Rutherford County Schools

8th 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.

RCS Science Instructional Model

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.*

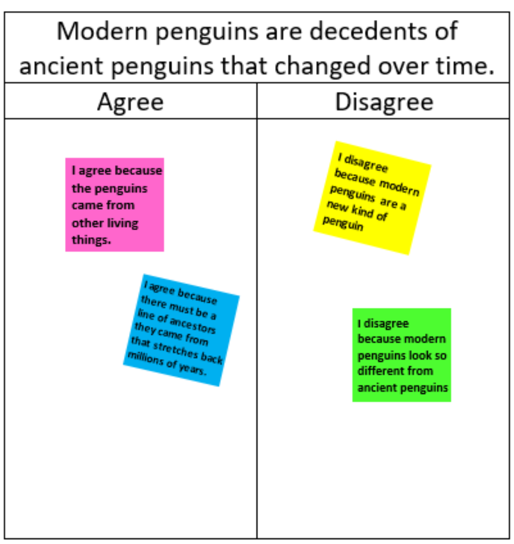
  The first step in creating a coherent science content storyline in a series of lessons is to identify the main learning goal of the lesson—what big idea do you want students to learn in this lesson?***

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/

Table of Contents:

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

Grading Period	Standards
Q1 37 Instructional Days **Storyline** *Drone Delivery Systems*[1] August 14-September 12 8.PS2.2, 8.PS2.1, 8.ETS1.1 September 13-29	Classroom Procedures, Get-To-Know-You Activities, Introduce phenomena and the three dimensions (SEPs, CCCS, & DCIs) with a focus on Scientific Modeling
	8.PS2.3 Position, forces, and direction (velocity and acceleration)[1]
	8.PS2.4 Newton's Second Law[1]
	8.PS2.5 Newton's Third Law[1]
	8.PS2.2 Non-contact forces
	8.PS2.1 Magnetism and electricity
	8.ETS1.1 Optimal solution design: electromagnets

Grading Period	Standards
Q2 44 Instructional Days* **Storyline** *Sound of Music*[2] October 9-31 8.ESS1.1-1.2 and 8.ETS1.2 November 1-14 **Storyline** *Ain't No Mountain High Enough (Lessons 1-8)*[3] November 15-December 19	**8.PS4.1 Basic properties of waves[2]**
	8.PS4.2 Mechanical waves and electromagnetic waves[2]
	8.PS4.3 Waves and communication systems[2]
	8.ESS1.1 The universe and its stars
	8.ESS1.2 Gravity, celestial motion, and tides
	8.ETS1.2 Technology, the solar system, and the universe
	8.ESS3.2 Natural hazards: volcanoes and earthquakes[3]
	8.ESS2.2 Seismic waves and Earth's structure[3]
	8.ESS2.3 Rocks: processes and forces[3]
	8.ESS2.4 Plate movement and convection cycles[3]

Grading Period	Standards
Q3 & Q4 49 Instructional Days* **Storylines** *Ain't No Mountain High Enough (Lessons 9-12)*[3] January 8-18 *Pedro's Connection*[4] January 19-March 14 8.LS4.5 March 15-22	8.ESS2.5 Processes of plate tectonics[3]
	8.ESS3.1 Tectonic plates and resource distribution[3]
	8.LS4.1 Fossil record[4]
	8.LS4.3 Phenotypic variation[4]
	8.LS4.2 Evidence of common ancestry[4]
	8.LS4.4 Natural selection[4]
	8.ESS2.1 Biogeology: extinction events[4]
	8.LS4.5 Technology and artificial selection

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.

8.PS2.1	Design and conduct investigations depicting the relationship between magnetism and electricity in electromagnets, generators, and electrical motors, emphasizing the factors that increase or diminish the electric current and the magnetic field strength.

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

Student investigations should be built around questions that the students ask to understand the cause and effect relationship in electromagnetic devices. The relationship between electricity and magnetism is reciprocal, so investigations should include systems that convert electricity into magnetism, as well as systems that create magnetism into electricity.

For systems that convert electricity into magnetic force student should ask testable questions about the impacts of: the strength of the magnetic field (a result of factors such as current in the wire or loops in a coil), distances between the interacting objects, orientation of resulting objects, and the magnetic strength of the objects.
Outcomes of these investigations should permit students to understand that the magnetic field can vary in strength as well as north-south polarity.

The same sets of variables can be used to understand induction. Polarities either in wires or coils of wire can be observed using a compass. From experimental results, students should also be able to predict the behavior in systems they design.

Learning Targets - DCIs
Motion and Stability: Forces and Interactions

1. Magnetic fields can vary in strength as well as north-south polarity.
2. The cause and effect relationships that affect magnetic forces are due to the distance between, the relative orientation of, and the magnetic strength of the interacting objects.
3. The magnitude of any electric current present in the interaction, or other factors is related to the effect of the electric current (e.g., number of turns of wire in a coil).
4. The cause and effect relationships that affect electric forces are due to the magnitude and signs of the electric charges on the interacting objects, the distances between the interacting objects, and the magnetic forces.

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

1. Ask questions to design an investigation to show the relationship between magnetism and electricity in electromagnets, generators, and motors highlighting the cause and effect relationship between strength or the current and the electromagnetic field.
2. Design and conduct an investigation to explore the behavior of electromagnets and to observe how characteristics of the circuit forming the electromagnet affect its strength and the position of its north and south poles.
3. Engage in argument from evidence to explain whether a specific claim about magnetism and electricity accurately describes the cause and effect relationship between the two.

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

Anchoring:
- Homopolar motors work without gasoline.
  **Show first 1:12 minutes. Can be used with 8.ETS1.1.*
- Cell phones can be charged wirelessly.

Investigative:
- Engineers made a floating planter.*
  **Show 9:22-10:00.*
- Magnets will fall slower through a metallic tube than a nonmetallic tube.
- A compass does not work well when placed too close to an electric wire.

Lesson Resources

- Lesson from TDOE: Planning and carrying out investigations (lesson goes with homopolar motor anchoring phenomenon)
- Simple Motors & Electromagnets (lesson/unit goes with the homopolar motor anchoring phenomenon)

- Investigating Electric Motors
- Air Bonsai (performance task/assessment)
- Invisible Forces (GRC lesson goes with compass investigative phenomenon)
- Science Snacks: Eddy Currents (investigation goes with magnets/tubes investigative phenomenon)
- Science Snacks: Magnetic Shielding
- Magnetism (Nearpod)
- Electromagnetic Induction (Playposit)
- Maglev Train (Playposit)
- Magnetism: Induction (video)
- Understanding Electromagnet Induction (video)
- How Does an Electromagnet Work? (video)
- Magnetism: Motors and Generators (video)
- Electromagnets, Generators, and Motors Stations

Textbook Connections	**Previous Standard(s)**
Chapter 2: Magnetism and Electromagnetism Lesson 3: Electromagnetic Forces (page 62) Lesson 4:Electricity, Magnetism, and Motion (page 68) Lesson 5: Electricity from Magnetism (page 62)	6.PS3.1 Analyze the properties and compare sources of…electrical… energy. 3.PS2.1 Explain the cause and effect relationship of magnets. 3.PS2.2 Solve a problem by applying the use of the interactions between two magnets.
Content to Explore	
magnetism electricity electromagnet generator electrical motor electric current magnetic field electromagnetic induction	

8.PS2.2	Conduct an investigation to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

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

Student investigations should center around two objects that can exert a force on each other, even without coming into physical contact, with the intent of building an understanding of fields. The investigations should explore the nature of the force (gravitational, electric, or magnetic) and students should be able to identify which type of field is responsible for the interaction they are investigating.

Variables under investigation might include the nature of the object exerting the field, or the distances between the objects (positions in the field). Finally, students should record their observations. Data might take the form of: changes in the motion of an object, the weight suspended in a system, or physically sensing a push or a pull against the student.

In conjunction with 8.PS2.4, students can carry out investigations to explore why Earth's gravitational field causes all objects to fall at the same rate. Investigations of electromagnetics/generators might be done concurrent with 8.PS2.1, or evidence of electric fields might be gathered from observations of pith balls around statically charged conductors.

Learning Targets - DCIs
Motion and Stability: Forces and Interactions

1. Fields exist around objects that allow them to exert force on other objects without the objects physically touching another object.
2. Attraction (pulling) and repulsion (pushing) occur in the various types of non-contact forces.
3. Variables (i.e. nature of the object or distance) affect the magnitude of non-contact forces (i.e. gravitational, electric, or magnetic).

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

1. Plan and carry out an investigation to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. (cause and effect)
2. Analyze and interpret data from the investigation to show that two interacting objects can exert forces on each other even though the two objects are not in contact with each other highlighting that changing the distance, charge or magnetic orientation, and strength of the charge or magnetic field can affect the interaction between the two objects.
3. Construct and explanation using data as evidence to show that fields exist between objects that act on each other even though the objects are not in contact. (cause and effect)

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

Anchoring:

- The world's fastest train does not touch the track. **Show first 1:08 minutes.*
- Some objects can exert force on other objects without touching them.
- When you put a balloon against a stream of water, the water curves with the balloon.

Investigative:

- When you place the same poles of two magnets near each other, the magnets will repel. When you place opposite poles of two magnets near each other, the magnets will attract.
- A magnet falls more slowly through a copper pipe than a plastic pipe.
- When a magnet is placed near a compass, it changes the direction the needle is pointing.
- Earth is a giant magnet.

Lesson Resources

- Lesson from TDOE: Constructing explanations and designing solutions (can use world's fastest train anchoring phenomenon with this lesson)
- Magnetic Moments (GRC lesson goes with copper pipe investigative phenomenon)
- No Longer North (GRC lesson goes with compass investigative phenomenon)
- Science Snacks: Remote-Control Roller (investigation)
- What is a magnetic field? (video)

- The Science Behind Magnets (video)
- Earth is a giant magnet (Playposit)

Textbook Connections	Previous Standard(s)
Chapter 2: Magnetism and Electromagnetism Lesson 1: What is Magnetism (page 52) Lesson 2: Magnetic Fields (page 56) Chapter 5: Earth, Moon, and Sun Lesson 2: Gravity and Motion (page 166)	5.PS2.3 Use evidence to support that the gravitational force exerted by Earth on objects is directed toward the Earth's center. 5.PS2.4 Explain the cause and effect relationship between two factors (mass and distance) that affect gravity.

Content to Explore	
electric field	magnetic field
gravitational force	non-contact force
polarity	domains

8.PS2.3	Create a demonstration of an object in motion that describe the position, force, and direction of the object.

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

Students should investigate a system that includes an object, the position of the object and a set of forces acting on an object. The demonstration referenced in the standard refers to a complete description of a system used to investigate a number of forces acting on an object, accounting for the size and direction of the forces, as well as the mass of the object. The position of the object should be based on some frame of reference established by the student. Direction of the object refers to the direction of the motion of an object (velocity and acceleration). It is possible to describe and model both motion and position — the car was 20m beyond the intersection and traveling with a speed of 45km/hr. In examples such as the car referenced above, students should recognize that it may be more practical to reference the motion of the car with respect to the intersection. This means that the origin for their coordinate system/number line would be the origin and the object would have a present position at 20m.

Students should only consider motion that occurs in a single dimension. This does not mean that systems cannot include objects moving diagonally. In such circumstances, the student should recognize that part of describing the motion of an object includes establishing a frame of reference. If the object is moving diagonally, the frame of reference should be described parallel to the direction of motion, rather than simply describing the motion relative to up, down, right, and left directions. With this relative frame of reference, forces and motion can be labeled as either parallel or perpendicular to the objects motion.

Learning Targets - DCIs
Motion and Stability: Forces and Interactions

1. Objects move, stop moving, or change direction because of unbalanced forces.
2. An object's velocity and acceleration can change because of unbalanced forces.
3. Direction of the object refers to the direction of the motion of an object (i.e. velocity and acceleration).
4. Objects with more mass require more force to accelerate.
5. An object's positive and negative movements can be modeled using a motion map or time-position graph.
6. An established relative frame of reference should be used to describe motion, labeling the forces and motion as either parallel or perpendicular to the objects motion.

