Minnesota K-12 Academic Standards in Science – 2019, Commissioner Approved Draft

July 29, 2019

This draft is the recommendation of the Science Standards Review Committee and the Commissioner of Education pursuant to Minnesota Statutes, section 120B.021. The standards will become official through the Minnesota Rulemaking process. This draft may be used by school districts and educators for planning purposes.

The committee and the commissioner are recommending to Rulemaking that full implementation of the standards be in the 2023-24 school year. This is the year that the Minnesota Comprehensive Assessment (MCA-IV) will begin to assess these standards and benchmarks.

Introduction

The 2019 Minnesota K-12 Academic Standards in Science (Standards) set the expectations for achievement in science for grades K-12 students in Minnesota. The Standards are grounded in the belief that all students can and should be scientifically literate. Scientific literacy enables people to use scientific principles and processes to make personal decisions and to participate in discussions of scientific issues that affect society (NRC, 1996). Graduates should be prepared for career and college opportunities.

The Standards describe a connected body of science and engineering knowledge acquired through active participation in science experiences. These experiences include hands-on laboratory activities rooted in science and engineering practices.

The Standards are based on current science education found in A Framework for K-12 Science Education (*Framework*) (NRC, 2012), which emphasize the inclusion within science standards, curriculum, and instruction of three dimensions: Scientific and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas. The *Framework* is available as a free download at www.nap.edu.

Three Dimensions Summary

From *A Framework for K-12 Science Education*

Dimension 1: Science and Engineering Practices

This dimension focuses on the important practices used by scientists and engineers, which all students should learn to use with increasing sophistication over their years in school.

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Dimension 2: Crosscutting Concepts
This dimension lists key concepts, or themes, which connect knowledge from the various disciplines of science and engineering into a coherent scientific view of the world.

1. Patterns
2. Cause and effect: mechanism and explanation
3. Scale, proportion, and quantity
4. Systems and system models
5. Energy and matter: flows, cycles, and conservation
6. Structure and function
7. Stability and change

Dimension 3: Disciplinary Core ideas
This dimension includes the core ideas from the physical sciences, life sciences and earth and space sciences. Engineering, technology, and applications of science are included to provide an understanding of the built world.

Physical Sciences
- PS 1: Matter and its interactions
- PS 2: Motion and stability: Forces and interactions
- PS 3: Energy
- PS 4: Waves and their applications in technologies for information transfer

Life Sciences
- LS 1: From molecules to organisms: Structures and processes
- LS 2: Ecosystems: Interactions, energy, and dynamics
- LS 3: Heredity: Inheritance and variation of traits
- LS 4: Biological Evolution: Unity and diversity

Earth and Space Sciences
- ESS 1: Earth's place in the universe
- ESS 2: Earth's systems
- ESS 3: Earth and human activity

Engineering, Technology, and the Applications of Science
- ETS 1: Engineering design
- ETS 2: Links among Engineering, Technology, Science and Society

Organization of the Standards and Benchmarks

Standards

An *academic standard* is a "summary description of student learning in a required content area." (MN Statute 120B.018) This document utilizes an "anchor standard" approach. Thirteen standards establish the overall goals from kindergarten through grade 12. The standards statements are based on the Science and Engineering Practices of the *Framework.*

For ease of organization and consistency with standards in other content areas, the standards are grouped into four strands and eight substrands. Each substrand is one of the Science and Engineering Practices of the *Framework* and has one or two standards. Where there are two standards, the first standard represents the science aspect of the practice and usually the second standard represents an engineering aspect of the practice. Throughout the document a single asterisk (*) indicates an engineering related item.

Strands, Substrands and Standards

Strand 1: Exploring phenomena or engineering problems

Substrand 1: Asking questions and defining problems

> Standard 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.

Standard 2: Students will be able to ask questions about a problem to be solved so they can define constraints and specifications for possible solutions.*

Substrand 2: Planning and carrying out investigations

Standard 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.

Strand 2: Looking at data and empirical evidence to understand phenomena or solve problems

Substrand 1: Analyzing and interpreting data

Standard 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.

Substrand 2: Using mathematics and computational thinking

Standard 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.

Strand 3: Developing possible explanations of phenomena or designing solutions to engineering problems

Substrand 1: Developing and using models

Standard 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.

Standard 2: Students will be able to use models during the engineering design process to identify problems, design and test solutions, and communicate design features to others.*

Substrand 2: Constructing explanations and designing solutions

Standard 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.

Standard 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.*

Strand 4: Communicating reasons, arguments and ideas to others

Substrand 1: Arguing from evidence

Standard 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.

Standard 2: Students will be able to argue from evidence to justify the best solution to a problem or to compare and evaluate competing designs, ideas, or methods.*

Substrand 2: Obtaining, evaluating, and communicating information

Standard 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.

Standard 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.

Benchmarks

A *benchmark* is a "specific knowledge or skill that a student must master to complete part of an academic standard by the end of the grade level or grand band." (MN Statute 120B.018) The benchmarks are placed at the grade level where mastery is expected with the recognition that a progression of learning experiences in earlier grades builds the foundation for mastery later on.

Each benchmark statement incorporate aspects of the three dimensions of the *Framework.* The benchmarks indicate how students could demonstrate mastery of the knowledge and skills underlying that benchmark. It is intended that the specific combination of Practices, Crosscutting Concepts and Core Ideas indicated in the benchmark should NOT dictate instruction. Instruction will normally include a mixture of several practices and crosscutting concepts. For example, even though a grade or grade band may have one benchmark associated with the practice of asking questions, instruction should include the skill of asking questions at various points in most instructional units. It is recommended multiple related benchmarks be bundled together in a unit of curriculum and instruction.

Most benchmarks include statements of emphasis and examples which are displayed in italics. These statements help clarify the benchmark and may suggest learning activities or instructional topics. They are NOT intended to be directives for curriculum and assessment, nor a comprehensive fulfillment of the benchmark.

The benchmarks inform the graduation requirements for students:

"three credits of science, including at least one credit of biology, one credit of chemistry or physics, and one elective credit of science. The combination of credits under this clause must be sufficient to satisfy (i) all of the academic standards in either chemistry or physics and (ii) all other academic standards in science." (MN Statute 120B.024)

All students must satisfy all the 9-12 benchmarks in Earth and Space Science and Life Science, plus either the Chemistry or the Physics benchmarks, in addition to benchmarks at prior grades.

For further information and related documents refer to the Minnesota Department of Education Science Page.

National Research Council (1996). *National Science Education Standards.* Washington D.C. National Academies Press.

National Research Council (2012). *A Framework for K-12 Science Education Standards: Practices, Crosscutting Concepts, and Core Ideas.* Washington D.C. National Academies Press.

How to read the standards and benchmarks

Each benchmark has a 5 digit code. Strands, substrands and standards use relevant portions of that code. In the example below, for benchmark 5L.1.2.1.3

- The first symbol is the **grade and content area**: 5L is grade 5, Life Science.
  - Grades: 0 = Kindergarten, 9 = 9-12 benchmarks.
  - Content areas: E = Earth and Space Science, L = Life Science, P = Physical Science, 9C = Chemistry, 9P = Physics
- The second digit is the **strand**: 1 is Exploring phenomena or engineering problems
- The third digit is the **substrand:** 2 is Planning and carrying out investigations
- The fourth digit is the **standard:** 1 is Students will be able to design and…
- The fifth digit is the **benchmark**: 3 is Plan and conduct an investigation to obtain….

The benchmark statement is in plain text.

  * indicates an engineering related benchmark or standard

  ** indicates a computer science related benchmark

The benchmark is followed by a reference to the corresponding ideas in the *Framework*: P = Practice, CC = Crosscutting Concept, CI = Core Idea. Refer to the list of the dimensions on page 1-2

  In the example (P: 3, CC: 5, CI: LS1):

  - P: 3 is Practice 3: Planning and carrying out investigations,
  - CC: 5 is Crosscutting Concept 5: Energy and matter,
  - CI: LS1 is Core Idea Life Science 1: From molecules to organisms

Emphasis statements and examples are written in italics.

