Design Pattern

Grade 11 Overall Claim Students demonstrate a sophisticated understanding of the core ideas and applications of practices and crosscutting concepts in the disciplines of science.			
Explanatory Statements	Students integrate disciplinary core ideas and crosscutting concepts with scientific practices to investigate and explain how and why phenomena occur, and to design and refine solutions to problems.	Students connect knowledge across the disciplines of science to ask questions, plan and carry out investigations, and analyze and interpret data to support an argument about phenomena in a variety of contexts.	
Measurement Target 1 (Topic 1 Bundle): Students are able to evaluate evidence and apply scientific reasoning related to Earth's geologic processes and the dynamic feedback between the biosphere and other Earth systems to support an argument about the continual co-evolution of Earth's systems and life on Earth.			
Focal Knowledge, Skills, and Abilities (fKSAs)	**11.1a** Students are able to investigate how Earth's internal and surface processes operate at different spatial and temporal scales to explain the ages of crustal rocks.	**11.1b** Students are able to apply scientific reasoning and evidence to construct an account of Earth's formation and early history.	**11.1c** Students are able to construct an argument, using causal links and feedback mechanisms between changes in the biosphere and changes in Earth's other systems, that there is simultaneous co-evolution of Earth's systems and life on Earth.
Rationale	• Students will use empirical evidence of patterns to evaluate the merits of an argument. • Students will recognize and interpret patterns in systems at different scales. • Students construct an argument for why the principle that scientific knowledge is based on the assumption that natural laws operate today as they did in the past and that they will continue to do so in the future helps us understand that plate tectonics provides a framework for understanding Earth's geologic history.	• Students will describe that Earth's history can be understood through the study of other objects in the solar system, such as asteroids and meteorites, that have changed minimally over billions of years. • Students will use explanations of how things change and how they remain stable in assessing the extent to which the reasoning and data support the explanation or conclusion.	• Students will describe the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems. • Students will use explanations of how things change and how they remain stable in constructing an argument or counter-argument based on data and evidence.

Additional Knowledge, Skills, and Abilities (aKSAs)	• Declarative knowledge related to plate tectonics • Declarative knowledge of the fossil record • Knowledge that patterns can be used to predict and explain phenomena • Knowledge that patterns can be observed in systems at different scales • Organize data to support or refute ideas • Use reasoning to connect the evidence to support an explanation	• Declarative knowledge related to plate tectonics • Knowledge that Earth's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years and that these interactions have shaped Earth's history and will determine its future • Knowledge of how things change and how they remain stable • Use evidence and reasoning to construct an evidence-based account of the phenomenon	• Declarative knowledge related to feedbacks between the biosphere and Earth's other systems • Declarative knowledge of Earth's spheres (i.e., the atmosphere, the biosphere, the hydrosphere, and the lithosphere) • Knowledge of how things change and how they remain stable • Identify evidence to support a claim • Generalize or summarize data or information from multiple sources of evidence
Potential Observations	• Appropriateness of the evidence used • Correctness of the observations • Correctness of the temporal and spatial scales used • Correctness of the use of scientific terminology in their explanation • Completeness and appropriateness of their explanations • Support of logical and reasonable arguments about the motion of crustal plates • Use of scientific reasoning and process skills • Cite patterns as empirical evidence for causality in supporting explanations of phenomena • Organize data to support or refute ideas	• Appropriateness of the evidence used • Correctness of the scientific reasoning • Accuracy of the explanation • Completeness and appropriateness of their explanation • Correctness of the use of scientific terminology in their explanation • Use of scientific reasoning and process skills • Cite patterns as empirical evidence for causality in supporting explanations of phenomena • Organize data to support or refute ideas • Use reasoning to connect the evidence to support an explanation	• Identify causal or correlational effects • Correctness of the scientific reasoning • Identify causal links and feedback mechanisms • Determine the usefulness of the data • Completeness and appropriateness of their argument • Correctness of the use of scientific terminology in their argument • Use of scientific reasoning and process skills in investigations • Support of their claim by generalizing from multiple sources of evidence • Use of scientific reasoning and process skills • Use of logical and reasonable arguments

Potential Work Products	• Generate or identify an explanation of how Earth's internal and surface processes operate at different spatial and temporal scales based on findings • Explain the relationship between the motion of continental plates and the patterns in the ages of crustal rocks	• Use of evidence from Earth materials, meteorites, and other planetary surfaces to construct Earth's formation and early history • Identify or justify provided inferences to connect the evidence to the account of Earth's formation and early history • Generate or identify an explanation of how things change and how they remain stable based on findings	• Identify or explain how photosynthetic life altered the atmosphere through the production of oxygen • Identify or use logical and reasonable arguments to support that there is simultaneous co-evolution of Earth's system and life on Earth • Describe patterns in changes in the biosphere and changes in Earth's other systems as empirical evidence for causality in supporting explanations of phenomena
Characteristic Features	• Models provided in stimulus materials must illustrate a process or why a phenomenon exists (e.g., plate movement). • All items are presented in a context that revolves around movement of crustal rocks. • All phenomena for which a model is developed must be observable or fit available evidence (e.g., plate tectonics to explain the ages of crustal rocks). • All items must elicit core ideas as defined in *Framework for K-12 Science Education* (NRC, 2012). • All items must include elements from at least two dimensions.	• All items must prompt students to make connections between observed phenomenon or evidence and reasoning underlying the observation/evidence (e.g., the absolute ages of ancient materials [obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals], the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces). • All items must elicit core ideas as defined in *Framework for K-12 Science Education* (NRC, 2012). • All items must include elements from at least two dimensions.	• All items must prompt students to make connections between observed phenomenon or evidence and reasoning underlying the observation/evidence (e.g., changes in the biosphere and changes in Earth's other systems; ancient versus current atmospheric composition). • All items require the use of data and evidence to support a logical argument in a context that revolves around changes in the biosphere and changes in Earth's other systems. • All items must elicit core ideas as defined in *Framework for K-12 Science Education* (NRC, 2012). • All items must include elements from at least two dimensions.

Variable Features	• Complexity of empirical evidence needed to identify patterns • Sources of information (e.g., graphs, charts, data, text, and images) describing "real-world" phenomenon • What characteristics are included (given or determined by the student) • Core idea targeted in model (e.g., the degree to which nuclear processes are included)	• Complexity of the scientific reasoning required to link evidence to the claims • Complexity of the scientific reasoning required to assess the extent to which the reasoning and data support the explanation or conclusion • The evidence to be used to construct an explanation	• The data to be used to determine causal or correlational effects between systems • Complexity of the scientific reasoning required to assess the extent to which the reasoning and data support the argument • Sources of information (e.g., graphs, charts, data, text, and images) describing "real-world" phenomenon