Kentucky Academic Standards for Science

Unit Title	Estimated Time Frame
Plate Motion: The Mystery of the *Mesosaurus* Fossils	**23 Days**
Unit Anchor Phenomenon (Big Idea):	
Fossils of the *Mesosaurus*, an extinct reptile whose population once lived all together, are found in two locations that are separated by thousands of kilometers of ocean.	
Problem Students are Trying to Solve (Essential Question):	
Why are fossils of *Mesosaurus* separated by thousands of kilometers of ocean when the species once lived all together?	
Unit Three Dimensional Statement	
Students analyze data about plates, plate boundaries, and the patterns of geologic activity characteristic of plate boundaries (patterns)—through the use of physical and digital models and articles and videos featuring real-life scientists—in order to construct explanations about how the fossils of *Mesosaurus* (a population of extinct reptile that once lived all together) were separated by thousands of kilometers of ocean as a result of slow plate movement over millions of years (scale, proportion, and quantity).	
Essential Standards (Focal Performance Expectations) (KAS for Science):	
08-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. **Clarification Statement:** Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions. **Assessment Boundary:** Assessment does not include recalling the names of specific periods or epochs and events within them. KILP: 2 - Employ, develop, and refine schema to understand and create text. 3 - View literacy experiences as transactional, interdisciplinary and transformational. 8 - Engage in specialized, discipline specific literacy practices.	

06-ESS2-3: Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.
Clarification Statement: Examples of data include similarities of rock and fossil types on different continents, the shapes of the continents (including continental shelves), and the locations of ocean structures (such as ridges, fracture zones, and trenches)
Assessment Boundary: Paleomagnetic anomalies in oceanic and continental crust are not assessed.
KILP: 6 - Collaborate with others to create new meaning.
8 - Engage in specialized, discipline specific literacy practices.
9 - Apply high level cognitive processes to think deeply and critically about text.

Supporting Standards (Connections to Other Performance Expectations)**:**

06-ESS2-2. Construct an explanation based on evidence for how biological and geoscience processes have changed Earth's surface at varying time and spatial scales.
Clarification Statement: Emphasis is on how processes change Earth's surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides, biological or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition caused by the movements of water, ice, and wind. Examples of biological processes could include the decomposition of living organisms resulting in soil formation, the effect of vegetation on erosion, and the impact of beaver dams on the natural flow of waterways. Emphasis is on biological processes and geoscience processes that shape local geographic features, where appropriate.
Assessment Boundary: None provided.

Connections to Kentucky Interdisciplinary Literacy Practices (KILP):

2. Employ, develop, and refine schema to understand and create text.
3. View literacy experiences as transactional, interdisciplinary and transformational.
6. Collaborate with others to create new meaning.
8. Engage in specialized, discipline specific literacy practices.
9. Apply high level cognitive processes to think deeply and critically about text.

Connections to Standards for Mathematical Practice:

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
5. Use appropriate tools strategically.
6. Attend to precision.
8. Look for and express regularity in repeated reasoning.

Science & Engineering Practices Identified in Standards (While only a subset of science and engineering practices are explicitly identified as the mechanism for how students demonstrate mastery at the end of instruction, students should still utilize all of the science and engineering practices as they develop their understanding.) NGSS Appendix F	**Priority Content Disciplinary Core Ideas** NGSS Appendix E	**Crosscutting Concepts Identified in Standards** (While only a subset of crosscutting concepts are explicitly identified as the mechanism for how students demonstrate mastery at the end of instruction, students should still utilize all of the crosscutting concepts as they develop their understanding.) NGSS Appendix G
Constructing Explanations and Designing Solutions Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **Analyzing and Interpreting Data** Analyze and interpret data to provide evidence for phenomena.	**ESS1.C: The History of the Planet Earth** ● The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. ● Tectonic processes continually generate new ocean sea floor at ridges and destroy old seafloor at trenches. (HS.ESS1.C GBE),(secondary) **ESS2.B: Plate Tectonics and Large-Scale System Interactions** ● Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart..	**Scale Proportion and Quantity** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. **Patterns** Patterns in rates of change and other numerical relationships can provide information about natural systems.