Grade	Strand	Substrand	Standard	Content Area	Benchmark
5	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	Life Science	5L.1.2.1.3 Plan and conduct an investigation to obtain evidence that plants get the materials they need for growth chiefly from air and water. (P: 3, CC: 5, CI: LS1) *Examples of plants may include aquatic plants that grow without soil. Examples of observational evidence may include growth patterns for plants grown in different environments.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
K	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	Earth and Space Science	0E.1.1.1.1 Ask questions to obtain information from weather forecasts to prepare for and respond to severe weather.* (P: 1, CC: 7, CI: ESS3, ETS2) *Emphasis is on local forms of severe weather that may arise quickly and should include examples of engineered solutions to severe weather (such as clothing to wear or places to safely shelter).*
K	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	Earth and Space Science	0E.1.1.1.2 Ask questions about how a person may reduce the amount of natural resources the individual uses.* (P: 1, CC: 2, CI: ESS3) *Examples of questions may include reusing paper to reduce the number of trees cut down and recycling cans and bottles to reduce the amount of plastic, glass, or metal used.*
K	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	Physical Science	0P.1.2.1.1 Collect and organize observational data to determine the effect of sunlight on Earth's surface. (P: 3, CC: 2, CI: PS3, ETS2) *Examples of Earth's surface may include sand, soil, rocks, and water. Data may be organized in pictographs or bar graphs. Examples of observations may include heating, growth of plants, melting of snow, and shadows.*
K	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	Life Science	0L.1.2.1.2 Make observations of plants and animals to compare the diversity of life in different habitats. (P: 3, CC: 1, CI: LS4) *Emphasis is on the diversity of living things in a variety of different habitats and patterns across those habitats.*
K	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	Physical Science	0P.2.1.1.1 Sort objects in terms of natural/human-made, color, size, shape, and texture, then communicate the reasoning for the sorting system. (P: 4, CC: 2, CI: PS1) *Emphasis is on using observations to describe patterns and/or relationships in the natural and designed world in order to order to answer scientific qustions and solve problems.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
K	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	Earth and Space Science	0E.2.1.1.2 Make daily and seasonal observations of local weather conditions to describe patterns over time.** (P: 4, CC: 1, CI: ESS2) *Examples of qualitative observations may include descriptions of the weather (such as sunny, cloudy, rainy, and warm). Examples of quantitative observations may include numbers of sunny, windy, and rainy days in a month. Examples of patterns may include that it is usually cooler in the morning than in the afternoon and that different months have different numbers of sunny days versus cloudy days in different months.*
K	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	Life Science	0L.2.1.1.3 Record and use observations to describe patterns of what plants and animals (including humans) need to survive.** (P: 4, CC: 1, CI: LS1) *Examples of patterns may include that animals need to take in food, but plants do not; different animals need different kinds of food; plants require light; and that all living things need water.*
K	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	Physical Science	0P.2.2.1.1 Identify and describe patterns that emerge from the effects of different strengths or different directions of pushes and pulls on the motion of an object.** (P: 5, CC: 2, CI: PS2) *Emphasis is on different relative strengths or different directions, but not both at the same time. Examples of pushes or pulls may include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.*
K	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	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.	Life Science	0L.3.1.1.1 Develop a simple model to represent the relationship between the needs of different plants and animals (including humans) and the places they live. (P: 2, CC: 4, CI: LS2) *Examples of relationships may include that deer eat buds and leaves, therefore, they usually live in forested areas; and grasses need sunlight, so they often grow in meadows. Examples of models may include food chains, collages, and/or sorting activities.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
K	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.*	Physical Science	0P.3.2.2.1 Design and build a structure to reduce the warming effect of sunlight on Earth's surface.* (P: 6, CC: 2, CI: PS3, ETS1) *Emphasis of the practice is on choosing appropriate materials and tools to solve a problem. Emphasis of the core idea is on understanding the heating effects of sunlight. Examples of structures may include umbrellas, canopies, and tents.*
K	4 Communicating reasons, arguments and ideas to others	4.1 Engaging in Arguing from evidence	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.	Physical Science	0P.4.1.1.1 Construct an argument supported by evidence for whether a design solution works as intended to change the speed or direction of an object with a push or a pull.* (P: 7, CC: 2, CI: PS2, ETS1) *Examples of problems requiring a solution may include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions may include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.*
K	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Physical Science	0P.4.2.2.1 Communicate design ideas for a structure that reduces the warming effect of sunlight on Earth's surface.* (P: 8, CC: 2, CI: PS3, ETS1) *Examples of written designs include models, drawings, writing, or numbers.*
1	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	Life Science	1L.1.1.1.1 Ask questions based on observations about the similarities and differences between young plants and animals and their parents. (P: 1, CC: 2, CI: LS3) *Examples of observations may include leaves from the same kind of plant are the same shape but can differ in size; and a particular breed of dog looks like its parents but is not exactly the same.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
1	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	Physical Science	1P.1.2.1.1 Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. (P: 3, CC: 2, CI: PS4) *Examples of vibrating materials that make sound may include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate may include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.*
1	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	Physical Science	1P.2.1.1.1 Identify and describe patterns obtained from testing different materials and determine which materials have the properties that are best suited for producing and/or transmitting sound.* (P: 4, CC: 1, CI: PS1, ETS1) *Examples of materials may be wood, paper, string, plastics, cloth, etc.*
1	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	Earth and Space Science	1E.2.2.1.1 Use quantitative data to identify and describe patterns in the amount of time it takes for Earth processes to occur and determine whether they occur quickly or slowly. (P: 5, CC: 7, CI: ESS1) *Emphasis of the core idea is that some Earth processes happen quickly (like tornadoes and thunderstorms) and some slowly (like the erosion of soil). Examples of data may include firsthand observations data from books, videos, pictures, or historical photos.*
1	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	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.	Life Science	1L.3.1.1.1 Develop a simple model based on evidence to represent how plants or animals use their external parts to help them survive, grow, and meet their needs. (P: 2, CC: 6, CI: LS1) *Examples of external parts may include acorn shells, plant roots, thorns on branches, turtle shells, animal scales, animal tails, and animal quills.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
1	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.*	Physical Science	1P.3.2.2.1 Design and build a device that uses light or sound to solve the problem of communicating over a distance.* (P: 6, CC: 6, CI: PS4, ETS1, ETS2) *Examples of devices may include paper cup and string "telephones" and a pattern of drum beats.*
1	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.*	Life Science	1L.3.2.2.2 Plan and design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.* (P: 6, CC: 6, CI: LS1, ETS2) *Examples of human problems that can be solved by mimicking plant or animal solutions may include designing clothing or equipment to protect bicyclists by mimicking turtle shells, acorn shells, and animal scales; stabilizing structures by mimicking animal tails and roots on plants; keeping out intruders by mimicking thorns on branches and animal quills, and detecting intruders by mimicking eyes and ears.*
1	4 Communicating reasons, arguments and ideas to others	4.1 Engaging in Arguing from evidence	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.	Earth and Space Science	1E.4.1.1.1 Construct an argument based on observational evidence for how plants and animals (including humans) can change the non-living aspects of the environment to meet their needs. (P: 7, CC: 4, CI: ESS2) *Examples of plants and animals changing their environment may include a squirrel digging in the ground to hide its food and tree roots breaking concrete.*
1	4 Communicating reasons, arguments and ideas to others	4.1 Engaging in Arguing from evidence	4.1.2 Students will be able to argue from evidence to justify the best solution to a problem or to compare and evaluate competing designs, ideas, or methods.*	Earth and Space Science	1E.4.1.2.1 Construct an argument with evidence to evaluate multiple solutions designed to slow or prevent wind or water from changing the shape of the land.* (P: 7, CC: 7, CI: ESS2, ETS2) *Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water; and different designs for using shrubs, grass, and trees to hold back the land.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
1	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Earth and Space Science	1E.4.2.1.1 Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.* (P: 8, CC: 4, CI: ESS3) *Examples of human actions that impact the land may include cutting trees to produce paper, using resources to produce bottles, and using water for bathing and brushing teeth. Examples of solutions may include reusing paper and recycling cans and bottles.*
1	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Life Science	1L.4.2.1.2 Obtain information using various features of texts and other media to determine patterns in the behavior of parents and offspring that help offspring survive. (P: 8, CC: 1, CI: LS1) *Examples of text features include headings, glossaries, electronic menus, pictures, illustrations, icons, etc. Examples of behavior patterns may include the signals that offspring make (such as crying, chirping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring).*
1	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Physical Science	1P.4.2.2.1 Communicate solutions that use materials to provide shelter, food, or warmth needs for communities including Minnesota American Indian tribes and communities.* (P: 8, CC: 2, CI: PS1, ETS2) *Examples of cultures may include those within the local context of the learning community and within the context of Minnesota . Examples of solutions may include past and current building practices that incorporate natural building materials and other green practices as used in sweat lodges, green roofs, moss used for insulation, or sustainable food production and tools used for ricing (harvesting and finishing).*
2	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	Physical Science	2P.1.1.1.1 Ask questions about an object's motion based on observation, that can be answered by an investigation. (P: 1, CC: 1, CI: PS2) *Examples of questions may include what is causing the motion, what type of motion (circular, bouncing, etc.) and what changes are happening in the motion.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
2	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	Physical Science	2P.1.2.1.1 Plan and conduct an investigation to describe how heating and cooling affects different kinds of materials based upon their observable properties. (P: 3, CC: 1, CI: PS1) *Examples of materials may include metals, cloth, plastics, styrofoam, wood and glass.*
2	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	Earth and Space Science	2E.2.1.1.1 Represent data to describe typical weather conditions expected during a particular season. (P: 4, CC: 1, CI: ESS2) *Examples of data may include temperature, precipitation, and wind direction. Data displays can include pictographs and bar graphs.*
2	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	Earth and Space Science	2E.2.1.1.2 Analyze data from tests of objects designed to reduce the impacts of a weather-related hazards and compare the strengths and weaknesses of how each performs.* (P: 4, CC: 2, CI: ESS3, ETS1) *Emphasis is on data from tests of student-designed objects. Examples of design solutions to weather-related hazards may include barriers to prevent flooding or snow drifting, structures for sun shading, materials for clothing, and orientation of bus shelters.*
2	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	Physical Science	2P.2.2.1.1 Identify and predict quantitative patterns of the effects of balanced and unbalanced forces on the motion of an object.** (P: 5, CC: F412, CI: PS2) *Examples may include an unbalanced force on one side of a ball can make it start moving; and balanced forces pushing on a box from both sides will not produce any motion at all. Data displays may include pictographs and bar graphs.*
2	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	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.	Physical Science	2P.3.1.1.1 Develop a simple diagram or physical model to illustrate how some changes caused by heating or cooling can be reversed and some cannot.** (P: 2, CC: 2, CI: PS3) *Examples of reversible changes may include materials such as water and butter at different temperatures. Examples of irreversible changes may include cooking an egg, freezing a plant leaf, and heating paper. Examples of diagrams may include a flow chart.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
2	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.*	Life Science	2L.3.2.2.1 Engineer a device that mimics the structures and functions of plants or animals in seed dispersal.* (P: 6, CC: 6, CI: LS2, ETS1) *Emphasis is on how specific structures have particular functions. Examples of seed dispersal by animals may include feeding and subsequent elimination of seeds, or attachment of seeds/pollen to animal structures. Examples of seed dispersal by plants may include various wind-catching designs (as in dandelions or maple trees) or colors and smells that attract pollinators.*
2	4 Communicating reasons, arguments and ideas to others	4.1 Engaging in Arguing from evidence	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.	Life Science	2L.4.1.1.1 Construct an argument with evidence that evaluates how in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. (P: 7, CC: 2, CI: LS4, ETS2) *Emphasis is on the interdependence of parts of a system (organisms and their habitat). Examples of habitats should include those found in Minnesota, such as a wetland, prairie, or garden. Examples of evidence may include needs and characteristics of the organisms and habitats involved.*
2	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Earth and Space Science	2E.4.2.1.1 Obtain and use information from multiple sources to identify where water is found on Earth. (P: 8, CC: 1, CI: ESS2) *Emphasis of the practice is on learning how to use texts and maps to integrate and evaluate content. Examples may include liquid water in oceans, lakes, rivers, and ponds; and solid water in glaciers and polar ice caps.*
2	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Earth and Space Science	2E.4.2.1.2 Obtain and use information from multiple sources, including electronic sources, to describe climates in different regions of the world.** (P: 8, CC: 1, CI: ESS2) *Emphasis of the practice is on learning how to use electronic sources to integrate and evaluate content. Examples of information may include data on an area's typical weather conditions and how these patterns are considered climate.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
2	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Physical Science	2P.4.2.2.1 Obtain information and communicate how Minnesota American Indian Tribes and communities and other cultures apply knowledge of the natural world in determining which materials have the properties that are best suited for an intended purpose.* (P: 8, CC: 2, CI: PS1, ETS1) *Examples of cultures may include those within the local context of the learning community and within the context of Minnesota* . *Emphasis of the practice is on obtaining, interpreting, and communicating information related to how various cultures have built materials suited for intended purposes according to their properties. Examples of materials may include instruments (Cedar for knockers and Black Spruce for poles) for ricing, birch bark for baskets or other containers for carrying water, and sinew for connecting parts of tools.*
3	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problem	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.	Physical Science	3P.1.1.1.1 Ask questions based on observations about why objects in darkness can be seen only when illuminated. (P: 1, CC: 2, CI: PS4) *Emphasis should be on addressing the misconception that people can see in the dark if they wait long enough and on the way eyes receive light. Examples of observations may include those made in a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight.*
3	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	Physical Science	3P.1.2.1 1 Plan and conduct a controlled investigation to determine the effect of placing objects made with different materials in the path of a beam of light. (P: 3, CC: 2, CI: PS4) *Emphasis is on conducting fair tests by controlling variables. Examples of materials may include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror).*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
3	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	Life Science	3L.1.2.1.2 Plan and conduct an investigation to determine how amounts of sunlight and water impact the growth of a plant. (P: 3, CC:2, CI: LS2) *Emphasis of the practice is on conducting fair tests and using data to support explanations. Examples of investigations may include simple experiments with fast-growing plants.*
3	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	Earth and Space Science	3E.2.1.1.1 Record observations of the sun, moon, and stars and use them to describe patterns that can be predicted.** (P: 4, CC: 1, CI: ESS1) *Examples of patterns may include that the sun and moon appear to rise in one part of the sky, move across the sky, and set; and stars other than our sun are visible at night but not during the day.*
3	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	Earth and Space Science	3E.2.2.1.1 Organize and electronically present collected data to identify and describe patterns in the amount of daylight in the different times of the year.** (P: 5, CC: 1, CI: ESS1) *Emphasis is on relative comparisons of the amount of daylight in the winter to the amount in the spring or fall.*
3	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	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.	Physical Science	3P.3.1.1.1 Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. (P: 2, CC: 2, CI: PS4) *Examples of models may include diagrams, drawings, physical models, or computer programs.*
3	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	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.	Life Science	3L.3.1.1.2 Develop multiple models to describe how organisms have unique and diverse life cycles but all have birth, growth, reproduction, and death in common. (P: 2, CC: 4, CI: LS1) *Emphasis is on the pattern of changes organisms go through during their life. Examples of models may include diagrams, drawings, physical models, or computer programs.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
3	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.	Life Science	3L.3.2.1.1 Construct an explanation using evidence from various sources for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. (P: 6, CC: 2. CI: LS4) *Examples of cause and effect relationships may include how individual plants of the same species with different length thorns may be more or less likely to be eaten by predators; or animals that have better camouflage coloration than others of their species may be more likely to survive and therefore more likely to leave offspring.*
3	4 Communicating reasons, arguments and ideas to others	4.1 Engaging in Arguing from evidence	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.	Life Science	3L.4.1.1.1 Construct an argument about strategies animals use to survive. (P: 7, CC: 2, CI: LS2) *Emphasis is on group behavior and how being part of a group helps animals obtain food, defend themselves, and cope with changes. Examples of animals should include wolves or other animals that live in Minnesota.*
3	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Life Science	3L.4.2.1.1 Obtain information from various types of media to support an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.** (P: 8, CC: 4, CI: LS1) *Examples of structures may include thorns, stems, roots, colored petals, heart, stomach, lungs, brain, and skin. Examples of media may include electronic sources.*
3	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Earth and Space Science	3E.4.2.2.1 Gather information and communicate how Minnesota American Indian Tribes and communities and other cultures use patterns in stars to make predictions and plans. (P 8, CC: 1, CI: ESS1) *Examples of cultures may include those within the local context of the learning community and within the context of Minnesota . Examples may include using star maps to predict seasons, star patterns to inform navigation, and using star stories to identify numeric patterns that guide behavior.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
4	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	Physical Science	4P.1.1.1.1 Ask questions to determine cause and effect relationships of electric and magnetic interactions between two objects not in contact with each other. (P: 1, CC: 2, CI: PS2) *Examples of an electric force may include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of a magnetic force may include the force between two permanent magnets, the force between an electromagnet and steel paper clips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships may include how the distance between objects affects the strength of the force and how the orientation of magnets affects the direction of the magnetic force.*
4	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	Earth and Space Science	4E.1.1.1.2 Ask questions about how water moves through the Earth system and identify the type of question. (P: 1, CC: 5, CI: ESS2) *Emphasis is on the processes of evaporation, condensation, and precipitation. Examples of types of questions may include those that can be tested by an experiment, and questions that may answered from a text.*
4	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	1.1.2 Students will be able to ask questions about a problem to be solved so they can define constraints and specifications for possible solutions.*	Physical Science	4P.1.1.2.1 Define a simple design problem that can be solved by applying scientific ideas about magnets.* (P: 1, CC: 2, CI: PS2, ETS2) *Examples of problems may include constructing a latch to keep the door shut and creating a device to keep two moving objects from touching each other.*
4	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	Earth and Space Science	4E.1.2.1.1 Make observations and measurements to provide evidence of the effects of weathering or the rate of erosion by the forces of water, ice, wind, or vegetation.* (P: 3, CC: 2, CI: ESS2) *Emphasis is on predicting the rate of change when variables are changed. Examples of variables to test may include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
4	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	Earth and Space Science	4E.1.2.1.2 Plan and carry out fair tests in which variables are controlled and failure points are considered to improve a model or prototype to prevent erosion.* (P: 3, CC: 2, CI: ESS2, ETS1; ETS2) *Examples of prototypes to prevent erosion include retaining walls, wind breaks, use of shrubs or other vegetation, and drainage systems.*
4	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	Earth and Space Science	4E.2.2.1.1 Interpret charts, maps and/or graphs of the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.** (P: 5, CC: 4, CI: ESS2) *Emphasis is on oceans, lakes, rivers, glaciers, ground water, and polar ice caps.*
4	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	Earth and Space Science	4E.3.1.1.1 Develop a model based in part on student observations or data to describe ways the geosphere, biosphere, hydrosphere, and atmosphere interact. (P: 2, CC: 4, CI: ESS2) *Emphasis is on how rock, living things, water, and/or air are individual systems that make up the larger Earth system and interact with each other.*
4	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.	Earth and Space Science	4E.3.2.1 1 Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. (P: 6, CC: 1, CI: ESS1) *Examples of evidence from patterns may include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time; and a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock.*
4	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.*	Earth and Space Science	4E.3.2.2.1 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.* (P: 6, CC: 2, CI: ESS3, ETS1) *Emphasis is on cause and effect relationships to explain change. Examples of solutions may include designing an earthquake resistant building and improving monitoring of volcanic activity.*

