Rutherford County Schools

6th Grade Science Curriculum Guide

2023-2024

Disciplinary Core Ideas

Life Science

From molecules to organisms: Structures and processes

LS1.A: Structure and function
LS1.B: Growth and development of organisms
LS1.C: Organization for matter & energy flow in organisms
LS1.D: Information processing

Ecosystems: Interactions, energy, and dynamics

LS2.A: Interdependent relationships in ecosystems
LS2.B: Cycles of matter and energy transfer in ecosystems
LS2.C: Ecosystem dynamics, functioning, and resilience
LS2.D: Social interactions and group behavior

Heredity: Inheritance and variation of traits

LS3.A: Inheritance of traits
LS3.B: Variation of traits

Biological change: Unity and diversity

LS4.A: Evidence of common ancestry
LS4.B: Natural selection
LS4.C: Adaptation
LS4.D: Biodiversity and humans

Earth & Space Science

Earth's place in the universe

ESS1.A: The universe and its stars
ESS1.B: Earth and the solar system
ESS1.C: The history of planet Earth

Earth's systems

ESS2.A: Earth materials and systems
ESS2.B: Plate tectonics and large-scale system interactions
ESS2.C: The roles of water in Earth's surface processes
ESS2.D: Weather and climate
ESS2.E: Biogeology

Earth and human activity

ESS3.A: Natural resources
ESS3.B: Natural hazards
ESS3.C: Human impacts on Earth systems
ESS3.D: Global climate change

Physical Science

Matter and its interactions

PS1.A: Structure and properties of matter
PS1.B: Chemical processes
PS1.C: Nuclear processes

Motion and stability: Forces and interactions

PS2.A: Forces, fields, and motion
PS2.B: Types of interactions
PS2.C: Stability and instability in physical systems

Energy

PS3.A: Definitions of energy
PS3.B: Conservation of energy and energy transfer
PS3.C: Relationship between energy and forces & fields
PS3.D: Energy in chemical processes and everyday life

Waves and their applications in technologies for information transfer

PS4.A: Wave properties
PS4.B: Electromagnetic radiation
PS4.C: Information technologies and instrumentation

Engineering, Technology, and the Application of Science

ETS1: Engineering design
ETS2: Links among engineering, technology, science, and society
ETS3: Applications of science

Science and Engineering Practices

Asking questions and defining problems

A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world(s) works and which can be empirically tested.

Developing and using models

A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations.

Planning and carrying out investigations

Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters.

Analyzing and interpreting data

Scientific investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results.

Using mathematics and computational thinking

In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; solving equations exactly or approximately; and recognizing, expressing, and applying quantitative relationships.

Constructing explanations and designing solutions

The end-products of science are explanations and the end-products of engineering are solutions. The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories.

Engaging in argument from evidence

Argumentation is the process by which evidence-based conclusions and solutions are reached. In science and engineering, reasoning and argument based on evidence are essential to identifying the best explanation for a natural phenomenon or the best solution to a design problem.

Obtaining, evaluating, and communicating information

Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity.

Crosscutting Concepts

Patterns

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

Cause and effect

Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.

Scale, proportion, and quantity

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

Systems and system models

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

Energy and matter

Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior.

Structure and function

The way an object is shaped or structured determines many of its properties and functions.

Stability and change

For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.

RCS Science Instructional Model

Overview

A high-quality science unit is defined as a science content storyline—the sequence of main learning goals across lessons and the sequence of science ideas within lessons. ***Thoughtful sequencing of main learning goals and science ideas along with matched activities/investigations is critical to planning coherent science content storylines for students and to the students' ability to construct the storyline for themselves and make sense of the anchoring phenomenon.***

Storyline Components

Anchoring Phenomenon: An anchoring phenomenon connects all student learning and science ideas within a unit; it is a naturally occurring event that the students are trying to make sense of throughout the unit.

Unit Learning Goal: A unit learning goal is the big science idea (disciplinary core idea—DCI) that students are expected to learn and take away from the unit; the unit learning goal shows the relationship among science ideas that can be used to explain multiple phenomena; serves to organize supporting science ideas, activities/investigations, and vocabulary; ***the unit goal is teacher facing***.

Unit Driving Question: The Unit Driving Question should be related to the anchoring phenomenon and gives students a purpose what they are learning throughout the unit; the Unit Driving Question is developed by the class by using questions from the Driving Question Board; students will work to answer this question by the end of the unit.

Unit Activities/Investigations: Keep in mind that the activities and investigations you choose to for the unit need to be ***closely matched*** to the unit learning goal and the lesson main learning goal with a focus on the 3-dimensions of the TN Academic Standards—***Disciplinary Core Ideas*** (DCIs), ***Science & Engineering Practices*** (SEPs), and ***Crosscutting Concepts*** (CCCs).

Lesson Framework

Lesson Main Learning Goal: *To identify the complete science concept you want students to learn (for teacher)*

- The lesson main learning goals has the same requirements of the unit learning goal; the lesson main learning goal also focuses attention on how the science ideas in a lesson are sequenced and linked to one another and to lesson activities/investigations to help students construct a coherent ***story*** that makes sense to them.*
  The first step in creating a coherent science content storyline in a series of lessons is to identify the main learning goal of the lesson—what big idea do you want students to learn in this lesson?***

Lesson Focus Question: *To provide a focus for the lesson that keeps attention on main learning goal (for students);* each lesson in the unit will have its own focus question that will be introduced at the beginning and highlighted throughout

- A focus question sets the purpose for the lesson (or series of lessons) by focusing students' attention on the intended learning goal for the lesson; while the main learning goal for the lesson is teacher facing, the focus question is student facing, but should closely match the main learning goal and be in a language students understand. Ideal uses of the focus question are to:
  - elicit students' initial ideas at the beginning of a lesson,
  - engage students' interest in the science content of the lesson,
  - serve as an organizer throughout the lesson, and
  - bring closure to the storyline at the end of the lesson.

Link Science Ideas: To make the science content storyline visible to students and engage students in thinking about science ideas related to the anchoring phenomenon and activities/investigations, you should:

- make explicit links between science ideas and activities (before, during, and after each activity/investigation)
- link science ideas to other science ideas
  - Before lesson: link to ideas from previous lessons
  - During lesson: as appropriate
  - End: link ideas developed during lesson and in previous lessons; foreshadow next lesson
- highlight key science ideas and focus question throughout—multiple times throughout lesson
- make key science ideas visible by keeping track of them on an Idea Tracker, a poster/chart paper that stays hanging in the classroom

Idea Tracker	
Focus Question	What we figured out…

Set-up for Activity/Investigation

- The purpose of the activity as it relates to the main learning goal and to the developing storyline.
- Set-up for the activity makes explicit links to science ideas.
- Students should be required to think or make predictions about their ideas related to the learning goal before they being the activity/investigation.

Activity/Investigation

- Activities/investigations are designed so so that it requires students to make links between the activity/investigation and the science ideas and use specific SEPs & CCCs throughout.

Follow-up to Activity/Investigation

- Follow up the activity/investigation by focusing on linking the activity with science ideas and the science content storyline.

Activities/investigations should *ALWAYS* be matched to the main learning goal and connect back to the anchoring phenomenon! There may be one or more than one activity or investigation in each lesson. If there is more than one, you will always do the set-up, activity, and follow-up for each activity or investigation and number them. For example, Set-up for Activity 1, Activity 1, and Follow-up to Activity 1. One important aspect of the activities/investigations is to provide opportunities of content representations and models matched to the learning goal.

Synthesize and Summarize: *The science content storyline needs to be tied together at the end of the lesson*

- A summary statement is one way to make connections between science ideas or between science ideas and activities/investigations addressed in the lesson and to highlight how they support the main learning goal of the lesson and the anchoring phenomenon.
- Give students the opportunity to revisit the Driving Question Board and revise their initial claim and model to help make sense of the anchoring phenomenon, as well as the class consensus model.

Day 1

The structure of Day 1 is a little different than the remaining days in the unit because it sets the stage and purpose fort the ENTIRE unit.

Lesson Main Learning Goal: *To identify the complete science concept you want students to learn (for teacher)*

- The lesson main learning goals has the same requirements of the unit learning goal; the lesson main learning goal also focuses attention on how the science ideas in a lesson are sequenced and linked to one another and to lesson activities/investigations to help students construct a coherent ***story*** that makes sense to them.*

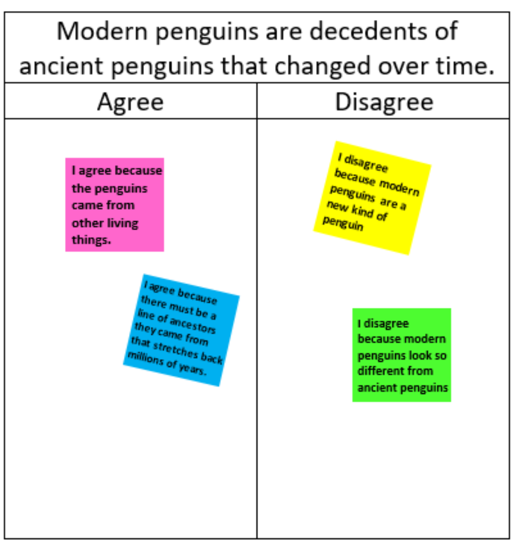
  The first step in creating a coherent science content storyline in a series of lessons is to identify the main learning goal of the lesson—**what big idea do you want students to learn in this lesson?***

Introduction:

- Introduce anchoring phenomenon
- Allow students to make observations and ask questions about the phenomenon
- In small groups, students will share their questions and develop one question for their group and record it in their notebooks; the group question and all other questions will be displayed on the Driving Question Board in clusters by similarity.

Unit Driving Question: *Here the Unit Driving Question is established instead of the lesson focus question.*

- Based on group questions, the class will develop a driving question that they will work towards answering to make sense of the phenomenon.
- Elicit student ideas about the driving question by having students develop an initial model and claim.



Set-up for Activity:

- Review the driving question.
- In small groups, have students discuss their initial models and claims and write their initial science ideas (including misconceptions) on multiple agree/disagree charts—one idea per chart.

Activity:

- Have students add sticky notes to the T-charts justifying why they agree or disagree. (Their justifications will first come from personal experience since content has not been taught yet.)
- Students can add stickies with evidence on them to the "Agree" or "Disagree" side of each claim, throughout the unit. You can use different colors of stickies for each source of evidence (e.g., Experiment-pink, Personal experience-green, Video-blue...).

Follow-up to Activity:

- Students share ideas about the claims and relate their ideas to the driving question.
- As a class, work together to develop a class consensus model, starting with the initial model students developed on their own.

Summarize/Synthesize:

- Students summarize one or more claims (science ideas) they agree with and why, as well as one or more they may disagree with and why.

Link to Next Lesson:

- Teacher links anchoring phenomenon, driving question, and science ideas/claims to next lesson.

Credits:
https://ambitiousscienceteaching.org/
https://bscs.org/

RCS 6th Grade Science Curriculum Guide

Table of Contents:

Pacing Guide: ***Essential Standards are bolded and highlighted in yellow.***

Grading Period	Standards
Q1 37 Instructional Days **Storyline** *Organ Transportation*[1] August 14-September 29	Classroom Procedures, Get-To-Know-You Activities, Introduce phenomena and the three dimensions (SEPs, CCCS, & DCIs) with a focus on Scientific Modeling
	6.PS3.1 Types and sources of energy[1]
	6.PS3.2 Transformation between potential and kinetic energy[1]
	6.PS3.3 Relationship between kinetic energy and the mass of an object in motion[1]
	6.PS3.4 Thermal energy moves through objects—radiation, conduction, convection[1]
	6.ETS1.2 Solutions that impact energy transfer[1]

Grading Period	Standards
Q2 44 Instructional Days* **Storyline** *The Town That Slowly Sank*[2] October 9-20 *Archie's First Tern*[3] October 23-December 19	6.ESS2.4 Impact of humans and other organisms on the hydrologic cycle[2]
	6.ESS2.2 Convection patterns and uneven heating of the earth[3]
	6.ESS2.1 Oceanic convection currents[3]
	6.ESS2.3 Climate and heat transfer[3]
	6.ESS2.6 Air masses, high and low-pressure systems, and frontal boundaries[3]
	6.ESS2.5 Weather data and predictions[3]

Grading Period	Standards
Q3 & Q4 49 Instructional Days* 6.LS2.4 6.LS2.2 & 6.LS2.7 6.LS2.3 January 8-31 **Storyline** *Orangutan Candy*[4] February 1-March 13 6.ESS3.1 & 6.ESS3.2 March 14-22	6.LS2.4 Biomes
	6.LS2.2 Competitive, symbiotic, and predatory interactions
	6.LS2.7 Auditory and visual methods of communication for survival
	6.LS2.3 Food webs and energy pyramids
	6.LS2.1 Impact of environmental variables on population size[4]
	6.LS2.6 Ecosystems change over time[4]
	6.LS4.1 Changes in biodiversity[4]
	6.ESS3.3 Impacts of human activities[4]
	6.LS2.5 Invasive species in TN[4]
	6.LS4.2 Maintaining biodiversity[4]
	6.ETS1.1 Evaluate design solutions for maintaining ecosystems and biodiversity[4]
	6.ESS3.1 Renewable and nonrenewable resources
	6.ESS3.2 Technology and renewable/alternative energy

Grading Period	Standards
Q4	Review Testing April 1-12 (based on preliminary TCAP dates)
	State Testing April 15-May 3 (preliminary dates)
	STEM Investigations/End-of-Year Activities

*Two instructional days were subtracted for district benchmark testing.