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

1. Investigate a system that includes an object, the position of the object and a set of forces acting on an object to show a number of forces acting on an object highlighting the size and direction of the forces, as well as the mass of the object.
2. Develop and use a model to show the change in position, force, and direction of an object highlighting the cause of the change is the input of unbalanced forces within the system being modeled.
3. Develop and use a model to show the change in acceleration or velocity due to mass or force applied highlighting the effects of unbalanced forces within a system.
4. Create a motion map or time-position graph as a model to show the change in velocity highlighting the input of unbalanced forces within a system.

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

Anchoring:	Investigative:
• When drops airdrop packages with medical supplies and testing equipment during the monsoon season in Africa, the supplies get damaged during the landing. • Skateboarders are able to skate a full loop without falling off. • The motion of a person is different when using a seatbelt. *(Play with sound off.)*	• When a motorcyclist attempts to jump over an obstacle, the position, force, and direction of the motorcyclist can be determined before the jump. • Usain Bolt is the fastest man in the world. • In a coupled pendulum, one pendulum moves while the other pendulum stops. • Two objects that look the same may roll down a hill at different rates.

Lesson Resources

- ***UPDATED!*** Drone Delivery Systems Teacher Guide (storyline unit taught with drone anchoring phenomenon and standards 8.PS2.3-2.5)
    - Drone Delivery Systems folder
- Intro to Motion Maps (video)
- How to Draw Motion Maps (video)
- Free-Body Diagram Scenarios (investigation/formative assessment)
- Newton's Laws of Motion Skateboarder Model (assessment goes with skateboarders anchoring phenomenon)
- Science Snacks: Downhill Race (investigation goes with objects rolling downhill anchoring phenomenon)
- Science Snacks: Falling for Gravity (investigation)
- PhET: Projectile Motion (simulation)
    - Student Handout (w/ answer key)
- PhET: Forces and Motion Basics (simulation)
    - Student handout
- Insane Pool Trickshots (video)
- Science of NFL Football: Newton's First Law (video)
- Newton's Three Laws of Motion (video)

Textbook Connections	Previous Standard(s)
Chapter 1: Forces Lesson 3: Newton's Laws (page 24) Lesson 4: Momentum (page 32) Lesson 5: Free Fall and Circular Motion (page 36)	5.PS2.2 Make observations and measurements of an object's motion to provide evidence that patterns can be used to predict future motion. 5.PS2.1 Test the effects of balanced and unbalanced forces on the speed and direction of motion of objects. 5.PS2.5 Explain how forces can create patterns within a system (moving in one direction, shifting back and forth, or moving in cycles), and describe conditions that affect how fast or slowly these patterns occur.

Content to Explore

speed	velocity
acceleration	force (gravity, normal, etc.)
motion map	inertia
motion	Newton's Laws

8.PS2.4	Plan and conduct an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

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

This standard is an introduction to Newton's Second Law. This law explains why it is harder to change the motion of more massive objects. Free-body diagrams are an excellent tool for students to use to quantitatively represent multiple forces acting on an object. Students can use the free body diagrams to determine total amounts of force acting parallel or perpendicular to the direction of motion of an object.

Student investigations should include systems with both balanced and unbalanced forces with the objective of gathering evidence that the change in the motion of an object is a result of the sum of the forces on the object and the mass of the object. Conceptually, it is very important that students recognize that the net force is always a sum. If forces act in opposite directions, students should recognize that forces combined by adding a positive value with a negative value, and never through subtraction of a positive value from another positive value.

The investigation should include the collection of data that describes the motion of the object (velocity) or changes to the motion of the object (acceleration), the total force acting on the object, and the mass of the object.

Students should be involved in decisions about how to measure the motion of the object, the forces acting on the object, and assigning dependent and independent variables. Variables can include mass, motion, and forces.

Learning Targets - DCIs
Motion and Stability: Forces and Interactions

1. The net force is the amount of force causing the object to change acceleration.
2. An object subjected to balanced forces does not change its motion (sum of F=0); an object subjected to unbalanced forces changes its motion over time (sum of F≠0).
3. Acceleration can change depending on the mass of the object and/or the force applied to the object.
4. A free body diagram can be used to show all the forces acting on an object.

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

1. Plan and carry out an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. (stability and change)
2. Collect, analyze, and interpret data from the investigation to show unbalanced forces acting on an object highlighting the effects on the object's acceleration.
3. Develop a model (i.e., free body diagram) to show forces acting on the object highlighting the effects of the forces put into a system.

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

Anchoring:

- When drops airdrop packages with medical supplies and testing equipment during the monsoon season in Africa, the supplies get damaged during the landing.
- The motion of a person is different when using a seatbelt. *(Play with sound off)*
- When a golf ball and a steel ball are dropped at the time in air, they both hit the ground at the same time, but when dropped in water the steel ball falls faster than the golf ball.
  **Can be used as an investigative phenomenon.*

Investigative:

- Two objects that look the same may roll down a hill at different rates.
- The future motion of a ping pong ball can be predicted.
- Heavy pumpkins smash when dropped off the house but little ones just bounce.

Lesson Resources

- ***UPDATED!*** Drone Delivery Systems Teacher Guide (storyline unit taught with drone anchoring phenomenon and standards 8.PS2.3-2.5)

  - Drone Delivery Systems folder
- Virtual Car: Velocity and Acceleration (simulation)
- Developing and Using Models/Mathematical Computation: Acceleration Investigation
- Study Jams: Newton's Second Law: Acceleration (video)
- Science Snacks: Downhill Race (investigation goes with objects rolling downhill investigative phenomenon)
  - Use a can of Coke vs. a can of Coke Zero instead of the cookie tins. Race for the phenomenon.
  - After the race, students should ask questions and develop a driving question.
  - Use this video to help elicit student ideas: https://youtu.be/OBzvN9FLx4Q.
- Designing a Trick Shot System (lesson goes with ping pong ball investigative phenomenon)
- Falling in Slow Motion (lesson goes with golf ball/steel ball anchoring/investigative phenomenon)
- Smashing Pumpkins (GRC lesson goes with pumpkins investigative phenomenon)
- cK-12: Bumper Cars (simulation)
- cK-12: Everglades Airboat (simulation)
- cK-12: Elevator (simulation)
- cK-12: Airplane (simulation)
- cK-12: Unicycle (simulation)
- cK-12: Hot Air Balloon (simulation)
- Marshmallow Launcher (lab)
- Hot Wheels Lab
- Bowling Ball vs. Feathers (Playposit)
- Newton's 2nd Law of Motion (video)
- Newton's Three Laws of Motion (video)

Textbook Connections	**Previous Standard(s)**
Chapter 1: Forces Lesson 3: Newton's Laws of Motion (page 24)	5.PS2.4 Explain the cause and effect relationship between two factors (mass and distance) that affect gravity. 5.PS2.1 Test the effects of balanced and unbalanced forces on the speed and direction of motion of objects.
Content to Explore	
net force balanced forces mass free-body diagram Newton's 2nd Law unbalanced forces acceleration	

8.PS2.5	Evaluate and interpret that for every force exerted on an object there is an equal force exerted in the opposite direction.

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

This standard provides students with exposure to Newton's Third Law.

Properly labeling forces including subscripts, makes identification of third law pairs of forces more easily identifiable. Proper labels for forces include an upper case "F" to indicate force, followed by subscripts indicating the type of force (gravitational/weight, friction, normal, tension, etc.), then the object experiencing the force, and finally the object exerting the force. For example, a label for the force of tension acting on a yo-yo, suspended by a string is $F_{t,yo\text{-}yo,\ string}$ ($F_{t,y,s}$).

Students often incorrectly identify gravity as the equal and opposite force ($F_{g,yo\text{-}yo,earth}$) when asked to identify the equal and opposite force acting on the yo-yo described above. This is reasonable because the directions of the tension and weight forces are opposite. However, the correct equal and opposite force for this system would be the force of tension exerted on the string by the yo-yo ($F_{t,s,y}$). Equal and opposite force will always be of the same type. In this case, both pairs were tension forces, as opposed to the incorrect pairing of a gravity/weight force with a tension force. If forces are accurately labeled, the labels will be identical, with only the order of the last two subscripts reversed. The correct pair of equal and opposite forces was $F_{t,y,s}$ and $F_{t,y,s}$, not the incorrectly identified pair: $F_{t,y,s}$ and $F_{g,y,e}$.

Equal and opposite forces exist whether or not the objects are moving, and even in a collision where only one object moves (e.g., jumping off the ground).

Learning Targets - DCIs
Motion and Stability: Forces and Interactions

1. For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction.
2. Equal and opposite forces exist whether or not the objects are moving, and even in a collision where only one object moves.
3. Multiple forces (e.g. gravitational, friction, normal, tension, etc.) can be identified by labeling all forces with an uppercase "F" to indicate force, followed by subscripts indicating the type of force (e.g. F_g).

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

1. Develop a model to show the force exerted on an object highlighting that the magnitude of force exerted on an object results in an equal magnitude of force in the opposite direction (cause and effect).
2. Construct an explanation for the causes of the motion of an object.
3. Apply Newton's Third Law to design a solution to a problem involving motion of two colliding objects. (systems and system models)

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

Anchoring:	Investigative:
• When drops airdrop packages with medical supplies and testing equipment during the monsoon season in Africa, the supplies get damaged during the landing. • The motion of a person is different when using a seatbelt. (*Play with sound off.)* • Pushing backward on a skateboard causes you to move forward. **Can be used as an investigative phenomenon.*	• A paper airplane can fly forward when dropped straight down.

Lesson Resources

- ***UPDATED!*** Drone Delivery Systems Teacher Guide (storyline unit taught with drone anchoring phenomenon and standards 8.PS2.3-2.5)

- Drone Delivery Systems folder
- Newton's Skateboard (GRC lesson goes with skateboard anchoring phenomenon)
- Air Force (GRC lesson goes with paper airplane investigative phenomenon)
- Newton's Third Law (video)
- Incredible Science: Newton's Cradle (video)
- Science of NFL Football: Newton's Third Law of Motion (video)
- Newton's Three Laws of Motion (video)

Textbook Connections		Previous Standard(s)
Chapter 1: Forces Lesson 3: Newton's Laws of Motion (page 24)		5.PS2.1 Test the effects of balanced and unbalanced forces on the speed and direction of motion of objects. 5.PS2.2 Make observations and measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.
Content to Explore		
Newton's Third Law	force	
gravitational force	friction	
normal force	tension	

8.PS4.1	Develop and use models to represent the basic properties of waves including frequency, amplitude, wavelength, and speed.

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

Waves transfer energy from the place where they form (source), to another place. Consider a rock thrown into a pond: Before the rock lands in the water, it has the energy of motion (kinetic energy). The water slows down the rock when the rock hits the water and some energy of motion is "lost." The energy "lost" by the rock because of the collision forms ripples (waves) on the surface of the pond. These ripples move across a pond carrying energy away from where the impact occurred. The behavior of the source of the wave determines the properties of the wave.

The frequency of the wave is an outcome of patterns in the motion of the source. For example, speakers producing produce higher pitch sounds (high frequency) move back and forth at a faster rate.

The amplitude of a wave is an outcome of the amount of energy being transferred from the source. A speaker moves back and forth as an electromagnetic force to pull back the speaker cone. When the electromagnet is turned off or reversed, the speaker cone snaps forward, creating one wave pulse. If more energy is used to push/pull the speaker cone further, the outcome is a wave with greater amplitude.

The wavelength of the sound wave generated by the speaker system is an outcome of how the distance a pulse has traveled away from the speaker before the next wave is created. Waves of identical frequencies will have different wavelengths if they are traveling through different mediums. This can be explained by a difference in velocity. Consider a pair of waves created by a pair of speakers creating compressions at identical, constant rates. If one speaker is transmitting through air, and the other water, the wave fronts will move away from the source at different rates. The wave traveling through water will travel 4x as fast. Before the speaker cone snaps back to create a second compression from each speaker, the initial compression of the wave traveling through the water will have traveled four times further from its source (speaker cone) than the wave front traveling through the air. Visualizing this pattern repeated over time, we see a wavelength that is four times greater in the water than in air.

Learning Targets - DCIs
Waves and Their Applications in Technologies for Information Transfer

1. Waves transfer energy from the place where they form (source) to another place.
2. The behavior of the source of the wave determines the properties of the wave.
3. The frequency of the wave is an outcome of patterns in the motion of the source.
4. The amplitude of a wave is an outcome of the amount of energy being transferred from the source.
5. The wavelength is the spatial period of a periodic wave—the distance over which the wave's shape repeats.
6. Wavelength is inversely proportional to frequency of a wave: waves with higher frequencies have shorter wavelengths; waves with lower frequencies have longer wavelengths.
7. The speed of a wave is directly proportional the frequency and wavelength of the wave.
8. The speed of a wave will change depending on the medium through which the wave travels.