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4	4 Communicating reasons, arguments and ideas to others	4.1 Engaging in Arguing from evidence	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.	Life Science	4L.4.1.1.1 Construct or support an argument that traits can be influenced by different environments. (P: 7, CC: 2, CI: LS3) *Emphasis of the practice is on using evidence, data and/or a model to support an argument. Examples of the environment affecting a trait may include the stunted growth of a typically tall plant grown with insufficient water or an animal's weight being influenced by the availability of food.*
4	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Earth and Space Science	4E.4.2.1.1 Read and comprehend grade appropriate complex texts and/or other reliable media to describe that energy and fuels are derived from natural resources and their uses affect the environment. (P: 8, CC: 2, CI: ESS3, ETS2) *Examples of information about natural resources should include details about those found in Minnesota. Examples of renewable energy resources may include wind, water behind dams, and sunlight; non-renewable energy resources include fossil fuels and fissile materials. Examples of environmental effects may include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution and global warming from burning fossil fuels.*
4	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Life Science	4L.4.2.1.2 Obtain information from various media sources to determine that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.** (P: 8, CC: 1, CI: LS3) *Emphasis of the practice is to compare and/or combine information across texts and other reliable media. Emphasis is on organisms other than humans and the patterns in traits between offspring and their parents or among siblings.*

