Minnesota Science

Grades 9, 10, 11, 12

Adopted 2019

Grades 9-12

Earth's Systems

1. Asking questions and defining problems. 9ES.1.1
    1. Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's ideas, and the information they read. 9ES.1.1.1
        1. Ask questions to clarify how seismic energy traveling through Earth's interior can provide evidence for Earth's internal structure. 9ES.1.1.1.1
2. Planning and carrying out investigations. 9ES.1.2
    1. Students will be able to design and conduct investigations in the classroom, laboratory, and/or field to test students' ideas and questions, and will organize and collect data to provide evidence to support claims the students make about phenomena. 9ES.1.2.1
        1. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. 9ES.1.2.1.1

1. Analyzing and interpreting data. 9ES.2.1
    1. Students will be able to represent observations and data in order to recognize patterns in the data, the meaning of those patterns, and possible relationships between variables. 9ES.2.1.1
        2. Analyze geoscience data to make a claim that one change to the Earth's surface can create feedbacks that cause changes to other Earth systems. 9ES.2.1.1.2
2. Using mathematics and computational thinking. 9ES.2.2
    1. Students will be able to use mathematics to represent physical variables and their relationships; compare mathematical expressions to the real world; and engage in computational thinking as they use or develop algorithms to describe the natural or designed worlds. 9ES.2.2.1
        2. Develop a computational model, based on observational data, experimental evidence, and chemical theory, to describe the cycling of carbon among Earth's systems. 9ES.2.2.1.2

1. Developing and using models. 9ES.3.1
    1. Students will be able to develop, revise, and use models to represent the students' understanding of phenomena or systems as they develop questions, predictions and/or explanations, and communicate ideas to others. 9ES.3.1.1
        2. Develop and use a model based on evidence to explain how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean floor features. 9ES.3.1.1.2
        3. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. 9ES.3.1.1.3
        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. 9ES.3.1.1.4

1. Engaging in argument from evidence. 9ES.4.1
    1. Students will be able to engage in argument from evidence for the explanations the students construct, defend and revise their interpretations when presented with new evidence, critically evaluate the scientific arguments of others, and present counter arguments. 9ES.4.1.1
        2. Evaluate the evidence and reasoning for the explanatory model that Earth's interior is layered and that thermal convection drives the cycling of matter. 9ES.4.1.1.2
2. Obtaining, evaluating and communicating information. 9ES.4.2
    1. Students will be able to read and interpret multiple sources to obtain information, evaluate the merit and validity of claims and design solutions, and communicate information, ideas, and evidence in a variety of formats. 9ES.4.2.1
        1. Compare, integrate and evaluate sources of information in order to determine how specific factors, including human activity, impact the groundwater system of a region. 9ES.4.2.1.1

Earth and Human Activity

2. Planning and carrying out investigations. 9EH.1.2

    1. Students will be able to design and conduct investigations in the classroom, laboratory, and/or field to test students' ideas and questions, and will organize and collect data to provide evidence to support claims the students make about phenomena. 9EH.1.2.1

        2. Plan and conduct an investigation of the properties of soils to model the effects of human activity on soil resources. 9EH.1.2.1.2

1. Analyzing and interpreting data. 9EH.2.1

    1. Students will be able to represent observations and data in order to recognize patterns in the data, the meaning of those patterns, and possible relationships between variables. 9EH.2.1.1

        3. 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's systems and human infrastructure. 9EH.2.1.1.3

2. Using mathematics and computational thinking. 9EH.2.2

    1. Students will be able to use mathematics to represent physical variables and their relationships; compare mathematical expressions to the real world; and engage in computational thinking as they use or develop algorithms to describe the natural or designed worlds. 9EH.2.2.1

        3. Develop or use an algorithmic representation, based on investigations of causes and effects in complex Earth systems, to illustrate the relationships within some part of the Earth system and how human activity might affect those relationships. 9EH.2.2.1.3

2. Constructing explanations and designing solutions. 9EH.3.2

    2. Students will be able to use their understanding of scientific principles and the engineering design process to design solutions that meet established criteria and constraints. 9EH.3.2.2

