Middle School Physical 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.

- **Macroscopic patterns are related to the nature of microscopic and atomic-level structure.**

MS-PS1-2

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

MS-PS4-1

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-PS1-4; MS-PS2-3; MS-PS2-5

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.

- **Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small**.

MS-PS1-1

- **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-PS3-1; MS-PS3-4

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.

- **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-PS2-1; MS-PS2-4; MS-PS3-2

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-PS1-5
- **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-PS1-6; 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.

- **Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.**
MS-PS1-3; MS-PS4-2; MS-PS4-3

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.

• **Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.** MS-PS2-2

Dr. Art's CCC Recommendations for Middle School Physical Science

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

NGSS elementary grades feature 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 Physical Science, students experience patterns and infer causal relationships in diverse contexts such as alterations in motion (MS-PS2-1 through MS-PS2-5), changes in physical state (MS-PS1-4), and the properties of waves (MS-PS4-1, MS-PS4-2, and MS-PS4-3).

The **Patterns** CCC bullet cited in association with MS-PS1-2 states that "Macroscopic patterns are related to the nature of microscopic and atomic-level structure." This statement introduces the huge idea that structures and interactions at microscopic and atomic levels cause a lot of the phenomena that we observe at our macroscopic level of reality. The context in that PE refers to the interactions of substances where changes in atomic bonding result in the appearance of new substances via chemical reactions. Thus, this **Patterns** CCC relates very directly to the CCCs of both **Cause and Effect** and **Scale**. It can be very effective in MS Physical Science to help students utilize this Patterns bullet about the atomic level to investigate and explain macroscopic phenomena in ways that automatically connect also with both **Cause and Effect** and **Scale**. These connections also reinforce the description in the 6-8 Grade Span Overview of the "mechanism" aspect of the Cause and Effect CCC.

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. Middle school Physical Science introduces the atomic/molecular theory of matter and thereby provides the conceptual foundation for understanding how interactions among invisible, incredibly tiny particles can result in the macroscopic phenomena that we directly experience and try to understand (MS-PS1-1 through MS-PS1-6).

The actual bullet citation in Physical Science for the CCC of **Scale, Proportion, and Quantity** states: "Time, space and energy phenomena can be observed at various scales using models to study systems that are too large or too small." Why should students or the rest of us care about that statement? 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 at our level of reality. We see a solid turning into a liquid, and might mistakenly conclude that the molecules have changed from being solid to being liquid. Instead, the individual molecules do not have the property of being either solid or liquid. What has happened is that an increase in thermal energy has increased the motions of the individual molecules and caused them to move more independently from each other.

The 6-8 Grade Span Overview 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. More than the other two science disciplines, physical science provides students with many opportunities to investigate phenomena by designing and conducting controlled experiments using simple materials such as ramps and marbles. Students can develop system models to design their experiments and then afterwards modify the models to better explain their results. The CCC of **Energy and Matter** can help guide their thinking with respect to the relationships among the transfers of energy, initial motions and/or positions of the matter, and the amount of matter (MS-PS2-1 through MS-PS2-5). All of these motions can also be analyzed from the point of view of **Stability and Change**.

Engineering design and construction projects often depend on the nature of the materials, the transfers of energy, and the forces acting on the design object or tool. Three middle school physical science Performance Expectations cite a CCC bullet of **Structure and Function** that states: "Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used" (MS-PS1-3, MS-PS4-2, and MS-PS4-3). The 6-8 Grade Span Overview document discusses how the function of a tool is an example of how a system has properties that are qualitatively different than those of its parts. Function is just one example of a qualitatively different property. In analyzing and explaining phenomena, it can be very helpful to keep in mind that the properties of a whole system are generally are very different than those of its parts.