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4	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Earth and Space Science	4E.4.2.2.1 Obtain and combine multiple sources of information about ways individual communities, including Minnesota American Indian Tribes and communities and other cultures use evidence and scientific principles to make decisions about the uses of Earth's resources.* (P: 8, CC: 4, CI: ESS3, ETS1) *Examples of cultures may include those within the local context of the learning community and within the context of Minnesota . Examples may include balancing the water, soil, wildlife, plant, and human needs to support sustainable use of resources.*
5	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	Physical Science	5P.1.1.1.1 Ask investigatable questions and predict reasonable outcomes about the changes in energy, related to speed, that occur when objects interact. (P: 1, CC: 5, CI: PS3) *Emphasis is on the change in energy due to a change in speed, not on the forces, as objects interact. Example of a question: Where and how do marbles move after a collision?*
5	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	Physical Science	5P.1.2.1.2 Conduct an investigation to determine whether the mixing of two or more substances results in new substances. (P: 3, CC: 2, CI: PS1) *Emphasis is on conducting fair tests by controlling variables.*
5	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	Physical Science	5P.1.2.1.3 Evaluate appropriate methods and tools to identify materials based on their properties prior to investigation. (P: 3, CC: 3, CI: PS1) *Examples of materials to be identified may include baking soda and other powders, metals, minerals, and liquids. Examples of properties may include color, hardness, reflectivity, electrical conductivity, ability to conduct heat, response to magnetic forces, and solubility; density is not intended as an identifiable property.*
5	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	Life Science	5L.1.2.1.4 Plan and conduct an investigation to obtain evidence that plants get the materials they need for growth chiefly from air and water. (P: 3, CC: 5, CI: LS1) *Examples of plants may include aquatic plants that grow without soil. Examples of observational evidence may include growth patterns for plants grown in different environments.*

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5	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyze and interpret data	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.	Physical Science	5P.2.1.1.1 Analyze and interpret data to show that energy can be transferred from place to place by sound, light, heat, and electric currents. (P: 4, CC: 5, CI: PS3) *Emphasis of the practice is on analyzing student observations and data to serve as evidence to support a claim.*
5	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	Physical Science	5P.2.2.1.1 Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved. (P: 5, CC: 3, CI: PS1) *Examples of reactions or changes may include phase changes, dissolving, and mixing to form new substances. Mass and weight are not distinguished.*
5	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	Earth and Space Science	5E.2.2.1.2 Use data to describe patterns in the daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.** (P: 5, CC: 1, CI: ESS1) *Examples of patterns may include the number of daylight hours over the course of a year, selected stars that are visible only in particular months, and the length and direction of shadows over a year.*
5	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	Physical Science	5P.3.1.1 1 Develop and refine a model to describe that matter is made of particles too small to be seen. (P: 2, CC: 3, CI: PS1) *Examples of evidence supporting a model may include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.*
5	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	Physical Science	5P.3.1.1.2 Use models to describe that energy in animals' food (used for body repair, growth, and motion and to maintain body warmth) was once energy from the sun. (P: 2, CC: 5, CI: PS3) *Examples of models may include diagrams, and flow charts.*

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5	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	Life Science	5L.3.1.1.3 Create an electronic visualization of the movement of matter among plants, animals, decomposers, and the environment.** (P: 2, CC: 4, CI: LS2) *Emphasis is on the idea that matter that is not food is changed by plants into matter that is food. Examples of systems through which matter cycles may include organisms, ecosystems, and the Earth. Examples of an electronic visualization may include a computer program, simulation, or animation.*
5	12 Exploring phenomena or engineering problems	3.2 Constructing explanations and designing solutions	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.	Physical Science	5P.3.2.1.1 Construct an explanation based on evidence relating the speed of an object to the energy of that object. (P: 6, CC: 5, CI: PS3). *The emphasis of the practice is on students identifying the evidence that supports particular points in the explanation. Examples of evidence may include the damage and the height attained when going up a ramp.*
5	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.*	Physical Science	5P.3.2.2 1 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.* (P: 6, CC: 5, CI: PS3, ETS1, ETS2) *Examples of devices may include electric circuits that convert electrical energy into motion, light, or sound; and a passive solar heater that converts light into heat. Examples of constraints may include the materials, cost, or time to design the device.*
5	4 Communicating reasons, arguments and ideas to others	4.1 Engaging in Arguing from evidence	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.	Earth and Space Science	5E.4.1.1.1 Use evidence to support an argument that the apparent brightness of the sun and stars is due to their relative distances from Earth. (P: 7, CC: 3, CI: ESS1) *Evidence may include analogies of light bulbs and distances.*
5	4 Communicating reasons, arguments and ideas to others	4.1 Engaging in Arguing from evidence	4.1.2 Students will be able to argue from evidence to justify the best solution to a problem or to compare and evaluate competing designs, ideas, or methods.*	Life Science	5L.4.1.2.1 Evaluate the merit of a solution to a problem caused by changes in plant and animal populations as a result of environmental changes.* (P: 7, CC: 4, CI: LS4, ETS1) *Emphasis is on evaluating solutions (based on evidence and design criteria and constraints), not developing new solutions. Examples of environmental changes may include land characteristics, water distribution, temperature, food availability, or the presence of other organisms.*