        1. Evaluate or refine a technological solution to reduce the human impacts on a natural system and base the evaluations or refinements on evidence and analysis of pertinent data. 9EH.3.2.2.1

1. Engaging in argument from evidence. 9EH.4.1

    1. Students will be able to engage in argument from evidence for the explanations the students construct, defend and revise their interpretations when presented with new evidence, critically evaluate the scientific arguments of others, and present counter arguments. 9EH.4.1.1

        3. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. 9EH.4.1.1.3

2. Obtaining, evaluating and communicating information. 9EH.4.2

2. Students will be able to gather information about and communicate the methods that are used by various cultures, especially those of Minnesota American Indian Tribes and communities, to develop explanations of phenomena and design solutions to problems. 9EH.4.2.2

    1. Apply place-based evidence, including those from Minnesota American Indian Tribes and communities and other cultures, to construct an explanation of how a warming climate impacts the hydrosphere, geosphere, biosphere, or atmosphere. 9EH.4.2.2.1

Earth's Place in the Universe

1. Analyzing and interpreting data. 9EU.2.1
    1. Students will be able to represent observations and data in order to recognize patterns in the data, the meaning of those patterns, and possible relationships between variables. 9EU.2.1.1
        1. Analyze data to make a valid scientific claim about the way stars, over their life cycle, produce elements. 9EU.2.1.1.1
2. Using mathematics and computational thinking. 9EU.2.2
    1. Students will be able to use mathematics to represent physical variables and their relationships; compare mathematical expressions to the real world; and engage in computational thinking as they use or develop algorithms to describe the natural or designed worlds. 9EU.2.2.1
        1. Use mathematical and computational representations to predict the motion of natural and human-made objects that are in orbit in the solar system. 9EU.2.2.1.1

1. Developing and using models. 9EU.3.1
    1. Students will be able to develop, revise, and use models to represent the students' understanding of phenomena or systems as they develop questions, predictions and/or explanations, and communicate ideas to others. 9EU.3.1.1
        1. Develop and use 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. 9EU.3.1.1.1
2. Constructing explanations and designing solutions. 9EU.3.2
    1. Students will be able to apply scientific principles and empirical evidence (primary or secondary) to explain the causes of phenomena or identify weaknesses in explanations developed by the students or others. 9EU.3.2.1
        1. Construct an explanation that links astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe to the Big Bang. 9EU.9E.3.2.1.1
        2. 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. 9EU.3.2.1.2

1. Engaging in argument from evidence. 9EU.4.1
    1. Students will be able to engage in argument from evidence for the explanations the students construct, defend and revise their interpretations when presented with new evidence, critically evaluate the scientific arguments of others, and present counterarguments. 9EU.4.1.1
        1. Evaluate the 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. 9EU.4.1.1.1

Heredity: Inheritance and Variation of Traits

1. Asking questions and defining problems. 9LH.1.1
    1. Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's ideas, and the information they read. 9LH.1.1.1
        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. 9LH.1.1.1.1
1. Analyzing and interpreting data. 9LH.2.1
    1. Students will be able to represent observations and data in order to recognize patterns in the data, the meaning of those patterns, and possible relationships between variables. 9LH.2.1.1
        1. Apply concepts of probability to explain and predict the variation and distribution of expressed traits in a population. 9LH.2.1.1.1
1. Engaging in argument from evidence. 9LH.4.1
    1. Students will be able to engage in argument from evidence for the explanations the students construct, defend and revise their interpretations when presented with new evidence, critically evaluate the scientific arguments of others, and present counterarguments. 9LH.4.1.1
        2. Make and defend a claim based on evidence that heritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors. 9LH.4.1.1.2