6.PS3.1	Analyze the properties and compare the sources of kinetic, elastic potential, gravitational potential, electric potential, chemical, and thermal energy.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

A system contains energy if some objects in the system are moving, or if the system possesses stored energy. Energy due to the motion of large objects is known as kinetic energy. Thermal energy is energy due to the total amount of motion of the particles in a material. Energy that is stored by a system is called potential energy.

Specifically, a system stores elastic potential energy when a force stretches an object that can be deformed (spring, rubber band). Gravitational potential energy is stored by a gravitational field when a force moves an object through the gravitational field (e.g., lifted upwards). Electric potential stores energy when a force moves one charged particle across the electric field produced by another charged particle. For any of the above examples, more energy is stored when the force moves the object a greater distance (e.g., stretching a spring further stores more elastic potential energy).

When different components are listed in the description of a system, the system will have different energy types. For example, a system which includes the Earth and a falling ball possess both kinetic energy and gravitational potential energy. If the Earth is not included, the system cannot contain gravitational potential energy, because that would require Earth's gravitational field.

Learning Targets - DCIs
Energy

1. A system can contain kinetic energy (energy of motion) or potential energy (stored energy); when different components are listed in the description of a system, the system will have different energy types.
2. All forms of energy can be classified as either kinetic or potential.
3. Potential energy can be categorized further into gravitational potential energy and elastic potential energy.
4. Gravitational potential energy is stored by a gravitational field when a force moves an object through the gravitational field (e.g., lifted upwards).
5. A system stores elastic potential energy when a force stretches an object that can be deformed (e.g. spring or rubber band).
6. Thermal energy is energy due to the total amount of motion of the particles in a material.
7. Electric potential energy stores energy when a force moves one charged particle across the electric field produced by another charged particle.
8. Chemical energy is the potential of a chemical substance to undergo a chemical reaction to transform into other substances (e.g. batteries, food, gasoline, etc.).

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Develop and use models to analyze and compare sources of different energy highlighting that energy in a system has various forms.
2. Construct an argument to differentiate between gravitational potential and elastic potential energy highlighting that energy is stored based on an object's position.
3. Construct an explanation of how objects have different forms of energy highlighting energy in a system.
4. Given a type of energy, develop an argument describing the source of the energy using evidence from the properties of the energy source.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:	Investigative:
• Even though organs have a short shelf life, they can be removed and transplanted to a new recipient after preserving the organ and transporting it quickly. • Energy Transfer Machines (Rube Goldberg Machine)—suggestion: turn down the volume at	• Energy transformations take place daily at school and around the house. • Trampoline gymnasts can jump 30+ feet in the air! *Funny video to use with this phenomenon. • The Drinking Bird • The Gravity Light

2:52 so students do not hear the answers to the type of energy being transferred. • The Soccet Ball generates power as you play.	• The northern lights (or aurora borealis) are caused by energy transfer.

Lesson Resources

- ***UPDATED!*** Organ Transportation Teacher Guide (storyline unit taught with organ transplant anchoring phenomenon and standards 6.PS3.1-3.4 and 6.ETS1.2)
    - Organ Transportation Folder
- Energy Transformed 1: How Energy Transforms (lesson)
- Energy Transformed 2: Toys Tell The Story (lesson)
- Energy in Systems: Where Does It Go? (lesson)
- Energy in Systems: Looking at Subsystems (lesson)
- ck-12: Trampoline Interactive Physics Simulation
    - Lesson/Investigation
    - Slow Mo Guys Diving into 1000 Mousetraps on a Trampoline (may be a good transition before the trampoline simulation)
- *Energy Transfer—Design Your Own Rube Goldberg Machine*: Design and build a Rube Goldberg machine using the Engineering Design Process to complete a task that has at least 4 energy transfers using household or recycled materials (investigation goes with Energy Transfer Machines anchoring phenomenon and 6.PS3.2).
    - "How to Make a Rube Goldberg Machine" (article)
    - Sway
- Energy Transformation Scavenger Hunt! Keep an energy transformation journal documenting the energy transformations that take place at school or at home for one day (or for the week). How many energy transformations were discovered? Which energy transformations occurred most often? Discuss the energy transformations found and specifically how energy is being transferred (investigation goes with energy transformations investigative phenomenon and 6.PS3.2).
- Energy Detectives
- Science Snacks: Over the Hill (investigation)
- TED-Ed: Where does energy come from? (video)
- Forms of Energy (video)

Textbook Connections	**Previous Standard(s)**
SE: Chapter 1 (p. 8-29) TE: Lesson Planner (p. 8A-8B; 14A-14B; 20A-20B)	4.PS3.1 Use evidence to explain the cause and effect relationship between the speed of an object and the energy of an object.

Content to Explore

energy	kinetic energy
potential energy	elastic potential energy
gravitational potential energy	electric potential energy
chemical energy	thermal energy

6.PS3.2	Construct a scientific explanation of the transformation between potential and kinetic energy.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

The role of forces:
If we see that the motion of an object is changing, we know that kinetic energy of the object is increasing or decreasing and that there must be a force causing the change to the motion of the object (5.PS2.1). Therefore, forces are ways to transfer energy to or from an object.

Potential energy can be transferred to kinetic energy when an object storing potential energy exerts a force. For example, when a person pulls back a slingshot, the force they exert on the elastic bands stores elastic potential energy (6.PS3.1). If the person releases the slingshot, the elastic potential energy stored in the bands allows the bands to exert a force on the projectile, which builds the kinetic energy of the projectile.

Transfers of kinetic energy to potential energy are also possible. For example, when we see that a ball thrown straight upwards begins to slow down as it reaches its highest height, we know that its kinetic energy is decreasing. Kinetic energy has been transferred from the ball and is becoming potential energy, stored in the Earth's gravitational field.

Learning Targets - DCIs
Energy

1. Applying forces transfer energy to and from an object.
2. When a force is exerted, there is an energy transformation taking place (consider the different forms of kinetic and potential energy, such as gravitational potential and elastic potential energy).
3. When the motion of an object is changing, kinetic energy is increasing or decreasing and there is a force causing the change to the motion of the object.
4. Potential energy can be transferred to kinetic energy when an object storing potential energy exerts a force.
5. As kinetic energy is decreasing, it is being transferred to potential energy and stored.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Use a model of a pendulum and data collected to explain how the force of gravity affects a falling object.
2. Design an investigation to demonstrate kinetic and potential energy and the factors that affect them.
3. Plan and carry out a controlled investigation with appropriate variables to explain the transformation between potential and kinetic energy highlighting that energy changes through transformations in a closed, stable system.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:

- Even though organs have a short shelf life, they can be removed and transplanted to a new recipient after preserving the organ and transporting it quickly.
- In the design of a rollercoaster, the first hill is the highest.
- Energy Transfer Machines (Rube Goldberg Machine)—suggestion: turn down the volume at 2:52 so students do not hear the answers to the type of energy being transferred.
- The northern lights (or aurora borealis) are caused by energy transfer.

Investigative:

- If I throw a ball up in the air, it slows down as it ascends, stops at its maximum height, and then speeds up as it descends back towards the ground.
- A ball dropped from 1 m will bounce up but not return to the original height.
- When you jump on a trampoline, different types of energy are present.
- Energy transformations take place daily at school and around the house.
- The Drinking Bird
- The Gravity Light

Lesson Resources

- ***UPDATED!*** Organ Transportation Teacher Guide (storyline unit taught with organ transplant anchoring phenomenon and standards 6.PS3.1-3.4 and 6.ETS1.2)
    - Organ Transportation Folder
- Lesson from TDOE: Constructing explanations and designing solutions (investigation goes with the ball drop anchoring phenomenon)
    - PhET: Energy Skate Park—Basics (simulation)
- Science Snacks: Bottle Racer (investigation)
- PhET: Virtual Pendulum Lab
- cK-12: How much energy does it take to run a roller coaster?
- Energy in a Roller Coaster Ride
- Marble Roller Coaster: Converting Potential Energy to Kinetic Energy
- NASA: Kinetic and Potential Energy (Roller Coaster)
- Investigating Kinetic and Potential Energy
- Investigating How Bouncing Balls and Roller Coasters are Related (Crosscutting Concepts)
- Pendulum Inquiry
- cK-12: Trampoline Interactive Physics Simulation (investigation to go with the trampoline anchoring phenomenon and 6.PS3.1)
- *Energy Transfer—Design Your Own Rube Goldberg Machine*: Design and build a Rube Goldberg machine using the Engineering Design Process to complete a task that has at least 4 energy transfers using household or recycled materials (investigation goes with Energy Transfer Machines anchoring phenomenon and 6.PS3.1).
    - "How to Make a Rube Goldberg Machine" (article)
    - Sway
- Energy Transformation Scavenger Hunt! Keep an energy transformation journal documenting the energy transformations that take place at school or at home for one day (or for the week). How many energy transformations were discovered? Which energy transformations occurred most often? Discuss the energy transformations found and specifically how energy is being transferred (investigation goes with energy transformations investigative phenomenon and 6.PS3.1)

Textbook Connections	Previous Standard(s)
SE: Chapter 1 (p 2-19) TE: Lesson Planner (p 8A – 8B; 14A – 14B)	4.PS3.2 Observe and explain the relationship between potential energy and kinetic energy. 3.PS3.2 Recognize that energy is present when objects move; describe the effects of energy transfer from one object to another.
Content to Explore	
kinetic energy, potential energy, energy transfer, force, elastic potential energy, gravity, gravitational potential energy	

6.PS3.3	Analyze and interpret data to show the relationship between kinetic energy and the mass of an object and its speed.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

Typically, scientists would determine the relationships between these properties using graphs. However, students in 6th grade have not yet covered the necessary graphing concepts. Instead, students can show the relationships using ratios. The ratio of change to mass to change in kinetic energy will be a constant ratio, however, the ratio of change in speed to change in kinetic energy will not be a constant ratio. In other words, if the mass of an object is doubled, the kinetic energy will also double. However, if the speed of an object doubles, the kinetic energy will more than double. If the speed doubles, the kinetic energy will increase four times. If the speed triples, the kinetic energy will increase to nine times its initial value. Students are likely to recognize this increase as squaring given (6.EE.A.1).

Learning Targets - DCIs
Energy

1. Kinetic energy is affected by changing the mass and/or speed of an object.
2. Speed has a greater effect on kinetic energy than mass.
3. Kinetic energy is proportional to the mass of the moving object and grows with the square of its speed.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Ask questions about what affects kinetic energy of an object highlighting the cause and effect relationship between kinetic energy, mass, and speed.
2. Analyze and interpret data in order to show the relationship between kinetic energy and the mass and speed of an object highlighting the relationship using proportions/ratios.
3. Create and interpret graphs describing the cause and effect relationship of kinetic energy to mass and speed of an object. Reports should explain the results and integrate visual displays within the text.
4. Write a claim explaining why the most massive object has the most speed (scale, proportion, and quantity). Make sure to also include evidence and reasoning through developing a model using arrows.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:

- Even though organs have a short shelf life, they can be removed and transplanted to a new recipient after preserving the organ and transporting it quickly.
- When an adult does a cannonball into the swimming pool, their splash is much larger than a kid's cannonball splash.
- If a full water bottle is dropped onto a fluffed-up pillow, it will make an indentation in the pillow as it comes to a stop.

Investigative:

- When a golf ball rolls across the floor and collides with another golf ball, the second ball moves.
- The water bottle that is more full (has more mass) rolls across the table faster.
- If you drop a full water bottle and an empty water bottle from the same height onto the pillow, the full bottle will leave the deeper impression.

Lesson Resources

- ***UPDATED!*** Organ Transportation Teacher Guide (storyline unit taught with organ transplant anchoring phenomenon and standards 6.PS3.1-3.4 and 6.ETS1.2)
  - Organ Transportation Folder
- Lesson from TDOE: Using mathematics and computational thinking (investigation goes with the water bottle and pillow anchoring phenomenon)
- Making a Splash (investigation goes with the cannonball anchoring phenomenon)
- Exploring the Relationship Between Potential & Kinetic Energy
- Kinetic and Potential Energy Lab + Report

Textbook Connections	Previous Standard(s)
SE: Chapter 1 (10-11) TE: Lesson Planner (p 8A – 8B)	4.PS3.3 Describe how stored energy can be converted into another form for practical use.

