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| **Pattern**Observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them. | **Cause and Effect: Mechanism and Explanation**Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain new contexts. |
| **Scale, Proportion, and Quantity**In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system’s structure or performance. | **Systems and System Models**Defining the system under study – specifying itsboundaries and making explicit a model of that system – provides tools for understanding and testing ideas that are applicable throughout science and engineering. |
| **Energy and Matter: Flows, Cycles, and****Conservation**Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems’ possibilities and limitations. | **Structure and Function**The way in which an object or living thing is shaped and its substructure determine many of its properties and functions. |
| **Stability and Change**For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of the system are critical elements of study. |  |

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| **Cause and Effect** Simple tests can be designed to gather evidence to support or refute student ideas about causes. (K-PS2-1),(K-PS2-2)  | **Cause and Effect** Events have causes that generate observable patterns. (K-PS3-1),(K-PS3-2)  |
| **Patterns** Patterns in the natural and human designed world can be observed and used as evidence. (K-LS1-1)  | **Patterns** Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (K-ESS2-1)  |
| **Systems and System Models** Systems in the natural and designed world have parts that work together. (K-ESS2-2)  | **Cause and Effect** Events have causes that generate observable patterns. (K-ESS3-2),(K-ESS3-3)  |
| **Systems and System Models** Systems in the natural and designed world have parts that work together. (K-ESS3-1)  | **Cause and Effect** Simple tests can be designed to gather evidence to support or refute student ideas about causes. (1-PS4-1),(1-PS4-2),(1-PS4-3)  |

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| **Patterns** Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (1-LS1-2)  | **Structure and Function** The shape and stability of structures of natural and designed objects are related to their function(s). (1-LS1-1)  |
| **Patterns** Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (1-LS3-1)  | **Patterns** Patterns in the natural world can be observed, used to describe phenomena, and used as evidence. (1-ESS1-1),(1-ESS1-2)  |
| **Patterns** Patterns in the natural and human designed world can be observed. (2-PS1-1)  | **Cause and Effect** Events have causes that generate observable patterns. (2-PS1-4)  |
| **Cause and Effect** Simple tests can be designed to gather evidence to support or refute student ideas about causes. (2-PS1-2)  | **Energy and Matter** Objects may break into smaller pieces and be put together into larger pieces, or change shapes. (2-PS1-3)  |

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| **Cause and Effect** Events have causes that generate observable patterns. (2-LS2-1)  | **Structure and Function** The shape and stability of structures of natural and designed objects are related to their function(s). (2-LS2-2)  |
| **Stability and Change** Things may change slowly or rapidly. (2-ESS1-1), (2-ESS2-1)  | **Patterns** Patterns in the natural world can be observed. (2-ESS2-2),(2-ESS2-3)  |
| **Patterns** Patterns of change can be used to make predictions. (3-PS2-2)  | **Cause and Effect** Cause and effect relationships are routinely identified. (3-PS2-1)  |
| **Cause and Effect** Cause and effect relationships are routinely identified, tested, and used to explain change. (3-PS2-3)  | **Patterns** Patterns of change can be used to make predictions. (3-LS1-1)  |

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| **Cause and Effect** Cause and effect relationships are routinely identified and used to explain change. (3-LS2-1)  | **Patterns** Similarities and differences in patterns can be used to sort and classify natural phenomena. (3-LS3-1)  |
| **Cause and Effect** Cause and effect relationships are routinely identified and used to explain change. (3-LS3-2)  | **Cause and Effect** Cause and effect relationships are routinely identified and used to explain change. (3-LS4-2),(3-LS4-3)  |
| **Scale, Proportion, and Quantity** Observable phenomena exist from very short to very long time periods. (3-LS4-1)  | **Systems and System Models** A system can be described in terms of its components and their interactions. (3-LS4-4)  |
| **Patterns** Patterns of change can be used to make predictions. (3-ESS2-1),(3-ESS2-2)  | **Cause and Effect** Cause and effect relationships are routinely identified, tested, and used to explain change. (3-ESS3-1)  |

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| **Energy and Matter** Energy can be transferred in various ways and between objects. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4)  | **Patterns** Similarities and differences in patterns can be used to sort and classify natural phenomena. (4-PS4-1)  |
| **Patterns** Similarities and differences in patterns can be used to sort and classify designed products. (4-PS4-3)  | **Cause and Effect** Cause and effect relationships are routinely identified. (4-PS4-2)  |
| **Systems and System Models** A system can be described in terms of its components and their interactions. (4-LS1-1),(4-LS1-2)  | **Patterns** Patterns can be used as evidence to support an explanation. (4-ESS1-1)  |
| **Patterns** Patterns can be used as evidence to support an explanation. (4-ESS2-2)  | **Cause and Effect** Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS2-1)  |

