



Grades 9–12

3.3.9-12.I Earth and Space Science: Earth's Systems

Students who demonstrate understanding can *develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.*

Clarifying Statement: Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.

Assessment Boundary: N/A

Science and Engineering Practices (SEP)	Disciplinary Core Ideas (DCI)	Crosscutting Concepts (CCC)
<p>Developing and Using Models</p> <p>Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).</p> <ul style="list-style-type: none"> Develop a model based on evidence to illustrate the relationships between systems or between components of a system. <hr/> <p style="text-align: center;">Connections to Nature of Science</p> <p>Scientific Knowledge is Based on Empirical Evidence</p> <ul style="list-style-type: none"> Science disciplines share common rules of evidence used to evaluate explanations about natural systems. Science includes the process of coordinating patterns of evidence with current theory. 	<p>ESS2.A: Earth Materials and Systems</p> <ul style="list-style-type: none"> Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. <p>ESS2.B: Plate Tectonics and Large-Scale System Interactions</p> <ul style="list-style-type: none"> The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection. <p>PS4.A: Wave Properties</p> <ul style="list-style-type: none"> Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet. 	<p>Energy and Matter</p> <ul style="list-style-type: none"> Energy drives the cycling of matter within and between systems. <hr/> <p style="text-align: center;">Connections to Engineering, Technology, and Applications of Science</p> <p>Interdependence of Science, Engineering, and Technology</p> <ul style="list-style-type: none"> Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.

Pennsylvania Context: N/A



PA Career Ready Skills: Situate self in any social context as a means to determine a response.

Connections to Other Standards Content and Practices

Standard Source	Possible Connections to Other Standard(s) or Practice(s)
Agriculture (AFNR)	CS.06.01.01.a: Research and explain the foundational cycles in AFNR (e.g., water cycle, nutrient cycle, carbon cycle, etc.).
Science, Environmental Literacy and Sustainability (NAAEE)	9-12 Strand 2.1.A. Earth's physical systems: Learners describe the major processes and systems that form Earth and relate these processes, especially those that are large-scale and long-term to characteristics of Earth. They explain how changes in one system (hydrosphere, atmosphere, geosphere, and biosphere) result in changes to another. They describe how human sustainability depends on Earth systems.
PA Core Standards: ELA	<p>CC.3.5.9-12.A: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.</p> <p>CC.3.5.11-12.A: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.</p> <p>CC.3.5.9-10.G: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.</p> <p>CC.3.5.11-12.G: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.</p>
PA Core Standards and Practices: Math	<p>MP.2: Reason abstractly and quantitatively.</p> <p>MP.4: Model with mathematics.</p> <p>CC.2.1.HS.F.3: Apply quantitative reasoning to choose and interpret units and scales in formulas, graphs, and data display.</p> <p>CC.2.1.HS.F.4: Use units as a way to understand problems and to guide the solution of multistep problems.</p> <p>CC.2.1.HS.F.5: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.</p>
PA Standards: Social Studies	N/A
Educational Technology (ISTE)	1.6. Creative Communicator: Students communicate clearly and express themselves creatively for a variety of purposes using the platforms, tools, styles, formats and digital media appropriate to their goals.
Technology and Engineering (ITEEA)	STEL-10: Assess how similarities and differences among scientific, mathematical, engineering, and technological knowledge and skills contributed to the design of a product or system.