# Wisconsin Standards for Science

# Crosscutting Concepts

**SCI.CC1: Students use science and engineering practices, disciplinary core ideas, and *patterns* to make sense of phenomena, and solve problems.**

**SCI.CC1.m**

* Recognize macroscopic patterns are related to the nature of microscopic and atomic-level structure.
* Identify patterns in rates of change and other numerical relationships that provide information about natural and human-designed systems.
* Use patterns to identify cause and effect relationships and use graphs and charts to identify patterns in data.

**SCI.CC1.h**

* Observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena.
* Recognize classifications or explanations used at one scale may not be useful or need revision using a different scale, thus requiring improved investigations and experiments.
* Use mathematical representations to identify and analyze patterns of performance in order to reengineer a designed system.

**SCI.CC2: Students use science and engineering practices, disciplinary core ideas, and *cause and effect* relationships to make sense of phenomena and solve problems.**

**SCI.CC2.m**

* Classify relationships as causal or correlational, and recognize correlation does not necessarily imply causation.
* Use cause and effect relationships to predict phenomena in natural or designed systems.
* Understand that phenomena may have more than one cause, and some cause and effect relationships in systems can only be explained using probability.

**SCI.CC2.h**

* Understand empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects.
* Suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems.
* Propose causal relationships by examining what is known about smaller scale mechanisms within the system.
* Recognize changes in systems may have various causes that may not have equal effects.

**SCI.CC3: Students use science and engineering practices, disciplinary core ideas, and an understanding of *scale, proportion and quantity* to make sense of phenomena and solve problems.**

**SCI.CC3.m**

* Observe time, space, and energy phenomena at various scales using models to study systems that are too large or too small.
* Understand phenomena observed at one scale may not be observable at another scale, and the function of natural and designed systems may change with scale.
* Use proportional relationships (e.g., speed as the ratio of distance traveled to time taken) to gather information about the magnitude of properties and processes.
* Represent scientific relationships through the use of algebraic expressions and equations.

**SCI.CC3.h**

* Understand the significance of a phenomenon is dependent on the scale, proportion, and the quantity at which it occurs.
* Recognize patterns observable at one scale may not be observable or exist at other scales, and some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.
* Use orders of magnitude to understand how a model at one scaler relates to a model at another scale.
* Use algebraic thinking to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

**SCI.CC4: Students use science and engineering practices, disciplinary core ideas, and an understanding of *systems* to make sense of phenomena and solve problems.**

**SCI.CC4.m**

* Understand systems may interact with other systems: they may have sub-systems and be a part of larger complex systems.
* Use models to represent systems and their interactions – such as inputs, processes, and outputs – and energy, matter, and information flows within systems.
* Learn that models are limited in that they only represent certain aspects of the system under study.

**SCI.CC4.h**

* Investigate or analyze a system by defining its boundaries and initial conditions, as well as its inputs and outputs.
* Use models (e.g., physical, mathematical, computer models) to stimulate the flow of energy, matter, and interactions within and between systems ant different scales.
* Use models and simulations to predict the behavior of a system and recognize that these predictions have limited precision and reliability due to the assumptions and approximations inherent in the models.
* Design systems to do specific tasks.

**SCI.CC5: Students use science and engineering practices, disciplinary core ideas, and an understanding of *energy and matter* to make sense of phenomena and solve problems.**

**SCI.CC5.m**

* Understand matter is conserved because atoms are conserved in physical and chemical processes.
* Understand that within a natural or designed system the transfer of energy drives the motion and cycling of matter.
* Energy may take different forms (e.g., energy in fields, thermal energy, and energy of motion). The transfer of energy can be tracked as energy flows through a designed or natural system.

**SCI.CC5.h**

* Understand that the total amount of energy and matter in closed systems is conserved.
* Describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system.
* Learn that energy cannot be created or destroyed, it only moves between one place and another place, between objects and/or fields, or between systems.
* Energy drives the cycling of matter within and between systems.
* In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.

**SCI.CC6: Students use science and engineering practices, disciplinary core ideas, and an understanding of *structure and function* to make sense of phenomena and solve problems.**

**SCI.CC6.m**

* Model complex and microscopic structures and systems and visualize how their function depends on the shapes, composition, and relationships among their parts.
* Analyze man complex natural and designed structures and systems to determine how they function.
* Design structures to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

**SCI.CC6.h**

* Investigate systems by examining the properties of different materials, the structures of different components, and their interconnections to reveal the system’s function and solve a problem.
* Infer the functions and properties of natural and designed objects and systems from their overall structure, the way their components are shaped and used, and the molecular substructures of their various materials.

**SCI.CC.7: Students use science and engineering practices, disciplinary core ideas, and an understanding of *stability and change* to make sense of phenomena and solve problems.**

**SCI.CC7.m**

* Explain stability and change in natural or designed systems by examining changes over time, and considering forces at different scales, including the atomic scale.
* Understand 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.

**SCI.CC7.h**

* Understand much of science deals with constructing explanations of how things change and how they remain stable.
* Quantify and model changes in systems over very short or very long periods of time.
* See some changes are irreversible, and negative feedback can stabilize a system, while positive feedback can destabilize it.
* Recognize that systems can be designed for greater or lesser stability.