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| **Cause and Effect** Cause and effect relationships are routinely identified and used to explain change. (4-ESS3-1)  | **Cause and Effect** Cause and effect relationships are routinely identified, tested, and used to explain change. (4-ESS3-2)  |
| **Cause and Effect** Cause and effect relationships are routinely identified, tested, and used to explain change. (5-PS1-4) |  **Scale, Proportion, and Quantity** Natural objects exist from the very small to the immensely large. (5-PS1-1) |
| **Scale, Proportion, and Quantity** Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. (5-PS1-2),(5-PS1-3)  | **Cause and Effect** Cause and effect relationships are routinely identified and used to explain change. (5-PS2-1)  |
| **Energy and Matter** Energy can be transferred in various ways and between objects. (5-PS3-1)  | **Energy and Matter** Matter is transported into, out of, and within systems. (5-LS1-1)  |

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|  **Systems and System Models** A system can be described in terms of its components and their interactions. (5-LS2-1)  | **Patterns** Similarities and differences in patterns can be used to sort, classify, communicate and analyze simple rates of change for natural phenomena. (5-ESS1-2)  |
| **Scale, Proportion, and Quantity** Natural objects exist from the very small to the immensely large. (5-ESS1-1)  | **Scale, Proportion, and Quantity** Standard units are used to measure and describe physical quantities such as weight and volume. (5-ESS2-2)  |
| **Systems and System Models** A system can be described in terms of its components and their interactions. (5-ESS2-1)  | **Systems and System Models**  A system can be described in terms of its components and their interactions. (5-ESS3-1)  |
| **Influence of Engineering, Technology, and Science on Society and the Natural World** People’s needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1)  | **Influence of Engineering, Technology, and Science on Society and the Natural World** Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)  |

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| **Patterns** Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (MS-PS1-2)  | **Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)  |
| **Scale, Proportion, and Quantity** 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)  | **Energy and Matter** Matter is conserved because atoms are conserved in physical and chemical processes. (MS-PS1-5)  |
| **Energy and Matter** The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS1-6)  | **Structure and Function** 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)  |
| **Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3),(MS-PS2-5)  | **Systems and System Models** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1),(MS-PS2-4) |

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| **Stability and Change** Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales. (MS-PS2-2)  | **Scale, Proportion, and Quantity** 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** Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems. (MS-PS3-2)  | **Energy and Matter** Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). (MS-PS3-5)  |
| **Energy and Matter** The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS3-3)  | **Patterns** Graphs and charts can be used to identify patterns in data. (MS-PS4-1)  |
| **Structure and Function** 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-PS4-2)  | **Structure and Function** Structures can be designed to serve particular functions. (MS-PS4-3)  |

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| **Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS1-8)  | **Cause and Effect** 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** Phenomena that can be observed at one scale may not be observable at another scale. (MS-LS1-1)  | **Systems and System Models** 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** Matter is conserved because atoms are conserved in physical and chemical processes. (MS-LS1-7)  | **Energy and Matter** Within a natural system, the transfer of energy drives the motion and/or cycling of matter. (MS-LS1-6)  |
| **Structure and Function** Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the relationships among its parts, therefore complex natural structures/systems can be analyzed to determine how they function. (MS-LS1-2)  | **Patterns** Patterns can be used to identify cause and effect relationships. (MS-LS2-2)  |

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| **Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-LS2-1)  | **Energy and Matter** The transfer of energy can be tracked as energy flows through a natural system. (MS-LS2-3)  |
| **Stability and Change** Small changes in one part of a system might cause large changes in another part. (MS-LS2-4),(MS-LS2-5)  | **Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural systems. (MS-LS3-2)  |
| **Structure and Function** 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 structures/systems can be analyzed to determine how they function. (MS-LS3-1) | **Patterns** Patterns can be used to identify cause and effect relationships. (MS-LS4-2)  |
| **Patterns** Graphs, charts, and images can be used to identify patterns in data. (MS-LS4-1),(MS-LS4-3)  | **Cause and Effect** Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. (MS-LS4-4),(MS-LS4-5),(MS-LS4-6) |