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6	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	ESS: Earth's Place in the Universe	6E.1.1.1.1 Ask questions that arise from observations of patterns in the movement of night sky objects to test the limitations of a solar system model. (P: 1, CC: 1, CI: ESS1) *Emphasis is on students questioning the limitations of their own models and questioning the kinds of revisions needed to account for new data. Examples of observations may include the student's own observations or observations made by others. Examples of night sky objects include the Moon, constellations, and planets.*
6	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	ESS: Earth's Systems and Processes	6E.1.1.1.2 Ask questions to examine an interpretation about the relative ages of different rock layers within a sequence of several rock layers. (P: 1, CC: 1, CI: ESS1) *Emphasis is on the interpretation of rock layers using geologic principles like superposition and cross-cutting relationships.*
6	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	ESS: Human Impacts and Sustainability in Earth's Systems	6E.1.1.1.3 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. (P: 1, CC: 7, CI: ESS3) *Emphasis is on the major role that human activities play in causing the rise in global temperatures. Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
6	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	ESS: Weather and Climate	6E.1.2.1.1 Collect data and use digital data analysis tools to identify patterns to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.** (P: 3, CC: 2, CI: ESS2) *Emphasis is on how weather at a fixed location changes in response to moving air masses and to interactions at frontal boundaries between air masses. Examples of weather data may include temperature, air pressure, precipitation, and wind. Examples of data analysis may include weather maps, diagrams, and visualizations or may be obtained through laboratory experiments (such as with condensation).*
6	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	ESS: Earth's Place in the Universe	6E.2.1.1.1 Analyze and interpret data to determine similarities and differences among features and processes occurring on solar system objects. (P: 4, CC: 3, CI: ESS1) *Examples of objects may include moons, planets, comets or asteroids. Example features may include characteristics of an object's atmosphere, surface or interior. Examples of processes may include erosion, deposition, cratering, or volcanism.*
6	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	ESS: Earth's Systems and Processes	6E.2.1.1.2 Analyze and interpret data on the distribution of fossils, rocks, continental shapes, and seafloor structures to provide evidence of past plate motions. (P: 4, CC: 1, CI: ESS2) *Examples of data may include similarities of rock and fossil types on different continents, the shapes of the continents (including the continental shelves), and the locations of ocean floor features such as ridges and trenches.*
6	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	ESS: Human Impacts and Sustainability in Earth's Systems	6E.2.1.1.3 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.* (P: 4, CC: 1, CI: ESS3, ETS1) *Examples of natural hazards may be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events. Examples of data may include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies may include building tornado shelters or barriers to protect from flooding.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
6	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	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.	ESS: Earth's Place in the Universe	6E.3.1.1.1 Develop and use scale models of solar system objects to describe the sizes of objects, the location of objects, and the motion of the objects; and include the role that gravity and inertia play in controlling that motion. (P: 2, CC: 3, CI: ESS1) *Emphasis is on the regularity of the motion and accounting for Earth-based visual observations of the motion of these objects in our sky. Emphasis is also on recognizing the limitations of any of the models. Examples may include physical models (such as the analogy of distance along a football field or computer visualizations of orbits) or conceptual models (such as mathematical proportions relative to the size of familiar objects such as students' school or state). Not included are Kepler's Laws and retrograde motion of planets.*
6	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	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.	Earth's Systems and Processes	6E.3.1.1.2 Develop a model, based on observational evidence, to describe the cycling and movement of Earth's rock material and the energy that drives these processes. (P: 2, CC: 5, CI: ESS2) *Emphasis of the practice is on using observations of processes like weathering and erosion of soil and rock, deposition of sediment, and crystallization of lava to inform model development. Emphasis of the core idea is on how these processes operate over geologic time to form rocks and minerals through the cycling of Earth's materials. Examples of models may be conceptual or physical.*
6	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	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.	ESS: Earth's Systems and Processes	6E.3.1.1.3 Develop a model, based on observational and experimental evidence, to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity. (P: 2, CC: 5, CI: ESS2) *Emphasis of the practice is on developing a way to represent the mechanisms of water changing state, the global movements of water and energy, and on how the observational and experimental evidence supports the model. Examples of models may be conceptual or physical.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
6	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.	ESS: Earth's Systems and Processes	6E.3.2.1.1 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. (P: 6, CC: 3, CI: ESS1) *Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of major events may include the evolution or extinction of particular organisms, the formation of mountain chains and the formation of ocean basins. Not included is using radioactive decay to age date rocks.*
6	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.	ESS: Earth's Systems and Processes	6E.3.2.1.2 Construct a scientific explanation based on evidence for how the uneven distribution of Earth's mineral, energy, or groundwater resources is the result of past geological processes. (P: 6, CC: 2, CI: ESS3) *Emphasis is on how these resources are limited and typically non-renewable on a human timeframe. Examples of uneven distribution of resources may include petroleum (like in the North Dakota Bakken Shale), metal ores (like iron in the rocks of Minnesota's Iron Range), or groundwater in the different regions of Minnesota.*
6	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.	ESS: Earth's Systems and Processes	6E.3.2.1.3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* (P: 6, CC: 2, CI: ESS3, ETS1) *Emphasis of the practice is on applying scientific principles about Earth's natural processes (like how water moves through the ground and air) to designing solutions to problems caused by human activity. Emphasis of the core idea is on how human activity impacts Earth's environments. Examples of parts of the design process may include assessing the kinds of solutions that are feasible, and designing and evaluating solutions that may reduce those impacts. Examples of human activities that impact the environment may include withdrawing too much water from aquifers, altering stream flow by building dams or levees, increasing runoff caused by impermeable surfaces like parking lots, or adding undesirable materials to the air, water or land.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
6	4 Communicating reasons, arguments and ideas to others	4.1 Engaging in Argument from Evidence	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.	ESS: Earth's Systems and Processes	6E.4.1.1.1 Construct an argument, supported by evidence, for how geoscience processes have changed Earth's surface at varying time and spatial scales. (P: 7, CC: 3, CI: ESS2) *Emphasis is on how processes like erosion, deposition, mountain building, and volcanism affect the surface of Earth. Some processes, like mountain building take a long time. Other processes, like landslides, happen quickly. Examples may include how weathering, erosion and glacial activity have shaped the surface of Minnesota.*
6	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	ESS: Earth's Place in the Universe	6E.4.2.2.1 Communicate how a series of models, including those used by Minnesota American Indian Tribes and communities and other cultures, are used to explain how motion in the Earth-Sun-Moon system causes the cyclic patterns of lunar phases, eclipses and seasons. (P: 8, CC: 1, CI: ESS1) *Examples of cultures may include those within the local context of the learning community and within the context of Minnesota. Emphasis is on students questioning the limitations of their models and revising them to account for new observations. Models may be physical, graphical or conceptual.*
7	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	LS: Heredity: inheritance and Variation of Traits	7L.1.1.1.1 Ask questions about the processes and outcomes of various methods of communication between cells of multicellular organisms. (P: 1, CC: 6, CI: LS1) *Examples of questions about processes and outcomes may include questions about disruptions to normal communication processes in the human body, such as in cancer, diabetes, paralysis, or other disorders.*
7	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	LS: Heredity: inheritance and Variation of Traits	7L.1.1.1.2 Ask questions that arise from careful observations of phenomena or models to clarify and or seek additional information about how changes in genes can affect organisms. (P: 1, CC: 6, CI: LS3) *Examples of changes may include neutral, harmful, or beneficial effects to the structure and function of the organism.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
7	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	LS: From Molecules to Organisms: Structures and Processes	7L.1.2.1.1 Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. (P: 3, CC: 3, CI: LS1) *Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or of many and varied cells.*
7	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	LS: Ecosystems: Interactions, Energy, and Dynamics	7L.2.1.1.1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.** (P: 4, CC: 2, CI: LS2) *Emphasis is on cause and effect relationships between resources and growth of individual organisms and the number or organisms in ecosystems during periods of abundant and scarce resources. Examples may include populations of MN deer, moose, wolf, scavengers or aquatic populations in Lake Superior or algal blooms in lakes and ponds. Examples of evidence may include the use of flow charts to organize and sequence the algorithm, and to show relationships.*
7	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	LS: Evolution: Unity and Diversity	7L.2.1.1.2 Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth. (P: 4, CC: 1, CI: LS4) *Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.*
7	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	LS: Evolution: Unity and Diversity	7L.2.1.1.3 Analyze visual data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.** (P: 4, CC: 1, CI: LS4) *Emphasis is on inferring general patterns of relatedness among embryos of different organisms by comparing their macroscopic appearances on diagrams or pictures.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
7	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	LS: Evolution: Unity and Diversity	7L.2.2.1.1 Use an algorithm to explain how natural selection may lead to increases and decreases of specific traits in populations.** (P: 5, CC: 2, CI: LS4) *Emphasis is on using proportional reasoning to develop mathematical models, probability statements, or simulations to support explanations of trends in changes to populations over time.*
7	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	LS: From Molecules to Organisms: Structures and Processes	7L.3.1.1.1 Develop and use a model to describe the function of a cell as a whole and describe the way cell parts contribute to the cell's function. (P: 2, CC: 6, CI: LS1) *Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.*
7	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	LS: From Molecules to Organisms: Structures and Processes	7L.3.1.1.2 Develop and use a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. (P: 2, CC: 5, CI: LS1) *Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released. Examples may include models of sugar breakdown into molecules of glucose that power our bodies, or protein breakdown into amino acids that are later reassembled to create body structures.*
7	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	LS: Ecosystems: Interactions, Energy, and Dynamics	7L.3.1.1.3 Develop and use a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. (P: 2, CC: 5, CI: LS2) *Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
7	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	LS: Heredity: inheritance and Variation of Traits	7L.3.1.1.4 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. (P: 2, CC: 2, CI: LS3) *Emphasis is on using models, such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variations.*
7	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	3.2.1 Students will be able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.	LS: From Molecules to Organisms: Structures and Processes	7L.3.2.1.1 Construct an explanation based on evidence for how environmental and genetic factors influence the growth of organisms and/or populations. (P: 6, CC: 2, CI: LS1, ETS2) *Examples of environmental factors may include local environmental conditions such as availability of food, light, space, and water. Examples of genetic factors may include large breed cattle and species of grass affecting growth of organisms. Examples of evidence may include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, and fish growing larger in large ponds than they do in small ponds. Examples of human activity may include agricultural practices, phosphorus and nitrogen loading in lakes, hybridization and breeding practices.*
7	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	3.2.1 Students will be able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.	LS: From Molecules to Organisms: Structures and Processes	7L.3.2.1.2 Construct an explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. (P: 6, CC: 2, CI: LS1) *Emphasis of the core idea is on plants and algae using energy from light to make sugars (food for themselves and as an energy source for other organisms) from carbon dioxide (from air) and water; and in the process release oxygen.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
7	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	3.2.1 Students will be able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.	LS: Evolution: Unity and Diversity	7L.3.2.1.3 Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. (P: 6, CC: 1, CI: LS4) *Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity of differences of the gross appearance of anatomical structures.*
7	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	3.2.1 Students will be able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.	LS: Evolution: Unity and Diversity	7L.3.2.1.4 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. (P: 6, CC: 2, CI: LS4) *Emphasis is on using simple probability statements and proportional reasoning to construct explanations.*
7	4 Communicating reasons, arguments and ideas to others	4.1 Arguing from evidence	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.	LS: From Molecules to Organisms: Structures and Processes	7L.4.1.1.1 Support or refute an explanation by arguing from evidence for how the body is a system of interacting subsystems composed of groups of cells. (P: 7, CC: 4, CI: LS1) *Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples may include arguments that deal with the interaction of subsystems within a system and the normal functioning of those systems.*
7	4 Communicating reasons, arguments and ideas to others	4.1 Arguing from evidence	4.1.1 Students will be able to engage in argument from evidence for the explanations they construct, defend and revise their interpretations when presented with new evidence, critically evaluate the scientific arguments of others, and present counter arguments.	LS: From Molecules to Organisms: Structures and Processes	7L.4.1.1.2 Support or refute an explanation by arguing from evidence and scientific reasoning for how animal behavior and plant structures affect the probability of successful reproduction. (P: 7, CC: 2, CI: LS1) *Examples of behaviors that affect the probability of animal reproduction may include nest building to protect young, herding of animals to protect young from predators, and vocalization and/or colorful plumage to attract mates for breeding. Examples of animal behaviors that affect the probability of plant reproduction may include transferring pollen or seeds, and creating conditions for seed germination and growth. Examples of plant structures may include bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
7	4 Communicating reasons, arguments and ideas to others	4.1 Arguing from evidence	4.1.2 Students will be able to argue from evidence to justify the best solution to a problem or to compare and evaluate competing designs, ideas, or methods.*	LS: Ecosystems: Interactions, Energy, and Dynamics	7L.4.1.2.1 Construct an argument supported by empirical evidence that changes in physical or biological components of an ecosystem affect populations.* (P: 7, CC: 7, CI: LS2) *Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes and/or impacts to ecosystems. Examples of physical components may include human-built structures like urban developments, or dams.*
7	4 Communicating reasons, arguments and ideas to others	4.1 Arguing from evidence	4.1.2 Students will be able to argue from evidence to justify the best solution to a problem or to compare and evaluate competing designs, ideas, or methods.*	LS: Ecosystems: Interactions, Energy, and Dynamics	7L.4.1.2.2 Evaluate competing design solutions for maintaining biodiversity or ecosystem services.* (P: 7, CC: 2, CI: LS2, ETS2) *Emphasis is on evaluating a solution that reduces environmental harm while still benefiting humans. Examples of ecosystem services (natural processes within ecosystems that humans also benefit from) may include water purification as it cycles through Earth's systems, nutrient recycling, climate stabilization, decomposition of wastes, and pollination. Examples of design solution constraints may include scientific, economic, and social considerations.*
7	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	LS: Ecosystems: Interactions, Energy, and Dynamics	7L.4.2.2.1 Gather multiple sources of information and communicate how Minnesota American Indian Tribes and communities and other cultures use knowledge to predict or interpret patterns of interactions among organisms across multiple ecosystems. (P: 8, CC: 1, CI: LS2, ETS2) *Examples of cultures may include those within the local context of the learning community and within the context of Minnesota. Emphasis is on predicting consistent patterns of interactions in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems. Examples of types of interactions may include competition, predation and mutualisms.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
8	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	PS: Matter and its Interactions	8P.1.1.1.1 Ask questions about locations of common elements on the periodic table to note patterns in the properties of similarly grouped elements. (P: 1, CC: 1, CI: PS1) *Emphasis is on the similar properties within columns of the periodic table. Examples of questions that students may think to ask may include how are the properties of elements in a column similar and different.*
8	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	PS: Motion and Stability: Forces and Interactions	8P.1.1.1.2 Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. (P: 1, CC: 2, CI: PS2) *Examples of data may include the number of turns of wire in a coil, the strength of magnets, and the current through the wire and their effect on the speed of rotation in a simple motor.*
8	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	PS: Matter and its Interactions	8P.1.2.1.1 Plan and conduct an investigation of changes in pure substances when thermal energy is added or removed and relate those changes to particle motion. (P: 3, CC: 2, CI: PS1) *Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs.*
8	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	PS: Motion and Stability: Forces and Interactions	8P.1.2.1.2 Plan and conduct an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. (P: 3, CC: 7, CI: PS2) *Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.*
8	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	PS: Motion and Stability: Forces and Interactions	8P.1.2.1.3 Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact. (P: 3, CC: 2, CI: PS2) *Examples of this phenomenon may include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls. Examples of investigations may include first-hand experiences or simulations.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
8	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	PS: Energy	8P.1.2.1.4 Plan and conduct an investigation to determine how the temperature of a substance is affected by the transfer of energy, the amount of mass, and the type of matter. (P: 3, CC: 2, CI: PS 3) *Emphasis is on conceptualizing temperature as the average kinetic energy of a substance's particles. Examples of investigations may include comparing final water temperatures after different masses of ice melt in equal volumes of water with the same initial temperature, and temperature changes of different materials with the same mass as they heat or cool in the environment.*
8	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	PS: Matter and its Interactions	8P.2.1.1.1 Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. (P: 4, CC: 1, CI: PS1) *Examples of reactions may include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride. Examples of properties may include density, melting point, boiling point, solubility, flammability, and odor.*
8	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	PS: Energy	8P.2.1.1.2 Construct and interpret graphical displays of data to describe the relationship of kinetic energy to the mass and speed of an object. (P: 4, CC: 3, CI: PS3) *Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples may include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a Wiffle ball versus a tennis ball.*
8	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	PS: Waves and their Applications	8P.2.2.1.1 Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. (P: 5, CC: 1, CI: PS4) *Emphasis is on describing waves (standard repeating waves) with both qualitative and quantitative thinking. Not included is electromagnetic waves.*