Content to Explore		
energy	kinetic energy	
potential energy	mechanical energy	
mass	speed	

6.PS3.4	Conduct an investigation to demonstrate the way that heat (thermal energy) moves among objects through radiation, conduction, or convection.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

In everyday language, "heat" is used to refer to thermal energy (the motion of particles) and energy transfer. Students should comprehend the difference between these two uses and understand that scientist only use the term heat when referencing energy transfer from one object to another.

The colloquial use of "heat" to describe the amount of warmth an object possesses should be abandoned, in favor of the use of "thermal energy." Thermal energy is the total energy due to the movement of particles in a substance. Thermal energy is related to temperature which can be measured using a thermometer, however thermal energy must also account for mass of the sample.

There are three specific means of heating: conduction, convection, and radiation. Radiation (infrared or visible light) can be seen as a form of heating, but is unique from conduction and convection, because it can transfer energy across empty space. Students can observe changes in thermal energy (by recording temperature) or changes in state (by observing pure substances) using any of the above methods of heating.

Learning Targets - DCIs
Energy

1. Heat is the transfer of thermal energy from one object to another by either conduction, convection, or radiation, and temperature is the measurement of the average kinetic energy of the particles in a substance—students must know the difference between the two.
2. Thermal energy is the total energy of the motion of particles (atoms) in an object, and these particles move differently in solids, liquids, and gases.
3. Thermal energy always moves from a warmer object to a colder one.
4. Thermal energy can be observed by recording temperature and observing changes in states of matter.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Plan and conduct an investigation in order to demonstrate the ways thermal energy transfers between objects by conduction, convection, and radiation highlighting the effects of energy moving through a system.
2. Design a device and conduct a procedure where energy can move among objects through radiation, conduction, or convection. Devices should release and absorb thermal energy in a controlled measurable way.
3. Construct a claim using evidence to support which method of thermal energy transfer is present in a real-world example.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:

- Even though organs have a short shelf life, they can be removed and transplanted to a new recipient after preserving the organ and transporting it quickly.
- Snow Shadow (search for Snow Shadow): After an overnight snow shower, most of the snow has melted from the parking lot in the picture. The remaining snow seems to match the shape of a shadow cast by an adjacent building.
- It is warmer upstairs than downstairs.
- Metal in the oven can burn you, but the air doesn't.

Investigative:

- Food coloring moves differently in hot water than cold water.
- Engineering Problems:
  - The handle on some frying pans get extremely hot when cooking food.
  - A cup or mug does not always keep hot beverages hot and cold beverages cold.
  - Some windows do not keep the house cooler in the summer and warmer in the winter.
- When heat transfers through convection, it generates currents.
- The Drinking Bird
- A solar oven allows you to cook food using the sun's heat.

Lesson Resources

- ***UPDATED!*** Organ Transportation Teacher Guide (storyline unit taught with organ transplant anchoring phenomenon and standards 6.PS3.1-3.4 and 6.ETS1.2)
  - Organ Transportation Folder
- Lesson from TDOE: Planning and carrying out investigations (investigation goes with hot/cold water anchoring phenomenon)
- Dye in Motion (investigation goes with the hot/cold water anchoring phenomenon)
- Engineering Challenges: (these challenges go with the investigative engineering problems)
  - Design a safer handle for a frying pan.
  - Design ways to improve a mug so it keeps hot beverages hot and cold beverages cold.
  - Design windows so they keep the house cooler in the summer and warmer in the winter.
- Modeling conduction, convection, and radiation
- Heat Transfer—Conduction, Convection, Radiation (video)
- Conduction, Convection, Radiation: Investigating Heat Transfers (5E lesson)
- cK-12: How can metal in the oven burn you, but the air doesn't? (investigation goes with anchoring phenomenon)
- Energy Change (GRC lesson goes with hot pack investigative phenomenon)
  - Engineering Challenge: Design, construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.
- TED-Ed: Where does energy come from? (video)

Textbook Connections	Previous Standard(s)
SE: Chapter 2 (p 32-55) TE: Lesson Planner (p 38A – 38B; 42A – 42B; 46A – 46B)	*Did not find any specific parallels to heat transfer in lower grade levels.*

Content to Explore

heat (thermal energy)	conduction
convection	radiation
temperature	kinetic energy

6.LS2.1	Evaluate and communicate the impact of environmental variables on population size.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

Organisms have needs for similar resources: food, water, and habitat. The abundance of a particular resource can have an impact an individual organism. So, by extension, the abundance of that resource may also impact the population as a whole. Students should be exposed to multiple sources and types of data on populations (e.g. size, reproductive rates, and growth information over time). Students should use their evaluations of both individual organisms and populations as functions of a particular environmental variable to communicate whether observed patterns indicate causation or merely correlation.

Increasing population sizes result in increased competition for these resources. An ecosystem will increase in size until it reaches its carrying capacity. Examples may include a population of antelope decreasing because of a drought and then the lion population decreasing also as a result. Another example could include the relationship between deer and wolf populations: When the deer population increases, the wolf population will increase until it causes the deer population to decrease, which in turn causes the wolf population to decrease, and the cycle continues. Each of these variables dictates the niche of the organism, for example, the wolf is the carnivore and tertiary consumer in its ecosystem.

Learning Targets - DCIs
Ecosystems: Interactions, Energy, and Dynamics

1. All organisms have the need for similar resources (food, water, shelter), and the availability of these resources can impact an individual organism and/or a population.
2. Increasing population size can create competition for resources which may affect multiple different populations.
3. A population will increase until it reaches carrying capacity.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Evaluate organisms and populations as functions of environmental variables to communicate observed patterns that indicate causation or correlation.
2. Analyze data in a model to determine factors (resources) affecting population changes.
3. Construct an explanation to describe the cause and effect relationship between populations and carrying capacity.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:
- Buying candy in the United States could lead to the death of orangutans in Indonesia.
- Sea Otters (keystone species) affect kelp populations.
- The number of mollusks in Hilo, Hawaii changes when the quantity of algae changes.
- Predators exist in natural ecosystems without killing all of the species lower on the food chain; however, predators are typically not put into aquariums because they would kill all of the species lower on the food chain.

Investigative:
- A new predator can cause devastating effects on the food web.
- Drought tolerant plants: Certain types of plants survive in harsh conditions due to their adaptations.
- Canada geese migrate north at different times each Spring.
- Northern right whales migrate each Spring up the eastern coast of the United States.
- Engineering Problems:
    - Sediment buildup in streams, reservoirs, and lakes degrades the quality of water for drinking, wildlife, and the surrounding land.
    - After a heavy rain, stormwater runoff over parking lots and other hard surfaces can collect pollutants and travel directly into bodies of water contaminating local waterways.

Lesson Resources

- ***UPDATED!*** Orangutan Candy Teacher Guide (storyline unit taught with buying candy anchoring phenomenon and standards 6.LS2.1, 2.5, 2.6, 4.1, 4.2, 6.ESS3.3, & 6.ETS1.1)
  - Orangutan Candy folder with student journal, PowerPoints, and other resources
- A Slug's Life (investigation goes with the mollusk anchoring phenomenon)
- Population Growth Patterns: Carrying Capacity
- Population Growth Limits: Graphing Population Growth
- Population Dynamics: Carrying Capacity and Limiting Factors (video)
- Population Growth Limits (Real World): Flooded Forest
- Oh Deer!
- Engineering Challenges: (these challenges go with the investigative engineering problems)
  - Design a system to reduce sediment buildup in streams, reservoirs, and lakes
  - Design a system that reduces the effects of runoff over parking lots and other hard surfaces during heavy rain.
- Population and Limiting Factors Lab
- Deer Population in Colorado (Formative Assessment—Data Analysis)

Textbook Connections	Previous Standard(s)
SE: Chapter 3 (p 56- 75) TE: Lesson Planner (p 62A – 62B; 68A – 68B) Scenario-based Invest.: Fantasy Food Chain: Pg. 13 Scenario-based Invest.: Mealworm Migration-pg.50 **Content to Explore** population; population size; causation; correlation; carrying capacity; ecosystem; niche	4.LS2.5 Analyze and interpret data about changes (land characteristics, water distribution, temperature, food, and other organisms) in the environment and describe what mechanisms organisms can use to affect their ability to survive and reproduce. 2.LS2.1 Develop and use models to compare how animals depend on their surroundings and other living things to meet their needs in the places they live. 2.LS2.2 Predict what happens to animals when the environment changes (temperature, cutting down trees, wildfires, pollution, salinity, drought, land preservation).

6.LS2.2	Determine the impact of competitive, symbiotic, and predatory interactions in an ecosystem.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

Population sizes are influenced by the interactions of organisms within the ecosystem. Predators can decrease population sizes, while mutualistic relationships create a sort of interdependence where the two populations within a community move in tandem. Changes in one population may result in changes to different populations.

Students should be familiar with several basic patterns for interactions between organisms: competitive, symbiotic (mutualistic) and predatory. These general patterns for interactions are not limited to specific ecosystems; they are observable in many different ecosystems. Specific examples might be used to support the idea that mutually beneficial relationships between two species might occur when resources are scarce but be less common when resources are abundant.

(The focus should be on relationships within a food web of an ecosystem and the recognition of types of symbiosis, not on specific examples.)

Learning Targets - DCIs
Ecosystems: Interactions, Energy, and Dynamics

1. Population size is influenced by competitive, symbiotic and predatory interactions within an ecosystem.
2. Changes in one population may result in changes to a different population. Cause and effect relationships occur within food webs of an ecosystem due to interactions between organisms.
3. Patterns of interactions are not limited to specific ecosystems and include competition, mutualism, and predation.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Use mathematical data to explain how interactions in an ecosystem influence population. (Cause and effect)
2. Construct explanations to show interdependent relationships in ecosystems highlighting the patterns that explain the cause and effect relationship between organisms.
3. Synthesize evidence and make connections to phenomenon to identify patterns of interactions within an ecosystem.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:	Investigative:
• Snakes can help farmers by saving their seedlings. • The monarch butterfly population decreased by 90% over the past 20 years.	• A group of whales work with one another, and their environment, in order to capture food (video) • The stunning sea slugs steal 'weapons' from their ingested hydroid prey. • Whales Give Dolphins a Lift • Slime Cannon Attack—How Velvet Worm slime jets work • The duck-billed platypus—an Australian mammal—hunts prey by detecting their electric fields.

Lesson Resources

- Lesson from TDOE: Engaging in argument from evidence
- Unit from TDOE: Communications: Survival Strategies of Populations (taught with standards 6.LS2.7 and 6.ETS1.1)
- Symbiosis Stations
- Symbiosis Videos:
  - "Goliath Grouper at Cleaning Station #1" (mutualism)
  - "Lion vs Hyenas" (competition)
  - "How the mosquito sucks human blood" (parasitism)
  - "Golden frog and a Bromeliad (commensalism)

- Iguana chased by killer snakes (predation)
- Exploring Symbiosis
- Symbiotic Strategies
- Grain, Mice, and Snakes (performance assessment that goes with the snakes anchoring phenomenon)
- Monarch Butterfly Real World Data Analysis (performance assessment that goes with the monarch butterfly anchoring phenomenon)
- Amoeba Sisters—Ecological Relationships (video)
- Ecological Relationships—Competition—Predator and Prey—Symbiosis (video)

Textbook Connections	Previous Standard(s)
SE: Chapter 3 (p 76-87) TE: Lesson Planner (p 76A – 76B) Scenario-based Investigation: That Can't Possibly Work! pg. 22	2.LS2.1 Develop and use models to compare how animals depend on their surroundings and other living things to meet their needs in the places they live.

Content to Explore

symbiosis	mutualism
competition	parasitism
predator	prey
predation	commensalism

6.LS2.3	Draw conclusions about the transfer of energy through a food web and energy pyramid in an ecosystem.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

Students should be able to consider the transfer of energy between three groups: producers, consumers, and decomposers. Transfer of energy into an ecosystem by consumers is accompanied by transfer of matter. Sources for matter (water, air) include non-living parts of the ecosystem. Energy radiated by the sun is captured by plants and used to combine matter to store chemical energy (food). Inputs of matter into the ecosystem accompany the Sun's energy capture. Consumers combine the food with oxygen, permitting the use of the stored energy and matter for growth. Throughout its lifetime, an organism will use, on average, 90 percent of the energy it consumes. Ultimately, this 90% of energy is released back into the environment as heat. The remaining 10% can be passed along to further consumers or decomposers.

The flow of energy and the flow of matter within the ecosystem are entirely connected, yet we see matter cycle between living and non-living components of the ecosystem, while energy flows into, out of, and within ecosystems.

(Emphasis for energy flow should be placed on the 10% rule and how energy is transferred to the environment as heat and approximately 10% of potential energy is passed to the next trophic level.)

