

## Middle School Life Science CCCs (Discipline Specific Model)

**PATTERNS** In grades 6-8, students recognize that macroscopic patterns are related to the nature of microscopic and atomic-level structure. They identify patterns in rates of change and other numerical relationships that provide information about natural and human designed systems. They use patterns to identify cause and effect relationships, and use graphs and charts to identify patterns in data.

- **Patterns can be used to identify cause and effect relationships.**

MS-LS2-2; MS-LS4-2

- **Graphs, charts, and images can be used to identify patterns in data.**

MS-LS4-1; MS-LS4-3

**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.

- **Cause and effect relationships may be used to predict phenomena in natural or designed systems.**

MS-LS1-8; MS-LS2-1; MS-LS3-2

- **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; MS-LS4-4; MS-LS4-5; MS-LS4-6

**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.

- **Phenomena that can be observed at one scale may not be observable at another scale.**

MS-LS1-1

**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

**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.

- **Matter is conserved because atoms are conserved in physical and chemical processes.**

MS-LS1-7

- **Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter.**

MS-LS1-6

- **The transfer of energy can be tracked as energy flows through a designed or natural system.**

MS-LS2-3

**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; MS-LS3-1

**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.

- **Small changes in one part of a system might cause large changes in another part.**

MS-LS2-4; MS-LS2-5

## Dr. Art's CCC Recommendations for Middle School Life Science

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

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. In middle grades Life Science, students experience patterns and infer causal relationships in diverse contexts such as the fossil record (MS-LS4-1 and MS-LS4-2), ecosystem interactions (MS-LS2-1 and MS-LS2-2), animal behaviors and plant structures (MS-LS1-4), and the distribution of traits in a population (MS-LS4-4 and MS-LS4-6).

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 Grades 6-8 for this bullet occurs in Earth & Space Science with respect to designing a method for monitoring and minimizing a human impact on the environment (MS-ESS3-3). Complex phenomena in Life Science such as environmental interactions/impacts and the phenotypic distribution of traits 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 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 MS Life Science. Another relevant cause/effect bullet that is cited 5 times in MS-LS 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 the 6-8 Grade Span Overview 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**, the 6-8 Grade Span Overview explains the importance of students experiencing the importance of scale considerations in multiple contexts and in each middle school grade level. 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 the 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 these

two very different scale levels of muscle cell and whole body 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 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 MS Life Science, 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 organism systems (MS-LS1-6 and MS-LS1-7). Similar to the situation with respect to organisms but now at a larger **Scale** level, students can combine using **Systems and System Models** and flows of **Energy and Matter** to investigate and understand ecosystem interactions and their consequences (MS-LS2-1 through MS-LS2-5).

With respect to **Structure and Function**, natural selection and evolution have designed cellular structures (MS-LS1-2) as well as organism structures and behaviors to promote improved survival and reproduction (MS-LS4-2 through MS-LS4-6). The MS-LS4 evolution Performance Expectations provide many opportunities to utilize the CCC of **Stability and Change**, and to deepen students’ experience with, understanding of, and skills in using this CCC.