From Molecules to Organisms: Structures and Processes

2. Planning and carrying out investigations. 9LO.1.2
    1. Students will be able to design and conduct investigations in the classroom, laboratory, and/or field to test students' ideas and questions, and will organize and collect data to provide evidence to support claims the students make about phenomena. 9LO.1.2.1
        1. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. 9LO.1.2.1.1
1. Developing and using models. 9LO.3.1
    1. Students will be able to develop, revise, and use models to represent the students' understanding of phenomena or systems as they develop questions, predictions and/or explanations, and communicate ideas to others. 9LO.3.1.1
        1. Develop and use a model to illustrate the levels of organization of interacting systems and how that translates into specific functions in multicellular organisms. 9LO.3.1.1.1
        2. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. 9LO.3.1.1.2
        3. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. 9LO.3.1.1.3
        4. Use a model to illustrate that cellular respiration is a chemical process in which energy from food is used to create new compounds. 9LO.3.1.1.4
2. Constructing explanations and designing solutions. 9LO.3.2
    1. Students will be able to apply scientific principles and empirical evidence (primary or secondary) to explain the causes of phenomena or identify weaknesses in explanations developed by the students or others. 9LO.3.2.1
        1. Construct an explanation based on evidence for how the structure of DNA determines the structure of the proteins that carry out the essential functions of life. 9LO.3.2.1.1
        2. Construct and revise an explanation based on evidence for how various elements combine with carbon to form molecules that form the basis for life on Earth. 9LO.3.2.1.2
        3. Construct and revise an explanation based on evidence about the role of photosynthesis and cellular respiration (including anaerobic processes) in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere. 9LO.3.2.1.3

Biological Evolution: Unity and Diversity

1. Analyzing and interpreting data. 9LB.2.1
    1. Students will be able to represent observations and data in order to recognize patterns in the data, the meaning of those patterns, and possible relationships between variables. 9LB.2.1.1
        2. 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. 9LB.2.1.1.2
2. Constructing explanations and designing solutions. 9LB.3.2
    1. Students will be able to apply scientific principles and empirical evidence (primary or secondary) to explain the causes of phenomena or identify weaknesses in explanations developed by the students or others. 9LB.3.2.1
        4. Construct an explanation based on evidence that the process of evolution primarily results from four factors: reproduction within a species, heritable genetic variation of individuals in that species, competition for limited resources, and increased survival and reproduction of the individuals best suited for the environment. 9LB.3.2.1.4
        5. Construct an explanation based on evidence for how natural selection leads to the adaptation of populations. 9LB.3.2.1.5
1. Engaging in argument from evidence. 9LB.4.1
    1. Students will be able to engage in argument from evidence for the explanations the students construct, defend and revise their interpretations when presented with new evidence, critically evaluate the scientific arguments of others, and present counterarguments. 9LB.4.1.1
        3. 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. 9LB.4.1.1.3
2. Obtaining, evaluating and communicating information. 9LB.4.2
    1. Students will be able to read and interpret multiple sources to obtain information, evaluate the merit and validity of claims and design solutions, and communicate information, ideas, and evidence in a variety of formats. 9LB.4.2.1
        1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. 9LB.4.2.1.1

Ecosystems: Interactions, Energy, and Dynamics

2. Using mathematics and computational thinking. 9LE.2.2
    1. Students will be able to use mathematics to represent physical variables and their relationships, compare mathematical expressions to the real world, and engage in computational thinking as they use or develop algorithms to describe the natural or designed worlds. 9LE.2.2.1
        1. Use a computational model to support or revise an evidence-based explanation for factors that have ecological and economic impacts on different sized ecosystems, including factors caused by the practices of various human groups. 9LE.2.2.1.1
        2. Use a computational model to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. 9LE.2.2.1.2
1. Engaging in argument from evidence. 9LE.4.1
    1. Students will be able to engage in argument from evidence for the explanations the students construct, defend and revise their interpretations when presented with new evidence, critically evaluate the scientific arguments of others, and present counterarguments. 9LE.4.1.1
        1. Evaluate evidence for the role of group behavior on an individual's and species' chances to survive and reproduce. 9LE.4.1.1.1
2. Obtaining, evaluating and communicating information. 9LE.4.2
    2. Students will be able to gather information about and communicate the methods that are used by various cultures, especially those of Minnesota American Indian Tribes and communities, to develop explanations of phenomena and design solutions to problems. 9LE.4.2.2
        1. Obtain and communicate information about how Minnesota American Indian Tribes and communities and other cultures construct solutions to mitigate threats to biodiversity. 9LE.4.2.2.1