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

1. Develop a mathematical model to show the energy transferred by a wave highlighting that the speed of the wave is directly proportional to the frequency and wavelength of the wave.
2. Develop a model of wave movement to show wave properties including frequency, amplitude, wavelength, and speed highlighting the patterns and cause and effect relationships that exist between waves and medium.
3. Construct an explanation to predict the change in the energy of the wave if any one of the parameters of the wave is changed. (patterns)

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

Anchoring:	Investigative:
• Loud music from a truck makes a window in the parking lot move. A speaker moved when it produced sound.	• When you drop a rock into a pond, you see energy being transmitted through the water in the form of waves.

• The Tacoma Narrows Bridge, also known as Galloping Gertie, moved in a wave-type motion. **Show without sound during initial introduction.* • Waves can move objects. • Sound waves can put out fires. • Sound waves can break glass.	• The sound of a train approaching you changes as the train gets closer. Then it sounds different as it passes you and moves away from you. • Inhaling helium changes the sound of your voice. • A big wave at the beach can knock me down, but a small wave can't.

Lesson Resources

- ***UPDATED!*** Sound of Music (storyline unit can be taught with loud music anchoring phenomenon and standards 8.PS4.1-4.3)
- Lesson from TDOE: Using mathematics and computational thinking
- Power of Music (investigation goes with the waves can move objects anchoring phenomenon)
- Wave Properties (Playposit)
- Traveling Waves (Playposit)
- Wave pendulum (video)
- Ocean Sounds
  - Performance assessment
  - Scoring Rubric
- Science Snacks: String Machine (great teacher demo to model wave properties)
- Sound in Space (performance task/assessment)
- Wave Energy Inquiry (lesson goes with beach wave investigative phenomenon)
- Waves Stations (stations used with 8.PS4.2)
- GCSE Physics—Intro to Waves—Longitudinal and Transverse Waves #61 (video)

Textbook Connections	Previous Standard(s)
Chapter 3: Characteristics of Waves Lesson 1: What are Waves? (page 96) Lesson 2: Properties of Waves (page 102) Lesson 3: Interactions of Waves (page 108) Chapter 4: Electromagnetic Waves Lesson 1: Nature of Electromagnet Waves (page 122)	5.PS2.5 Explain how forces can create patterns within a system (moving in one direction, shifting back and forth, or moving in cycles), and describe conditions that affect how fast or slowly these patterns occur.

Content to Explore

wave	energy
frequency	amplitude
wavelength	wave speed
medium	crest
trough	

8.PS4.2	Compare and contrast mechanical waves and electromagnetic waves based on refraction, reflection, transmission and absorption and their behavior through a vacuum and/or various media.

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

A wave is a means of transporting energy from a source to some other location. The interaction between waves and their transmitting medium can result in a decrease in the energy of the wave.

Models can be created to explain phenomena that occur as a result from the behaviors of either electrical or mechanical waves that result from interactions between the wave and the medium transmitting the wave. Additionally, students should note that electromagnetic (light) waves will interact at boundaries of matter but are uniquely able to travel without a medium.

At boundaries, light and mechanical waves may undergo changes that result from being refracted, reflected, transmitted or absorbed. For example, a mechanical wave will reflect and invert when it reaches the immobile end of its medium (e.g. a wave reflecting at the end of string that is tied in place) but will reflect without inverting if the end can move freely (e.g., a wave traveling through water in a tub that reflects off the side of the tub). Electromagnetic waves will reflect and travel in straight lines with predictable patterns for their angles of reflection.

Learning Targets - DCIs
Waves and Their Applications in Technologies for Information Transfer

1. A wave is a means of transporting energy.
2. The interaction between waves and their transmitting medium can result in a change in energy of the wave.
3. Mechanical waves require a medium to move through.
4. Electromagnetic waves do not require a medium to move and can travel through a vacuum.
5. Electromagnetic waves and mechanical waves may be refracted, reflected, transmitted or absorbed through various mediums.

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

1. Ask questions about the properties of mechanical and electromagnetic highlighting the structure and function of each type of wave.
2. Develop and use a model to describe that waves are reflected, refracted, absorbed, or transmitted through various materials and/or vacuum highlighting how waves interact with materials. (structure and function)
3. Construct and explanation describing the relationship between waves and their interaction with materials (e.g. reflection, refraction, absorption, transmission, interference, and media). (cause and effect)

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

Anchoring:

- Loud music from a truck makes a window in the parking lot move. A speaker moved when it produced sound.
- Even though Daniel Kish lost his eyes to cancer before he was 13 months old, he is able to perceive the environment.
  Start the video at 0:33 minutes.
- Sometimes a large ring or circle of light, called a halo by scientists, can be seen around the sun or moon.

Investigative:

- When a small beaker is placed in a large beaker of vegetable oil, the small beaker seems to disappear.
  Show first 0:47 minutes or do the demo live.
- Series of investigative phenomena:
  - When you yell or scream into a tunnel, the sound seems to go away and then come back.
  - A pencil in a glass of water appears broken.
  - Laser shining through goggles reacts differently if the goggles are covered with tape.
- Speaking into a fan causes my voice to change.

	• Sometimes there are patterns of a ring of missing snow around the tree trunks. • The stunning blue color of the peacock tarantula is really an optical illusion. *Click here for the original tweet from The Wonder of Science.

Lesson Resources

- ***UPDATED!*** Sound of Music (storyline unit can be taught with loud music anchoring phenomenon and standards 8.PS4.1-4.3)
- Lesson from TDOE: Analyzing and interpreting data (lesson goes with vegetable oil investigative phenomenon)
- Investigative phenomena series: Student Handout
- The Original Auto-Tune (GRC lesson goes with fan investigative phenomenon)
- Tree Snow Wells (GRC lesson goes with snow investigative phenomenon)
- It's Not Magic, It's Science (performance task)
- 8.PS4.2 Performance Task
- Waves Stations (stations used with 8.PS4.1)
- Slinky Lab
- Mechanical Waves (interactive)
- Light Waves (interactive)
- Electromagnetic Waves (video)

Textbook Connections	Previous Standard(s)
Chapter 3: Characteristics of Waves Lesson 1: What Are Waves? (page 96) Chapter 4: Electromagnetic Waves Lesson 1: Nature of Electromagnet Waves (page 128)	4.PS4.1 Use a model of a simple wave to explain regular patterns of amplitude, wavelength, and direction. 4.PS4.2 Describe how the colors of available light sources and the bending of light waves determine what we see.

Content to Explore

wave	medium
electromagnetic waves	mechanical waves
refraction	reflection
transmission	absorption

8.PS4.3	Evaluate the role that waves play in different communication systems.

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

Digitizing is the process of converting information into a series of binary ones and zeroes representing either an on or off state. Once digitized, information can be transmitted as wave pulses and stored reliably and recreated at a later time. Devices that do not work digitally, function in analog. Analog devices can have infinite states. The difference between analog and digital is analogous to the difference between a light switch (digital) and a dimmer switch (analog).

Models of different systems of communication can unveil the benefits of digitizing information. Students might design a way that information can be digitized using only two states and transmit a message using their system, considering how accuracy and distance that the message can be transmitted increase as a result of the encoding process. For example, students might attempt to transmit a written message in speech or speaking into cup-on-a-string system (analog), as compared to encoding this encoding this information in a pattern of plucks of the string, array of illuminated lights, or flashes of a single light.

Students should explore similar applications of information transfer in the functioning of radios, televisions, cellphones, and wireless computer networks.

Learning Targets - DCIs
Waves and Their Applications in Technologies for Information Transfer

1. In analog technology, a wave is recorded or used in its original form.
2. In digital technology, the analog wave is sampled and the information is converted into binary (numbers—1's and 0's) and then transmitted into wave pulses and stored reliably and recreated at a later time.
3. Digitized signals are a more reliable way to encode and transmit information.

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

1. Construct an explanation to show the role that waves play in different communication systems highlighting the structure and function of waves.
2. Given materials from a variety of different types of sources of information (e.g., texts, graphical, video, digital), gather sufficient evidence to support a claim to show that using waves to carry digital signals is a more reliable way to encode and transmit information than using waves to carry analog signals. (structure and function)

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

Anchoring:

- Loud music from a truck makes a window in the parking lot move. A speaker moved when it produced sound.
- Digital v Analog songs (Do not show the video, just have students listen; HOWEVER, the person recording didn't quite get the volume equal, so you may have to turn up the second clip more than the first)
  - Clip #1
  - Clip #2

Investigative:

- Some buoys can detect whale calls.
- The Arecibo message was an interstellar radio message containing information about life on our planet.
- Cell phones can be used to communicate to people across long distances.
- A prisoner of war, Jeremiah Denton, communicated through Morse code by blinking his eyes during a propaganda video.

Lesson Resources

- ***UPDATED!*** Sound of Music (storyline unit can be taught with loud music anchoring phenomenon and standards 8.PS4.1-4.3)
- Science Friday: Binary, Pixels, and Data, Oh My! (digital vs analog activity—a.k.a Alien Telephone)
- How Stuff Works: Can you explain the basic difference between analog and digital technology?
- Analog TV vs Digital TV (video)
- Preserving Grandma's Family Memorabilia (activity)

- Cell Phone Signal (performance task/assessment)
- Communication Problem Solving
- Communication Device Essay
- Radio Waves (various resources)
- Electromagnetic Spectrum: Radio Waves
- Using Waves to Communicate (lesson)

Textbook Connections	**Previous Standard(s)**
Chapter 4: Electromagnetic Waves Lesson 1: Nature of Electromagnet Waves (page 128) Lesson 3: Wireless Communication (140)	4.PS4.1 Use a model of a simple wave to explain regular patterns of amplitude, wavelength, and direction.
Content to Explore	
digital analog binary radio waves	

8.LS4.1	Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change in life forms throughout Earth's history.

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

The fossil record is a powerful tool for understanding how living organisms have changed throughout Earth's history, assuming that Earth's processes and the physical laws governing these processes have remained constant.

Whether or not an organism becomes fossilized is dictated by factors such as the nature of its body tissues and structures, its behavior, the organism's habitat, and the nature of the organism's death and burial. Fossils might also include preserved evidence from organisms interacting with their environment and leaving traces such as footprints. Some organisms (e.g. hard-shelled, sediment-dwelling organisms) are more likely to be found as fossils. A chronological history of life on Earth can be reconstructed using sedimentary evidence and radioactive dating. Students may compare structural similarities and differences of organic evidence in geological cross sections to determine evidence of presence and changes in taxa on a geologic time scale.

Students should examine data pertaining to the fossil record, looking for patterns within these data. Patterns might include proliferations or disappearances of life either of a single species, or a large number of species, as well as changes to the complexity of organisms throughout time. Analysis of the data should acknowledge law of superposition in geologic strata to determine relative ages of fossils or layers.

Learning Targets - DCIs
Biological Change: Unity and Diversity

1. The fossil record is a tool for understanding how living organisms have changed throughout Earth's history.
2. Whether or not an organism becomes fossilized is dictated by factors such as the nature of its body tissues and structures, its behavior, the organism's habitat, and the nature of the organism's death and burial.
3. Fossils might also include preserved evidence from organisms interacting with their environment and leaving traces (e.g. footprints).
4. Some organisms (e.g. hard-shelled, sediment-dwelling organisms) are more likely to be found as fossils.
5. A chronological history of life on Earth can be reconstructed using sedimentary evidence and radioactive dating.
6. Geologic cross sections provide evidence of the relative age of these fossils, which can be estimated per the law of superposition with older fossils being found in deeper layers and newer fossils found in higher layers.
7. The great variety of fossil types with numerous examples of extinct and extant plant and animal species including both aquatic and terrestrial organisms reveals that life on Earth demonstrates tremendous diversity and structural changes over time. The appearance and disappearance of fossil variants confirms that extinctions occur.
8. The appearance of fossil variants with changes in form and body structure over time provides evidence for evolution.