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8	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	PS: Energy	8P.2.2.1.2 Create a computer program to illustrate the transfer of energy within a system where energy changes form.** (P: 5, CC: 7, CI: PS3) *Emphasis of the programming skills is the use of sequences, events and conditionals. Examples of a system may include a roller coaster, a pendulum, an electric water heater, and a solar electric collector.*
8	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	PS: Matter and its Interactions	8P.3.1.1.1 Develop models to describe the atomic composition of simple molecules and crystals. (P: 2, CC: 3, CI: PS1) *Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules may include ammonia and methane. Examples of crystal structures may include sodium chloride or quartz, pyrite or diamonds. Does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or crystal structure.*
8	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	PS: Matter and its Interactions	8P.3.1.1.2 Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. (P: 2, CC: 5, CI: PS1) *Emphasis is on the law of conservation of matter. Examples of models may include physical models, digital formats, or drawings, which represent atoms. Not included are atomic masses, balancing symbolic equations, or intermolecular forces.*
8	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	PS: Energy	8P.3.1.1.3 Develop and revise a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. (P: 2, CC: 5, CI: PS3) *Emphasis is on relative amounts potential energy and not on calculations of potential energy. Examples of objects within systems interacting at varying distances may include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models may include representations, diagrams, pictures, and written descriptions of systems.*

