Grades 9, 10, 11, 12

Adopted 2013

Appendix G: Crosscutting Concepts

Patterns

1. Observe patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them. AG.1

1. Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. 9-12.AG.1.1
2. Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus requiring improved investigations and experiments. 9-12.AG.1.2
3. Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system. 9-12.AG.1.3
4. Mathematical representations are needed to identify some patterns. 9-12.AG.1.4
5. Empirical evidence is needed to identify patterns. 9-12.AG.1.5

Cause and Effect: Mechanism and Prediction

2. 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. AG.2

1. Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. 9-12.AG.2.1
2. Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. 9-12.AG.2.2
3. Systems can be designed to cause a desired effect. 9-12.AG.2.3
4. Changes in systems may have various causes that may not have equal effects. 9-12.AG.2.4

Scale, Proportion, and Quantity

3. 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. AG.3

1. The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. 9-12.AG.3.1

   Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly. 9-12.AG.3.2

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3. Patterns observable at one scale may not be observable or exist at other scales. 9-12.AG.3.3
4. Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. 9-12.AG.3.4
5. Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). 9-12.AG.3.5

Systems and System Models

4. A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems. AG.4
1. Systems can be designed to do specific tasks. 9-12.AG.4.1
2. When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. 9-12.AG.4.2
3. Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. 9-12.AG.4.3
4. Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. 9-12.AG.4.4

Energy and Matter: Flows, Cycles, and Conservation

5. Tracking energy and matter flows, into, out of, and within systems helps one understand their system's behavior. AG.5
1. The total amount of energy and matter in closed systems is conserved. 9-12.AG.5.1
2. Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. 9-12.AG.5.2
3. Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. 9-12.AG.5.3
4. Energy drives the cycling of matter within and between systems. 9-12.AG.5.4
5. In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. 9-12.AG.5.5

Structure and Function

6. The way an object is shaped or structured determines many of its properties and functions. AG.6
1. Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. 9-12.AG.6.1

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2. The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. 9-12.AG.6.2

Stability and Change

7. For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand. AG.7

1. Much of science deals with constructing explanations of how things change and how they remain stable. 9-12.AG.7.1
2. Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. 9-12.AG.7.2
3. Feedback (negative or positive) can stabilize or destabilize a system. 9-12.AG.7.3
4. Systems can be designed for greater or lesser stability. 9-12.AG.7.4