**Science and Engineering Practices**

**SCI.SEP1:** **Students *ask questions and define problems,* in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.**

**SCI.SEP1.A: Asking questions**

**SCI.SEP1.A.m. Students ask questions to specify relationships between variables and clarify arguments and models. This includes the following:**

* Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify or seek additional information.
* Ask questions to identify and clarify evidence and the premise(s) of an argument.
* Ask questions to determine relationships between independent and dependent variables and relationships in models.
* Ask questions to clarify or refine a model, an explanation, or an engineering problem.
* Ask questions that require sufficient and appropriate empirical evidence to answer.
* Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.
* Ask questions that challenge the premise(s) of an argument or the interpretation of a data set

**SCI.SEP1.A.h. Students ask questions to formulate, refine, and evaluate empirically testable questions. This includes the following:**

* Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and seek additional information.
* Ask questions that arise from examining models or theories to clarify and seek additional information and relationships.
* Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.
* Ask questions to clarify and refine a model or an explanation.
* Evaluate a question to determine if it is testable and relevant.
* Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.
* Ask and evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of the design.

**SCI.SEP1.B: Solving Problems**

**SCI.SEP1.B.m**

* Students define a design problem that can be solved through the development of an object, tool, process, or system, and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.

**SCI.SEP1.B.h. Students formulate, refine, and evaluate design problems using models and simulations. This includes the following:**

* Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical, and environmental considerations.
* Clarify and refine an engineering problem.

**SCI.SEP2: Students *develop and use models,* in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.**

**SCI.SEP2.A: Developing Models**

**SCI.SEP2.A.m. Students develop, use, and revise models to describe, test, and predict more abstract phenomena and design systems. This includes the following:**

* Evaluate limitations of a model for a proposed object or tool.
* Develop or modify a model—based on evidence – to match what happens if a variable or component of a system is changed.
* Use and develop a model of simple systems with uncertain and less predictable factors.
* Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.
* Develop and use a model to predict and describe phenomena.
* Develop a model to describe unobservable mechanisms.
* Develop and use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.

**SCI.SEP2.A.h. Students use, synthesize, and develop models to predict and show relationships among variables and between systems and their components in the natural and designed world. This includes the following:**

* Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria.
* Design a test of a model to ascertain its reliability.
* Develop, revise, and use models based on evidence to illustrate and predict the relationships between systems or between components of a system.
* Develop and use multiple types of models to provide mechanistic accounts and predict phenomena. Move flexibly between these model types based on merits and limitations.
* Develop a complex model that allows for manipulation and testing of a proposed process or system.
* Develop and use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and solve problems.

**SCI.SEP3: Students *plan and carry out investigations*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.**

**SCI.SEP3.A: Planning and Conducting Investigations**

**SCI.SEP3.A.m. Students plan and carry out investigations that use multiple variables and provide evidence to support explanations or solutions. This includes the following:**

* Individually and collaboratively plan an investigation, identifying: independent and dependent variables and controls, tools needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.
* Conduct an investigation. Evaluate and revise the experimental design to produce data that serve as the basis for evidence to meet the goals of the investigation.
* Evaluate the accuracy of various methods for collecting data.
* Collect data under a range of conditions that serve as the basis for evidence to answer scientific questions or test design solutions.
* Collect data about the performance of a proposed object, tool, process, or system under a range of conditions.

**SCI.SEP3.A.h. Students plan and carry out investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models: This includes the following:**

* Individually and collaboratively plan an investigation or test a design to produce data that can serve as evidence to build and revise models, support explanations for phenomena, and refine solutions to problems. Consider possible variables or effects and evaluate the investigation’s design to ensure variables are controlled.
* Individually and collaboratively plan and conduct an investigation to produce data to serve as the basis for evidence. In the design: decide on types, how much, and accuracy of data needed to produce reliable measurements. Consider limitations on the precision of the data (e.g., number of trials, cost, risk, time) and refine the design accordingly.
* Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.
* Select appropriate tools to collect, record, analyze, and evaluate data.
* Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.
* Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points, or to improve performance relative to criteria for success.

**SCI.SEP4: Students *analyze and interpret data*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.**

**SCI.SEP4.A: Analyze and Interpret Data**

**SCI.SEP4.A.m. Students extend quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis. This includes the following:**

* Construct, analyze, or interpret graphical displays of data and large data sets to identify linear and nonlinear relationships.
* Use graphical displays (e.g., maps, charts, graphs, and tables) of large data sets to identify temporal and spatial relationships.
* Distinguish between causal and correlational relationships in data.
* Analyze and interpret data to provide evidence for explanations of phenomena.
* Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.
* Consider limitations of data analysis (e.g., measurement error), and seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).
* Analyze and interpret data to determine similarities and differences in findings.
* Analyze data to define an optimal operational range for a proposed object, tool, process, or system that best meets criteria for success.

**SCI.SEP4.A.h. Students engage in more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. This includes the following:**

* Analyze data using tools, technologies, and models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.
* Apply concepts of statistics and probability to scientific and engineering questions and problems, using digital tools when feasible. Concepts should include determining the fit of functions, slope, and intercepts to data, along with correlation coefficients when the data is linear.
* Consider and address more sophisticated limitations of data analysis (e.g., sample selection) when analyzing and interpreting data.
* Compare various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.
* Evaluate the impact of new data on a working explanation or model of a proposed process or system.
* Analyze data to optimize design features or characteristics of system components relative to criteria for success.