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

1. Analyze and interpret data from the fossil record that reveals patterns about the existence, diversity, extinction, and change in life forms throughout Earth's history.
2. Analyze and interpret data to acknowledge the law of superposition in geologic strata to determine relative ages of fossils or layers. (patterns)
3. Obtain and communicate information about the causes and effects of changes in life in Earth's history.

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

Anchoring:	Investigative:
• A giant fossil of an ancient penguin, Pedro, could be connected to modern day penguins.	• Dinosaurs did not go extinct. • *Fossils of a 340-Pound Giant Penguin Found in New Zealand*

• Some fossils are found only in certain layers of rocks and can be used to determine specific geologic times.	

Lesson Resources

- ***UPDATED!*** Pedro's Connection Teacher Guide (storyline unit taught with ancient penguin anchoring phenomenon and standards 8.LS4.1-4.4 and 8.ESS2.1)
    - Pedro's Connection folder with student journal, PowerPoints, and other resources
- Unit from TDOE: Geologic Time and the Fossil Record (unit goes with fossils/geologic time anchoring phenomenon
- Farin Finds a Fossil in Fredonia on a Frosty Friday in February (performance task/assessment)
- Fossilized remains of Gryphon found (performance task/assessment)
- Ancient Horse Fossil (performance task/assessment)
- cK-12: Earth's History and Clues from Fossils (various resources)
- cK-12: Fossil Record (various resources)
- Law of Superposition Lab
- Geologic Time Scale and Fossils (Playposit)
- Solve a Sedimentary Layer Puzzle
    - Instructions
    - Student Handout

Textbook Connections	Previous Standard(s)
Chapter 14: A Trip Through Geologic Time Lesson 1: Fossils (page 504) Lesson 2: The Relative Age of Fossils (page 510) Lesson 3: Radioactive Dating (page 516) Chapter 15: Change Over Time Lesson 1: Darwin's Theory (page 552) Lesson 2: Evidence of Evolution (page 562)	5.LS4.1 Analyze and interpret data from fossils to describe types of organisms and their environments that existed long ago. Compare similarities and differences of those to living organisms and their environments. Recognize that most kinds of animals (and plants) that once lived on Earth are now extinct.

Content to Explore

Law of Superposition	geologic column
fossils	trace fossils
fossil record	absolute vs. relative age
geologic time scale	stratigraphy

8.LS4.2	Construct an explanation addressing the similarities and differences of the anatomical structures and genetic information between extinct and extant organisms using evidence of common ancestry and patterns between taxa.

TDOE Standard Explanation

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

Comparisons of anatomical structures can be used as evidence to infer that organisms which appear similar to one another are more likely to be closely related, compared to an organism with vastly different anatomical structures. In 7.LS1 and 7.LS3, students come to understand that the appearance of an organism is dictated by actions of the proteins encoded in its genes. Therefore, organisms that appear more similar are also more likely to share similar genetic information.

The rationale for determining relative relatedness based upon anatomical similarities and differences applies comparisons between both organisms living today, as well as those that once lived, but are no longer found on Earth. Students may compare and contrast examples of the skeletal structure of birds, reptiles and dinosaurs or embryonic forms of mammals compared to other kingdoms. Students may examine cladograms to infer relatedness.

Students should recognize patterns seen in anatomical structures and embryonic development between time and taxa. Cladogram dissection as well as construction should be utilized to deepen understanding of hierarchal relationships between the organisms.

Learning Targets - DCIs

Biological Change: Unity and Diversity

1. Anatomical features in living organisms and extinct organisms, such as wings, feathers, fins, gills, limbs, horns, branches, flowers, roots, etc., can be used as evidence to infer that organisms which appear similar to one another are more likely to be closely related, compared to an organism with vastly different anatomic structures.
2. Genetics determines the observable anatomical features (phenotypes) that we see in extinct and extant organisms.
3. Cladograms can be used to infer relatedness among organism and to deepen understanding of hierarchal relationships between organisms.
4. The primary reason that extinct and extant organisms display similarities is because they diverged from common ancestors in the past.

Tasks and Assessments—SEPs & CCCs

Each task and assessment correspond with a learning target.

1. Construct an explanation to describe similarities and differences in the anatomy of extinct and extant organisms highlighting patterns in the fossil record to infer common ancestry.
2. Engage in argument using skeletal structures of birds, reptiles and dinosaurs or embryonic forms of mammals across kingdoms as evidence to highlight patterns seen in anatomical structures and embryonic development between time and taxa.
3. Develop models (cladograms) to show species relationships and common ancestry highlighting patterns concerning anatomical features.

Phenomena—Anchoring & Investigative

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

Anchoring:	Investigative:
• A giant fossil of an ancient penguin, Pedro, could be connected to modern day penguins. • Different animals look the same at one point in their lives. • The 250-300-million-year-old fossil Seymouria, which was found in Seymour, Texas, is a common ancestor to an animal alive today.	• Humans did not always look the way we do now. • The Giraffe and the Okapi are related.

Lesson Resources

- ***UPDATED!*** Pedro's Connection Teacher Guide (storyline unit taught with ancient penguin anchoring phenomenon and standards 8.LS4.1-4.4 and 8.ESS2.1)
    - Pedro's Connection folder with student journal, PowerPoints, and other resources
- Lesson from TDOE: Engaging in Argument from Evidence (lesson goes with Seymouria anchoring phenomenon)
- Organism Sort: group various organisms based on "relatedness" and defend choices with evidence (can be used as a phenomenon).
- Embryos and Evolution (investigation goes with different animals look the same anchoring phenomenon)
- Comparative Embryology: The Vertebrate Body
- cK-12: Comparative Anatomy and Embryology
- What Can Embryos Tell Us About Evolution? (video)
- The Evolution Lab
- Evidence for Evolution: Forelimbs of Vertebrate Animals (homologous structures)
- Bozeman Science: Evidence of Common Ancestry and Diversity (video)

Textbook Connections	Previous Standard(s)
Chapter 15: Change Over Time Lesson 1: Darwin's Theory (page 552) Lesson 2: Evidence of Evolution (page 562) Lesson 3: Rate of Change (page 566) Lesson 4: Advances in Genetics (page 570)	5.LS4.1 Analyze an interpret data from fossils to describe types of organisms and their environments that existed long ago. Compare similarities and differences of those to living organisms and their environments. Recognize that most kinds of animals (and plants) that once lived on Earth are now extinct.

Content to Explore

common ancestry	extinct
extant	taxa
anatomical structure	homologous structure
genetic code/sequence	embryonic development
cladogram	relative relatedness

8.LS4.3	Analyze evidence from geology, paleontology, and comparative anatomy to support that specific phenotypes within a population can increase the probability of survival of that species and lead to adaptation.

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

Natural selection occurs because there are variations in the phenotypes of a population. A conceptually accurate understanding of natural selection must recognize that variation precedes adaptation. Over-emphasizing the idea that a particular structure (phenotype) has proliferated because of natural selection can result in under-emphasis of the emergence of the phenotype as a part of variation. This inequity, favoring discussions of morphological adaption over genetic variation, perpetuates the incorrect idea that adaptation occurs in single organisms. A student should understand that adaptation occurs in populations over time. This standard should emphasize variability, not adaptation.

Student arguments (from data, information, simulations, etc.) should focus on a particular phenotype within a population of organisms, noting that there may be a number of phenotypes for a trait. Students should reconcile that these variations are an outcome of differences in the genetic information between individuals and are thus heritable.

Even though all organisms may live in the same environment, the variation within the species means that individual organisms may each interact differently with the environment. Some interactions may favor the survival and reproduction of some individuals over others. Students should specifically identify how a given phenotype affects the probability of survival for an individual.

Learning Targets - DCIs
Biological Change: Unity and Diversity

1. Natural selection occurs because there are variations in the phenotypes of a population.
2. Since environments change over time, the organisms that live in those environments must also change (adapt) to the new conditions or they may go extinct.
3. Genetic outcomes due to reproduction and/or mutations results in novel recombination of DNA causing phenotype variations in the offspring.
4. Having a variety of traits in offspring increases the probability that at least some portion of the species population will be able to survive changed environment conditions.
5. Due to variation, some members of a population with well adapted traits are going to have a better chance of surviving and reproducing than other members and that these well-adapted traits will become common in future generations due to inheritance.
6. Phenotypes affect the probability of survival of an individual in their current environment and in a changed environment.

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

1. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. (cause and effect)
2. Engage in an argument from evidence to support a claim about which members of a species population will survive an environmental change to show that genetic variations increase survival probability highlighting cause and effect connections between specific genetic traits and survival.
3. Design a solution to the problems of lack of genetic variation in a population and how to increase the stability of the population.

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

Anchoring:	Investigative:
• A giant fossil of an ancient penguin, Pedro, could be connected to modern day penguins. • The stickleback fish in lakes vs. oceans are different.	• "Bananas as We Know Them are Doomed" • Some moths fly away from light. • Chipmunks and other rodents can carry a large quantity of food in their cheeks.

• Some moths changed colors in England in the 1800s. • There are a variety of finches on the Galapagos Island.	• Female peafowl are attracted to male peacocks with the largest and most ornate train. • Native greenback cutthroat trout were thought to be extinct until a small population was rediscovered in a small tributary of the South Platte River in 1950. • The Paddlefish is an organism found in the rivers of Oklahoma, that has a large beak or nose.

Lesson Resources

- ***UPDATED!*** Pedro's Connection Teacher Guide (storyline unit taught with ancient penguin anchoring phenomenon and standards 8.LS4.1-4.4 and 8.ESS2.1)
    - Pedro's Connection folder with student journal, PowerPoints, and other resources
- Survivor Unit (unit goes with stickleback anchoring phenomenon and taught with 8.LS4.3 and 8.LS4.4)
    - Teach Genetics: Natural Selection (original resource)
- The Evolution Lab
- Natural Selection - Peppered Moth (video)
- Why Were the Finches Affected by the Drought of 1977? (also goes with 8.LS4.4)
- Mathematical Representations of Natural Selection (performance task/assessment goes with finches anchoring phenomenon and also 8.LS4.4)
- Grant's Finches (performance task/assessment goes with finches anchoring phenomenon and also 8.LS4.4)
- Green Gene Trout Pool (GRC lesson goes with greenback trout investigative phenomenon)
- Well Adapted Paddlefish (GRC lesson goes with Paddlefish investigative phenomenon)

Textbook Connections	Previous Standard(s)
Chapter 15: Change Over Time Lesson 1: Darwin's Theory (page 552) Lesson 2: Evidence of Evolution (page 562) Lesson 3: Rate of Change (page 566) Lesson 4: Advances in Genetics (page 570)	5.LS4.2 Use evidence to construct an explanation for how variations in characteristics among individuals within the same species may provide advantages to these individuals in their survival and reproduction.

Content to Explore

natural selection	genetic variation
phenotype	adaptation
morphological adaptation	

8.LS4.4	Develop a scientific explanation of how natural selection plays a role in determining the survival of a species in a changing environment.

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

8.LS4.3 emphasizes that variation in a population of organisms can make it more or less probable that an individual organism survives and reproduces. Standard 8.LS4.4 examines how natural selection acts on the variation in an entire population to impact the survival of a species based on surviving members passing on their genetic information.

In a single generation, environmental conditions (e.g. abiotic factors, competition, resource availability, etc.) may favor the survival and reproduction of some individuals over others. It is possible that mutations may lead to a new phenotype in an individual, making it more probable that the individual reproduces, and thus passes along this genetic information to their offspring (8.LS4.3). If environmental conditions continue to favor individuals with this phenotype, then over time (generations), the proportion of individuals with the phenotype will increase. The survival of a species is dependent on variation which permits adaptation. Without adaptation, a species cannot survive and changing environments can eliminate the species.

Learning Targets - DCIs
Biological Change: Unity and Diversity

1. Natural selection acts on the variation in an entire population to impact the survival of a species based on surviving members passing on their genetic information.
2. Individuals with the most well adapted traits are more likely to survive and reproduce while those with less adapted traits are more likely to die. Those that survive are considered more fit for those specific environmental conditions, and they are likely to pass on their well-adapted genetic traits to their offspring enabling the species to survive.
3. Environmental conditions may favor the survival and reproduction of individuals with certain traits over others and these conditions can include biotic factor such as predation, competition, and food availability and abiotic factors such as the amount of precipitation, temperature ranges, humidity, elevation, air or ocean currents, and salinity.