Prerequisite Skills for Focal Performance Expectations Science & Engineering Practices (from NGSS Appendix F and/or FCPS Enduring Science Skills Document)	**Prerequisite Disciplinary Core Ideas** (from NGSS Appendix E) (Prerequisite Content Knowledge)	**Prerequisite Crosscutting Concepts** (from NGSS Appendix G)

1. Compare and contrast data collected by different groups (represented in bar graphs, pictographs and/or pie charts) to reveal patterns that indicate relationships.
2. Analyze, interpret and compare (across groups) data to:
  a. make sense of phenomena, using logical reasoning, mathematics, and/or computation to reveal patterns that indicate relationships.
  b. Evaluate and refine a problem statement or the design of a proposed object, tool, or process.
  c. Use digital tools when feasible.
3. Identify and use evidence (e.g., measurements, observations, relationships, patterns) to construct or support particular points in a complex explanation that specifies variables.
4. Uses evidence (e.g., measurements, observations, patterns) AND applies scientific ideas to generate multiple solutions to a problem.
5. Compares multiple student-generated solutions based on how well they meet the criteria and constraints of the design solution
	ESS1.C: The History of the Planet Earth
	● Some events on Earth occur very quickly; others can occur very slowly. (K-2)
	● Certain features on Earth can be used to order events that have occurred in a landscape. (3-5)
	
	ESS2.B: Plate Tectonics and Large-Scale System Interactions
	● Maps show where things are located. One can map the shapes and kinds of land and water in any area. (K-2)
	● Earth's physical features occur in patterns, as do earthquakes and volcanoes. Maps can be used to locate features and determine patterns in those events. (3-5)
		● Recognize that patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.
		● Identify similarities and differences in order to sort and classify natural objects and designed products.
		● Identify patterns related to time, including simple rates of change and cycles, and to use these patterns to make predictions.
		● Use relative scales (e.g., bigger and smaller; hotter and colder; faster and slower) to describe objects.
		● Use standard units to measure length.
		● Recognize natural objects and observable phenomena exist from the very small to the immensely large.
		● Use standard units to measure and describe physical quantities such as weight, time, temperature, and volume.

Preconceptions/Misconceptions:

1. A common alternate conception students have about the soft, solid portion of the mantle just below the plates is that it is comprised of a sea of hot, liquid magma upon which the plates “float.” In fact, this portion of the mantle, the asthenosphere, is a layer of solid rock with more ductile properties than the tectonic plates above it. (This is due to the pressure and temperature conditions under Earth’s surface.) This understanding of mantle is informed by multiple lines of evidence that have revealed how this layer deforms in response to stress. Under different short-term conditions, the asthenosphere can deform elastically or plastically to stress. When stress is applied over long periods of time, the asthenosphere will flow in response. Although the specific viscoelastic properties of the mantle are beyond the scope of this unit, a soft, solid material that exhibits many of the same properties as the asthenosphere—Silly Putty®—is used in a hands-on activity as a helpful tool to address common alternate conceptions about this layer of Earth.

2. A common alternate conception that students have is that plate motion is caused by a geologic event, such as an earthquake. The *Plate Motion* unit directly addresses this alternate conception through experiences with the Simulation. Students engage in discussion about why they think earthquakes cause plates to move and what they would expect to see in the Simulation. The evidence they gather refutes this alternate conception and shows that plates move, which causes earthquakes.

Pedagogical Considerations:

1. We chose to avoid the term *crust* because it is typically used inaccurately (when what is meant is lithosphere). However, because *lithosphere* and *asthenosphere* are difficult terms, we chose to use the terms *Earth’s outer layer* and/or *plates* to refer to the lithosphere and *mantle* to refer to the asthenosphere, the portion of the mantle that is ductile. These terms were selected in order to prioritize students’ understanding of plate behavior without requiring students to memorize and use technical terms. For the same reason, we chose to refer to plates with that simple term rather than the longer and more technical term *tectonic plates*.

2. This unit focuses only on convergent and divergent plate boundaries because they are more common and most clearly show how plates move as a system.