**SCI.SEP5: Students use *mathematics and computational thinking*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.**

**SCI.SEP5.A: Qualitative and Quantitative Data**

**SCI.SEP5.A.m. Students identify patterns in large data sets and use mathematical concepts to support explanations and arguments. This includes the following:**

* Decide when to use qualitative vs. quantitative data.
* Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.
* Use mathematical representations to describe and support scientific conclusions and design solutions.
* Create algorithms (a series of ordered steps) to solve a problem.
* Apply mathematical concepts and processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems.
* Use digital tools and mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem.

**SCI.SEP5.A.h. Students use algebraic thinking and analysis, a range of linear and nonlinear functions (including trigonometric functions, exponentials, and logarithms), and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. This includes the following:**

* Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success.
* Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.
* Use mathematical, computational, and algorithmic representations of phenomena or design solutions to describe and support claims and explanations.
* Apply techniques of algebra and functions to represent and solve scientific and engineering problems.
* Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model “makes sense” by comparing the outcomes with what is known about the real world.
* Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m3, acre-feet, and others).

**SCI.SEP6: Students *construct explanations and design solutions*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.**

**SCI.SEP6.A: Construct an Explanation**

**SCI.SEP6.A.m. Students construct explanations supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. This includes the following:**

* Construct an explanation that includes qualitative or quantitative relationships between variables that predict and describe phenomena.
* Construct an explanation using models or representations.
* Construct a scientific explanation based on valid and reliable evidence obtained from sources, including the students’ own experiments. Solutions should build on the following assumption: theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
* Apply scientific ideas, principles, and evidence to construct, revise, or use an explanation for real world phenomena, examples, or events.
* Apply scientific reasoning to show why the data or evidence is adequate for the explanation.

**SCI.SEP6.A.h. Students create explanations that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. This includes the following:**

* Make quantitative and qualitative claims regarding the relationship between dependent and independent variables.
* Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources, including students’ own investigations, models, theories, simulations, and peer review. Explanations should reflect the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
* Apply scientific ideas, principles, and evidence to provide an explanation of phenomena taking into account possible, unanticipated effects.
* Apply scientific reasoning, theory, and models to link evidence to the claim and to assess the extent to which the reasoning and data support the explanation.

**SCI.SEP6.B: Design Solutions**

**SCI.SEP6.B.m. Students design solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories. This includes the following:**

* Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process, or system.
* Undertake a design project, engaging in the design cycle, to construct and implement a solution that meets specific design criteria and constraints.
* Optimize performance of a design by prioritizing criteria, making trade-offs, testing, revising, and retesting.

**SCI.SEP6.B.h. Students create designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. This includes the following:**

* Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, and prioritized criteria. Consider trade-offs.
* Apply scientific ideas, principles, and evidence to solve design problems, taking into account possible unanticipated effects.

**SCI.SEP7: Students *engage in argument from evidence*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.**

**SCI.SEP7.A: Argue from Evidence**

**SCI.SEP7.A.m. Students construct a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world. This includes the following:**

* Compare and critique two arguments on the same topic. Analyze whether they emphasize similar or different evidence and interpretations of facts.
* Respectfully provide and receive critiques about one’s explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.
* Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.
* Make an oral or written argument that supports or refutes the advertised performance of a device, process, or system. Based the argument on empirical evidence concerning whether or not the technology meets relevant criteria and constraints.
* Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.

**SCI.SEP7.A.h. Students use appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world. Arguments may also come from current scientific or historical episodes in science. This includes the following:**

* Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.
* Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
* Respectfully provide and receive critiques on scientific arguments by probing reasoning and evidence, by challenging ideas and conclusions, by responding thoughtfully to diverse perspectives, and by determining what additional information is required to resolve contradictions.
* Construct, use, and present oral and written arguments or counter-arguments based on data and evidence.
* Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge and student-generated evidence.
* Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments. Consider relevant factors (e.g. economic, societal, environmental, and ethical considerations).

**SCI.SEP8: Students will *obtain, evaluate and communicate information*, in conjunction with using crosscutting concepts and disciplinary core ideas, to make sense of phenomena and solve problems.**

**SCI.SEP8.A: Obtain, Evaluate, and Communicate Information**

**SCI.SEP8.A.m. Students evaluate the merit and validity of ideas and methods. This includes the following:**

* Critically read scientific texts adapted for classroom use to determine the central ideas, to obtain scientific and technical information, and to describe patterns in and evidence about the natural and designed world(s).
* Clarify claims and findings by integrating text-based qualitative and quantitative scientific information with information contained in media and visual displays.
* Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication. Describe how they are supported or not supported by evidence and evaluate methods used.
* Evaluate data, hypotheses, and conclusions in scientific and technical texts in light of competing information or accounts.
* Communicate scientific and technical information (e.g. about a proposed object, tool, process, or system) in writing and through oral presentations.