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

1. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. (cause and effect)
2. Construct an explanation describing how the process of natural selection effects the survival of a species in a changing environment. (stability and change)

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

Anchoring:

- A giant fossil of an ancient penguin, Pedro, could be connected to modern day penguins.
- The stickleback fish in lakes vs. oceans are different.
- Some plants can tolerate droughts.
- There are a variety of finches on the Galapagos Island.

Investigative:

- Walking sticks are hard to see because they look like a stick.
- Many chicks produce a portable case for their poop.
- Some butterflies and moths have patterns on their wings that imitate eyes.
- Snakes camouflage to hide.

Lesson Resources

- ***UPDATED!*** Pedro's Connection Teacher Guide (storyline unit taught with ancient penguin anchoring phenomenon and standards 8.LS4.1-4.4 and 8.ESS2.1)
  - Pedro's Connection folder with student journal, PowerPoints, and other resources
- Survivor Unit (unit goes with stickleback anchoring phenomenon and taught with 8.LS4.3 and 8.LS4.4)
  - Teach Genetics: Natural Selection (original resource)
- Now You See Me (GRC lesson goes with walking sticks investigative phenomenon)
- Who's the Fittest? (lesson goes with finches anchoring phenomenon)

- Tuskless African Elephant Populations (performance task/assessment)
- Why Were the Finches Affected by the Drought of 1977? (goes with 8.LS4.3)
- Mathematical Representations of Natural Selection (performance task/assessment goes with finches anchoring phenomenon and 8.LS4.3)
- Grant's Finches (performance task/assessment goes with finches anchoring phenomenon and 8.LS4.3)
- Natural Selection Explained Simply (video)
- Bozeman Science: Natural Selection (video)
- What is Natural Selection? (video)
- Simulating Natural Selection (video)
- Evolution 101 & how natural selection works (video)
- Evidence of evolution that you can find on your body (video)
- How Can Evolution Be Observed in Mouse Populations?
    - Rock pocket mouse cards

Textbook Connections	Previous Standard(s)
Chapter 15: Change Over Time Lesson 1: Darwin's Theory (page 552) Lesson 2: Evidence of Evolution (page 562) Lesson 3: Rate of Change (page 566) Lesson 4: Advances in Genetics (page 570)	5.LS4.2 Use evidence to construct an explanation for how variations in characteristics among individuals within the same species may provide advantages to these individuals in their survival and reproduction.

Content to Explore

variation	adaptation
population	natural selection
mutation	competition
evolution	abiotic factors
biotic factors	

8.LS4.5	Obtain, evaluate, and communicate information about the technologies that have changed the way humans use artificial selection to influence the inheritance of desired traits in other organisms.

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

Natural selection is driven by the impact of interactions between individuals and their environment on variation within a population, over time.

In artificial selection, humans may attempt to deliberately introduce variation by attempting to cause new phenotypes that may favor human needs. When favorable phenotypes emerge, humans may attempt to preserve these desirable phenotypes, even if the impacted individuals might be less likely to survive in environments outside of human protection (natural environments).

Techniques for artificial selection might include selective breeding, genetic modification (change to genome by addition of a new gene), or gene therapy (introduction of a new allele for an existing gene).

Learning Targets - DCIs
Biological Change: Unity and Diversity

1. Natural selection is driven by the impact of interactions between individuals and their environment on variation within a population, over time.
2. In artificial selection, humans may attempt to deliberately introduce variation by attempting to cause new phenotypes that may favor human needs.
3. Techniques for artificial selection might include selective breeding, genetic modification (change to genome by addition of a new gene), or gene therapy (introduction of a new allele for an existing gene).

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

1. Obtain, evaluate, and communicate information to show artificial selection technologies that humans have used to influence the inheritance of desirable traits. (cause and effect)
2. Construct and explanation to show the effects of technologies in selective breeding.

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

Anchoring:

- Supercows are genetically bred to fetch six figures at auction.

Investigative:

- In 1985 half of the Papaya crop was destroyed by Papaya Ring Spot Virus however today Papaya is not affected by the virus.
- There are now over 330 dog breeds in the world.
- Fruits and vegetables used to look so different you might not even recognize them.
- The Australian shepherd is just one of many breeds of dog who suffer from the double merle gene.

Lesson Resources

- Lesson from TDOE: Obtaining, evaluating, and communicating information (lesson goes with Supercows anchoring phenomenon)
- Papacalypse? (GRC lesson goes with papaya investigative phenomenon)
- Artificial Selection of Tomatoes (performance task/assessment)

Textbook Connections

Chapter 15: Change Over Time
Lesson 4: Advances in Genetics

Content to Explore

natural selection	artificial selection
selective breeding	traits
genetic modification	gene therapy
phenotypes	

Previous Standard(s)

5.LS4.2 Use evidence to construct an explanation for how variations in characteristics among individuals within the same species may provide advantages to these individuals in their survival and reproduction.

8.ESS1.1	Research, analyze, and communicate that the universe began with a period of rapid expansion using evidence from the motion of galaxies and composition of stars.

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

Multiple lines of evidence support that the universe began with a period of rapid expansion. This standard introduces two specific lines: the composition of stars and the motion of galaxies. These two ideas are introduced in this grade due the connections to standards within the 8.PS4 disciplinary core ideas.

Stars give off light based on what elements are being fused at the core of this star. To explain, if we pretend that a star existed that was made of Neon, then it would shine the same red color as a lit up neon sign. Every element has its own characteristic color, much like a fingerprint in light. From this "fingerprint" of light, scientists can look at our sun or other stars and know what elements they are made of. We also know that stars of similar size have similar composition. This "fingerprint" is properly called an emission spectrum.

Looking at galaxies, it is possible to determine the sizes of stars and to use the light them emit to determine their composition. All of the colors (frequencies) of light emitted by these galaxies are shifted to longer wavelengths than what is normally observed the elements that make up the stars in that galaxy. This lengthening of the light emitted by these stars is known as a red shift, because all of the colors shift towards the red (longer) wavelengths of light. The motion of the stars emitting the waves is "stretching" the wavelengths of the light as the stars move away. Students will have experienced phenomena caused by this Doppler effect if they have ever heard the change in the sound of a siren as the source passes them.

We observe this same red shift in all galaxies, indicating that all galaxies are in motion away from each other. This is the opposite of what we would expect from gravity, which would pull the galaxies together. Furthermore, we observe that the galaxies that are the most distant, have the greatest degree of a red shift, indicating that they are traveling away from us at the fastest rate. Put together, these pieces of evidence support that all galaxies are moving away from a central point and must have been set onto this outward trajectory by some initial force.

Learning Targets - DCIs
Earth's Place in the Universe

1. The universe began with a period of rapid expansion which resulted in the formation of stars and galaxies—The Big Bang Theory.
2. Stars radiate visible light which can be analyzed with spectroscopes to determine the elements inside the star, and that this has revealed that the most common elements in the universe are hydrogen and helium which matches Big Bang model predictions.
3. All of the colors (frequencies) of light emitted by stars are shifted to longer wavelengths, which is known as a red shift, because all of the colors shift towards the red (longer) wavelengths of light; the motion of the stars emitting the waves is "stretching" the wavelengths of the light as the stars move away (e.g. Doppler effect).
4. The same red shift is observed in all galaxies, indicating that all galaxies are in motion away from each other and that the galaxies that are the most distant, have the greatest degree of a red shift, indicating that they are traveling away from us at the fastest rate.
5. All galaxies are moving away from a central point and must have been set onto this outward trajectory by some initial force.

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

1. Ask questions about the formation of the universe highlighting the patterns of galaxy and star movements.
2. Research, analyze and construct an explanation (communicate information) to show that the universe began with a period of rapid expansion using evidence from the motion of galaxies and the composition of stars. (energy and matter)
3. Collect data and evidence to create a model which supports the theory that our universe formed by rapid expansion from a small dense point and continues to expand highlighting the patterns of galaxy and star movements and the composition of stars.

Phenomena—Anchoring & Investigative *Anchoring phenomena- carry through the entire unit; Investigative phenomena- supports the anchoring phenomenon*	
Anchoring: • Cosmic surveyors have mapped the galaxies in the universe over the past several decades and have noticed a changed in the position of the galaxies. • You are (and you aren't) the center of the universe. **Use Microsoft Edge for Adobe Flash Player.*	Investigative: • The sound of a speeding car passing by makes a "neeeeeoowwm" sound. • The car horn sounds different as it moves towards and away from the camera.

Lesson Resources

- Exploring the Universe (unit goes with cosmic surveyors anchoring phenomenon)
- Exploring the Spectrum (inquiry lab)
  - Foldable Spectrometry Kit
  - Build your own CD spectroscope
- Doppler Effect (lesson)
- Red Shift, Blue Shift (lesson)
- How do we know the Universe is expanding? (video)
- Big Bang Simulation with a Balloon (video investigation)
  - Student investigation (PDF)
  - Student Investigation (PPT)
- What is the Big Bang? (video)
- Big Bang Stations
- Bozeman Science: Doppler Effect (video)
- Formation of the Universe (Playposit)
- Evidence to Support the Big Bang Theory (Playposit)
- The Beginning of Everything—The Big Bang (video)
- The Big Bang Theory (performance task/assessment)
- Galaxy Distance (performance task/assessment)

Textbook Connections	**Previous Standard(s)**
Chapter 7: Stars, Galaxies, and the Universe Lesson 4: Characteristics of Stars (page 258) Lesson 6: The Expanding Universe (page 270)	5.ESS1.2 Research and explain the position of the Earth and the solar system within the Milky Way galaxy and compare the size and shape of the Milky Way to other galaxies in the universe.

Content to Explore

expansion/inflation	Big Bang Theory
red shift	blue shift
gravity	Doppler effect
emission spectrum	star composition
cosmic background radiation	electromagnetic spectrum
Hubble's Law	

8.ESS1.2	Explain the role of gravity in the formation of our sun and planets. Extend this explanation to address gravity's effect on the motion of celestial objects in our solar system and Earth's ocean tides.

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

Gravity is the force that attracts all forms of matter towards one another. Even a pair of atoms will exert a pull on each other. In space, atoms of hydrogen or helium pull on one another and as a result move together (8.PS2.4). As time goes on, more particles are drawn together, and create a position in space with a large cluster of atoms, together producing an increasingly significant gravitational field. As the field increases, atoms that are drawn into the growing crowd of atoms will move into the group with ever-increasing speeds. Initially, the mutual repulsion positive charges of each nuclei keep particles from colliding as they get near each other in the imminent cloud of gas. However, at some point, the inbound atoms move with such speed that the repulsion of the nuclei cannot prevent two atoms from colliding. The outcome is an enormous explosion, but moreover the birth of a new element. What began as a pair of hydrogen nuclei each with one proton, is now a helium nucleus with those two original protons fused in a single nucleus. This event marks the birth of a star such as our sun.

Enormous stars eventually explode, and the tremendous energy released is able to fuse larger nuclei leading to the formation of the heavier elements on the periodic table. In the collapse of a nebula, dust and gas are drawn together by mutual gravitational attraction. As each particle has some initial velocity, the centrally directed force of gravity causes the particles to begin to swirl, accumulate, and compress into a large flask disk like a spinning disk of pizza dough. Planets accumulate within these spinning protoplanetary disks. This process occurred in our solar system long, long ago. By observing patterns in other distant nebula, we are able to reconstruct the history of our own solar system.

Tides are significant because they are an observable event that provides evidence that gravity can act over tremendous distances. The ability of gravity to act at great distances is a requirement to support that the sun and planets formed from the influence of gravity. Students should be able to address the changing distribution of water in tidal patterns for spring and neap tides.

Learning Targets - DCIs
Earth's Place in the Universe

1. Gravity is an attractive force found throughout the universe which attracts any form of matter to any other form of matter.
2. The amount of mass effects the strength of the gravitational force and the distance between two objects also effects gravitational strength.
3. Gravity causes nuclear fusion to occur in nebulas to form stars as hydrogen atoms are fused together into helium atoms releasing vast amounts of energy.
4. The heat and gravity inside stars form other larger/heavier elements.
5. The various elements (types of atoms) in a nebula are pulled together due to gravity in a process called accretion to form stars, planets, moons, etc.
6. Gravity causes nebulas to spin and flatten into disks and how this motion is conserved as stars and planets form resulting in the planets revolving/orbiting around the star.
7. Gravity causes celestial objects (stars, planets, etc.) to rotate, and how it forms these objects into spheres.
8. Rotation and the moon's and the sun's gravitational force pulls on the Earth's oceans resulting in high tides, low tides, spring tides, and neap tides.