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| **Patterns** Patterns can be used to identify cause-and-effect relationships. (MS-ESS1-1)   | **Scale, Proportion, and Quantity** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS1-3),(MS-ESS1-4)  |
| **Systems and System Models** Models can be used to represent systems and their interactions. (MS-ESS1-2) | **Patterns** Patterns in rates of change and other numerical relationships can provide information about natural systems. (MS-ESS2-3)  |
| **Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS2-5)  | **Scale Proportion and Quantity** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-ESS2-2)  |
| **Systems and System Models** 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** Within a natural or designed system, the transfer of energy drives the motion and/or cycling of matter. (MS-ESS2-4)  |

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| **Stability and Change** Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale. (MS-ESS2-1) | **Patterns** Graphs, charts, and images can be used to identify patterns in data. (MS-ESS3-2)  |
| **Cause and Effect** Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3)  | **Cause and Effect** Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-ESS3-1),(MS-ESS3-4)  |
| **Stability and Change** Stability might be disturbed either by sudden events or gradual changes that accumulate over time. (MS-ESS3-5)  |   |
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| **Patterns** 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. (HS-PS1-1),(HS-PS1-2),(HS-PS1-3),(HS-PS1-5)  | **Energy and Matter** In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8)  |
| **Energy and Matter** The total amount of energy and matter in closed systems is conserved. (HS-PS1-7)  | **Energy and Matter** 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. (HS-PS1-4)  |
| **Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6)  | **Patterns** 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. (HS-PS2-4)  |
| **Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-1),(HS-PS2-5)  | **Cause and Effect** Systems can be designed to cause a desired effect. (HS-PS2-3)  |

**HS-PS 2**

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| **Systems and System Models** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2)  | **Structure and Function** 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. (HS-PS2-6)  |
| **Cause and Effect** 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. (HS-PS3-5)  | **Systems and System Models** 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. (HS-PS3-4)  |
| **Systems and System Models** 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. (HS-PS3-1)  | **Energy and Matter** 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. (HS-PS3-3)  |
| **Energy and Matter** Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)  | **Stability and Change** Systems can be designed for greater or lesser stability. (HS-PS4-2)  |

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| **Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1)  | **Cause and Effect** 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. (HS-PS4-4)  |
| **Cause and Effect** Systems can be designed to cause a desired effect. (HS-PS4-5)  | **Systems and System Models** 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. (HS-PS4-3)  |
| **Systems and System Models** 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. (HS-LS1-2), (HS-LS1-4)  | **Energy and Matter** 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. (HS-LS1-5), (HS-LS1-6)  |
| **Energy and Matter** Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (HS-LS1-7)  | **Structure and Function** 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. (HS-LS1-1)   |

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| **Stability and Change** Feedback (negative or positive) can stabilize or destabilize a system. (HS-LS1-3) | **Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable. (HS-LS2-6),(HS-LS2-7)  |
| **Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS2-8)  | **Scale, Proportion, and Quantity** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-LS2-1)  |
| **Scale, Proportion, and Quantity** Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale. (HS-LS2-2)  | **Systems and System Models** 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. (HS-LS2-5)  |
| **Energy and Matter** Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (HS-LS2-4)  | **Energy and Matter** Energy drives the cycling of matter within and between systems. (HS-LS2-3)  |

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| **Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS3-1),(HS-LS3-2)  | **Scale, Proportion, and Quantity** 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). (HS-LS3-3)  |
| **Patterns** 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. (HS-LS4-1),(HS-LS4-3)  | **Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-LS4-2),(HS-LS4-4),(HS-LS4-5),(HS-LS4-6)  |
| **Patterns** Empirical evidence is needed to identify patterns. (HS-ESS1-5)  | **Scale, Proportion, and Quantity** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1)  |
| **Scale, Proportion, and Quantity** 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). (HS-ESS1-4)  | **Energy and Matter** Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2)  |

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| **Energy and Matter** In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3)  | **Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6)  |
| **Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4)  | **Energy and Matter** The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6)  |
| **Energy and Matter** Energy drives the cycling of matter within and between systems. (HS-ESS2-3)  | **Structure and Function** 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. (HS-ESS2-5)  |
| **Stability and Change** Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS2-7)  | **Stability and Change** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1)  |

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| **Stability and Change** Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS2-2)  | **Systems and System Models** 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. (HS-ETS1-4)  |
| **Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS3-1)  | **Systems and System Models** 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. (HS-ESS3-6)  |
| **Stability and Change** Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-3),(HS-ESS3-5)  | **Stability and Change** Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4)  |
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