**SCI.SEP8.A.h**

**Students evaluate the validity and reliability of claims, methods, and designs. This includes the following:**

* Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions, and to obtain scientific and technical information. Summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
* Compare, integrate, and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively, or text-based) in order to address a scientific question or solve a problem.
* Gather, read, and evaluate scientific and technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.
* Synthesize and evaluate the validity and reliability of multiple claims, methods, or designs that appear in scientific and technical texts or media reports. Verify the data when possible.
* Communicate scientific and technical information in multiple formats, including orally, graphically, textually, and mathematically. Examples of information could include ideas about phenomena or the design and performance of a proposed process or system.

**Disciplinary Core Idea: Life Science**

**SCI.LS1: Students use science and engineering practices, crosscutting concepts, and an understanding of *structures and processes (on a scale from molecules to organisms)* to make sense of phenomena and solve problems.**

**A. Structure and Function; B. Growth and Development of Organisms; C. Organization for Matter and Energy Flow in Organisms; D. Information Processing**

**SCI.LS1.A.m**

All living things are made up of cells. In organisms, cells work together to form tissues and organs that are specialized for particular body functions.

**SCI.LS1.B.m**

Animals engage in behaviors that increase the odds of reproduction. An organism’s growth is affected by both genetic and environmental factors.

**SCI.LS1.C.m**

Plants use the energy from light to make sugars through photosynthesis. Within individual organisms, food is broken down through a series of chemical reactions that rearrange molecules and release energy.

**SCI.LS1.D.m**

Each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain. The signals are then processed in the brain resulting in immediate behavior or memories.

**SCI.LS1.A.h**

Systems of specialized cells within organisms help perform essential functions of life. Any one system in an organism is made up of numerous parts. Feedback mechanisms maintain an organism’s internal conditions within certain limits and mediate behaviors.

**SCI.LS1.B.h**

Growth and division of cells in organisms occurs by mitosis and differentiation for specific cell types.

**SCI.LS1.C.h**

The molecules produced through photosynthesis are used to make amino acids and other molecules that can be assembled into proteins or DNA. Through cellular respiration, matter and energy flow through different organizational levels of an organism as elements are recombined to form different products and transfer energy.

**SCI.LS1.D.h**

Organisms can process and store a variety of information through specific chemicals and interconnected networks.

**HS-LS1-1.** Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.

**HS-LS1-2.** Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.

**HS-LS1-3.** Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

**HS-LS1-4.** Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.

**HS-LS1-5.** Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.

**HS-LS1-6.** Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and other large carbon-based molecules.

**HS-LS1-7.** Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

**SCI.LS2: Students use science and engineering practices, crosscutting concepts, and an understanding of the *interactions, energy, and dynamics within ecosystems* to make sense of phenomena and solve problems.**

**A. Interdependent Relationships in Ecosystems; B. Cycles of Matter and Energy Transfer in Ecosystems; C. Ecosystem Dynamics, Functioning, and Resilience; D. Social Interactions and Group Behavior**

**SCI.LS2.A.m**

Organisms and populations are dependent on their environmental interactions both with other living things and with nonliving factors, any of which can limit their growth. Competitive, predatory, and mutually beneficial interactions vary across ecosystems, but the patterns are shared.

**SCI.LS2.B.m**

The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. Food webs model how matter and energy are transferred among producers, consumers, and decomposers as the three groups interact within an ecosystem.

**SCI.LS2.C.m**

Ecosystem characteristics vary over time. Disruptions to any part of an ecosystem can lead to shifts in all of its populations. The completeness or integrity of an ecosystem’s biodiversity is often used as a measure of its health.

**SCI.LS2.D.m**

Changes in biodiversity can influence humans’ resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on -- for example, water purification and recycling.

**SCI.LS2.A.h**

Ecosystems have carrying capacities resulting from biotic and abiotic factors. The fundamental tension between resource availability and organism populations affects the abundance of species in any given ecosystem. The combination of the factors that affect an organism's success can be measured as a multidimensional niche.

**SCI.LS2.B.h**

Photosynthesis and cellular respiration provide most of the energy for life processes. Only a fraction of matter consumed at the lower level of a food web is transferred up, resulting in fewer organisms at higher levels. At each link in an ecosystem, elements are combined in different ways, and matter and energy are conserved. Photosynthesis and cellular respiration are key components of the global carbon cycle.

**SCI.LS2.C.h**

If a biological or physical disturbance to an ecosystem occurs, including one induced by human activity, the ecosystem may return to its more or less original state or become a very different ecosystem, depending on the complex set of interactions within the ecosystem.

**SCI.LS2.D.h**

Group behavior has evolved because membership can increase the chances of survival for individuals and their genetic relatives.

**HS-LS2-1.** Use mathematical and computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.

**HS-LS2-2.** Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

**HS-LS2-3.** Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.

**HS-LS2-4.** Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem

**HS-LS2-5.** Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

**HS-LS2-6.** Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.

**HS-LS2-7.** Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

**HS-LS2-8.** Evaluate the evidence for the role of group behavior on individual and species’ chances to survive and reproduce.

**SCI.LS3: Students use science and engineering practices, crosscutting concepts, and an understanding of *heredity* to make sense of phenomena and solve problems.**

**A. Inheritance of Traits; B. Variation of Traits**

**SCI.LS3.A.m**

Genes chiefly regulate a specific protein, which affect an individual’s traits.