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

1. Develop and use a model to show the role of gravity in the formation of our sun and planets. (systems and system models)
2. Construct an explanation of the origin of the solar system to show the role of gravity in formation of the sun and the planets resulting in the celestial motions we observe in our solar system today.
3. Construct an explanation describing how gravity causes matter to accrete into spheres causing the shapes of stars planets, and moons.
4. Obtain, evaluate, and communicate information to show the effect gravity and inertia have on the motion of celestial objects in our solar system (Kepler's laws).

5. Develop a model to show gravitational force pulling on Earth's oceans resulting in tides with the Sun-Earth-Moon system.

Phenomena—Anchoring & Investigative

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

Anchoring:

- Planets formed from dust.
- Astronomers were able to capture a photo of a black hole located in a distant galaxy.
  **The first image of a black hole: A three minute guide*
- Tides are a subtle but inexorable force that have shaped most objects in the universe.

Investigative:

- The formation of stars determines where new planetary systems can arise as well as the structure and evolution of galaxies.
- NASA has a plan to protect the Earth from killer asteroids.
- A woman in Alabama was hit by a meteorite in 1954.
- Earth travels around the Sun in an elliptical orbit and the Moon travels around Earth in an elliptical orbit.
- If a tetherball rope breaks while in motion around the pole, the ball flies off in a straight line.
- Newton's Cannon shows how the motion of a cannonball is fundamentally the same as the orbit of a celestial body like the moon.

Lesson Resources

- Gravity in Galaxies (lesson goes with Newton's Cannon investigative phenomenon)
- Planet Ballet (GRC lesson goes with Earth and Moon orbit investigative phenomenon)
- Why Orbit? (GRC lesson goes with tetherball investigative phenomenon)
- PhET: Gravity and Orbits (simulation)
- What Causes Tides?
- Formation of the Planets (video)
- Birth of our Solar System (video)
- Science in a Minute: Newton's Universal Law of Gravitation (video)
- Tides: Crash Course Astronomy #8 (video)
- What Physics Teachers Get Wrong About Tides! (video)
- Study Jams: Tides
- Earth's Place in the Universe One-Pager

Textbook Connections

Chapter 5: Earth, Moon, and the Sun
Lesson 2: Gravity and Motion (page 166)
Chapter 6: The Solar System
Lesson 2: Introducing the Solar System (page 192)

Content to Explore

gravity	inertia
tides	high tides
nebula	black hole
low tides	spring tides
neap tides	

Previous Standard(s)

5.ESS1.3 Use data to categorize different bodies in our solar system including moons, asteroids, comets, and meteoroids according to their physical properties and motion.

8.ESS2.1	Analyze and interpret data to support the assertion that rapid or gradual geographic changes lead to drastic population changes and extinction events.

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

The processes of natural selection and adaptation are driven by physical changes to Earth. This standard (8.ESS2.1) explores different types of geographic changes that can occur. When Earth undergoes sudden changes at a large scale, large amounts of variation in living organisms may be lost, however gradual processes may lead to gradual changes in populations over generations.

The fossil record can be analyzed to gather data about the types of organisms that have lived on Earth. The geologic record can provide information about geographic changes that have occurred. Making inferences from either of these records assumes that geologic and physical processes (e.g. weathering and erosion) function the same way now and in the past.

Data can be used to support that while rates may vary, a particular location is constantly experiencing either processes of erosion or deposition. Erosive processes remove layers from the geologic record, while sedimentation will add new layers in lower lying sites. Data may be drawn from rock strata, formation and erosion of Hawaiian Islands or Appalachian Mountains, glacial retreat, historic sea levels and elsewhere. Catastrophic events include meteor impacts, massive volcanic eruptions, tsunamis, and/or earthquakes. Gradual changes may include ice ages, warming periods, and or tectonic movements.

Learning Targets - DCIs
Earth's Systems

1. The fossil record and the geologic column have revealed that environments change over time forcing organisms to adapt or go extinct and that extinctions are common.
2. The Earth's biosphere has experienced at least five major extinction events according to fossil and geologic evidence.
3. Data can be gathered from rock layers (strata) to analyze ancient events that resulted in wide scale extinctions across the planet.
4. Rapid changes that caused planet-wide extinctions include asteroid impacts and volcanic eruptions. Gradual events which reduced species populations and/or resulted in extinctions include ice ages, warming periods, and or tectonic plate movement.

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

1. Analyze and interpret data from the fossil record and the geologic column to show that rapid or gradual geographic changes lead to drastic population changes and extinction events. (scale, proportion, and quantity)
2. Develop a model (e.g. timeline) of mass extinction events highlighting the rapid or gradual geographic changes that lead to the events. (scale, proportion, and quantity)
3. Construct an explanation comparing natural extinction rates with the elevated extinction rates of today. (scale, proportion, and quantity)
4. Develop and use a model (e.g. concept map) to describe the causes and consequences of a modern extinction.
5. Develop an argument that supports the claim that humans may be responsible for the sixth extinction event. (cause and effect)

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

Anchoring:

- A giant fossil of an ancient penguin, Pedro, could be connected to modern day penguins.
- Five mass extinction events have occurred on Earth since life began. Experts believe that humans will be responsible for the sixth extinction event.
- North America (like Africa today) was once covered with large megafauna (animals weighing more than

Investigative:

- Fossilized seashells are found in the desert near the city of Las Cruces in New Mexico.
- Dinosaur fossils have been found in Antarctica.
- Archaeopteryx was thought to be the remains of a flying reptile.

100 pounds), including giant mammoths, ground sloths, and beavers the size of a large bear.	

Lesson Resources

- ***UPDATED!*** Pedro's Connection Teacher Guide (storyline unit taught with ancient penguin anchoring phenomenon and standards 8.LS4.1-4.4 and 8.ESS2.1)
    - Pedro's Connection folder with student journal, PowerPoints, and other resources
- Racing Extinction (lesson goes with five mass extinction events anchoring phenomenon)—*UPDATED!*
- Plate Tectonics & Permian Extinction (video)
- 'The Great Dying' Was Our Worst Extinction Ever, And It Could Happen Again (video)
- Siberian Traps likely triggered end-Permian mass extinction (video)
- Biogeology (Nearpod)
- Fossil Data Analysis
    - Data collection sheet
- Extinction Event Stations

Textbook Connections	Previous Standard(s)
Chapter 14: A Trip Through Geologic Time Lesson 6: Eras of Earth's History (page 528)	6.LS2.7 Compare and contrast auditory and visual methods of communication among organisms in relation to survival strategies of a population.

Content to Explore

mass extinction	extinction event
geographic changes	rapid/gradual changes
geographic record	glacial/interglacial periods

8.ESS2.2	Evaluate data collected from seismographs to create a model of Earth's structure.

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

Seismic waves are mechanical waves that transfer energy just like other mechanical waves. The source of their energy is usually from Earth's shifting plates. Like other mechanical waves, seismic waves interact with the medium through which they travel. Interactions include changes in the wave's speed as the medium changes, absorption, reflection, or refraction. For example, seismic waves traveling through the Earth's mantle will be refracted as the density of the material changes due to heating from Earth's core. Student models of Earth's structure should account for recorded wave behaviors.

Earthquakes produce two different waves visible on seismographs: pressure waves (P-waves) and shear waves (S-waves). These two waves travel at different speeds, their relative positions on a recorded seismogram will be further apart as the distance from the epicenter to seismograph increases.

The P-waves are longitudinal waves. They are able to compress both liquid and solid and therefore we expect them to travel through any matter in Earth's interior, regardless of its state. S-waves are a transverse wave. Student should explore models of s-waves to explain why s-waves cannot travel through liquids. On seismograms, both p and s waves are observable, unless an imaginary line connecting the location of the recording seismograph and the epicenter of the earthquake also passes through earth's outer core. When the waves from a seismic event pass through the outer core, only the p-waves are transmitted. The absence of s-waves is evidence for the liquid outer core.

Learning Targets - DCIs
Earth's Systems

1. Earth's shifting plates cause energy pulses (i.e. mechanical waves) called seismic waves.
2. Seismic waves interact with the medium through which they travel. Interactions include changes in the wave's speed as the medium changes, absorption, reflection, or refraction.
3. Devices such as seismographs/seismometers that can detect and take quantitative measures of seismic waves.
4. Earthquakes produce two different waves visible on seismographs: pressure waves (P-waves) and shear waves (S-waves), which travel at different speeds and their relative positions on a recorded seismogram will be further apart as the distance from the epicenter to seismograph increases.
5. The P-waves are longitudinal waves and are able to compress both liquid and solid and therefore we expect them to travel through any matter in Earth's interior, regardless of its state.
6. S-waves are a transverse wave and cannot travel through liquids.
7. Seismic waves refract (bend) as the travel from one medium to a different medium (solid to liquid) and that this can also change the speed of the wave(s).
8. The internal structure of our planet can be determined by analyzing data from seismic waves that have traveled through the Earth.

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

1. Develop a model to show wave energy as it moves through solid and liquid layers of our planet tracking energy changes as the wave travels through Earth's interior.
2. Use seismic data to construct a model of the interior layers of the earth in order to show energy flow through the Earth's Layers.
3. Construct an explanation to describe the types of seismic waves produced by shifting tectonic plates highlighting the transfer of energy produced by tectonic plate movement.
4. Develop and use a model to show that P waves travel at different speeds in different layers inside the Earth and will refract highlighting changes of movement in the flow of energy through Earth layers.

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

Anchoring:	Investigative:
• Mt. Everest is getting taller and moving farther northeast every year, while other mountains are shrinking	• Mud volcanoes litter the Salton Sea shoreline in southern California.

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- Scientists have only dug 0.2% of the distance to the center of the Earth.
- Paricutin is a volcano that developed and erupted in the 1940s. The volcano surged suddenly from the cornfield of local farmer, growing over 150 feet within 24 hours and slowly devouring the town of San Juan.
- Article and Video
**Can also be used with 8.ESS2.4 and 8.ESS3.2.*

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- On Feb 7, 1812, an earthquake occurred near the Missouri-Tennessee border which caused church bells to ring in Boston, brick walls fell in Cincinnati, and created Reelfoot lake in TN and Big Lake on the Arkansas border.

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<td colspan="2">

Lesson Resources

</td>
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<tr>
<td colspan="2">

- ***NEW!*** Ain't No Mountain High Enough Teacher Guide (storyline unit taught with ancient penguin anchoring phenomenon and standards 8.ESS2.2-2.5 and 8.ESS3.1-3.2)
  - Ain't No Mountain High Enough folder with student journal, PowerPoints, and other resources
- Lesson from TDOE: Developing and using models (lesson goes with center of the Earth anchoring phenomenon)
- Alien Planet Interior Structure (practice with seismographic data)
- How a Seismograph Works (video)
- Seismic Imaging (video)
- The Mystery of the Earth's Core Explained (video)
- Earth's Interior Isn't Quite What We Thought It Was (video)
- Seismic Waves (Nearpod)
- P and S Wave Research/Explore

</td>
</tr>
<tr>
<th>Textbook Connections</th>
<th>Previous Standard(s)</th>
</tr>
<tr>
<td>Chapter 8: Introducing Earth and Its Resources
Lesson 2: Earth's Interior (page 292)</td>
<td rowspan="3">4.ESS2.4 Analyze and interpret data on the four layers of the earth, including thickness, composition, and physical states of these layers.</td>
</tr>
<tr>
<th>Content to Explore</th>
</tr>
<tr>
<td>

seismograph	mechanical waves
seismic waves	medium
P-Wave	S-Wave
crust	mantle
inner core	outer core

</td>
</tr>
</table>

8.ESS2.3	Describe the relationship between the processes and forces that create igneous, sedimentary, and metamorphic rocks.

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

Different processes are responsible for forming each different type of rock. It is possible to understand parts of the geologic history of places or regions by looking at the types of rocks found there. While understanding traditional models for the rock cycle is expected, it is important that students are able to use these models to explain events that have occurred in the past, accounting for changes that take place over spans of time far exceeding human lifetimes.

Igneous rocks indicate undisturbed or younger areas. Patterns in the distribution of igneous rocks coincide with the patterns for earthquakes and the plate boundaries explained in tectonic theory.