Learning Targets - DCIs
Ecosystems: Interactions, Energy, and Dynamics

1. The transfer of energy is accomplished by the transfer of matter, and the source of energy is the sun and that energy is passed from consumers to producers to decomposers.
2. The flow of energy and flow of matter in an ecosystem are connected.
3. Matter cycles between living and non-living components in an ecosystem, and only 10% of energy can be passed on to consumers and decomposers.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Create models demonstrating that energy begins with the sun and moves through all roles and levels in an ecosystem.
2. Use models to demonstrate how energy transfers and cycles in an ecosystem highlighting that energy changes through transformation in the system.
3. Develop an explanation of how matter cycles between organism and the abiotic factors in an ecosystem.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:	Investigative:
• Material in the buffalo dung cycles to the wolves in Lamar Valley of Yellowstone National Park. • Lions are known for eating antelope, but lions will eventually become food for antelope.	• Oceanic feeding frenzy, in which predators interact to obtain food (energy), is a food web in action. • Biosphere 2 was created in the 1990's to model all the elements of Biosphere 1 (The Earth). • Larva farming can help reduce food waste

Lesson Resources

- Cycling of Matter & Energy Flow—Eating for Energy (lab investigation)
- Ecology Lab (lessons, simulation, and data table)
- Yellowstone Park—Dung to Dot (performance assessment goes with buffalo dung anchoring phenomenon)
- The Circle of Life (investigation goes with the lions and antelope anchoring phenomenon)
- Building an Energy Pyramid
- Ecosystems: Food Pyramid (cK-12 interactive)
- Trophic Levels (cK-12 interactive)
- Popcorn Relay Race
- Food Chain Game
- Biodomes Engineering Design Project (investigation goes with the Biosphere 2 investigative phenomenon)

- Got Energy? Spinning a Food Web
- Weaving the Web
- Amoeba Sisters—Food Webs and Energy Pyramids: Bedrocks of Biodiversity (video)

Textbook Connections	Previous Standard(s)
SE: Chapter 4 (p 102- 111) TE: Lesson Planner (p 102A – 102B)	4.LS2.2: Develop models of terrestrial and aquatic food chains to describe the movement of energy among producers, herbivores, carnivores, omnivores, and decomposers. 4.LS2.3: Using information about the roles of organisms (producers, consumers, decomposers), evaluate how those roles in food chains are interconnected in a food web, and communicate how the organisms are continuously able to meet their needs in a stable food web.
Content to Explore	
consumer, decomposer ecosystem, energy energy pyramid, food web food chain, trophic level producer, primary consumer secondary consumer, tertiary consumer	

6.LS2.4	Using evidence from climate data, draw conclusions about the patterns of abiotic and biotic factors in different biomes, specifically the tundra, taiga, deciduous forest, desert, grasslands, rainforest, marine, and freshwater ecosystems.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

Ecosystems can be seen as "organisms" with specific needs for energy similar to individual organisms. Just as organisms have identifiable characteristics, so too do ecosystems. Ecosystems are identifiable by both physical and biological components. This standard allows students to look at various regions on Earth and observe that similar combinations of biotic and abiotic factors persist and that these allow the classification of ecosystems into certain types. Emphasis is the connection between living and non-living factors in ecosystem stability: temperature and pattern of global ocean and wind currents, the temperature of the air that is blown onto land, and then the causation of climate to dictate the type of abiotic factors.

For example, the tundra has a lot of ice and permafrost because it is in the northern Hemisphere, does not receive direct sunlight so the water currents and resulting wind currents are cold, which causes a cold climate. Only biotic factors adapted to those abiotic factors can survive in that biome.

Learning Targets - DCIs
Ecosystems: Interactions, Energy, and Dynamics

1. Ecosystems have identifiable needs and characteristics, both physical and biological components.
2. Various regions on Earth have persistent combinations of biotic and abiotic factors, which allow the classification of ecosystems into certain types.
3. Biotic factors must adapt to the abiotic factors in the ecosystem to survive.
4. There is a connection between living and non-living factors in ecosystem stability—temperature and pattern of global ocean and wind currents result in the temperature of the air blown onto the land, causing a specific climate, which dictates specific types of abiotic factors in the biome.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Obtain, evaluate, and communicate information about Earth's major biomes—tundra, taiga, deciduous forest, desert, grasslands, rainforest, marine, freshwater—looking for patterns between the biotic and abiotic factors.
2. Develop a model (concept map) to show the cause and effect relationship between climate and the biotic and abiotic factors, highlighting the adaptations of the organisms in each biome.
3. Analyze climate data from graphs to find patterns in temperature and precipitation to predict biomes related to a phenomenon.
4. Construct an argument using evidence to support a claim about an identified biome related to a phenomenon highlighting the patterns in data.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:	Investigative:
• A zoo houses different organisms from all over the world, and all of the places where the organisms live are different. • The Global Seed Vault is frozen in a mountain deep inside the Arctic. It was designed to protect the world's seeds from any global disaster and ensure that humans would have a food supply forever. Now, warming temperatures are putting the vault and the seeds inside it in danger.	• Bears in certain climates go into hibernation. • Lizards that live on the dunes of the Sahara Desert of Africa and lizards living in the Painted Desert of America look different and are different colors. However, both have webbed feet and can move quickly over loose sand. • Sahara Resurrection Plant • Feedback loops in ecological systems create regular patterns—wide-ranging negative feedbacks keep positive feedbacks in check; a particular ecosystem functions within its unique habitat to create a specific, trademark interaction between biotic and abiotic factors.

Lesson Resources
• 6.LS2.4 Unit (unit goes with the zoo anchoring phenomenon) • Project Zootopia • Biome Quest Student Lab Sheet • Mission: Biomes • cK-12: Biomes • Study Jams: Biomes (video) • To Plant or Not to Plant (performance assessment)

Textbook Connections	Previous Standard(s)
SE: Chapter 4 (p 112—129) TE: Lesson Planner (p 112A – 112B; 122A – 122B) **Content to Explore** biotic factors, abiotic factors, climate, biome, adaptation	4.LS2.2 Develop models of terrestrial and aquatic food chains to describe the movement of energy among producers, herbivores, carnivores, omnivores, and decomposers. 4.LS2.3 Using information about the roles of organisms (producers, consumers, decomposers), evaluate how those roles in food chains are interconnected in a food web, and communicate how the organisms are continuously able to meet their needs in a stable food web.

6.LS2.5	Analyze existing evidence about the effect of a specific invasive species on native populations in Tennessee and design a solution to mitigate its impact.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

In 6.LS4.1, students discuss biodiversity. Invasive species that take hold in an ecosystem often outcompete native species in an ecosystem. In doing so, this single species may fill the niche of a variety of organisms, thereby decreasing the overall biodiversity of an ecosystem and reducing the availability of natural resources to native species.

Student solutions should take into account characteristics of both physical and biological components and the relationships between the components in the Tennessee specific ecosystem. For example, kudzu and native plant species compete for shared habitat resources and may incorporation of matter into the ecosystem if herbivores that feed on kudzu are not present.

Tennessee-specific examples may include kudzu, Tree of Heaven, fire ants, Africanized bees, and zebra mussels. Solution may impact both native and invasive species. Firewood transport ban for various counties is a good example.

("Devices" as written in the science and engineering practice refers to a management strategy for the invasive species.)

Learning Targets - DCIs
Ecosystems: Interactions, Energy, and Dynamics

1. Invasive species often outcompete native species in an ecosystem.
2. This competition reduces the resources available to native species and decreases the biodiversity of an ecosystem.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Obtain, evaluate, and communicate information to show the impact of a specific invasive species on native Tennessee populations highlighting the cause and effect relationship between native and invasive species.
2. Design a plan to mitigate the impact of invasive species on native species in an ecosystem.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:	Investigative:
• Buying candy in the United States could lead to the death of orangutans in Indonesia. • Zebra mussels are an invasive species that have been spreading up the Tennessee River system, causing economic and ecological damage.	• *Wisteria* sinensis, an invasive vine that can be found throughout the eastern U.S., including Rutherford County in Tennessee, can cause harm to wildland species.

Lesson Resources

- ***UPDATED!*** Orangutan Candy Teacher Guide (storyline unit taught with buying candy anchoring phenomenon and standards 6.LS2.1, 2.5, 2.6, 4.1, 4.2, 6.ESS3.3, & 6.ETS1.1)
  - Orangutan Candy folder with student journal, PowerPoints, and other resources
- Lessons from TDOE: Asking questions and defining problems
- Zebra Mussels (unit with 6.ETS1.1)
- Introduction to Invasive Species
- Classroom Takeover!
- Develop a solution for either removing Wisteria or a plan for creating a better environment for wildland species with Wisteria still living in the area (investigation goes with the Wisteria investigative phenomenon)
- Invasive Species in TN (website)
- Invasive Species in TN Fact Sheets (website)

Textbook Connections	Previous Standard(s)
SE: Chapter 5 (p 142- 156- most specifically on p 147) TE: Lesson Planner (p 144A – 144B; 150A – 150B)	4.LS2.4: Develop and use models to determine the effects of introducing a species to or removing a species from an ecosystem and how either one can damage the balance of an ecosystem.
Content to Explore	
invasive species native species biodiversity	

6.LS2.6	Research the ways in which an ecosystem has changed over time in response to changes in physical conditions, population balances, human interactions, and natural catastrophes.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

This standard can be considered a large umbrella. Standard 6.LS2.5 fits under this umbrella and lists a number of more specific types of impacts on ecosystems.

As part of their research, students should look for ecosystems that have undergone changes either environmental (natural hazards, human impacts, precipitation changes) or changes in the organisms found in the ecosystem (species introduction or removal) and the magnitude of these changes. Students should also then research impacts to the populations of organisms in the ecosystem and whether or not changes that can be seen in established populations might be caused by the change to the ecosystem, or if the two events are merely coincidental.

External agents will cause changes (even in healthy ecosystems), but a resilient ecosystem will stabilize. Examples may include the change in the world's oceans, changes in climate over time or an increase in human populations. Students can plan and carry out research to model this process.

Learning Targets - DCIs
Ecosystems: Interactions, Energy, and Dynamics

1. Ecosystems undergo environmental changes such as natural hazards, human impacts, and climate changes, and these changes effect organisms.
2. External agents cause change to an ecosystem but resilient ecosystems will stabilize.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Obtain, evaluate, and communicate information to show how an ecosystem has changed over time in response to changes in physical conditions, population balances, human interactions, and natural catastrophes highlighting that ecosystems can become unstable.
2. Engage in an argument about how climate change (or any other event) affects biodiversity.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:

- Buying candy in the United States could lead to the death of orangutans in Indonesia.
- The presence of Keystone Species in a habitat determines the number and types of species in that habitat.
- When the wolves of Yellowstone were missing and then later reintroduced there was an impact on the environment.
- Wolves had a positive impact on the changing landscape of Yellowstone in many different interconnected ways.

Investigative:

- Wildlife corridors maintain connectivity between fragmented habitats and the role it plays in the conservation of the species that depend on these corridors.
- Nature can be used as a tool to restore ecosystems.
- Mangroves can help mitigate the effects of climate change.
- Polar Bears Eat Goose Eggs: New eating habits in warmer climates

Lesson Resources

- ***UPDATED!*** Orangutan Candy Teacher Guide (storyline unit taught with buying candy anchoring phenomenon and standards 6.LS2.1, 2.5, 2.6, 4.1, 4.2, 6.ESS3.3, & 6.ETS1.1)
    - Orangutan Candy folder with student journal, PowerPoints, and other resources
- Google Earth: Exploring Earth's Keystone Species (investigation goes with the Keystone Species anchoring phenomenon)
- Wolves of Yellowstone (unit goes with wolves of Yellowstone anchoring phenomenon and taught with standards 6.LS4.1, 6.LS4.2, and 6.ETS1.1)
- Why is biodiversity so important?
- How do living things change their environments?

<table>
<tr><th>Textbook Connections</th><th>Previous Standard(s)</th></tr>
<tr><td>SE: Chapter 5 (p 142-159)
TE: Lesson Planner (p 144A – 144B; 150A – 150B)</td><td rowspan="3">2.LS2.2: Predict what happens to animals when the environment changes (temperature, cutting down trees, wildfires, pollution, salinity, drought, land preservation).
4.LS2.5: Analyze and interpret data about changes (land characteristics, water distribution, temperature, food, and other organisms) in the environment and describe what mechanisms organisms can use to affect their ability to survive and reproduce.</td></tr>
<tr><th>Content to Explore</th></tr>
<tr><td>ecosystem   population
Keystone Species   biodiversity</td></tr>
</table>

6.LS2.7	Compare and contrast auditory and visual methods of communication among organisms in relation to survival strategies of a population.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

Students should ask questions and postulate about the advantages and disadvantages of group sociality in animal populations. Since humans do not have the ability to comprehend the language of other species, we must infer then support the purpose for various forms of communication in other species. When we observe unique behaviors in animals, we search for an explanation for the purpose of that behavior.

Groups of organisms cease to exist if the group no longer provides a benefit to its individuals. Students may begin to draw conclusions about survival and reproduction based on observed communications. Examples include communication in social animals such as meerkats in the presence of different predators and how that can impact individual survival. Other examples include the predatory communication of group hunters such as the spotted hyena, African Hunting Dogs, and Orcas. Plant communication may include pheromones.