3. We present plate motion as a system with parts that affect one another rather than as a definite cause-and-effect story. This is because systems thinking is fundamental to Earth science and because the concept of density is beyond the scope of this unit. Students will learn in higher grades that a primary driver of the plate-tectonic system is density: cold, dense subducting slabs sink into the mantle and pull the plates they are attached to along with them.

4. We do not discuss density or decompression melting, which are beyond the scope of this unit. Instead, we emphasize the basic process of soft, solid mantle rising close to the surface and its addition to the plates to form new plate material.

5. A terminology choice was made to simplify the discussion of rock and rock behavior in the study of plate-mantle interactions. We chose to use the terms hard, solid to refer to rock that moves coherently (plates) and soft, solid to refer to rock that is ductile and flows over long periods of time (mantle).

6. Seafloor magnetic anomalies are beyond the scope of this unit, so we do not use seafloor age maps to provide additional evidence for plate motion over time. However, we do include an optional activity for teachers who can afford to provide additional time to explore this compelling evidence.

Essential Vocabulary:

cross section	pattern	mantle	mid-ocean ridge	analyze
outer layer	plate boundary	convergent	trench	rate
plate	earthquake	divergent	volcanic activity	

Assessment Profile:

[FCPS 6th Grade Common Unit Assessment Folder]

Pre-Unit Assessment (formative) → Lesson 1.1

Critical Junctures (formative) → Level 2 Progress Build - end of Lesson 2.6

End of Unit Assessment (Summative) → Lesson 4.4

Formative Assessments:
On-the-Fly Assessment 1: Understanding How Geologists Use Patterns to Study Earth (Lesson 1.3, Activity 3)
On-the-Fly Assessment 2: Understanding Plates (Lesson 1.4, Activity 3)
On-the-Fly Assessment 3: Identifying Challenging Words and Phrases (Lesson 2.2, Activity 2)
On-the-Fly Assessment 4: Insight from Student Annotations (Lesson 2.2, Activity 3)
On-the-Fly Assessment 5: Understanding and Modeling What Happens at Plate Boundaries (Lesson 2.4, Activity 4)
On-the-Fly Assessment 6: Understanding How Geologists Study Patterns to Better Understand Plate Boundaries (Lesson 2.5, Activity 2)
On-the-Fly Assessment 7: Using Patterns to Obtain Information (Lesson 3.1, Activity 2)
On-the-Fly Assessment 8: Understanding the Rate of Plate Motion (Lesson 3.1, Activity 3)
On-the-Fly Assessment 9: Progress with Identifying Challenging Words and Phrases (Lesson 3.2, Activity 3)
On-the-Fly Assessment 10: Insight from Students' Annotations (Lesson 3.2, Activity 4)
On-the-Fly Assessment 11: Interpreting Maps of Ancient Land Masses (Lesson 3.3, Activity 3)
On-the-Fly Assessment 12: Constructing Explanations (Lesson 4.2, Activity 2)
On-the-Fly Assessment 13: Reasoning About the Science Seminar (Lesson 4.3, Activity 3)

Other High Quality Resources
Next Generation Science Standards - Quality Examples of Science Lessons and Units Open SciEd Classroom Resources
FCPS Resources
FCPS Achievement & Trauma-Informed Strategies in the Classroom

Individual lesson information to be completed at the school level based on pre-unit assessment data and formative assessment data.