**SCI.LS3.B.m**

In sexual reproduction, each parent contributes half of the genes acquired by the offspring resulting in variation between parent and offspring. Genetic information can be altered because of mutations, which may result in beneficial, negative, or no change to proteins in or traits of an organism.

**SCI.LS3.A.h**

DNA carries instructions for forming species’ characteristics. Each cell in an organism has the same genetic content, but genes expressed by cells can differ.

**SCI.LS3.B.h**

The variation and distribution of traits in a population depend on genetic and environmental factors. Genetic variation can result from mutations caused by environmental factors or errors in DNA replication, or from chromosomes swapping sections during meiosis.

**HS-LS3-1.** Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

**HS-LS3-2.** Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and (3) mutations caused by environmental factors.

**HS-LS3-3.** Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

**SCI.LS4: Students use science and engineering practices, crosscutting concepts, and an understanding of *biological evolution* to make sense of phenomena and solve problems.**

**A. Evidence of Common Ancestry and Diversity; B. Natural Selection; C. Adaptation; D. Biodiversity and Humans**

**SCI.LS4.A.m**

The fossil record documents the existence, diversity, extinction, and change of many life forms and their environments through Earth’s history. The fossil record and comparisons of anatomical similarities between organisms enables the inference of lines of evolutionary descent.

**SCI.LS4.B.m**

Both natural and artificial selection result from certain traits giving some individuals an advantage in surviving and reproducing, leading to predominance of certain traits in a population.

**SCI.LS4.C.m**

Species can change over time in response to changes in environmental conditions through adaptation by natural selection acting over generations. Traits that support successful survival and reproduction in the new environment become more common.

**SCI.LS4.D.m**

Changes in biodiversity can influence humans’ resources and ecosystem services they rely on.

**SCI.LS4.A.h**

The ongoing branching that produces multiple lines of descent can be inferred by comparing DNA sequences, amino acid sequences, and anatomical and embryological evidence of different organisms.

**SCI.LS4.B.h**

Natural selection occurs only if there is variation in the genes and traits between organisms in a population. Traits that positively affect survival can become more common in a population.

**SCI.LS4.C.h**

Evolution results primarily from genetic variation of individuals in a species, competition for resources, and proliferation of organisms better able to survive and reproduce. Adaptation means that the distribution of traits in a population, as well as species expansion, emergence, or extinction, can change when conditions change.

**SCI.LS4.D.h**

Biodiversity is increased by formation of new species and reduced by extinction. Humans depend on biodiversity but also have adverse impacts on it. Sustaining biodiversity is essential to supporting life on Earth.

**HS-LS4-1.** Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.

**HS-LS4-2.** Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.

**HS-LS4-3.** Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.

**HS-LS4-4.** Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

**HS-LS4-5.** Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.

**HS-LS4-6.** Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

**Disciplinary Core Idea: Physical Science**

**SCI.PS1: Students use science and engineering practices, crosscutting concepts, and an understanding of *matter and its interactions* to make sense of phenomena and solve problems.**

**A. Structures and Properties of Matter; B. Chemical Reactions; C. Nuclear Processes**

**SCI.PS1.A.m**

The fact that matter is composed of atoms and molecules can be used to explain the properties of substances, diversity of materials, states of matter, phase changes, and conservation of matter.

**SCI.PS1.B.m**

Reacting substances rearrange to form different molecules, but the number of atoms is conserved. Some reactions release energy and others absorb energy.

**SCI.PS1.A.h**

The sub-atomic structural model and interactions between electric charges at the atomic scale can be used to explain the structure and interactions of matter, including chemical reactions and nuclear processes. Repeating patterns of the periodic table reflect patterns of outer electrons. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy to take the molecule apart.

**SCI.PS1.B.h**

Chemical processes are understood in terms of collisions of molecules, rearrangement of atoms, and changes in energy as determined by properties of elements involved.

**SCI.PS1.C.h**

Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy.

**HS-PS1-1.** Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.

**HS-PS1-2.** Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.

**HS-PS1-3.** Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

**HS-PS1-4.** Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

**SCI.PS2: Students use science and engineering practices, crosscutting concepts, and an understanding of *forces, interactions, motion and stability* to make sense of phenomena and solve problems.**

**A. Forces and Motion; B. Types of Interactions**

**SCI.PS2.A.m**

* Motion and changes in motion can be qualitatively described using concepts of speed, velocity, and acceleration (including speeding up, slowing down, and/or changing direction).
* The role of the mass of an object must be qualitatively accounted for in any change of motion due to the application of a force (Newton’s first and second law).
* For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton’s third law).

**SCI.PS2.B.m**

Forces that act at a distance involve fields that can be mapped by their relative strength and effect on an object

**SCI.PS2.A.h**

* Motion and changes in motion can be quantitatively described using concepts of speed, velocity, and acceleration (including speeding up, slowing down, and/or changing direction).
* Newton’s second law of motion (F=ma) and the conservation of momentum can be used to predict changes in the motion of macroscopic objects.
* If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.

**SCI.PS2.B.h**

* Forces at a distance are explained by fields that can transfer energy and can be described in terms of the arrangement and properties of the interacting objects and the distance between them. These forces can be used to describe the relationship between electrical and magnetic fields.
* Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.