Learning Targets - DCIs
Ecosystems: Interactions, Energy, and Dynamics

1. Living organisms (animals and plants) in populations communicate in various ways for a unique purpose for the organism's or population's benefit.
2. Auditory and visual methods of communication are often used for reproduction and as a survival mechanism including predatory communications.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Obtain information about a non-verbal communication (structure/function) in a group or colony of organism and communicate to classmates how the organisms communicate, what they are communicating, and the impacts of the communication within a system.
2. Ask questions to explain social interactions and group behavior in relation to survival in an ecosystem.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:	Investigative:
• Animals have different forms of communication for specific survival strategies. • Birds make different noises (vocalizations) and certain behaviors accompany these vocalizations.	• Hawaiian crickets go silent • Animals use different ways of "talking" with one another.

Lesson Resources

- Animal Sounds (unit goes with animal communication anchoring phenomenon)
- Unit from TDOE: Communications: Survival Strategies of Populations (taught with standards 6.LS2.2 and 6.ETS1.1; unit goes with bird anchoring phenomenon)
- Data Nuggets: How the cricket lost its song, Part I (investigation goes with the Hawaiian crickets investigative phenomenon)
- Data Nuggets: How the cricket lost its song, Part II (investigation goes with the Hawaiian crickets investigative phenomenon)
- Auditory Communication
- Visual Communication

Textbook Connections	Previous Standard(s)
SE: Chapter 3 (p 76-79) TE: Lesson Planner (p 76A – 76B)	3.LS2.1: Construct an argument to explain why some animals benefit from forming groups. 3.LS4.2: Infer that plant and animal adaptations help them survive in land and aquatic biomes.
Content to Explore	
auditory communication visual communication	

6.LS4.1	Explain how changes in biodiversity would impact ecosystem stability and natural resources.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

Biodiversity can both increase and decrease. Increases in biodiversity occur when new species of organisms emerge, but the loss of a species decreases biodiversity. Healthy ecosystems exist in a state of dynamic equilibrium. In this state, ecosystems are able to recover from disturbances.

The level of biodiversity in an ecosystem is an indicator of the health of an ecosystem. Low levels of biodiversity amplify the effects of disturbances, as the effect on a single species may spread across several niches.
Biodiversity also includes the observation of a variety of characteristics within a single population or species to promote the survival of that species. To model the effects of biodiversity in an ecosystem, consider two food webs of varying biodiversity, and consider the effects of the removal of one of the species within this food web.
Examples may include the loss of potentially medicinal plants in the rainforest, a shortage of potable water, ecosystems with population extinctions, and overfishing causing a decrease in the ability for human consumption of ocean species.

Learning Targets - DCIs
Biological Change: Unity and Diversity

1. Biodiversity increases when new species emerge and decrease when species are lost.
2. Healthy ecosystems exist in a state of dynamic equilibrium and can recover from disturbances; the level of biodiversity indicates the health of an ecosystem
3. Biodiversity includes the observation of a variety of characteristics within a single population or species to promote the survival of that species (genetic biodiversity)

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Analyze and interpret two food webs of varying biodiversity highlighting the effects of the removal of one species in the system (cause and effect).
2. Engage in an argument to show how changes in biodiversity would impact ecosystems and cause the system to become unstable.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:	Investigative:
• Buying candy in the United States could lead to the death of orangutans in Indonesia. • When the wolves of Yellowstone were missing and then later reintroduced there was an impact on the environment. • Loss of biodiversity impacts ecosystems. • Over 99% of all species that ever existed are extinct today.	• In some parts of Hawaii, nonnative grasses have been planted for cattle feed, replacing some of the native rainforest plants, which has decreased the biodiversity in these areas. • Forests in New Mexico were damaged by severe weather causing a decline in Mexican spotted owls, which resulted in an increase in populations of primary consumers in the area.

Lesson Resources

- ***UPDATED!*** Orangutan Candy Teacher Guide (storyline unit taught with buying candy anchoring phenomenon and standards 6.LS2.1, 2.5, 2.6, 4.1, 4.2, 6.ESS3.3, & 6.ETS1.1)
  - Orangutan Candy folder with student journal, PowerPoints, and other resources
- Wolves of Yellowstone (unit goes with wolves of Yellowstone anchoring phenomenon and taught with standards 6.LS2.7, 6.LS4.2, and 6.ETS1.1)
- Why is biodiversity so important?
- Biodiversity and Ecosystem Stability
- Biodiversity (video)

Textbook Connections	Previous Standard(s)
SE: Chapter 5 (p 150-159) TE: Lesson Planner (p 150A – 150B) Scenario-based Invest.: Fantasy Zoo- Pg. 55	3.LS4.3: Explain how changes to an environment's biodiversity influence human resources.
Content to Explore	
biodiversity food web	

6.LS4.2	Design a possible solution for maintaining biodiversity of ecosystems while still providing necessary human resources without disrupting environmental equilibrium.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

The living world provides humans with many materials they need, and humans can dramatically reshape the land and interactions between living systems to meet those needs. Patterns in human development have typically been negative with consequences (e.g., overpopulation, overuse of resources, destruction of habitat, pollution). Thoughtful consideration is needed if humans are to reduce their impacts.

Many of these negative consequences feed into a subsequent loss of biodiversity that can then have negative impacts for humans. Natural resources that can be threatened by disturbing environmental equilibrium include food, energy, and medicines as well as the loss of services provided by ecosystems including water purification and recycling of nutrients by decomposers.

Learning Targets - DCIs
Biological Change: Unity and Diversity

1. The world provides humans with the materials they need.
2. Humans can reshape the land and interactions between living systems to meet those needs usually negative with consequences.
3. Human impacts lead to loss in biodiversity and threaten resources including food, energy, water purification, recycling of nutrients, and medicines.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Engage in an argument to show possible solutions for maintaining biodiversity of ecosystems showing that ecosystems can become unstable.
2. Design a possible solution for maintaining biodiversity in the tropical rain forest while still providing humans with the resources they need (energy in a system).
3. Define problems and evaluate design constraints to show possible solutions for maintaining ecosystems and biodiversity highlighting that ecosystems can become unstable.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:

- Buying candy in the United States could lead to the death of orangutans in Indonesia.
- When the wolves of Yellowstone were missing and then later reintroduced there was an impact on the environment.
- Human agriculture has resulted in a loss of biodiversity, which has negative impacts for humans.
- Nearly one-third of the world's amphibians species are on the verge of extinction, which is bad for the well-being of humans.

Investigative:

- Farming practices have decreased the supply of bananas, resulting in possible extinction.
- Dams that provide hydroelectric power and recreation to the Pacific Northwest block the normal migration of salmon upstream to spawn. A "salmon cannon" has been created to solve the problem of salmon migration.

Lesson Resources

- ***UPDATED!*** Orangutan Candy Teacher Guide (storyline unit taught with buying candy anchoring phenomenon and standards 6.LS2.1, 2.5, 2.6, 4.1, 4.2, 6.ESS3.3, & 6.ETS1.1)
  - Orangutan Candy folder with student journal, PowerPoints, and other resources
- Wolves of Yellowstone (unit goes with wolves of Yellowstone anchoring phenomenon and taught with standards 6.LS2.7, 6.LS4.1, and 6.ETS1.1)
- Design ways to return biodiversity to regions that are dominated by human agriculture, and at the same time improve the success of farms (investigation goes with the human agriculture anchoring phenomenon).
- Biodiversity guide/lessons

- Biodiversity and Human Well-Being
- Human impacts on Biodiversity (video)
- Saving the World—One Ecosystem at a Time (investigation)
- What future is there for global diversity?
- Human Impact on Biodiversity (5E lesson)
- Seaside City (performance task/assessment)
    - Scoring rubric

<table>
<tr><th colspan="2">Textbook Connections</th><th>Previous Standard(s)</th></tr>
<tr><td colspan="2">SE: Chapter 5 (p 150-159) and Chapter 10 (p 350-393)
TE: Lesson Planner (p 150A – 150B; 350A – 350B; 356A – 356B; 362A – 362B; 368A – 368B; 376A – 376B; 386A – 386B)</td><td rowspan="3">3.LS4.3 Explain how changes to an environment's biodiversity influence human resources.</td></tr>
<tr><th colspan="2">Content to Explore</th></tr>
<tr><td>ecosystem
food web
criteria</td><td>biodiversity
global diversity
constraints</td></tr>
</table>

6.ESS2.1	Gather evidence to justify that oceanic convection currents are caused by the sun's transfer of heat energy and differences in salt concentration leading to global water movement.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

Students should be able to use evidence to create models for how oceanic convection currents originate. Such a model should include not only the sun's warming of equatorial waters, but also the impact ice at the poles causing water to descend.

The primary factors influencing ocean currents are unequal heating of the earth's surface, differences in energy transfer to land vs ocean, and density-related behaviors of heated or cooled water. Demonstrations of the temperature-based behavior can be performed by heating one side of a water-filled baking dish and cooling the opposite side. If the water is initially allowed to settle, drops of food coloring will trace out the convection patterns which develop. Pipets can be used to insert the food coloring into the lower currents. Demonstration of the effect of salt on creating a sinking mass of water can be accomplished by partially filling a large container with water then covering the surface of the water with plastic wrap and pouring an additional volume of salt-containing, colored water onto the wrap. With the gentle removal of the plastic wrap, the mixing will be visible. Reversing the order that the waters are added will provide the opposite effect.

(From third grade, students will have developed understandings of mass and volume; however, the topic of density will need to be explored to fully support 6.ESS2.1 and 6.ESS2.2. Calculations of density are beyond the scope of this standard.)

Learning Targets - DCIs
Earth's Systems

1. Radiation from the sun impacts ocean water movement by convection.
2. The sun heats water at the equator more directly that at the poles due to the tilt of earth.
3. Salt concentration impacts water density and ocean movement.
4. Ice at the poles causes water to descend and become saltier (dense).
5. Energy transfers to and from land more easily than to and from water (specific heat).
6. Density causes water to sink or rise.
7. Temperatures and salinity affect waters density.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Obtain and communicate information describing the cause and effect relationship between ocean currents and temperature and density.
2. Create a model demonstrating how oceanic convection currents originate and the patterns they form.
3. Engage in argument from evidence to justify that ocean currents are caused by the sun's heat and salinity and demonstrate changes in water movement when temperature and salinity change.
4. Plan an investigation demonstrating how temperature effects water movement.
5. Construct an explanation describing how the investigation will generate relevant patterns that occur between the sun's heating and the movement of ocean water.
6. Develop and communicate a scientific explanation for how density and temperature are the major drivers of global water movement. (patterns, cause and effect).

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:	Investigative:

• Arctic Terns have a life span of 30 years and within their lifetime, Arctic Terns migrate 1.8 million miles—equal to three trips to the moon and back.
• A ship travelling from Hong Kong encountered a severe storm, causing its cargo of over 28,000 rubber ducks to be lost at sea. Rubber ducks were
	• The Earth is not heated evenly.
	• The East Australia Current (EAC) plays a critical role in transporting turtles between habitats across the southern Pacific Ocean.
	  ○ Video
	  ○ Article

discovered several months later in Alaska. Over the years, rubber ducks were found all over the world.
  ◦ Video
  ◦ Article
• The world's largest landfill is located in the middle of the Pacific Ocean.*
World map for phenomenon model
	• Convection currents are created by a circular pattern caused by uneven heating of the sun.
	• A massive chunk of ice, extending far below the water's surface, detaches from a glacier and is launched 200ft (61m) into the air!
	This is due to its lower density compared to seawater.
	• The more salt in water, the denser the water will be, and it will sink.
	• When water freezes into ice it floats.
	• Sailboats are pushed across the lake by wind.
	• Water in a lake forms waves when the wind blows.

Lesson Resources

- ***NEW!*** Archie's First Tern Teacher Guide (storyline unit taught with Arctic Tern anchoring phenomenon and standards 6.ESS2.1-2.3, 6.ESS2.5-2.6)
  - Archie's First Tern folder with student journal, PowerPoints, and other resources
- Ocean Currents and Convection Currents (unit goes with the landfill anchoring phenomenon and taught with 6.ESS2.2 and 6.ESS2.4)
- Interactive Surface Currents Map
- Convection Currents Demo (video)
- Science Snacks: Convection Currents (investigation)
- Science Snacks: Eyedropper Hydrometer (investigation)
- Science Snacks: Inverted Bottles (investigation)
- Science Snacks: Convection Detection (investigation)
- Ducky Data (performance assessment that goes with the rubber ducks investigative phenomenon)
- TED-Ed: How do ocean currents work? (video)

Textbook Connections	Previous Standard(s)
SE: Chapter 7 (p 242-247) TE: Lesson Planner (p 144A – 144B; 150A – 150B)	**Content to Explore** (see below)
Content to Explore	**Did not find any specific parallels to heat transfer in lower grade levels.* **Did not find any specific parallels to standard in lower grade levels.* 3rd grade students learn about volume and mass but need more instruction about density.
convection — convection currents oceanic convection currents — density salinity — temperature	

6.ESS2.2	Diagram convection patterns that flow due to uneven heating of the earth.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

Models for which demonstrate convection patterns should incorporate the Sun, Earth (rotating), ocean, and land. The relationships between these components also make it possible to explain patterns in the distribution of climate types and resulting biomes (6.LS2.4).