Chapter 1 Problem Students are Trying to Solve: (Supporting Question)				
What is the land like where *Mesosaurus* fossils are found?				
Chapter 1 Three Dimensional Statement:				
Students use a digital model of plate motion and analyze evidence, including patterns of geologic activity and images of core samples, in order to learn that Earth's outer layer is made of hard solid rock divided into moving plates (patterns).				
		Anchor Resource Connections		
Lesson Learning Intention (describes clearly what the students will know and/or be able to do as a result of learning and teaching.)	**Lesson Success Criteria** (based on lesson sequence and connections to Learning Intention)	**Learning Progression** (from "Evidence sources and reflection opportunities" AND "Application of key concepts to problem" on the Coherence Flowchart)	**Key Concepts** (from Key Concepts section on the Coherence Flowchart)	**Amplify Progress Build Level** (these are found in Planning for the Unit on the Unit Landing Page in Progress Build)
The Pre-Unit Assessment is diagnostic and designed to reveal students' understanding of the unit's core content, both unit-specific science concepts and crosscutting concepts, prior to instruction by indicating, for formative purposes, where students initially fall along the levels of the Progress Build (PB). The Pre-Unit Assessment also measures students' understanding of important supporting content not explicitly included in the PB. As such, it offers a baseline from which to measure growth of understanding over the course of the unit.				
I am learning to: ● obtain information from a media source so that I can obtain information about how scientists use fossils as evidence to understand Earth's history. ● analyze data so that I can gather evidence to make a claim about the outer layer of Earth.	I know I am successful when I can: ● explain what I know about fossils. ● explain how fossils can be used in geologic investigations. ● use Active Reading strategies to learn about an extinct animal. ● explain what a cross section is ● use evidence from core samples to make a claim about what composes the Earth's	● Examine cross sections of Earth's surface (1.2)	● Earth's outer layer is made of hard, solid rock. (1.2)	**Progress Build Level 1: The Earth's entire outer layer (below the water and soil that we see) is made of solid rock that is divided into plates. Earth's plates can move.** Underneath the soil, vegetation, and water that we see on the surface of Earth is the outer layer of Earth's geosphere, the solid part of our rocky planet. This outer layer of Earth is covered entirely with hard, solid rock that is divided into sections called plates. And, these plates can move.

	outer layer. ● make a claim about the Earth's outer layer.			
I am learning to: ● obtain information from an animation and a model so that I can learn about the structure of Earth's outer layer. ● analyze maps so that I can determine where earthquakes occur.	I know I am successful when I can: ● obtain information from a three-dimensional model. ● use a digital model to collect evidence for comparison. ● describe what a plate is. ● define what a pattern is. ● identify patterns on maps of earthquake locations.	● Watch *Revealing Earth's Outer Layer* video (1.3) ● Explore Earth's outer layer in the Sim (1.3) ● Analyze maps showing plate boundaries and earthquakes (1.3)	● Earth's outer layer is divided into sections called plates. (1.3) ● Geologists look for patterns in landforms and in geologic events in order to better understand Earth. (1.3)	**Progress Build Level 1: The Earth's entire outer layer (below the water and soil that we see) is made of solid rock that is divided into plates. Earth's plates can move.**
I am learning to: ● gather evidence so that I can support a claim about cause and effect. ● make a model so that I can write an explanation of what an area of land was once like.	I know I am successful when I can: ● define the term earthquake. ● consider competing claims to Earth's plates during an earthquake. ● define the term plate boundary. ● use a model to create earthquakes to collect evidence to support a claim or to refute a claim. ● create a model of what land may have looked like in the past. ● evaluate two claims about plate motion.	● Observe earthquakes in the Sim (1.4) ● Model a plate boundary to show what the land is like where *Mesosaurus* fossils are found using the paper Modeling Tool(1.4) ● Discuss competing claims about the *Mesosaurus* fossils (1.4) ● Write an explanation to answer the Chapter 1 Question (1.4)	● The plates of Earth's outer layer move. (1.4)	**Progress Build Level 1: The Earth's entire outer layer (below the water and soil that we see) is made of solid rock that is divided into plates. Earth's plates can move.** .

	• write a response to the question: What is the land like where *Mesosaurus* fossils are found?			

Other High Quality Resources
Next Generation Science Standards - Quality Examples of Science Lessons and Units Open SciEd Classroom Resources
FCPS Resources
FCPS Achievement & Trauma-Informed Strategies in the Classroom

Individual lesson information to be completed at the school level based on pre-unit assessment data and formative assessment data.