The presence of sedimentary rocks in an area indicates that that area was once lower lying and that erosive processes occurring in nearby areas.

Metamorphic rocks can form from either igneous or sedimentary rocks, and are evidence for tectonic pressures, for example in the uplift of mountains.

Learning Targets - DCIs
Earth's Systems

1. Different rock cycle processes are responsible for forming rock from one type to another type (igneous, sedimentary, metamorphic) and each type of rock can be transformed into one of the other types under the right conditions.
2. Igneous rock is formed when molten rock cools and hardens into solid rock.
3. Metamorphic rock is the end result of rock that has been changed due to heat and pressure from tectonic processes.
4. Sedimentary rock is formed by a process called lithification and that the formation of sedimentary rock includes weathering, erosion, transportation, deposition, compaction, and cementation.

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

1. Ask questions in order to show the relationship between the processes and forces that create igneous, sedimentary, and metamorphic rocks highlighting the cause and effect relationship between rock types and the forces and process that formed them.
2. Develop and use a model to show the processes and forces that form igneous, sedimentary, and metamorphic rocks highlighting stability and change within the rock cycle.

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

Anchoring:

- Mt. Everest is getting taller and moving farther northeast every year, while other mountains are shrinking
- Evidence of ways that matter is cycled through the earth can be seen in even the biggest cities and busiest neighborhoods.
- Many types of rock formations are commonly found in parts of Tennessee.

Investigative:

- Each layer of rock tells a unique part of the environmental history of the Grand Canyon.
- Devil's Tower dominates the landscape at Devil's Tower National Park, Wyoming.
- Near St. George Utah the tops of the buttes are covered with lava flow, but the valleys and ravines are covered with sand and sandstone.
- Devil's Slide is an unusual geologic rock formation in Weber Canyon in Utah that has two parallel rock slabs protruding from the mountainside.

Lesson Resources

- ***NEW!*** Ain't No Mountain High Enough Teacher Guide (storyline unit taught with ancient penguin anchoring phenomenon and standards 8.ESS2.2-2.5 and 8.ESS3.1-3.2)
    - Ain't No Mountain High Enough folder with student journal, PowerPoints, and other resources

- Lesson from TDOE: Asking questions and defining problems (lesson goes with rock formations in Tennessee anchoring phenomenon)
- A View from Below (lesson goes with matter cycling anchoring phenomenon and 8.ESS2.4)
- Igneous Butte (GRC lesson goes with St. George Utah investigative phenomenon)
- What Caused the Devil's Slide? (GRC lesson goes with Devil's Slide investigative phenomenon)
- MY Rock Cycle Organizer
- A Starburst Rock Cycle
- Rock Cycle (interactive)
- The Rock Cycle: Sedimentary, Metamorphic, Igneous (video)

Textbook Connections	**Previous Standard(s)**
Chapter 9: Minerals and Rocks Lesson 2: Classifying Rocks (page 336) Lesson 3: Igneous Rocks (page 340) Lesson 4: Sedimentary Rocks (page 344) Lesson 5: Metamorphic Rocks (page 350) Lesson 6: The Rock Cycle (page354)	4.ESS2.1 Collect and analyze data from observations to provide evidence that rocks, soils, and sediments are broken into smaller pieces through mechanical weathering (frost wedging, abrasion, tree root wedging) and are transported by water, ice, wind, gravity, and vegetation.
Content to Explore	
sedimentary rock metamorphic rock igneous rock	

8.ESS2.4	Gather and evaluate evidence that energy from the earth's interior drives convection cycles within the asthenosphere which create changes within the lithosphere including plate movements, plate boundaries, and seafloor spreading.

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

Convection cycles occur when fluids are heated. The heated fluid flows upward. Fluid at the surface loses heat to the atmosphere and the cooled fluid descends as a result of its increased density. The heat driving convection cycle comes from the elements found in Earth's core and lower mantle (not from residual heat from Earth's formation).

The circular motion of the cycling asthenosphere drags the plates that make up Earth's floating lithospheres. The floating plates are moved together or apart at boundaries. Where plates move apart, liquid rock from earth's interior reaches the surface, and solidifies.

Earth's mantle must be primarily solid, otherwise S-waves would not travel through it. This can be cause confusion, when trying to explain how convection can occur within the mantle. Because students should recognize that convection does not occur in solids. The solid nature of the mantle is somewhat like considering glass a solid. Over very long periods of time, panes of glass oriented vertically become thinner at their tops and thicker at their bottoms as they flow downward. Similarly, Earth's mantle exhibits liquid behaviors at geologic time scales.

Learning Targets - DCIs
Earth's Systems

1. The Earth's interior is extremely hot due to decaying radioactive elements (and possibly residual heat from Earth's formation) and that this heat causes convection currents in the rock and magma that make up the Earth's interior.
2. Convection currents in the Earth occur when rock is heated to a fluid or semi-plastic state deep in the planet's interior. This heated rock flows upward and at or near the Earth's surface it loses heat and sinks downward. This happens repeatedly in the Earth's interior in re-occurring cycles.
3. The lithosphere is the (rigid) crust and (rigid) top part of the mantle while the asthenosphere is the (ductile/viscous) mantle directly beneath the lithosphere.
4. The lithosphere is broken into giant slabs called tectonic plates, and the circular motion of the cycling asthenosphere (e.g. convection currents) drag these plates resulting in tectonic plate movement forming divergent, convergent, and transform boundaries.

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

1. Obtain, evaluate, and communicate information to show that convection currents are driven by reactions in Earth's core highlighting the flow of energy within the Earth.
2. Develop a model to show how convection cycles cause tectonic processes highlighting how changes in temperature affects density in rock resulting in circular movement patterns in the Earth's interior.
3. Develop a model to show convection currents in the Earth's interior highlighting the mechanics and results of tectonic movement. (cause and effect)

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

Anchoring:

- Mt. Everest is getting taller and moving farther northeast every year, while other mountains are shrinking.
- Paricutin is a volcano that developed and erupted in the 1940s. The volcano surged suddenly from the cornfield of local farmer, growing over 150 feet within 24 hours and slowly devouring the town of San Juan.
  - Article and Video

  **Can also be used with 8.ESS2.2 and 8.ESS3.2.*

Investigative:

- Hot fluid rises and cool fluid sinks.
- Tectonic plates move 3-5 centimeters per year.
- Evidence of ways that matter is cycled through the earth can be seen in even the biggest cities and busiest neighborhoods.

Lesson Resources

- ***NEW!*** Ain't No Mountain High Enough Teacher Guide (storyline unit taught with ancient penguin anchoring phenomenon and standards 8.ESS2.2-2.5 and 8.ESS3.1-3.2)
    - Ain't No Mountain High Enough folder with student journal, PowerPoints, and other resources
- A View from Below (lesson goes with matter cycling anchoring phenomenon and 8.ESS2.3)
- Convection Cycle (Nearpod)
- Types of Plate Boundaries
- Science Snacks: Squeeze Box (demonstration/investigation)
- Convection Demos (video)
- Sea Floor Spreading & Plate Tectonic Evidence (video)
- Tectonic Plates—The Skin of Our Planet (video)

Textbook Connections	Previous Standard(s)
Chapter 8: Introducing the Earth and Its Resources Lesson 2: Earth's Interior (page 292) Chapter 10: Plate Tectonics Lesson 1: Drifting Continents (page 370) Lesson 2: Sea-Floor Spreading (page 374) Lesson 3: The Theory of Plate Tectonics (page 380)	6.ESS2.2 Diagram convection patterns that flow due to uneven heating of the earth.
Content to Explore	
convection currents tectonic plates mantle lithosphere asthenosphere density	

8.ESS2.5	Construct a scientific explanation using data that explains that the gradual processes of plate tectonics accounting for A) the distribution of fossils on different continents, B) the occurrence of earthquakes, and C) continental and ocean floor features (including mountains, volcanoes, faults, and trenches).

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

As this is one of the first scientific theories students will be exposed to by name, it is important properly communicate that theories are explanations of observations/patterns in nature. In this case, tectonic theory explains the three components of the standard. Though not part of the standard, it might be interesting to discuss prior explanations for these same observations.

Students have seen that a conductor that moves through a magnetic field can create its own magnetic field (8.PS2.1). Earth's liquid, moving, iron core creates Earth's magnetic field. As new rock forms at divergent plate boundaries, iron crystals in the newly formed rock orient themselves to Earth's magnetic field. Observing changes in the orientation of the iron crystals in the rocks is evidence of seafloor spreading.

When the locations of past earthquakes are plotted onto a map, a pattern emerges where the majority of earthquakes occur along coasts. Tectonic theory explains this pattern.

Fossilized remains of similar organisms are found on different continents with very different present-day environments *(conflict with 8.LS4)*. Tectonic theory accounts for this disparity, explaining that the two locations were once connected and at the time they were connected, the environmental conditions would have been the same.

Learning Targets - DCIs
Earth's Systems

1. Tectonic plate movement causes earthquakes and results in the formation of volcanoes, mountain ranges, trenches, and other geological features.
2. Widely separated fossils of the same species can be found on different continents due to tectonic plate movement over time breaking apart and moving ancient tectonic plates.
3. Plate movement from convergent boundaries can result in subductions zones where volcanoes often form, and this movement can crumple the crust forming mountain ranges (e.g. Himalayas).
4. Plate movement from divergent boundaries can split the crust and form new crust (e.g. Mid-Atlantic Ridge and Great Rift Valley).

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

1. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of past plate movements. (patterns)
2. Construct an explanation to show how tectonic plate movement causes earthquakes and forms mountain ranges, volcanoes, and trenches highlighting the scale and magnitude of the Earth's geologic change over time.
3. Construct an explanation to show the location of fossil remains on different continents separated by tectonic plate movement. (cause and effect)
4. Construct an explanation to show the changed orientation of iron in the crust on each side of the Mid-Atlantic Ridge is evidence of seafloor spreading. (cause and effect)

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

Anchoring:	Investigative:
• Mt. Everest is getting taller and moving farther northeast every year, while other mountains are shrinking. • Through paleomagnetic data, scientists can reconstruct what Earth may have looked like in the distant past. • The African continent is very slowly peeling apart. Scientists say a new ocean is being born.	• Extinct giant cicada fossil sites have been found all over the world on different continents. • The Hawaiian Islands are not all the same age. • People in Iceland get most of their energy from geothermal energy sources.

Lesson Resources

- ***NEW!*** Ain't No Mountain High Enough Teacher Guide (storyline unit taught with ancient penguin anchoring phenomenon and standards 8.ESS2.2-2.5 and 8.ESS3.1-3.2)
    - Ain't No Mountain High Enough folder with student journal, PowerPoints, and other resources
- Exploring Our Fluid Earth: Continental Movement by Plate Tectonics
- Volcano and Earthquake Data (investigation)
- Theory of Plate Tectonics Tasks
- Puzzle of Plate Tectonics (Playposit)
- Ring of Fire (Playposit)
- Fossil Evidence Research
- Plate Tectonics CER (performance task)
- What to See on the Seafloor (GRC lesson goes with Hawaiian Islands investigative phenomenon)
- Iceland has Geothermal Energy (GRC lesson goes with Iceland investigative phenomenon)

Textbook Connections	**Previous Standard(s)**
Chapter 10: Plate Tectonics Lesson 1: Drifting Continents (page 370) Lesson 2: Sea-Floor Spreading (page 374) Chapter 11: Earthquakes Lesson 1: Forces in Earth's Crust (page 400)	4.ESS2.2 Interpret maps to determine that the location of mountain ranges, deep ocean trenches, volcanoes, and earthquakes occur in patterns.
Content to Explore	
tectonic theory, plate tectonics, Alfred Wegener, Pangaea, fossil distribution, earthquakes, mountains, volcanoes, faults, trenches, seafloor spreading	

8.ESS3.1	Interpret data to explain that Earth's mineral, fossil fuel, and groundwater resources are unevenly distributed as a result of tectonic processes.

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

The formation and/or accumulation of resources occurs as a result of tectonic and natural processes. Data should connect natural resources locations to such processes. Mineral accumulations connect to processes such as water transport and ash spread by volcanoes.

