Elaboration and Unpacking of the CCCs

Grade 11, Measurement Target 1	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.	
CCCs[1]	**Patterns**	**Stability and Change**
	• Empirical evidence is needed to identify patterns. **(HS-ESS1-5)**	• Much of science deals with constructing explanations of how things change and how they remain stable. **(HS-ESS1-6), (HS-ESS2-7)**
Essential Knowledge and Skills	**HS-ESS1-5** • Evidence is required when identifying a pattern in an observed phenomenon. • Evidence is required to explain the pattern in a system under study. • Evidence is required to support a claim about the pattern in a system under study.	**HS-ESS1-6 and HS-ESS2-7** • Science deals with constructing explanations of how things change. • Science deals with constructing explanations of how things remain stable.
Evidence of a High Level of Performance	• Students recognize that different patterns may be observed at each of the scales at which a system is studied. • Students use empirical evidence to support the explanation about the ages of crustal rocks (e.g., pattern of the continental crust being older than the oceanic crust; pattern that the oldest continental rocks are located at the center of continents, with the ages decreasing from their centers to their margin; and pattern that the ages of oceanic crust are greatest nearest the continents and decrease in age with proximity to the mid-ocean ridges).	• Students can evaluate models of complex systems and comprehend subtle issues of stability or of sudden or gradual change over time. • Students recognize that much of science deals with constructing historical explanations of how things evolved to be the way they are today, which involves modeling rates of change and conditions under which the system is stable or changes gradually, as well as explanations of any sudden change.
Relationships to Practices[2]	• Patterns can be used to support an argument. • Data analysis serves to identify and characterize patterns. • Patterns can be used as empirical evidence for causality in supporting explanations of phenomena.	• Observations and data describe how things change. • Reasoning and data can be used to explain how things evolved to be the way they are today. • Arguments can be supported by quantifying and modeling changes in systems over very short or very long periods of time.

[1] These are the primary Crosscutting Concepts associated with the Performance Expectations for this Measurement Target. Additional Crosscutting Concepts Building to the PEs can be found on the website for the Next Generation Science Standards.

[2] These are meant to be examples; not an exhaustive list of connections to the practices. Additional Practices Building to the PEs can be found on the website for the Next Generation Science Standards.

Prerequisite Knowledge and Skills	• Ability to recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure • Ability to identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems • Ability to use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data	• Ability to explain stability and change in natural or designed systems by examining changes over time, and considering forces at different scales, including the atomic scale • Ability to explain how changes in one part of a system might cause large changes in another part
Student Challenges	• Middle and high school student thinking about chemical change tends to be dominated by the obvious features of the change. [1] For example, some students think that when something is burned in a closed container, it will weigh more because they see the smoke that was produced. Further, many students do not view chemical changes as interactions. They do not understand that substances can be formed by the recombination of atoms in the original substances. Rather, they see chemical change as the result of a separate change in the original substance, or changes, each one separate, in several original substances. For example, some students see the smoke formed when wood burns as having been driven out of the wood by the flame. [2] • Fourth graders' representations of changes over time are "data-driven" in the sense that the particular data in the problem are the most important. This contrasts with "system-driven" representations in which the emphasis is on overall patterns. Unfortunately, students are typically introduced to system-driven representations while they still think it is a wrong or meaningless way to convey information. [3]	

[1] Driver, R. (1985). Beyond appearances: The conservation of matter under physical and chemical transformations. In Driver, R. (Ed.), *Children's ideas in science* (pp. 145-169). Milton Keynes, UK: Open University Press.

[2] Andersson, B. (1990). Pupils' conceptions of matter and its transformations (Age 12-16). In Lijnse, P., Licht, P., de Vos, W., & Waarlo, A.J. (Eds.), *Relating macroscopic phenomena to microscopic particles* (pp. 12-35). Utrecht: CD-þ Press.

[3] Tierney, C., Nemirovsky, R. (1991). Children's spontaneous representations of changing situations. *Hands On!, 14*, 7-10.