Chapter 2 Problem Students are Trying to Solve: (Supporting Question)				
How did the South American Plate and African Plate move?				
Chapter 2 Three Dimensional Statement:				
Students analyze data about patterns of plate-mantle interactions at convergent and divergent plate boundaries (patterns) and gather information about geologic activity and the processes that create landforms as a result of the interactions (cause and effect).				
		Anchor Resource Connections		
Lesson Learning Intention (describes clearly what the students will know and/or be able to do as a result of learning and teaching.)	**Lesson Success Criteria** (based on lesson sequence and connections to Learning Intention)	**Learning Progression** (from "Evidence sources and reflection opportunities" AND "Application of key concepts to problem" on the Coherence Flowchart)	**Key Concepts** (from Key Concepts section on the Coherence Flowchart)	**Amplify Progress Build Level** (these are found in Planning for the Unit on the Unit Landing Page in Progress Build)
I am learning to….. so that I can….	I know I am successful when I can: ●			
I am learning to….. so that I can….	I know I am successful when I can: ●			
I am learning to….. so that I can….	I know I am successful when I can: ●			
Other High Quality Resources				
Next Generation Science Standards - Quality Examples of Science Lessons and Units Open SciEd Classroom Resources				
FCPS Resources				
FCPS Achievement & Trauma-Informed Strategies in the Classroom				

Individual lesson information to be completed at the school level based on pre-unit assessment data and formative assessment data.

Chapter 3 Problem Students are Trying to Solve: (Supporting Question)
How did the *Mesosaurus* fossils on the South American Plate and African Plate get so far apart?
Chapter 3 Three Dimensional Statement:
Students analyze and interpret data to determine current rates of plate motion (scale, proportion, and quantity) and evaluate evidence about the distribution of fossils (patterns) in order to construct explanations that the *Mesosaurus* fossils were separated by slow divergent plate motion over hundreds of millions of years.

		Anchor Resource Connections		
Lesson Learning Intention (describes clearly what the students will know and/or be able to do as a result of learning and teaching.)	**Lesson Success Criteria** (based on lesson sequence and connections to Learning Intention)	**Learning Progression** (from "Evidence sources and reflection opportunities" AND "Application of key concepts to problem" on the Coherence Flowchart)	**Key Concepts** (from Key Concepts section on the Coherence Flowchart)	**Amplify Progress Build Level** (these are found in Planning for the Unit on the Unit Landing Page in Progress Build)
I am learning to….. so that I can….	I know I am successful when I can: •			
I am learning to….. so that I can….	I know I am successful when I can: •			
I am learning to….. so that I can….	I know I am successful when I can: •			

Other High Quality Resources
Next Generation Science Standards - Quality Examples of Science Lessons and Units Open SciEd Classroom Resources
FCPS Resources
FCPS Achievement & Trauma-Informed Strategies in the Classroom

Individual lesson information to be completed at the school level based on pre-unit assessment data and formative assessment data.

Chapter 4 Problem Students are Trying to Solve: (Supporting Question)				
What best explains the pattern of volcanic activity and earthquakes on the Jalisco Block?				
Chapter 4 Three Dimensional Statement:				
Students analyze evidence and make oral and written arguments, using what they have learned about plate motion, to determine whether convergent plate motion or divergent plate motion best explains patterns of geologic activity (patterns) near Jalisco, Mexico.				
		Anchor Resource Connections		
Lesson Learning Intention (describes clearly what the students will know and/or be able to do as a result of learning and teaching.)	**Lesson Success Criteria** (based on lesson sequence and connections to Learning Intention)	**Learning Progression** (from "Evidence sources and reflection opportunities" AND "Application of key concepts to problem" on the Coherence Flowchart)	**Key Concepts** (from Key Concepts section on the Coherence Flowchart)	**Amplify Progress Build Level** (these are found in Planning for the Unit on the Unit Landing Page in Progress Build)
I am learning to….. so that I can….	I know I am successful when I can: ●			
I am learning to….. so that I can….	I know I am successful when I can: ●			
I am learning to….. so that I can….	I know I am successful when I can: ●			
Other High Quality Resources				
Next Generation Science Standards - Quality Examples of Science Lessons and Units Open SciEd Classroom Resources				
FCPS Resources				
FCPS Achievement & Trauma-Informed Strategies in the Classroom				