Chemistry: Matter and Its Interactions

1. Asking questions and defining problems. 9CM.1.1
    1. Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's ideas, and the information they read. 9CM.1.1.1
        1. Ask questions about the impact of greenhouse gases on the Earth's climate by analyzing their molecular structure and responses during energy absorption. 9CM.1.1.1.1
2. Planning and carrying out investigations. 9CM.1.2
    1. Students will be able to design and conduct investigations in the classroom, laboratory, and/or field to test students' ideas and questions and will organize and collect data to provide evidence to support claims the students make about phenomena. 9CM.1.2.1
        1. Plan and conduct an investigation to gather evidence to compare the structure of substances and infer the strength of electrical forces between particles. 9CM.1.2.1.1
        2. Plan and conduct an investigation of acid-base reactions to test ideas about the concentrations of the hydronium ion in an aqueous solution. 9CM.9C.1.2.1.2
1. Analyzing and interpreting data. 9CM.2.1
    1. Students will be able to represent observations and data in order to recognize patterns in the data, the meaning of those patterns, and possible relationships between variables. 9CM.2.1.1
        1. Analyze patterns in air or water quality data to make claims about the causes and severity of a problem and the necessity to remediate or to recommend a treatment process. 9CM.2.1.1.1
2. Using mathematics and computational thinking. 9CM.2.2
    1. Students will be able to use mathematics to represent physical variables and their relationships, compare mathematical expressions to the real world, and engage in computational thinking as they use or develop algorithms to describe the natural or designed worlds. 9CM.2.2.1
        1. Develop a data simulation, based on observations and experimental data of how the pressure, volume, temperature, and mass of a gas are related to each other, to predict the effect on a system of changing one of those variables. 9CM.2.2.1.1
        2. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. 9CM.2.2.1.2
1. Developing and using models. 9CM.3.1
    1. Students will be able to develop, revise, and use models to represent the students' understanding of phenomena or systems as they develop questions, predictions and/or explanations, and communicate ideas to others. 9CM.3.1.1

1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of valence electrons. 9CM.3.1.1.1
2. Develop a model based on evidence to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. 9CM.3.1.1.2
3. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. 9CM.3.1.1.3

2. Constructing explanations and designing solutions. 9CM.3.2
    1. Students will be able to apply scientific principles and empirical evidence (primary or secondary) to explain the causes of phenomena or identify weaknesses in explanations developed by the students or others. 9CM.3.2.1
        1. 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. 9CM.3.2.1.1
        2. Apply scientific principles and evidence to provide an explanation about the effects of changing the surface area, agitation, temperature, and concentration of the reacting particles on the rate at which the reaction occurs. 9CM.3.2.1.2
        3. Construct an explanation for the phenomenon of solution creation and identify from patterns how the properties of the resulting solution depend on the interactions between solute and solvent or on concentrations of solutes. 9CM.3.2.1.3
    2. Students will be able to use their understanding of scientific principles and the engineering design process to design solutions that meet established criteria and constraints. 9CM.3.2.2
        1. Evaluate the design and function of products and processes involving organic compounds to meet desired needs in relationship to the molecular structures and in particular the functional groups involved. 9CM.3.2.2.1

2. Obtaining, evaluating and communicating information. 9CM.4.2
    1. Students will be able to read and interpret multiple sources to obtain information, evaluate the merit and validity of claims and design solutions, and communicate information, ideas, and evidence in a variety of formats. 9CM.4.2.1
        1. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. 9CM.4.2.1.1
        2. Review text and online sources to develop a series of questions regarding the chemistry, utility, and safety of nuclear fission. 9CM.4.2.1.2
    2. Students will be able to gather information about and communicate the methods that are used by various cultures, especially those of Minnesota American Indian Tribes and communities, to develop explanations of phenomena and design solutions to problems. 9CM.4.2.2