Fossil fuels form the remains of plants and algae that filled that once filled swampy areas. Students can observe data to show that swampy areas are found in low lying regions, and that these areas undergo processes of sedimentation. As sedimentation and decomposition occur, the heavy layers being deposited trap heat and permit chemical reactions that transform the remains of decaying organisms into petroleum. Data analysis can include connecting the locations of areas that were low-lying swamps in pre-historic times to sites of present-day extraction of fossil fuels.

The processes that form different rock types have created non-uniform distribution of rock types. Granite and other metamorphic rocks are impermeable to water and layers of such metamorphic rock serve as enormous "bowls" trapping water. These areas fill with porous sediment, which does not prevent accumulation of water. Students can observe data about the types of rock in areas where aquifers are located, connecting this to general events that would have created necessary conditions for aquifer formation.

Learning Targets - DCIs
Earth and Human Activity

1. The formation and/or accumulation of resources occurs as a result of tectonic and natural processes.
2. Data should connect natural resources locations to specific processes. For example, mineral accumulations connect to water transport and ash spread by volcanoes, locations of areas that were low-lying swamps in pre-historic times to sites of present-day extraction of fossil fuels, and types of rock in areas where aquifers are located.

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

1. Use models to obtain information about the causes of the uneven distribution of natural resources on Earth.
2. Analyze and interpret data to show Earth's natural resources are unevenly distributed as a result of tectonic processes.
3. Develop an argument for how the evidence you have gathered supports the explanation that natural resources are not evenly distributed as a result of Earth processes and plate tectonics.

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

Anchoring:	Investigative:
• Mt. Everest is getting taller and moving farther northeast every year, while other mountains are shrinking. • Natural resources are unevenly distributed around the world.	• Bingham Canyon is only one of a few places worldwide where large amounts of copper are mined.

Lesson Resources

- ***NEW!*** Ain't No Mountain High Enough Teacher Guide (storyline unit taught with ancient penguin anchoring phenomenon and standards 8.ESS2.2-2.5 and 8.ESS3.1-3.2)
  - Ain't No Mountain High Enough folder with student journal, PowerPoints, and other resources
- Anchoring phenomenon: At random, teacher gives students index cards which are labeled as mineral, fossil fuel, or groundwater. Each card represents one metric ton. Students are split up into geographic regions and class tallies each region's resources. Students then answer: 1. Are the resources evenly distributed in this scenario and 2. How is this a model for Earth's resource distribution?
- The Copper Conundrum (GRC lesson goes with copper investigative phenomenon)
- Natural Resource Distribution Research

- Guide
- Grid and Map (answer key)

- Copper, The Poor Man's Gold (performance task/assessment)
- Is Your Penny Copper or Zinc? (performance task/assessment)

Textbook Connections	Previous Standard(s)
Chapter 8: Introducing Earth and Its Resources Lesson 1: The Earth System (page 286) Lesson 4: Fossils Fuels (page 304) Chapter 9: Minerals and Rocks Lesson 1: Properties of Minerals (page 324)	4.ESS3.1 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

natural resources	fossil fuels
minerals	tectonic plates
groundwater	aquifer

8.ESS3.2	Collect data, map, and describe patterns in the locations of volcanoes and earthquakes related to tectonic plate boundaries, interactions, and hotspots.

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

Tectonic theory explains the patterns that are seen in the locations where earthquakes occur. The data collected might include locations, magnitudes, and frequencies of tectonic phenomena, as well as types and significance of damage associated with the events.

As humans build cities and civilizations, knowledge of natural hazards allows for intentional development. Earthquakes occur and scientists are not yet able to predict when they will happen. However, we can generally predict where they are most likely going to happen. This knowledge allows developers to build buildings and make preparations for likely events. Preparations can include both plans to minimize damage, as well as how to respond to the most likely types of damage that will occur.

Learning Targets - DCIs
Earth and Human Activity

1. Plotting earthquake and volcano locations will reveal that these two tectonic events most frequently occur at or near plate boundaries.
2. Magma plumes rising up through the Earth's interior can form hotspots far away from plate boundaries where volcanoes form and earthquakes occurs (e.g. Hawaiian Islands, Galapagos Islands, Yellowstone Caldera, etc.).
3. National and international organizations collect tectonic data from earthquakes and volcanoes via seismographic readings including measurements and tracking of locations, magnitudes, frequency, and damage.
4. Scientists are not yet able to predict when earthquakes and volcanic eruptions will occur but that they can make fairly accurate predictions about where they are most likely going to happen.

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

1. Collect and map seismic data to show the locations of earthquakes and volcanoes and plate boundaries highlighting patterns for future predictions.
2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. (Patterns)

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

Anchoring:	Investigative:
• Mt. Everest is getting taller and moving farther northeast every year, while other mountains are shrinking. • Paricutin is a volcano that developed and erupted in the 1940s. The volcano surged suddenly from the cornfield of local farmer, growing over 150 feet within 24 hours and slowly devouring the town of San Juan. - Article and Video **Can also be used with 8.ESS2.2 and 8.ESS2.4.*	• Yellowstone National Park has a supervolcano, and if its effects would be worldwide.

Lesson Resources

- ***NEW!*** Ain't No Mountain High Enough Teacher Guide (storyline unit taught with ancient penguin anchoring phenomenon and standards 8.ESS2.2-2.5 and 8.ESS3.1-3.2)
  - Ain't No Mountain High Enough folder with student journal, PowerPoints, and other resources
- Interactive Map of Active Volcanoes and Recent Earthquakes World-Wide
- Can you build an earthquake proof house? (article and questions)
- The Quest for the Ring of Fire

Textbook Connections	Previous Standard(s)
Chapter 10: Plate Tectonics Lesson 3: The Theory of Plate Tectonics (page 380) Chapter 11: Earth Quakes Lesson 1: Forces in Earth's Crust (page 400) Lesson 2: Earthquakes and Seismic Waves (page408) Lesson 3: Monitoring Earthquakes (page 416) Chapter 12: Volcanoes Lesson 1: Volcanoes and Plate Tectonics (page 434) Lesson 2: Volcanic Eruptions (page 438) Lesson 3: Volcanic Landforms (page 446)	4.ESS2.2 Interpret maps to determine that the location of mountain ranges, deep ocean trenches, volcanoes, and earthquakes occur in patterns. 3.ESS3.1 Explain how natural hazards (fires, landslides, earthquakes, volcanic eruptions, floods) impact humans and the environment.
Content to Explore	
tectonic plates Ring of Fire hotspots earthquakes volcanoes supervolcano caldera	

8.ETS1.1	Develop a model to generate data for ongoing testing and modification of an electromagnet, a generator, and a motor such that optimal design can be achieved.

TDOE Standard Explanation

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

Within the field of engineering, models are often prototypes. The purpose of on-going testing of prototypes is to permit a variety of tests of a solution or a set of competing solutions. Data from each of the different tests can then be compiled and compared to either improve a particular design or select from a group of designs. An optimal design may not be the best performer on all tests, but if tests are designed with respect to the criteria and constraints for the design task, it is possible to accept compromises in light of project priorities.

Motors and generators both allow conversions between mechanical energy and electrical energy, but in different directions. Motors convert electrical energy into motion, while generators convert the energy of motion into electrical energy. This standard bundles well with 8.PS2.1, and testing and optimization of either type of device can as a way of exploring the patterns underlying principles of electromagnetism.

Examples of models may include creating, testing, and modifying simple electromagnets, using a coil of wire and a magnet to produce electric current, or creating a simple homopolar electric motor with magnets, a battery and paper clips.

Learning Targets - DCIs

Engineering Design

1. The engineering design process can be used to achieve an optimal design.
2. Electromagnets can be turned on or off, unlike permanent magnets.
3. Magnetic fields are created from the electric current of an electromagnet, and the strength of these fields can be increased or decreased by adding to or taking away from the number of loops around the iron core and/ or the strength of the power source.
4. Electrical motors convert electrical energy into mechanical energy (motion), while generators convert the energy of motion into electrical energy.
5. Electrical generators induce electrical current by moving a magnet through a coil of wire in a process called electromagnetic induction.

Tasks and Assessments—SEPs & CCCs

Each task and assessment correspond with a learning target.

1. Obtaining, evaluating, and communicating information about the design of electromagnets, generators, and simple motors explaining the patterns and underlying principles of electromagnetism.
2. Develop a model to generate data for ongoing testing and modification of an electromagnet, a generator, and a motor such that optimal design can be achieved. (scale, proportion, and quantity)

Phenomena—Anchoring & Investigative

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

Anchoring:	Investigative:
• Homopolar motors work without gasoline. *Show first 1:12 minutes.*	• Earth is the strongest magnet in the world. • A handheld device with a crank handle can create enough energy that it can charge a cell phone.

Lesson Resources

- Simple Motors & Electromagnets (lesson/unit goes with the homopolar motor anchoring phenomenon)
- Motors and Generators (Playposit)
- Electromagnets: How can electricity create a magnet? (video)
- How to make an electromagnet (video)
- How to make a simple electric motor (video)
- How to build a Simple Electric Generator (video)
- Magnetism: Induction (video)
- Building Electromagnets and Simple Motors (investigation)

<table>
<tr><th>Textbook Connections</th><th>Previous Standard(s)</th></tr>
<tr><td>Chapter 2: Magnetism and Electromagnetism
Lesson 3: Electromagnetic Force (page 62)
Lesson 4: Electricity, Magnetism, and Motion (page 68)
Lesson 5: Electricity from Magnetism (page 74)</td><td rowspan="3">4.PS4.2 Describe how the colors of available light sources and the bending of light waves determine what we see.</td></tr>
<tr><th>Content to Explore</th></tr>
<tr><td>electromagnet
solenoid
electrical charge
electrical current
magnetic field
generator
motor
electromagnetism
electromagnetic induction</td></tr>
</table>

8.ETS1.2	Research and communicate information to describe how data from technologies (telescopes, spectroscopes, satellites, and space probes) provide information about objects in the solar system and universe.

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

The increases in scientific knowledge facilitating technological advances have enabled dynamic views of our universe. Early astronomers were limited to observing patterns in the motion of the cosmos to make measurements using principles of geometry. Modern tools such as spectroscopes allow us to determine the types of elements making up distant stars by observing patterns in the color of light given off by the stars.

Examples may include the types of data/information that come from each of the various listed technologies and their uses. For example, how the Hubble Space telescope allows for imaging at greater distances than terrestrial-based telescopes.

Emphasis is on tool selection and its alignment with function as it embeds with the content standard. Students should discuss the development of each technology and be able to rudimentarily explain how each gathers information. Students should be able to connect the type of data (e.g. emission spectra vs transit times for planets) to the general types of information that can be gathered from that data (e.g. composition vs time required to orbit sun).

Learning Targets - DCIs
Engineering Design

1. Data is collected from telescopes, spectroscopes, satellites, and space probes to aid our understanding about the past, present, and future of our solar system, galaxies, and the universe.
2. Modern tools such as spectroscopes allow us to determine the types of elements making up distant stars by observing patterns in the color of light given off by the stars.
3. Space-based telescopes allow for imaging at greater distances than terrestrial-based telescopes.

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

1. Obtain, evaluate, and communicate information about telescopes, spectroscopes, satellites, and space probes in order to describe how each technology gathers information about celestial objects in our solar system, our galaxy, and our universe. (scale, proportion, and quantity)

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

Anchoring:	Investigative:
• The advancement of space probe technologies has changed our views of the universe.	• The Hubble Space Telescope's collects light from stars to help us analyze and better understand our universe. • NASA's Parker Solare Probe will touch the sun.

Lesson Resources

- Space Technology Research (Nearpod—***PLEASE DUPLICATE BEFORE YOU EDIT!***)
- Our Universe Has Trillions of Galaxies: Hubble Study (video)
- 5 Space Telescopes You Should Know About Besides Hubble (video)
- Spectroscopy for astronomy (video)
- How do we know what stars are made of? (video)
- Phoning Home—NASA JPL and communicating from Mars (video)

Textbook Connections	Previous Standard(s)
Chapter 6: The Solar System Lesson 2: Introducing the Solar System (page 192) Chapter 7: Stars, Galaxies, and the Universe Lesson 1: Telescopes (page 238) Lesson 2: The History of Space Exploration (page 244) Lesson 4: Characteristics (page 258)	5.ETS2.2 Describe how human beings have made tools and machines (X-ray cameras, microscopes, satellites, computers) to observe and do things that they could not otherwise sense or do at all, or as quickly or efficiently.

Content to Explore		
telescope satellite	spectroscope space probe	