California Integrated Science Grade 6
Cited CCCs and their Bullets[1]

PATTERNS

CAUSE AND EFFECT: MECHANISM AND PREDICTION In grades 6-8, students classify relationships as causal or correlational and recognize that correlation does not necessarily imply causation. They use cause and effect relationships to predict phenomena in natural or designed systems. They also understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

- **Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3)**
- **Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS1-8), (MS-LS3-2), (MS-ESS2-5)**
- **Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. (MS-LS1-4), (MS-LS1-5)**

SCALE, PROPORTION, AND QUANTITY In grades 6-8, students observe time, space and energy phenomena at various scales using models to study systems that are too large or too small. They understand phenomena observed at one scale may not be observable at another scale and that the function of natural and designed systems may change with scale. They use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude or properties and processes. They represent scientific relationships through the use of algebraic expressions and equations.

- **Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes. (MS-PS3-4)**
- **Phenomena that can be observed at one scale may not be observable at another scale. (MS-LS1-1)**

[1] Crosscutting concept in grey (Patterns) is not cited in California Integrated Grade 6 Performance Expectations.

SYSTEMS AND SYSTEM MODELS In grades 6-8, students understand that systems may interact with other systems; they may have sub-systems, and be part of larger complex systems. They can use models to represent systems and their interactions – such as inputs, processes, and outputs – and energy, matter and information flows within systems. They also learn that models are limited in that they only represent certain aspects of the system under study.

- **Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. (MS-LS1-3)**
- **Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. (MS-ESS2-6)**

ENERGY AND MATTER In grades 6-8, students learn that matter is conserved because atoms are conserved in physical and chemical processes. They also learn within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system.

- **Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. (MS-ESS2-4)**
- **Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). (MS-PS3-5)**
- **The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS3-3)**

STRUCTURE AND FUNCTION In grades 6-8, students model complex and microscopic structures and systems and visualize how their function depends on the shapes, composition, and relationships among its parts. They analyze many complex natural and designed structures and systems to determine how they function. They design structures to serve particular functions by taking into account properties of different materials and how materials can be shaped and used.

- **Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function. (MS-LS1-2)**

STABILITY AND CHANGE In grades 6-8, students explain stability and change in natural or designed systems by examining changes over time and considering forces at different scales, including the atomic scale. Students learn that changes in one part of a system might cause large changes in another part. Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms, and stability might be disturbed by either sudden events or gradual changes that accumulate over time.

- **Stability might be disturbed either by sudden events or gradual changes that accumulate over time. (MS-ESS3-5)**

Dr. Art's CCC Recommendations for California Integrated Grade 6

NOTE: Please read "Dr. Art's Overview Grade Span 6-8 CCC Recommendations" before reading the recommendation for this grade level.

Integrated Grade 6 is unusual in having no citations for the **Patterns** CCC. NGSS in K-5 features a strong emphasis on both **Patterns** and **Cause and Effect**. These two CCCs work well together since humans are hard wired to perceive patterns in phenomena and to try to explain the patterns in terms of what might be causing them. Even though the Patterns CCC is not cited in California Integrated Grade 6, students experience patterns and infer causal relationships in diverse contexts such as animal behavior and plant structures (MS-LS1-4), inherited traits (MS-LS3-2), weather changes (MS-ESS2-5), and energy transfers (MS-PS3-3 and MS-PS3-5).

A very important **Cause and Effect** CCC bullet states that "Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation." The only citation in Integrated 6-8 for this bullet occurs in Integrated Grade 6 with respect to designing a method for monitoring and minimizing a human impact on the environment (MS-ESS3-3). Complex phenomena such as environmental impacts and changing weather conditions (MS-ESS2-5) have many features that may lead to mistakenly attributing causation to two events that are both happening at the same time but are not causing each other.

As described in Dr. Art's Overview of the 6-8 Grade Span, both testing and predicting can help distinguish between causation and correlation. With respect to prediction, the CCC bullet "Cause and effect relationships may be used to predict phenomena" is cited three times in Integrated Grade 6. Another relevant bullet that is cited twice advises that "phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability." Students may expect cause and effect relationships to be "all or none," but this bullet can help them have more realistic expectations about the results from testing cause and effect relationships in complex systems. See also in Dr. Art's Overview Grade Span 6-8 the related discussion of how "mechanism" can provide evidence whether a relationship is causal or not.

With respect to the CCC of **Scale, Proportion, and Quantity**, Dr. Art's Overview of the 6-8 Grade Span explains the importance of students experiencing the importance of scale considerations in multiple contexts and in each middle school grade level. In Integrated Grade 6, students experience via life science a variety of size scales ranging from the microscopic (cells) to larger and larger levels (tissues, organs, body systems, the whole organism). Each level has its own distinctive processes that eventually result in the functioning of the whole organism and also depend on functioning of the whole organism. For example, muscle cells interact with the blood to take in oxygen and nutrients, and to release carbon dioxide and wastes. At the whole organism level, these cellular transfer processes are dependent upon and feed into the corresponding macroscopic processes of breathing, eating, digesting, and excreting. The processes at the two very different scale

levels of a muscle cell and the whole organism do not "know about" each other, but they intimately depend upon each other.

The corresponding CCC bullet states that "phenomena that can be observed at one scale may not be observable at another scale." Why should students or the rest of us care about that statement? Well, our lives depend upon it. Perhaps less importantly, the statement can help us to expect that phenomena that we observe at our level of reality are dependent (in fact, caused by) processes that are happening at levels that are invisible to us and that are very different than the processes that we experience and see at our level of reality.

Dr. Art's Overview 6-8 Grade Span document also recommends that in each middle school grade level students experience the CCC of **Systems and System Models** and also connect that CCC with at least one of the three other "systems thinking" CCCs. In Integrated Grade 6, the Performance Expectation that the body is a system of interacting subsystems composed of groups of cells (MS-LS1-3) provides ideal contexts for investigating and understanding the concept of systems within systems within systems. Cells and body systems are phenomenal examples of **Structure and Function** of systems, and they also exemplify how systems generally have properties (including functions) that are qualitatively different than those of their parts.

The functions of the cells and body systems also provide rich phenomena to explore flows of **Energy and Matter** into, within, and out of systems. Integrated Grade 6 also includes modeling in Earth and Space Science the water cycle with its various flows of **Energy and Matter** (MS-ESS2-4). Notably, Earth's water cycle is a great and very familiar example of a whole system property.

As described in Dr. Art's Overview 6-8 Grade Span, the NGSS descriptions of systems do not sufficiently convey that systems have properties that are very different than those of their parts. NGSS does include that systems have *functions* that arise from the interactions of parts. While a function is an example of a whole system property, there are many kinds of whole system properties that are not system functions. A car has the whole system function of transportation. A car's fuel efficiency and carbon footprint are other whole system properties. Students in Integrated Grade 6 can investigate how the flows of carbon into and out of vehicles are changing Earth's whole system property of global climate (the CCC of **Stability and Change** of systems associated with MS-ESS3-5).