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8	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	PS: Waves and their Applications	8P.3.1.1.4 Develop and use a model to qualitatively describe that waves are reflected, absorbed, or transmitted through various materials. (P: 2, CC: 4, CI: PS4) *Emphasis is on both light and mechanical waves. Examples of models may include drawings, simulations, a storyboard/diagram and written descriptions.*
8	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.	PS: Matter and its Interactions	8P.3.2.1.1 Construct an explanation based on evidence and scientific principles of a common phenomenon that can be explained by the motions of molecules. (P: 6, CC: 3, CI: PS1) *Emphasis of the core idea is that the movement of small particles (atoms or molecules) can explain the behavior of macroscopic phenomena. Examples of phenomena may include expansion of balloons, diffusion of odors, and pressure changes in gases due to heating and cooling.*
8	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.*	PS: Matter and its Interactions	8P.3.2.2.1 Construct, test and modify a device that either releases or absorbs thermal energy by chemical processes.* (P: 6, CC: 5, CI: PS1, ETS1) *Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of chemical reactions include dissolving ammonium chloride or calcium chloride in water.*
8	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.*	PS: Motion and Stability: Forces and Interactions	8P.3.2.2.2 Design a solution to a problem involving the motion of two colliding objects using Newton's 3rd Law.* (P: 6, CC: 4, CI: PS2, ETS1) *Examples of practical problems may include the impact of one dimensional collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
8	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.*	PS: Energy	8P.3.2.2.3 Design, construct, and test a device that either minimizes or maximizes thermal energy transfer.* (P: 6, CC: 5, CI: PS3, ETS1) *Emphasis is on using scientific principles to design the device. Examples of devices may include an insulated box, a solar cooker, and a foam cup.*
8	4 Communicating reasons, arguments and ideas to others	4.1 Arguing from evidence	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.	PS: Motion and Stability: Forces and Interactions	8P.4.1.1.1 Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. (P: 7, CC: 3, CI: PS2) *Examples of evidence for arguments may include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system. Not included are Newton's Law of Gravitation or Kepler's Laws.*
8	4 Communicating reasons, arguments and ideas to others	4.1 Arguing from evidence	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.	PS: Motion and Stability: Forces and Interactions	8P.4.1.1.2 Compare and evaluate evidence to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. (P: 7, CC: 5, CI: PS3) *Examples of empirical evidence used in the students' arguments may include the temperature or motion of an object before and after an energy transfer.*
8	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	PS: Matter and its Interactions	8P.4.2.1.1 Gather and evaluate information from multiple sources to describe that synthetic materials come from natural resources and impact society. (P: 8, CC: 6, CI: PS1) *Emphasis of the practice is to synthesize information from multiple appropriate sources and assess the credibility, accuracy and possible bias of each publication. Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials may include plastic, medicines, foods, and alternative fuels.*

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8	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	PS: Waves and their Applications	8P.4.2.1.2 Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.** (P: 8, CC: 6, CI: PS4) *Emphasis of the practice is on using information to support and clarify claims. Emphasis of the core idea is on understanding that waves (encoded both analog and digitally) can be used for communication purposes. Examples of encoding and transmitting information may include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen.*
9-12 Earth and Space Science	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	ESS: Earth's Systems and Processes	9E.1.1.1.1 Ask questions to clarify how seismic energy traveling through Earth's interior can provide evidence for Earth's internal structure. (P: 1, CC: 6,CI: ESS2) *Emphasis is on how wave propagation depends on the density of the medium through which the wave travels and how seismic data is used to support the idea of a layered earth.*
9-12 Earth and Space Science	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	ESS: Earth's Systems and Processes	9E.1.2.1.1 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes. (P: 3, CC: 6, CI: ESS2) *Emphasis is on physical and chemical investigations with water and a variety of solid materials to provide the evidence for how processes in the water cycle and rock cycle interact. Examples of physical investigations may include transportation and deposition of various sediment types and sizes, erosion of surfaces with varying amounts of soil moisture content and/or ground cover, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations may include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids). Examples specific to Minnesota may include chemical weathering of limestone to create karst topography.*

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9-12 Earth and Space Science	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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	ESS: Human Impacts and Sustainability in Earth's Systems	9E.1.2.1.2 Plan and conduct an investigation of the properties of soils to model the effects of human activity on soil resources. (P: 3, CC: 2, CI: ESS3, ETS2) *Emphasis is on identifying variables to test, developing a workable experimental design, and identifying limitations of the data. Examples of variables may include soil type and composition (particularly those found in Minnesota), erosion rate, water infiltration rates, nutrient profiles, soil conservation practices, or specific crop requirements.*
9-12 Earth and Space Science	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	ESS: Earth's Place in the Universe	9E.2.1.1.1 Analyze data to make a valid scientific claim about the way stars, over their life cycle, produce elements. (P: 4, CC: 5, CI: ESS1) *Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.*
9-12 Earth and Space Science	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	ESS: Earth's Systems and Processes	9E.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. (P: 4, CC: 7, CI: ESS2, ETS2) *Emphasis is on using data analysis tools and techniques in order to make valid scientific claims. Examples may include climate feedback mechanisms, such as how an increase in greenhouse gases causes a rise in global temperatures that melt glaciers and sea ice, which reduces the amount of sunlight reflected from the Earth's surface (albedo), increasing surface temperatures and further reducing the amount of ice. Examples may also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent and longevity.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
9-12 Earth and Space Science	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	ESS: Human Impacts and Sustainability in Earth's Systems	9E.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.* (P: 4, CC: 7, ESS3, ETS1) *Examples of evidence (for both data and climate model outputs) may include precipitation and temperature and their associated impacts on sea level, glacial ice volumes, and atmosphere and ocean composition. Engineering examples may include using climate change data (rising sea levels) to evaluate the impact on the ability of sewer system to handle runoff or of existing wells to produce potable water.*
9-12 Earth and Space Science	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	ESS: Earth's Place in the Universe	9E.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.** (P: 5, CC: 3, CI: ESS1, ETS2) *Emphasis is on Kepler's laws of planetary motion and Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.*
9-12 Earth and Space Science	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	ESS: Earth's Systems and Processes	9E.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.** (P: 2, CC: 5, CI: ESS2) *Emphasis is on quantitative modeling of carbon as it cycles through the ocean, air, rock (particularly limestone), soil, and organisms. Emphasis is also on using empirical evidence and scientific reasoning to inform the algorithmic thinking about the conservation and cycling of matter.*

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9-12 Earth and Space Science	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	ESS: Human Impacts and Sustainability in Earth's Systems	9E.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. (P: 5, CC: 4, CI: ESS3, ETS2) *Emphasis is on students identifying the interacting components of a system, mathematically modeling how those factors interact and accounting for the effects of human activity on the system. Examples may include local systems in which natural and human-influenced variables impact the amount of runoff.*
9-12 Earth and Space Science	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	ESS: Earth's Place in the Universe	9E.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. (P: 2, CC: 3, CI: ESS1) *Emphasis is on showing the relationships among the fuel, products and the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach the Earth. Examples of evidence that students might use include the masses and life times of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares, sunspot cycles, and non-cyclic variations over the centuries.*
9-12 Earth and Space Science	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	ESS: Earth's Systems and Processes	9E.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. (P: 2, CC: 7, CI: ESS2) *Emphasis is on how the appearance of land features (such as mountains, and valleys), and seafloor features (such as trenches and ridges) are a result of both constructive mechanisms (such as volcanism, and tectonic motion) and destructive mechanisms (such as weathering, and coastal erosion). Examples specific to Minnesota may include features formed relatively recently during continental glaciation and volcanic features that have long since been eroded away.*

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9-12 Earth and Space Science	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	ESS: Weather and Climate	9E.3.1.1.3 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. (P: 2, CC: 4, CI: ESS2) *Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean currents, which is constrained by the Coriolis effect and the outlines of continents. Examples of models may be diagrams, maps and globes, or digital representations.*
9-12 Earth and Space Science	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	ESS: Weather and Climate	9E.3.1.1.4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. (P: 2, CC: 2, CI: ESS2). *Emphasis is on using a model to describe the mechanism for how energy flow affects changes in climate. Examples of the causes of climate change differ by timescale and may include: 1 - 10 years: large volcanic eruptions, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10 - 100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10 - 100s of millions of years: long term changes in atmospheric composition.*
9-12 Earth and Space Science	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.	ESS: Earth's Place in the Universe	9E.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. (P: 6, CC: 5, CI: ESS1, ETS2) *Emphasis is on how the redshift of light from galaxies is an indication of cosmic expansion, on how the cosmic microwave background radiation is a remnant of the Big Bang, and on how the observed composition of ordinary matter, primarily found in stars and interstellar gases, matches that predicted by the Big Bang.*