A model for heating of the Earth shows more direct heating of the earth's equator relative to the poles creating two large convection cells which move ascend at the equator and descend at the poles north and south poles. The Coriolis force, due to the Earth's spin breaks the two convection cells into a total of six cells, three in the southern hemisphere and three in the norther hemisphere.

This breakup (Coriolis effect) can be modeled by a pair of students using a marker and a large sphere. If the sphere is stationary, a student can use a marker to draw a straight line from the equator to the poles. If the ball is rotated while drawing this same straight line, the resulting line drawn on the sphere will curve. Rate of rotation determines the severity of the curvature, Earth's rate of spin results in three cells, with deserts focused at latitudes near 30 degrees and 60 degrees north and south, and predictable surface winds.

(Memorization of the names of specific global winds and layers of the atmosphere are beyond the scope of this standard.)

Learning Targets - DCIs
Earth's Systems

1. Convection in the atmosphere relies on conduction and radiation from the sun to produce air movement.
2. Atmospheric convection patterns that flow are due to the uneven heating of the Earth cause 2 large convection cells to form.
3. Convection cells in Earth's atmosphere cause high and low-pressure belts at Earth's Surface.
4. Coriolis Effect is the apparent curving of air due to the earth rotation. This causes the large cells in each hemisphere to divide into smaller cells in each hemisphere.
5. Temperature and density change atmospheric convection patterns.
6. Earth's rate of spin results in three cells, with deserts focused at latitudes near 30 degrees and 60 degrees north and south, and predictable surface winds.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Construct an explanation about how convection currents cause wind formation.
2. Create a model illustrating how the sun's uneven heating causes convection cells in Earth's atmosphere and creates global winds
3. Model how wind forms, sources of energy that cause atmospheric movement, why air moves, how convection cells affect wind, and the Coriolis effect through explanations and illustrations.
4. Students will develop models to show convection patterns and how they flow due to uneven heating from the sun highlighting that heat energy drives the movement of matter in the system.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:

- Arctic Terns have a life span of 30 years and within their lifetime, Arctic Terns migrate 1.8 million miles—equal to three trips to the moon and back.
- A ship travelling from Hong Kong encountered a severe storm, causing its cargo of over 28,000 rubber ducks to be lost at sea. Rubber ducks were discovered several months later in Alaska. Over the years, rubber ducks were found all over the world.
  - Video and Article

Investigative:

- Convection currents can be seen throughout the earth and play a huge role in our everyday lives.
- Flags wave in the wind.
- The leaves on trees moves when the wind blows.
- Objects move in a curved path from the center to the edge of a spinning plate.
- Seen from space, clouds on Earth appear to be moving in a swirling motion.

• The world's largest landfill is located in the middle of the Pacific Ocean.**World map phenom. model* • Nashville, TN and Linosa, Italy are located on the same latitude in the Northern Hemisphere, but the average high temperature for July in Nashville is 90°F and in Linosa it is 77°F.	• The Ocean Clean Up Project studies convection currents to develop solutions.

Lesson Resources

- ***NEW!*** Archie's First Tern Teacher Guide (storyline unit taught with Arctic Tern anchoring phenomenon and standards 6.ESS2.1-2.3, 6.ESS2.5-2.6)
    - Archie's First Tern folder with student journal, PowerPoints, and other resources
- Lesson from TDOE: Developing and using models
- Ocean Currents and Convection Currents (unit goes with the landfill anchoring phenomenon and taught with 6.ESS2.1 and 6.ESS2.4)
- Location, Location, Location! (unit that goes with the latitude anchoring phenomenon and taught with 6.ESS2.3)
- Interactive Global Map of Wind Patterns
- Current Events: Crash Course Kids #34.1 (video)
- Up, Up & Away: Crash Course Kids #16.2 (video)
- Convection
- cK-12: Convection
- cK-12: Convection (video)
- cK-12: Convection: How is Your Home Heated?
- What are Convection Currents?
- Why is the Uneven Heating of Land and Water Responsible for Land and Sea Breezes?
- Ducky Data (performance assessment that goes with the rubber ducks investigative phenomenon)
- TED-Ed: How do ocean currents work? (video)

Textbook Connections	Previous Standard(s)
SE: Chapter 7 (p 228-233, 242-247) TE: Lesson Planner (p 228A – 228B)	**Did not find any specific parallels to standard in lower grade levels.*

Content to Explore

convection	convection currents
convection cells	convection patterns
conduction	radiation
high and low pressure	Coriolis effect
latitude	

6.ESS2.3	Construct explanation for how atmospheric flow, geographic features, and ocean currents affect the climate of a region through heat transfer.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

A number of interacting parts contribute to the distribution of similar climates across the globe. Such components include factors addressed in 6.ESS2.2, as well as the ocean, land masses, different land surfaces, and impacts of living organisms. Student explanations can include the impact of solar energy on relative changes in temperature occurring in land/ocean (e.g., land warms more quickly), high altitudes/low altitudes (e.g., high altitudes have lower temperatures), and earth surfaces (e.g., ice reflects sunlight). Living things alter the surface types in an area, thus impacting energy transfer to affected areas. On land, surface features such as mountains can direct the flow of air masses upwards, inducing temperature related effects such as rain.

While the Coriolis effect creates general patterns for distribution of similar climates, it is possible for the climate in a region to vary from the climate seen at similar latitudes due to the presence of geographic features such as mountains or lakes. Coastal air rising over mountains will be depleted of its moisture and create deserts on the back side of the mountain. Likewise, large bodies of water can influence the temperature and humidity of a region due to the ability of water to store large amounts of thermal energy.

Learning Targets - DCIs
Earth's Systems

1. Mountain ranges, bodies of water, and other geographical features cause climate variations (land warms and cools more quickly, and higher altitudes have lower temperatures). Ex. Mountains can direct the flow of air masses upwards, inducing temperature related effects such as rain.
2. Coastal air rising over mountains will be depleted of its moisture and create deserts on the back side of the mountain.
3. Large bodies of water can influence the temperature and humidity of a region due to the ability of water to store large amounts of thermal energy. Ice reflects sunlight, and other surfaces absorb thermal energy at different rates (albedo).
4. Geographic features impact atmospheric flow (orographic lifting, rain shadow effect, land breezes, and wind tunnels).

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Obtain, evaluate, and communicate information and discuss how mountain ranges, bodies of water and other geographic features cause climate variations.
2. Create an explanation on how wind and ocean currents, surface and deep, affect weather and climate along coastal regions.
3. Compare models of global winds and surface ocean currents to identify both common and unique model components, relationships, and mechanisms. Write an explanation comparing the heat flow causing each phenomenon.
4. Construct explanations and design solutions in order to show how atmospheric flow, geographic features, and ocean currents affect the climate of a region through heat transfer highlighting that sub-systems make up a larger system.
5. Develop models demonstrating how geographic features can change atmospheric flow.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:	Investigative:
• Arctic Terns have a life span of 30 years and within their lifetime, Arctic Terns migrate 1.8 million miles—equal to three trips to the moon and back. • Nashville, TN and Linosa, Italy are located on the same latitude in the Northern Hemisphere, but the average high temperature for July in Nashville is 90°F and in Linosa it is 77°F.	• Permafrost melting is releasing methane gas into the atmosphere. • Fog forms over a lade on a cool fall morning. • Clouds form as air passes over mountaintops.

• Ocean and wind currents affect weather and climate.	

Lesson Resources

- ***NEW!*** Archie's First Tern Teacher Guide (storyline unit taught with Arctic Tern anchoring phenomenon and standards 6.ESS2.1-2.3, 6.ESS2.5-2.6)
  - Archie's First Tern folder with student journal, PowerPoints, and other resources
- Location, Location, Location! (unit that goes with the latitude anchoring phenomenon and taught with 6.ESS2.2)
- Effect of Latitude on Climate
- How does the ocean affect climate and weather on land?
- Can Climate Change Affect Ocean Currents?
- Study Jams: Waves & Currents
- Ocean Currents and Climate (lesson)
- How Ocean Currents and Temperature affect climate and weather—The Weather Network (video)

Textbook Connections	**Previous Standard(s)**
SE: Chapter 9 (p 318- 335) TE: Lesson Planner (p 318A – 318B)	3.ESS2.4 Incorporate weather data to describe major climates (polar, temperate, and tropical) in different regions of the world. 5.ESS1.5 Relate the tilt of the Earth's axis, as it revolves around the sun, to the varying intensities of sunlight at different latitudes. Evaluate how this causes changes in day-length and seasons.
Content to Explore	
land breezes, humidity, orographic lifting, wind tunnels, climate, sea breezes, albedo, rain shadow effect	

Content to Explore

land breezes	climate
humidity	sea breezes
orographic lifting	albedo
wind tunnels	rain shadow effect

6.ESS2.4	Apply scientific principles to design a method to analyze and interpret the impact of humans and other organisms on the hydrologic cycle.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

In 4.ESS2.3, student consider the ways that living organisms impact the land. This standard advances that idea, noting that the increase in the number of organisms present on the planet means that changes to the Earth will occur at a faster rate. Some effects on the land are inevitable as humans attempt to meet their needs, however analysis of impacts can inform sustainable use of resources. Impacts on the hydrologic cycle might include impacts on runoff, use or contamination of aquifers, etc.

Students designs might focus on how to minimize impacts as a consequence of what their monitoring suggests, however emphasis should be on types of data to be collected and how students might collect data on factors such as location, frequency, purpose for data, in order to begin to define or resolve a design task.

Learning Targets - DCIs
Earth's Systems

1. The hydrologic cycle consists of evaporation, condensation, precipitation, transpiration, runoff, infiltration, and ground water storage.
2. Impacts that have occurred over time include changes to the water table, effects of weathering and erosion to land surfaces on watersheds and wetlands.
3. Humans impact the local hydrologic cycle by withdrawing water from streams and aquifers, constructing dams/levees, developing land around, agriculture, removal of wetlands, cutting down trees, paving roads, fracking, oil spills and pollution.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Create a model of the hydrologic cycle to show the components of the hydrologic cycle and how it functions as a system.
2. Obtain, evaluate, and communicate information about the negative impacts humans have on the hydrologic cycle highlighting the effects on drinkability, rivers and lakes, aquifers, ground water, surface water, reservoirs, oceans, water temperature, fresh water, and water quality.
3. Engage in argument from evidence describing what caused a specific phenomenon/event and how humans impacted the hydrologic cycle. (cause and effect)
4. Develop and design a solution based on collected data (i.e. measurements of precipitation and runoff) that could reduce human impact on water usage, land usage, or pollution and create a stable area to live.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:

- Over the course of one summer, the entire town of Moncton was underwater.
- Natural causes such as wind and rain have eroded the statue, but human impacts have increased the rate of erosion.
- A ship travelling from Hong Kong encountered a severe storm, causing its cargo of over 28,000 rubber ducks to be lost at sea. Rubber ducks were discovered several months later in Alaska. Over the years, rubber ducks were found all over the world.
    - Video and Article
- The world's largest landfill is located in the middle of the Pacific Ocean.*
  **World map for phenomenon model*

Investigative:

- As more homes are built, drilling water wells for the homes can disrupt the water cycle.
- Deforestation affects the water cycle.
- Eyeglasses fog up on a cold day when you walk into the house from the outside.
- Eyeglasses fog up on a hot and humid day when you walk outside from an airconditioned room.
- On a cold morning, you can see your breath.
- Water condenses on the outside of a glass of ice water.
- Airplanes leave contrails when flying at high altitudes.

Lesson Resources

- The Town That Slowly Sank (lesson goes with Moncton anchoring phenomenon); click here for detailed version
    - Presentation/information
    - Flood waters slowly inundate Moncton, beginning in the spring of 1915 (article)
    - The Water Cycle (article)
    - Damming of rivers drives major changes in the global carbon cycle (article)
    - Dams (article)
- Scientists looked at more than 200,000 bodies of water from space. This is why (article, video, & research)
- Water Table Performance Assessment/Task
- Ocean Currents and Convection Currents (unit goes with the landfill anchoring phenomenon and taught with 6.ESS2.1 and 6.ESS2.2)
- Ducky Data (performance assessment that goes with the rubber ducks investigative phenomenon)
- Code Blue: Endangered Oceans
- How is Climate Change Impacting the Water Cycle?
- Evapotranspiration and the Water Cycle
- Humans and the water cycle

Textbook Connections	Previous Standard(s)
SE: Chapter 7 (p 208- 227) and Chapter 8 (p 260- 263) TE: Lesson Planner (p 208A – 208B; 214A – 214B; 222A – 222B; 260A – 260B) Scenario-based Invest.: The Problem with Runoff-Pg. 19	3.ESS2.1 Explain the cycle of water on Earth. 4.ESS3.2 Create an argument, using evidence from research, that human activity (farming, mining, building) can affect the land and ocean in positive and/or negative ways.