**HS-PS2-1.** Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

**HS-PS2-2.** Use mathematical representations (qualitative and quantitative) to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

**HS-PS2-3.** Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

**HS-PS2-4.** Use mathematical representations (qualitative and quantitative) of Newton’s law of gravitation and Coulomb’s law to describe and predict the gravitational and electrostatic forces between objects.

**HS-PS2-5.** Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

**HS-PS2-6.** Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

**SCI.PS3: Students use science and engineering practices, crosscutting concepts, and an understanding of energy to make sense of phenomena and solve problems.**

**A. Definitions of Energy; B. Conservation of Energy and Energy Transfer; C. Relationships Between Energy and Forces; D. Energy in Chemical Processes and Everyday Life**

**SCI.PS3.A.m**

Kinetic energy can be distinguished from the various forms of potential energy.

**SCI.PS3.B.m**

Energy changes to and from each type can be tracked through physical or chemical interactions. The relationship between the temperature and the total energy of a system depends on the types, states, and amounts of matter.

**SCI.PS3.C.m**

When two objects interact, each one exerts a force on the other, and these forces can transfer energy between the interacting objects.

**SCI.PS3.D.m**

Sunlight is captured by plants and used in a chemical reaction to produce sugar molecules for storing this energy. This stored energy can be released by respiration or combustion, which can be reversed by burning those molecules to release energy.

**SCI.PS3.A.h**

Systems move towards more stable states.

**SCI.PS3.B.h**

The total energy within a system is conserved. Energy transfer within and between systems can be described and predicted in terms of energy associated with the motion or configuration of particles (objects).

**SCI.PS3.C.h**

Fields contain energy that depends on the arrangement of the objects in the field.

**SCI.PS3.D.h**

Photosynthesis is the primary biological means of capturing radiation from the sun; energy cannot be destroyed, but it can be converted to less useful forms.

**HS-PS3-1.** Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

**HS-PS3-2.** Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).

**HS-PS3-3.** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

**HS-PS3-4.** Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).

**HS-PS3-5.** Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

**SCI.PS4: Students use science and engineering practices, crosscutting concepts, and an understanding of *waves and their applications in technologies for information transfer* to make sense of phenomena and solve problems.**

**A. Wave Properties; B. Electromagnetic Radiation; C. Information Technologies and Instrumentation**

**SCI.PS4.A.m**

A simple wave model has a repeating pattern with a specific wavelength, frequency, and amplitude, and mechanical waves need a medium through which they are transmitted. This model can explain many phenomena including sound and light. Waves can transmit energy.

**SCI.PS4.B.m**

The construct of a wave is used to model how light interacts with objects.

**SCI.PS4.C.m**

Waves can be used to transmit digital information. Digitized information is comprised of a pattern of 1s and 0s.

**SCI.PS4.A.h**

The wavelength and frequency of a wave are related to one another by the speed of the wave, which depends on the type of wave and the medium through which it is passing. Waves can be used to transmit information and energy.

**SCI.PS4.B.h**

Both an electromagnetic wave model and a photon model explain features of electromagnetic radiation broadly and describe common applications of electromagnetic radiation.

**SCI.PS4.C.h**

Large amounts of information can be stored and shipped around as a result of being digitized.

**HS-PS4-1.** Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

**HS-PS4-2.** Evaluate questions about the advantages of using a digital transmission and storage of information.

**HS-PS4-3.** Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

**HS-PS4-4.** Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

**HS-PS4-5.** Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

**Disciplinary Core Idea: Earth and Space Science**

**SCI.ESS1: Students use science and engineering practices, crosscutting concepts, and an understanding of *Earth’s place in the universe* to make sense of phenomena and solve problems.**

**A. The Universe and Its Stars; B. Earth and the Solar System; C. The History of Planet Earth**

**SCI.ESS1.A.m**

The solar system is part of the Milky Way, which is one of many billions of galaxies.

**SCI.ESS1.B.m**

The solar system contains many varied objects held together by gravity. Solar system models explain and predict eclipses, lunar phases, and seasons.

**SCI.ESS1.C.m**

Rock strata and the fossil record can be used as evidence to organize the relative occurrence of major historical events in Earth’s history.

**SCI.ESS1.A.h**

Light spectra from stars are used to determine their characteristics, processes, and lifecycles. Solar activity creates the elements through nuclear fusion. The development of technologies has provided the astronomical data that provide the empirical evidence for the Big Bang theory.

**SCI.ESS1.B.h**

Kepler’s laws describe common features of the motions of orbiting objects. Observations from astronomy and space probes provide evidence for explanations of solar system formation. Cyclical changes in Earth’s tilt and orbit, occurring over tens to hundreds of thousands of years, cause cycles of ice ages and other gradual climate changes.

**SCI.ESS1.C.h**

The rock record resulting from tectonic and other geoscience processes as well as objects from the solar system can provide evidence of Earth’s early history and the relative ages of major geologic formations.

**HS-ESS1-1.** Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun’s core to release energy that eventually reaches Earth in the form of radiation.

