will explore in middle school and they will be able to **construct explanations** based on what evidence they collected (MS-ESS2-6).

Math Connection
Measure effects of environment on the growth of seedlings.

- Effects of drought
- Soil vs. hydroponics
- Amount of sunlight hours per day

Students would make daily observations of each plan, recording height measurement, number of leaves, color, sketch or photo, etc.

The *CA NGSS* emphasize students’ ability to describe the differences between the climate characteristics of the different climate zones. However, it does not require that students know or recognize the names of any of Earth’s biomes. A focus on such terminology could distract from the real goal of honing students' ability to make observations, recognize ***patterns*** in those observations, **ask questions** about what might be ***causing*** them, and then **engage in arguments from evidence**.

Engineering Connection:

A variety of hazards results from natural weather processes (e.g., floods, coastal erosion, droughts, wind, precipitation or snow). Humans cannot eliminate natural hazards but can take steps to reduce their impacts. To reinforce this concept, teachers can ask students to design houses that can reduce the impact of different hazardous weather conditions and then test their designs. Hazardous weather conditions for this activity include heavy snow, heavy rain, drought, and high wind. Class activities could focus on weather hazards relevant to the local conditions of the region near the school, which students have experienced. Students' engineering design projects show possible solutions to a problem and are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions are compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)