Content to Explore

hydrologic cycle	evaporation	weathering
condensation	precipitation	watershed
transpiration	runoff	aquifer
infiltration	ground water	water table
erosion	wetland	

6.ESS2.5	Analyze and interpret data from weather conditions, weather maps, satellites, and radar to predict probable local weather patterns and conditions.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

Weather predictions are based on models of probability, not of certainty. As the tools used by weather scientists have become more capable, the quantity of data being captured increases, and the volume of data builds over time, predictions become increasingly accurate.

Students math skills in the statistics and probability domain are just beginning to explore basic elements of statistics that are appropriate for use when compiling large amounts of data. Data might include changes in conditions (e.g., temperature, pressure, humidity, wind speed) or accumulations of weather data organized in a variety of formats including tables and transposed onto maps.

Learning Targets - DCIs
Earth's Systems

1. Meteorologist use specific tools to collect weather data. Barometers measure air pressure and increasing barometric readings indicate high pressure system with clearing skies while decreasing readings indicate low pressure advancing with increasing clouds and likely precipitation.
2. Weather maps, satellites, radar, and tables provide information such as wind speed, wind direction, air temperature, humidity, and air pressure and help use make predictions about the weather.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Record, analyze, and interpret daily weather data over an extended period using a variety of instruments (i.e., barometer, anemometer, sling psychrometer, rain gauge and thermometer).
2. Construct an explanation describing a pattern or relationship they can infer from the weather data observations, comparing how the representations and analyses help them to identify patterns in the data. (stability and change).
3. Student will analyze and interpret data to show local weather patterns and conditions using weather maps, satellites, and radar highlighting that the flow of energy drives the movement of matter in the system.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:

- Arctic Terns have a life span of 30 years and within their lifetime, Arctic Terns migrate 1.8 million miles—equal to three trips to the moon and back.
- Earth's climate changes over a long period of time and organisms adapt to live in the variety of climates that exist on Earth.

Investigative:

- Climate change has thawed the winters of New Jersey.
- The Atacama Desert is the driest place in the world.
  **The specific location of the desert (in a two-sided rain shadow near the Tropic of Capricorn) has created the arid environment. The average rainfall is 1/2 inch per year but many areas have received no rain for several years.*

Lesson Resources

- ***NEW!*** Archie's First Tern Teacher Guide (storyline unit taught with Arctic Tern anchoring phenomenon and standards 6.ESS2.1-2.3, 6.ESS2.5-2.6)
  - Archie's First Tern folder with student journal, PowerPoints, and other resources
- Lesson from TDOE: Analyzing and interpreting data
- Earth's Changing Climates (lesson that goes with the anchoring phenomenon)
- Climate Change (lesson that goes with the anchoring phenomenon)
- Earth's changing climates (module that goes with the anchoring phenomenon)
- How to use and interpret Doppler weather radar
- Climate Data Online
- Weather Forecasting
- World Climographs
- Interactive Satellite Maps

- Charles' Law and the Rising Water Activity[3]
- Underwater Candle Experiment

Textbook Connections	Previous Standard(s)
SE: Chapter 8 (300-305) TE: Lesson Planner (p 30A – 300B)	3.ESS2.3 Use tables, graphs, and tools to describe precipitation, temperature, and wind (direction and speed) to determine local weather and climate. 3.ESS2.4 Incorporate weather data to describe major climates (polar, temperate, and tropical) in different regions of the world.

Content to Explore

weather	weather maps
satellites	radar
meteorology	meteorologist
barometer	high and low pressure
wind speed	wind direction
air temperature	humidity
air pressure	anemometer
sling psychrometer	rain gauge
thermometer	

6.ESS2.6	Explain how relationships between the movement and interactions of air masses, high and low-pressure systems, and frontal boundaries result in weather conditions and severe storms.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

Student explanations should focus on the interactions of air masses and the patterns connecting the different types of interactions with the resulting weather conditions, including severe storm.

The underlying principle is that high pressure areas will push into or fill low pressure areas. Low pressure areas are columns of the atmosphere with a lower-pressure than surrounding air. As the surrounding higher pressure air pushes in to fill this area, the air in this low pressure column is displaced upward where condensation and precipitation occur as the elevation of this air increases. This air mass spins due again to Earth's rotation (Coriolis Effect). The opposite phenomenon occurs for high pressure areas, with a resulting spin in the opposite direction. The convergence of opposing pressure fronts creates severe weather phenomena due to the inverse nature of the air masses.

Seasonal patterns can be observed with connections to landforms as well as oceans. For example, students in Tennessee might observe typical boundaries for high and low pressure fronts in summer vs winter.

This standard includes both occluded and stationary fronts, but not the memorization of specific air masses (e.g., continental polar or maritime tropical).

Learning Targets - DCIs
Earth's Systems

1. Air masses are formed all over the Earth and have characteristics based on where they originate. Factors that influence air masses are temperature and moisture.
2. Factors that affect air pressure include temperature, moisture, height from sea level, and rotation of the earth.
3. Frontal boundaries form when air masses meet. Cold, warm, occluded, or stationary fronts form depending on how the masses interact. Each front produces changes in weather conditions.
4. Movement and interactions of air masses, high and low-pressure systems, and frontal boundaries result in weather conditions and severe storms such as hurricanes, tornadoes, or thunderstorms.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Develop and use models to show the relationships between the movement and interactions of air masses, high and low-pressure systems, and frontal boundaries resulting in weather conditions and severe storms highlighting that the components of the systems are related.
2. Create a model showing how convection currents are causes as a result of high and low-pressure systems interacting.
3. Analyze weather symbols and data. Have students describe a pattern or relationship they can infer from the observations of the weather maps.
4. Engage in an argument about weather predictions in an area based on provided data and weather patterns.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:

- Arctic Terns have a life span of 30 years and within their lifetime, Arctic Terns migrate 1.8 million miles—equal to three trips to the moon and back.
- Weather changes over time and varies in different areas of the world.
- Tornado Alley in the southern plains of the central United States consistently experiences a high frequency of tornadoes each year.

Investigative:

- The cloud formation over the equator is more frequent than over the poles.
- The greater the pressure difference in a tornado, the stronger and more destructive it will be.
- Clouds form over mountains.
- Asperitas clouds are associated with the aftermath of convective thunderstorms, one theory suggests they are the result of mammatus clouds descending into areas of the sky where wind direction changes.
  - Video
  - Picture

Lesson Resources

- ***NEW!*** Archie's First Tern Teacher Guide (storyline unit taught with Arctic Tern anchoring phenomenon and standards 6.ESS2.1-2.3, 6.ESS2.5-2.6)
  - Archie's First Tern folder with student journal, PowerPoints, and other resources
- Why Do So Many Tornadoes Hit the Midwest?
- Study Jams: Air Masses and Fronts
- Air Masses and Fronts
- What is Air Pressure?
- High and Low Pressure
- Science Snacks: Wiggle Pressure (investigation)
- Evidence of Air Masses and Changing Weather (performance assessment)
- Birthday Weather Bonanza (performance assessment)
- Weather Channels: Crash Course Kids #34.2 (video)

Textbook Connections	Previous Standard(s)
SE: Chapter 8 (p 264-299) TE: Lesson Planner (p 264A – 264B)	3.ESS2.2 Associate major cloud types (nimbus, cumulus, cirrus, and stratus) with weather conditions. 3.ESS2.3 Use tables, graphs, and tools to describe precipitation, temperature, and wind (direction and speed) to determine local weather and climate.

Content to Explore

air masses	high and low pressure
frontal boundaries	cold front
warm front	occluded front
stationary front	

6.ESS3.1	Differentiate between renewable and nonrenewable resources by asking questions about their availability and sustainability.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

Renewable resources are resources that can be re- generated within a human lifetime. While this then infers that non-renewable resources must develop over longer periods of time. Beyond mere memorization of those parameters, students should recognize that the processes that create mineral, groundwater, and energy (fuels) happen at geologic rates as a result of geologic processes. Because geologic processes do not occur uniformly, there is not a uniform distribution of resources. (e.g., oil deposits in the middle east, coal deposits in the western United States, gold deposits in California, the use of Tennessee waterways for hydroelectric power generation.) As humans use non- renewable resources, they are restored, but in amounts of time that greatly exceed those of near generations. Thus, these resources are considered limited.

It is not intended that students memorize the processes for the formation of all non-renewables, but rather to understand that they are in some way connected to geologic processes. A limited number of examples can be used to establish this idea.

Learning Targets - DCIs
Earth and Human Activity

1. Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources.
2. Minerals, freshwater, and biosphere resources are limited and many are not renewable over a human lifetime.
3. Renewable resources can be regenerated within a human lifetime.
4. Nonrenewable resources must develop over a longer period of time.
5. The resources are distributed unevenly around Earth as a result of past geologic processes.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Ask questions to identify where humans get their resources highlighting the patterns of resource distribution.
2. Define problems that are related to using resources that are limited highlighting how resources are not stable and can change over time.
3. Construct explanations and design solutions to differentiate between renewable and nonrenewable resources based on availability and sustainability highlighting the cause and effect relationship.
4. Obtain, evaluate, and communicate information about the distribution of resources around earth highlighting the cause and effect relationship of geologic rate and geologic processes.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:	Investigative:
• The earth has many natural resources that can be renewed in our lifetime; however, many natural resources cannot be renewed in our lifetime. • A dairy farm can turn cow poop into electricity.	• Different kinds of trash can be used as harvestable resources. • A group of grandmothers became their village's first solar engineers and swapped petroleum lamps for solar panels, bringing electricity to more than 200 families in their village. • A farm in Australia uses seawater and sunlight to grow sustainable food in the desert.

Lesson Resources

- Lesson from TDOE: Obtaining, evaluating, and communicating information
- Renewable and Nonrenewable Resources (investigation goes with the earth resources anchoring phenomenon and taught with 6.ESS3.2)
- U.S. Energy Mapping System (interactive map of energy resources)
- Renewable and Nonrenewable Resources (information)
- Difference Between Renewable and Nonrenewable Resources
- Renewable vs. Nonrenewable Energy Resources

Textbook Connections		Previous Standard(s)
SE: Chapter 6 (p 172- 193) TE: Lesson Planner (p 178A – 178B; 188A – 188B) Scenario-based Invest. Some Resources are Worth Saving- Pg.25		4.ESS.3.1 Obtain and combine information to describe that energy and fuels are derived from natural resources and that some energy and fuel sources are renewable (sunlight, wind, water) and some are not (fossil fuels, minerals).
Content to Explore		
renewable resources	nonrenewable resources	
availability	sustainability	
biosphere	geologic processes	

6.ESS3.2	Investigate and compare existing and developing technologies that will utilize renewable and alternate energy sources.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

Utilization of natural resources involves weighing environmental, economic, and oftentimes political conversations. Environmental discussions should include models which help to predict effects and gains of using a natural resource on the environment. Economic considerations include the amount of energy which can be harvested for the cost. For example, the economy of installing residential photovoltaic systems depends on the availability of sunlight in a person's location or on their property. Political conversations are impacted by considering global distributions of energy sources. As technologies progress, energy harvesting becomes less expensive and more efficient such that conversations regarding the utilization of renewable and alternate energy sources may shift over time.

Learning Targets - DCIs
Earth and Human Activity

1. Environmental discussions predict the effects and gains of using natural resources.
2. Economic considerations include cost benefit analysis and depend on the availability of resources.
3. Political conversations consider the global distribution of resources.
4. As environmental, economic and political conversations occur technologies develop allowing energy to become less expensive and more efficient.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Obtain, evaluate, and communicate information about the pros and cons for specific renewable energy sources including the benefits of renewable energy sources and their impacts on the environment and ecosystems. (energy and matter)
2. Create an argument from evidence comparing existing and developing technologies that will utilize renewable and alternate energy sources predicting the effects and gains of using a natural resource on the environment.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:
- The earth has many natural resources that can be renewed in our lifetime; however, many natural resources cannot be renewed in our lifetime.
- A dairy farm can turn cow poop into electricity.

Investigative:
- Using and harnessing solar energy can be more cost effective and cleaner than burning fossil fuels.
- Solar panels provide power to Walt Disney World.

Lesson Resources

- Renewable and Nonrenewable Resources (investigation goes with anchoring phenomenon and 6.ESS3.1)
- Renewable Energy: Clean Tech Solutions
- Environmental Impacts of Renewable Energy Technologies
- Alternative Energy for Transportation
- Engineering challenge: Gone with the Wind Energy
- Calculating Your Foodometer
- History of Alternative Energy and Fossil Fuels
- The race to develop renewable energy technologies
- What's Next for Technology and Renewable Energy?
- Science Snacks: Light Wind (investigation/engineering challenge)

Textbook Connections	Previous Standard(s)
SE: Chapter 10 (p 350-361, 376- 392) TE: Lesson Planner (p 350A – 350B; 356A – 356B; 376A – 376B; 386A – 386B) Scenario-based Invest.: Light Bulbs Can't Use Much Energy- Pg. 16	4.ESS.3.1 Obtain and combine information to describe that energy and fuels are derived from natural resources and that some energy and fuel sources are renewable (sunlight, wind, water) and some are not (fossil fuels, minerals).