**HS-ESS1-2.** Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.

**HS-ESS1-3.** Communicate scientific ideas about the way stars, over their life cycle, produce elements.

**HS-ESS1-4.** Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

**HS-ESS1-5.** Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.

**HS-ESS1-6.** Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth’s formation and early history.

**SCI.ESS2: Students use science and engineering practices, crosscutting concepts, and an understanding of *Earth’s systems* to make sense of phenomena and solve problems.**

**A. Earth Materials and Systems; B. Plate Tectonics and Large-Scale Interactions; C. The Roles of Water in Earth’s Surface Processes; D. Weather and Climate; E. Biogeology**

**SCI.ESS2.A.m**

Energy flows and matter cycles within and among Earth’s systems, including the sun and Earth’s interior as primary energy sources. Plate tectonics is one result of these processes.

**SCI.ESS2.B.m**

Plate tectonics is the unifying theory that explains movements of rocks at Earth’s surface and geological history. Maps are used to display evidence of plate movement.

**SCI.ESS2.C.m**

Water cycles among land, ocean, and atmosphere, and is propelled by sunlight and gravity. Density variations of sea water drive interconnected ocean currents. Water movement causes weathering and erosion, changing landscape features.

**SCI.ESS2.D.m**

Complex interactions determine local weather patterns and influence climate, including the role of the ocean.

**SCI.ESS2.E.m**

The fossil record documents the existence, diversity, extinction, and change of many life forms throughout history (linked to content in LS4.A).

**SCI.ESS2.A.h**

Feedback effects exist within and among Earth’s systems.

**SCI.ESS2.B.h**

Radioactive decay within Earth’s interior contributes to thermal convection in the mantle.

**SCI.ESS2.C.h**

The planet’s dynamics are greatly influenced by water’s unique chemical and physical properties.

**SCI.ESS2.D.h**

The role of radiation from the sun and its interactions with the atmosphere, ocean, and land are the foundation for the global climate system. Global climate models are used to predict future changes, including changes influenced by human behavior and natural factors.

**SCI.ESS2.E.h**

The biosphere and Earth’s other systems have many interconnections that cause a continual coevolution of Earth’s surface and life on it.

**HS-ESS2-1.** Develop a model to illustrate how Earth’s internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

**HS-ESS2-2.** Analyze geoscience data to make the claim that one change to Earth’s surface can create feedbacks that cause changes to other Earth systems.

**HS-ESS2-3.** Develop a model based on evidence of Earth’s interior to describe the cycling of matter by thermal convection.

**HS-ESS2-4.** Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in changes in climate.

**HS-ESS2-5.** Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

**HS-ESS2-6.** Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

**HS-ESS2-7.** Construct an argument based on evidence about the simultaneous coevolution of Earth’s systems and life on Earth.

**SCI.ESS3: Students use science and engineering practices, crosscutting concepts, and an understanding of the Earth and human activity to make sense of phenomena and solve problems.**

**A. Natural Resources; B. Natural Hazards; C. Human Impacts on Earth Systems; D. Global Climate Change**

**SCI.ESS3.A.m**

Humans depend on Earth’s land, oceans, fresh water, atmosphere, and biosphere for different resources, many of which are limited or not renewable. Resources are distributed unevenly around the planet as a result of past geologic processes.

**SCI.ESS3.B.m**

Patterns can be seen through mapping the history of natural hazards in a region and understanding related geological forces.

**SCI.ESS3.C.m**

Human activities have altered the hydrosphere, atmosphere, and lithosphere which in turn has altered the biosphere. Changes to the biosphere can have different impacts for different living things. Activities and technologies can be engineered to reduce people’s impacts on Earth.

**SCI.ESS3.D.m**

Evidence suggests human activities affect global warming. Decisions to reduce the impact of global warming depend on understanding climate science, engineering capabilities, and social dynamics.

**SCI.ESS3.A.h**

Resource availability has guided the development of human society and use of natural resources has associated costs, risks, and benefits.

**SCI.ESS3.B.h**

Natural hazards and other geological events have shaped the course of human history at local, regional, and global scales.

**SCI.ESS3.C.h**

Sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources, including the development of technologies.

**SCI.ESS3.D.h**

Global climate models used to predict changes continue to be improved, although discoveries about the global climate system are ongoing and continually needed.

**HS-ESS3-1.** Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

**HS-ESS3-2.** Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

**HS-ESS3-3.** Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.

**HS-ESS3-4.** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

**HS-ESS3-5.** Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

**HS-ESS3-6.** Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

**Disciplinary Core Idea: Engineering, Technology, and the Application of Science**

**SCI.ETS1: Students use science and engineering practices, crosscutting concepts, and an understanding of *engineering design* to make sense of phenomena and solve problems.**

**A. Defining and Delimiting Engineering Problems; B. Developing Possible Solutions; C. Optimizing the Design Solution**

**SCI.ETS1.A.m**

The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions.

**SCI.ETS1.B.m**

* A solution needs to be tested and then modified on the basis of the test results in order to improve it.
* There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
* Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.
* Models of all kinds are important for testing solutions.

**SCI.ETS1.C.m**

* Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.
* The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.

**SCI.ETS1.A.h**

* Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.
* Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

**SCI.ETS1.B.h**

* When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.
* Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical. They are also useful in making a persuasive presentation to a client about how a given design will meet his or her needs.

