

California Integrated Science Grade 7 Cited CCCs and their Bullets¹

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)**
- **Patterns in rates of change and other numerical relationships can provide information about natural and human designed systems. (MS-ESS2-3)**
- **Patterns can be used to identify cause and effect relationships. (MS-LS2-2)**
- **Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2)**

CAUSE AND EFFECT: MECHANISM AND PREDICTION In grades 6-8, students classify relationships as 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-LS2-1), (MS-ESS3-1)**

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), (MS-ESS2-2)**

SYSTEMS AND SYSTEM MODELS

¹ Crosscutting Concept in grey (Systems and System Models) is not cited in California Integrated Grade 7 Performance Expectations.

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), (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-PS1-6), (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.

- **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)**

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-ESS2-1)**
- **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 California Integrated Grade 7

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 Grades 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. Dr. Art’s Overview 6-8 Grade Span recommends in each grade level an emphasis on patterns that readily connect with causal relationships. In Integrated Grade 7, students experience patterns and infer causal relationships in diverse contexts such as changes of physical state (MS-PS1-2 and MS-PS1-4), effect of resources on ecosystem populations (MS-LS2-1 and MS-LS2-2), and how geoscience processes affect the distribution of natural resources (MS-ESS2-3 & MS-ESS3-1).

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 refers to the huge idea that structures and interaction 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 Integrated Grade 7 to help students utilize this atomic level Patterns bullet to investigate and explain macroscopic phenomena in ways that automatically connect also with both **Cause and Effect** and **Scale**. See also the description in Dr. Arts Overview 6-8 Grade Span of the “mechanism” aspect of the Patterns CCC.

Since middle school introduces atomic/molecular theory, Integrated Grade 7 learning should definitely focus on relationships between the atomic scale and macroscopic scale. The actual bullet citation in Integrated Grade 7 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.” One cited context relates to geoscience processes that shape Earth’s surface (MS-ESS2-2). The DCI for this Performance Expectation states, “The planet’s systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years.”

Surprisingly, Integrated Grade 7 does not include any citations for the important CCC of **Systems and System Models**. This absence is in stark contrast with the six Performance Expectations that begin with the phrase “develop a model.” 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. Systems modeling in Integrated Grade 7 can readily connect with flows of **Energy and Matter** in various contexts including chemical reactions (MS-LS1-7), the flows of matter and energy in ecosystems (MS-LS2-3), the rock cycle (MS-ESS2-1), and

plate tectonics (MS-ESS2-3). These same contexts can also be investigated from the point of view of **Stability and Change**.

As described in Dr. Art's Overview 6-8 Grade Span, the NGSS descriptions of systems do not sufficiently convey that systems generally 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.

Ecosystems are prominent in Integrated Grade 7 (MS-LS2-1 through MS-LS2-5). Because of their complex web of interrelationships, ecosystems are often modeled to help understand the effects of natural and human changes. For education purposes re systems thinking, they have the benefit of already incorporating the "systems" word in their name. Natural ecosystems do not necessarily have a function, but they definitely have properties that are very different from the properties of their parts. Examples of these whole system properties include ecosystem services, ecosystem biodiversity, ecosystem stability/resilience, and ecosystem carbon sequestration.