NINTH - TWELFTH GRADE

SCIENCE STANDARDS GUIDANCE

WI Science Standards

Crosscutting Concepts	
Patterns	SCI.CC1.h Students observe patterns in systems at different scales and cite patterns as empirical evidence for causality in supporting their explanations of phenomena. They 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. They use mathematical representations to identify and analyze patterns of performance in order to reengineer a designed system.
Cause & Effect	SCI.CC2.h Students understand empirical evidence is required to differentiate between cause and correlation and to make claims about specific causes and effects. They suggest cause and effect relationships to explain and predict behaviors in complex natural and designed systems. They also propose causal relationships by examining what is known about smaller scale mechanisms within the system. They recognize changes in systems may have various causes that may not have equal effects.
Scale, Proportion, and Quantity	SCI.CC3.h Students understand the significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. They 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. They use orders of magnitude to understand how a model at one scale relates to a model at another scale. They 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).
Systems and System Models	SCI.CC4.h Students investigate or analyze a system by defining its boundaries and initial conditions, as well as its inputs and outputs. They use models (e.g., physical, mathematical, computer models) to simulate the flow of energy, matter, and interactions within and between systems at different scales. They also 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. They also design systems to do specific tasks.
Energy and Matter	SCI.CC5.h Students understand that the total amount of energy and matter in closed systems is conserved. They describe changes of energy and matter in a system in terms of energy and matter flows into, out of, and within that system. They also 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.
Structure and Function	SCI.CC6.h Students 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. They 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.
Stability and Change	SCI.CC7.h Students understand much of science deals with constructing explanations of how things change and how they remain stable. They quantify and model changes in systems over very short or very long periods of time. They see some changes are irreversible, and negative feedback can stabilize a system, while positive feedback can destabilize it. They recognize systems can be designed for greater or lesser stability.

Science and Engineering Practices

Defining Problems	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.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.
Developing and Using Models	SCI.SEP2.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.
Planning and Conducting Investigations	SCI.SEP3.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.
Analyzing and Interpreting Data	SCI.SEP4.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 and contrast 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.

Using Mathematics and Computational Thinking	SCI.SEP5.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).
Constructing an Explanation & Designing Solutions	SCI.SEP6.A.h Students create explanations that are supported by multiple and independent studentgenerated 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.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 realworld problem, based on scientific knowledge, student-generated sources of evidence, and prioritized criteria. Consider tradeoffs. Apply scientific ideas, principles, and evidence to solve design problems, taking into account possible unanticipated effects.
Arguing from Evidence	SCI.SEP7.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).
Obtaining, Evaluating, and Communicating Information	SCI.SEP8.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 Ideas	
Structure and Processes	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.
Interactions, Energy, and Dynamics Within Ecosystems	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.
Heredity	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.
Biological Evolution	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.
Matter and Its Interactions	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.
Forces, Interactions, Motion, and	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.

Stability	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.
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.
Waves and Their Applications in Technologies for Information Transfer	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.
Earth's Place in the Universe	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.
Earth's Systems	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.
Earth and Human Activity	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.
	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.

Engineering, Technology, and the Application of Science - Engineering Design	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.
Engineering, Technology, and the Application of Science - Links Among Engineering, Technology, Science, and Society	SCI.ETS2.A.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.
	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.
Engineering, Technology, and the Application of Science - Nature of Science and Engineering	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.