**SCI.ETS1.C.h**

Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.

**HS-ETS1-1.** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

**HS-ETS1-2.** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

**HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

**HS-ETS1-4.** Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

**SCI.ETS2: Students use science and engineering practices, crosscutting concepts, and an understanding of the links among Engineering, Technology, Science, and Society to make sense of phenomena and solve problems.**

**A. Interdependence of Science, Engineering, and Technology; B. Influence of Engineering, Technology, and Science on Society and the Natural World**

**SCI.ETS2.A.m**

* Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.
* Science and technology drive each other forward

**SCI.ETS2.B.m**

* All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.
* The uses of technologies are driven by people’s needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.
* Technology use varies over time and from region to region.

**SCI.ETS2.A.h**

* Science and engineering complement each other in the cycle known as research and development (R&D).
* Many research and development projects may involve scientists, engineers, and others with wide ranges of expertise

**SCI.ETS2.B.h**

* Modern civilization depends on major technological systems, such as agriculture, health, water, energy, transportation, manufacturing, construction, and communications.
* Engineers continuously modify these systems to increase benefits while decreasing costs and risks.
* New technologies can have deep impacts on society and the environment, including some that were not anticipated.
* Analysis of costs and benefits is a critical aspect of decisions about technology.

**HS-LS2-7.** Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

**HS-LS4-6.** Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

**HS-ESS3-2.** Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.

**HS-ESS3-4.** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

**SCI.ETS3: Students use science and engineering practices, crosscutting concepts, and an understanding of the nature of science and engineering to make sense of phenomena and solve problems.**

**A. Science and Engineering Are Human Endeavors; B. Science and Engineering Are Unique Ways of Thinking with Different Purposes; C. Science and Engineering Use Multiple Approaches to Create New Knowledge and Solve Problems**

**SCI.ETS3.A.m**

* Individuals and teams from many nations, cultures and backgrounds have contributed to advances in science and engineering.
* Scientists and engineers are persistent, use creativity, reasoning, and skepticism, and remain open to new ideas.
* Science and engineering are influenced by what is valued in society.

**SCI.ETS3.B.m**

* Science asks questions to understand the natural world and assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. Science carefully considers and evaluates anomalies in data and evidence.
* Engineering seeks solutions to human problems, including issues that arise due to human interaction with the environment. It uses some of the same practices as science and often applies scientific principles to solutions.
* Science and engineering have direct impacts on the quality of life for all people. Therefore, scientists and engineers need to pursue their work in an ethical manner that requires honesty, fairness and dedication to public health, safety and welfare.

**SCI.ETS3.C.m**

* A theory is an explanation of some aspect of the natural world. Scientists develop theories by using multiple approaches. Validity of these theories and explanations is increased through a peer review process that tests and evaluates the evidence supporting scientific claims.
* Theories are explanations for observable phenomena based on a body of evidence developed over time. A hypothesis is a statement that can be tested to evaluate a theory. Scientific laws describe cause and effect relationships among observable phenomena.
* Engineers develop solutions using multiple approaches and evaluate their solutions against criteria such as cost, safety, time and performance. This evaluation often involves trade-offs between constraints to find the optimal solution.

**SCI.ETS3.A.h**

* Individuals from diverse backgrounds bring unique perspectives that are valuable to the outcomes and processes of science and engineering.
* Scientists’ and engineers’ backgrounds, perspectives, and fields of endeavor influence the nature of questions they ask, the definition of problems, and the nature of their findings and solutions.
* Some cultures have historically been marginalized in science and engineering discourse.
* Scientists and engineers embrace skepticism and critique as a community. Deliberate deceit in science is rare and is likely exposed through the peer review process. When discovered, intellectual dishonesty is condemned by the scientific community.

**SCI.ETS3.B.h**

* Science is both a body of knowledge that represents current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge. These processes differentiate science from other ways of knowing.
* Science knowledge has a history that includes the refinement of, and changes to, theories, ideas and beliefs over time.
* Science and engineering innovations may raise ethical issues for which science and engineering, by themselves, do not provide answers and solutions.

**SCI.ETS3.C.h**

* Scientists use a variety of methods, tools and techniques to develop theories. A scientific theory is an explanation of some aspect of the natural word, based on evidence that has been repeatedly confirmed through observation, experimentation (hypothesis-testing), and peer review.
* The certainty and durability of science findings varies based on the strength of supporting evidence. Theories are usually modified if they are not able to accommodate new evidence.
* Engineers use a variety of approaches, tools, and techniques to define problems and develop solutions to those problems. Successful engineering solutions meet stakeholder needs and safety requirements and are economically viable. Trade-offs in design aspects balance competing demands.

**HS-ETS3-1.** Ask questions to clarify an author’s motivation for promoting unscientific or falsified information on science topics (e.g. climate change, vaccines, GMOs, nuclear energy) (SEP.1.h).

**HS-ETS3-2.** Create simulations of antibiotic resistance, showing how varying use of antibiotics over time has affected evolution of bacteria, and reflecting on how an understanding of the pros and cons of antibiotic use has changed over time (LS4.C.h).

**HS-ETS3-3.** Provide evidence that multiple approaches to understanding climate change have resulted in stronger theories of why change happens over time (ESS3.D.h).