Content to Explore

renewable energy sources	alternate energy sources
cost benefit analysis	global distribution

6.ESS3.3	Assess the impacts of human activities on the biosphere including conservation, habitat management, species endangerment, and extinction.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

Beyond creating explanations for observations of changes to the environment, this standard can also be interpreted treated as a design task where students are developing a device to monitor human impacts, similar to 6.ESS2.4. Part of the design process should involve recognizing that many human activities are necessary but analyzing the impacts of the activities can help to development responsible constraints.

Human activities have greatly altered rates of change to Earth's surface. As humans develop land and build roads, large amounts of natural habitat are lost, affecting the species indigenous to that habitat. Students can obtain and evaluate evidence that increases in human populations or increases in the amount of energy consumed per person also increase negative effects, but engineered solutions can mitigate some of these negative effects. For example, development of low energy consumption lightbulbs (such as LED) can reduce the amount of energy used in a home. Assessments of human activities should include models which can assist in making predictions for the efficacy of conservation efforts with competing interests.

Learning Targets - DCIs
Earth and Human Activity

1. While human activities are necessary, these activities often have negative impacts on the biosphere; human impact has altered rates of change to Earth's surface.
2. Analyzing the positive and/or negative impact of these activities can lead to the engineering of solutions, including conservation and habitat management, and the development of responsible constraints.
3. Increase in human population and energy consumption directly relates to the negative effects on biodiversity, including species endangerment and extinction.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Obtain, evaluate, and communicate information about how humans negatively and positively impact an area (cause and effect).
2. Construct an explanation describing the impacts of human activities on the biosphere highlighting the cause and effect relationship of human activities in regard to conservation, habitat management, species endangerment, and extinction.
3. Plan and carryout an investigation to test possible solutions to minimize human impact on the wetland environment (cause and effect).
4. Design a solution or device to monitor human impacts analyzing the impacts of the human activities to develop responsible constraints (cause and effect).

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:

- Buying candy in the United States could lead to the death of orangutans in Indonesia.
- Humans have significantly impacted the environment causing sea ice to decrease dramatically in the last few years.
- Honey bees are mysteriously disappearing.
- Marine snow in the abyssal plains of the ocean, which are made up of tiny plants and animals in the upper part of the ocean that die, are being poisoned with toxic oil from oil spills.
    - What is Underwater Snow?
    - Gulf Coast oil spill into coastal wetlands

Investigative:

- Smart moths have evolved to fly away from city lights.
    - City moths avoid the light (article)
- Marine fish populations are declining.
- Deforestation led to the collapse of the Polynesian culture on the island of Rapa Nui (Easter Island).
- Not all lights use the same amount of electricity.
- Deepwater Horizon oil spill has dramatically affected stingrays' sensory abilities.

- Marine Oil Snow is Falling in the Gulf of Mexico

Lesson Resources

- ***UPDATED!*** Orangutan Candy Teacher Guide (storyline unit taught with buying candy anchoring phenomenon and standards 6.LS2.1, 2.5, 2.6, 4.1, 4.2, 6.ESS3.3, & 6.ETS1.1)
  - Orangutan Candy folder with student journal, PowerPoints, and other resources
- Polar Bear, Going, Going, Gone (performance task that goes with sea ice anchoring phenomenon)
- Engineering challenge: Design a solution for the colony collapse disorder (engineering challenge goes with the honey bees anchoring phenomenon)
- Engineering challenge: Design a solution to clean up after oil spill in a wetland habitat (engineering challenge goes with the marine snow anchoring phenomenon).
  - Plan and carryout an investigation to test possible solutions to minimize human impact on the wetland environment (graphic organizer)
  - Design the solution
- What Happens After An Oil Spill? (video)
- Ocean Alert: Overfishing
- Seaside City (performance task/assessment)
  - Scoring rubric
- How Easter Island Works: Easter Island's Collapse (article goes with the deforestation investigative phenomenon)—click 'previous' to read more about the historical information.
- Engineering challenge: Develop a plan to reduce school energy consumption (engineering challenge goes with electricity investigative phenomenon).
  - Light Up My Life (lesson)

Textbook Connections	Previous Standard(s)
SE: Chapter 10 (p 362-393) TE: Lesson Planner (p 362A – 362B; 368A – 368B; 376A – 376B; 386A – 386B) STEM activity: Water Under the Dam pg. 17	4 ESS3.2 Create an argument, using evidence from research, that human activity (farming, mining, building) can affect the land and ocean in positive and/or negative ways. K.ESS3.3 Communicate solutions that will reduce the impact from humans on land, water, air, and other living things in the local environment.

Content to Explore

biosphere	conservation
habitat management	species endangerment
extinction	

6.ETS1.1	Evaluate design constraints on solutions for maintaining ecosystems and biodiversity.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

The wording and specificity of an engineering problem is a major factor in the quality of the solutions that may be created for a particular problem. Effective problems should have clear design constraints that incorporate scientific understanding. Constraints should recognize that humans have needs that are met only through use of natural resources but balance the importance of those needs with stewardship responsibilities. For example, attempting to eliminate an invasive species may only result in replacing one invasive species with a new invasive species or knowledge of local climate might influence plantings.

Examples include comparing recycling programs (deposits, curbside pickup, drop-off centers) and the cost/benefit analysis of recycling solutions. Address engineering design issues centered on water treatment (filtration, chemical treatment, reverse osmosis). Design solutions to minimize soil erosion (forestry practices, farming techniques, construction, and recreation). Examples of design solutions could include scientific, economic, or social considerations.

Learning Targets - DCIs
Engineering Design

1. Engineering problems need quality solutions for problems.
2. Effective problems have clear constraints that incorporate scientific understanding
3. Humans have needs that are met only through use of natural resources but balance those needs with responsibility.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Develop an argument for how a specific problem relating to maintaining ecosystems and biodiversity can be eliminated using clear design constraints that incorporate scientific understanding (stability and change).
2. Create a model that shows the benefits of sustainable land management and conservation and describe actions people can take to prevent human impacts (stability and change).
3. Define problems and evaluate design constraints to show possible solutions for maintaining ecosystems and biodiversity highlighting that ecosystems can become unstable.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:

- Buying candy in the United States could lead to the death of orangutans in Indonesia.
- Zebra mussels are an invasive species that have been spreading up the Tennessee River system, causing economic and ecological damage.
- When the wolves of Yellowstone were missing and then later reintroduced there was an impact on the environment.
- Human agriculture has resulted in a loss of biodiversity, which has negative impacts for humans.

Investigative:

- Invasive species often outcompete native species in an ecosystem, decreasing the overall biodiversity of an ecosystem and reducing the availability of natural resources to native species.
- Some ecosystems are isolated by highways, which act as a barrier to population movement and dispersal.
- Cover crops or fast-growing plants can be used to prevent soil erosion.
- Land with plants growing in the soil help to hold the soil in place and prevent erosion.
- Technology developed with a floater and a screen are used to concentrate debris and lead it into a collection system.
- High levels of pesticides can be found in streams after extreme rainfall.

Lesson Resources

- ***UPDATED!*** Orangutan Candy Teacher Guide (storyline unit taught with buying candy anchoring phenomenon and standards 6.LS2.1, 2.5, 2.6, 4.1, 4.2, 6.ESS3.3, & 6.ETS1.1)
  - Orangutan Candy folder with student journal, PowerPoints, and other resources
- Unit from TDOE: Communications: Survival Strategies of Populations (taught with 6.LS2.2 and 6.LS2.7)
- Zebra Mussels (unit with 6.LS2.5)
- Wolves of Yellowstone (unit goes with wolves of Yellowstone anchoring phenomenon and taught with standards 6.LS2.6, 6.LS4.1, and 6.LS4.2)
- Good "greef"! The corals are dying! (problem-based learning)
- Engineering challenges:
  - Design ways to return biodiversity to regions that are dominated by human agriculture, and at the same time improve the success of farms (engineering challenge goes with the human agriculture anchoring phenomenon).
  - Design ways to increase biodiversity of native plants and animals in an ecosystem (engineering challenge goes with invasive species investigative phenomenon).
  - Design ways to connect ecosystems that have been isolated by highways and, at the same time, make the highways safer without sacrificing efficiency (engineering challenge goes with highway investigative phenomenon).
    - Highways and Habitat (article)
    - The Environmental Impact of Roads (article)
  - Design possible erosion solutions (engineering challenge goes with erosion investigative phenomenon).
    - Erosion and Soil (show first 4:55 minutes for ideas)
  - Design a system that reduces movement of pesticides from farms into streams during extreme rainfall (engineering challenge goes with pesticides investigative phenomenon).
- The Monumental Effort to Rid the World's Oceans from Plastic (video)
- Biodiversity and Human Well-Being
- Saving the World—One Ecosystem at a Time (5E lesson)

Textbook Connections	Previous Standard(s)
SE: Chapter 5 (p 150-159) and Chapter 10 (p 362-392) TE: Lesson Planner (p 362A – 362B; 368A – 368B; 376A – 376B; 386A – 386B)	3.LS4.3 Explain how changes to an environment's biodiversity influence human resources.
Content to Explore	
constraints ecosystem biodiversity	

6.ETS1.2	Design and test different solutions that impact energy transfer.

TDOE Standard Explanation
Taken from the TN Science Standards Reference Document (updated 2019)

Even design solutions that meet criteria and constraints for a successful design may fail in production. The tests should be designed to expose failure in specific components of a device. The results of these tests can then be used to create a comprehensive solution. Design tasks might relate to selecting materials to minimize or maximize energy transfer into or out of a system by minimizing heat loss, or sound production or by maintaining initial kinetic energies.

Not all design challenges require the creation of a physical device. For example, this standard could pair with other ESS standards on assessing human impacts but address how a device operating in the field might be powered.

Learning Targets - DCIs
Engineering Design

1. Precise design criteria and constraints more likely lead to successful solutions.
2. Constraints include consideration to scientific principles of conservation of energy.
3. Testing methods should be designed to expose failure in specific components of a device. The results of these tests can then be used to create a comprehensive solution.
4. Minimizing or maximizing energy transfer in and out of a system or maintaining initial energy and minimizing heat loss or sound production.

Tasks and Assessments—SEPs & CCCs
Each task and assessment correspond with a learning target.

1. Plan and carry out a controlled investigation to design tests which determine the effectiveness of a device under varying conditions while tracking energy changes through transformations in a system.
2. Design a system (solution), selecting materials for their relevant properties related to thermal energy transfer (structure and function).
3. Construct and test a device to observe differences in thermal energy transfer among different materials.

Phenomena—Anchoring & Investigative
Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon

Anchoring:
- Even though organs have a short shelf life, they can be removed and transplanted to a new recipient after preserving the organ and transporting it quickly.
- Some containers keep liquids from warming up or cooling down.
- Air in a house is warmer upstairs than downstairs.

Investigative:
- Engineering Problems:
  - The handle on some frying pans get extremely hot when cooking food.
  - Some windows do not keep the house cooler in the summer and warmer in the winter.
  - Some clothing is too hot to wear in the summer and not warm enough in the winter.

Lesson Resources

- ***UPDATED!*** Organ Transportation Teacher Guide (storyline unit taught with organ transplant anchoring phenomenon and standards 6.PS3.1-3.4 and 6.ETS1.2)
  - Organ Transportation Folder
- Construct and test a device to observe differences in thermal energy transfer among different materials. Compare the rate of transfer of thermal energy from water using cups made of different materials (Styrofoam, coffee mug, and glass cup) by creating a line graph of the data they collected, plotting changes in temperatures.
- OpenSciEd Thermal Energy Unit (unit goes with containers anchoring phenomenon)
- Engineering challenge: Design a more efficient way to heat or cool air in a house or design a better insulated home.
- Engineering challenges: (these challenges go with the investigative engineering problems)
  - Design a safer handle for a frying pan.
  - Design windows so they keep the house cooler in the summer and warmer in the winter.
  - Design clothing that keeps you warmer in the winter and cooler in the summer.
- Do Different Colors Absorb Heat Better? (hands-on investigation)
- Developing Possible Solutions (video)

<table>
<tr><th colspan="2">Textbook Connections</th><th>Previous Standard(s)</th></tr>
<tr><td colspan="2">SE: Chapter 1 (p 20-25)
TE: Lesson Planner (p 20A – 20B</td><td rowspan="3">4.ETS1.1 Categorize the effectiveness of the design solutions by comparing them to specified criteria for constraints.</td></tr>
<tr><th colspan="2">Content to Explore</th></tr>
<tr><td>energy transfer
criteria</td><td>thermal energy
constraints</td></tr>
</table>