1. Communicate and evaluate claims by various stakeholders, including Minnesota American Indian Tribes and communities and other cultures, about the environmental impacts of various chemical processes on natural resources. 9CM.4.2.2.1

Physics: Waves and Their Applications in Technologies for Information Transfer

1. Asking questions and defining problems. PW.1.1
    1. Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's ideas, and the information they read. 9PW.1.1.1
        1. Evaluate questions about the advantages and disadvantages of using digital transmission and storage of information. 9PW.1.1.1.1
1. Engaging in argument from evidence. 9PW.4.1
    1. Students will be able to engage in argument from evidence for the explanations the students construct, defend and revise their interpretations when presented with new evidence, critically evaluate the scientific arguments of others, and present counter arguments. 9PW.4.1.1
        1. Evaluate the claims, evidence, and reasoning behind the argument that electromagnetic radiation can be described using either a wave model or a particle model, and that for some phenomena one model is more useful than the other. 9PW.4.1.1.1
2. Obtaining, evaluating and communicating information. 9PW.4.2
    1. Students will be able to read and interpret multiple sources to obtain information, evaluate the merit and validity of claims and design solutions, and communicate information, ideas, and evidence in a variety of formats. 9PW.4.2.1
        1. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. 9PW.4.2.1.1

Physics: Motion and Stability: Forces and Interactions

2. Planning and carrying out investigations. 9PM.1.2
    1. Students will be able to design and conduct investigations in the classroom, laboratory, and/or field to test students' ideas and questions, and will organize and collect data to provide evidence to support claims the students make about phenomena. 9PM.1.2.1
        1. 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. 9PM.1.2.1.1
1. Analyzing and interpreting data. 9PM.2.1
    1. Students will be able to represent observations and data in order to recognize patterns in the data, the meaning of those patterns, and possible relationships between variables. 9PM.2.1.1
        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. 9PM.2.1.1.1
2. Using mathematics and computational thinking. 9PM.2.2
    1. Students will be able to use mathematics to represent physical variables and their relationships, compare mathematical expressions to the real world, and engage in computational thinking as they use or develop algorithms to describe the natural or designed worlds. 9PM.2.2.1
        1. Apply mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. 9PM.2.2.1.1
        2. Apply mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. 9PM.2.2.1.2
2. Constructing explanations and designing solutions. 9PM.3.2
    2. Students will be able to use their understanding of scientific principles and the engineering design process to design solutions that meet established criteria and constraints. 9PM.3.2.2
        1. Develop a computer simulation to demonstrate the impact of a proposed solution that minimizes the force on a macroscopic object during a collision. 9PM.3.2.2.1

Physics: Energy

2. Planning and carrying out investigations. 9PE.1.2
    1. Students will be able to design and conduct investigations in the classroom, laboratory, and/or field to test students' ideas and questions, and will organize and collect data to provide evidence to support claims the students make about phenomena. 9PE.1.2.1
        2. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperatures are combined within a closed system results in a more uniform energy distribution among the components in the system. 9PE.1.2.1.2
2. Using mathematics and computational thinking. 9PE.2.2
    1. Students will be able to use mathematics to represent physical variables and their relationships, compare mathematical expressions to the real world, and engage in computational thinking as they use or develop algorithms to describe the natural or designed worlds. 9PE.2.2.1
        3. 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 or out of the system are known. 9PE.2.2.1.3
1. Developing and using models. 9PE.3.1
    1. Students will be able to develop, revise, and use models to represent the students' understanding of phenomena or systems as they develop questions, predictions and/or explanations, and communicate ideas to others. 9PE.3.1.1
        1. 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 positions of particles (objects). 9PE.3.1.1.1
        2. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between the two objects and the changes in energy of the two objects due to the interaction and describe how these forces are present in phenomena. 9PE.3.1.1.2
2. Constructing explanations and designing solutions. 9PE.3.2
    2. Students will be able to use their understanding of scientific principles and the engineering design process to design solutions that meet established criteria and constraints. 9PE.3.2.2
        2. Evaluate a solution to a complex energy-related problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, aesthetics, and maintenance, as well as social, cultural, and environmental impacts. 9PE.3.2.2.2