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9-12 Earth and Space Science	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	3.2.1 Students will be able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.	ESS: Earth's Place in the Universe	9E.3.2.1.2 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. (P: 6, CC: 7, CI: ESS1) *Emphasis of the practice is on linking the evidence to the claims about Earth's formation. Emphasis of the core idea is on using available evidence within the solar system to reconstruct the early history of Earth. Examples of evidence include the absolute ages of ancient materials, the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.*
9-12 Earth and Space Science	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.*	ESS: Human Impacts and Sustainability in Earth's Systems	9E.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.* (P: 6, CC: 7, CI: ESS3, ETS1, ETS2) *Emphasis is on prioritizing identified criteria and constraints related to social and environmental considerations. Examples of data for the impacts of human activities may include the quantities and types of pollutants released into air or groundwater, changes to biomass and species diversity, or areal changes in land surface use (for surface mining, urban development, or agriculture). Examples for limiting impacts may range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).*
9-12 Earth and Space Science	4 Communicating reasons, arguments and ideas to others	4.1 Arguing from evidence	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.	ESS: Earth's Place in the Universe	9E.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. (P: 7, CC: 1, CI: ESS1) *Emphasis is on evaluating the strengths, weaknesses and reliability of the given evidence along with its ability to support logical and reasonable arguments about the motion and age of crustal plates. Examples of evidence may include the ages of oceanic crust which increase with distance from mid-ocean ridges (a result of seafloor spreading), the ages of North American continental crust decreasing with distance away from a central ancient core (a result of past plate interactions).*

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9-12 Earth and Space Science	4 Communicating reasons, arguments and ideas to others	4.1 Arguing from evidence	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.	ESS: Earth's Systems and Processes	9E.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. (P: 7, CC: 5, CI: ESS2) *Emphasis is on how plate tectonics is controlled by mantle convection (due to the outward flow of energy from the decay of radioactive isotopes and the gravitational movement of denser materials toward the interior).*
9-12 Earth and Space Science	4 Communicating reasons, arguments and ideas to others	4.1 Arguing from evidence	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.	ESS: Human Impacts and Sustainability in Earth's Systems	9E.4.1.1.3 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* (P: 7, CC: 5, CI: ESS3, ETS1) *Emphasis is on the conservation, recycling, and reuse of resources (such as minerals, metals or soils) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for fracking sand, iron ore, and rare metals), and pumping (for oil and natural gas).*
9-12 Earth and Space Science	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	ESS: Weather and Climate	9E.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. (P: 8, CC: 2, CI: ESS2, ETS2) *Emphasis is on the making sense of technical information presented in a variety of formats (graphs, diagrams and words). Example of sources of information may include student experimental data. Examples of factors may include porosity, permeability, sediment or rock type, recharge or discharge factors, and potential energy. Examples of human factors may include usage rates, run-off, agricultural practices, and loss of wetlands.*

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9-12 Earth and Space Science	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	ESS: Human Impacts and Sustainability in Earth's Systems	9E.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. (P: 8, CC: 4, CI: ESS3) *Examples of cultures may include those within the local context of the learning community and within the context of Minnesota . Emphasis is on understanding and using American Indian knowledge systems to describe regional impacts of climate change to Minnesota. Examples may include the water cycle and how precipitation change over time impacts cultural practices related to nibi ("water" in the Ojibwe language); or the decline/species loss of wiigwaas ("paper birch" in the Ojibwe language and an important tree in Anishinaabe culture) due to climate stressors like drought or changes in snow cover.*
9-12 Life Science	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	LS: Heredity: Inheritance and Variation of Traits	9L.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. (P: 1, CC: 2, CI: LS3) *Examples of relationships may include relationships between mutated DNA sequences or chromosomal deletions and their effect on traits.*
9-12 Life Science	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	LS: From Molecules to Organisms: Structures and Processes	9L.1.2.1.1 Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis. (P: 3, CC: 7, CI: LS1) *Examples of investigations may include heart rate response to exercise, stomata response to moisture and temperature, and root development in response to water levels.*
9-12 Life Science	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	LS: Heredity: Inheritance and Variation of Traits	9L.2.1.1.1 Apply concepts of probability to explain and predict the variation and distribution of expressed traits in a population. (P: 4, CC: 3, CI: LS3) *Examples of traits in human groups may include lactose intolerance, or high-altitude adaptation.*

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9-12 Life Science	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	LS: Evolution: Unity and Diversity	9L.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. (P: 4, CC: 1, CI: LS4) *Emphasis is on analyzing shifts in the numerical distribution of traits and using these shifts as evidence to support explanations. Examples of advantageous traits may antibiotic resistance in bacteria, or the coloration and camouflage of animals in response to changing environmental conditions.*
9-12 Life Science	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	LS: Ecosystems: Interactions, Energy, and Dynamics	9L.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.** (P: 5, CC: 3, CI: LS2) *Examples of ecological impacts might include changes in the carrying capacity, species numbers and/or types of organisms present in an environment. Examples of human practices that can have positive or negative impacts, such as stream restoration versus deforestation as an ecological example. Examples of computational models may include online simulations of population dynamics, population ecology, or population growth.*
9-12 Life Science	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	LS: Ecosystems: Interactions, Energy, and Dynamics	9L.2.2.1.2 Use a computational model to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.** (P: 5, CC: 5, CI: LS2) *Examples of claims about matter cycles may include how carbon, nitrogen, or water cycles through the environment, and/or how disruptions to those systems affect matter cycling. Examples of energy flow may include the transfer of the sun's energy into and among organisms, and/or connections between fossil fuel burning and the carbon cycle. Examples of computational models may include online simulations and animated representations.*

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9-12 Life Science	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	LS: From Molecules to Organisms: Structures and Processes	9L.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. (P: 2, CC: 6, CI: LS1) *Emphasis is on specific functions at the organ system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli. Examples of models may include real (e.g. fish, birds, insects, etc.) or imaginary organisms with attention to the various structures and systems that assist the organism in performing necessary life functions.*
9-12 Life Science	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	LS: From Molecules to Organisms: Structures and Processes	9L.3.1.1.2 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. (P: 2, CC: 2, CI: LS1) *Examples of models may include diagrams and conceptual models.*
9-12 Life Science	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	LS: From Molecules to Organisms: Structures and Processes	9L.3.1.1.3 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. (P: 2, CC: 4, CI: LS1) *Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms. Examples of models may include diagrams, chemical equations, and conceptual models.*
9-12 Life Science	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	3.1.1 Students will be able to develop, revise, and use models to represent their understanding of phenomena or systems as they develop questions, predictions and/or explanations and communicate ideas to others.	LS: From Molecules to Organisms: Structures and Processes	9L.3.1.1.4 Use a model to illustrate that cellular respiration is a chemical process in which energy from food is used to create new compounds. (P: 2, CC: 5, CI: LS1) *Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
9-12 Life Science	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.	LS: From Molecules to Organisms: Structures and Processes	9L.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. (P: 6, CC: 6, CI: LS1).
9-12 Life Science	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.	LS: From Molecules to Organisms: Structures and Processes	9L.3.2.1.2 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. (P: 6, CC: 5, CI: LS1) *Emphasis is on using evidence from models and simulations to support explanations. Examples of molecules may include proteins, lipids, carbohydrates and nucleic acids.*
9-12 Life Science	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.	LS: Ecosystems: Interactions, Energy, and Dynamics	9L.3.2.1.3 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. (P: 6, CC: 7, CI: LS2) *Emphasis is on the importance of biological processes in the global scale cycling of carbon and on a conceptual understanding of the role of aerobic and anaerobic respiration in different environments.*
9-12 Life Science	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.	LS: Evolution: Unity and Diversity	9L.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. (P: 6, CC: 2, CI: LS4) *Emphasis is on using evidence to explain the influence each of the four factors has on the number, behavior, morphology, or physiology of organisms, in terms of their ability to compete for limited resources and subsequent survival of individuals and adaptation of their species. Examples of evidence may include mathematical models such as simple distribution graphs and proportional reasoning.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
9-12 Life Science	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.	LS: Evolution: Unity and Diversity	9L.3.2.1.5 Construct an explanation based on evidence for how natural selection leads to the adaptation of populations. (P: 6, CC: 2, CI: LS4) *Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems contribute to a change in gene frequency over time, leading to adaptation of populations. Examples of selective forces may include long-term climate change, or variations in seasonal temperatures, pH, light cycles, geographic barriers, or in response to the evolution of other organisms.*
9-12 Life Science	4 Communicating reasons, arguments and ideas to others	4.1 Arguing from evidence	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.	LS: Ecosystems: Interactions, Energy, and Dynamics	9L.4.1.1.1 Evaluate evidence for the role of group behavior on an individual's and species' chances to survive and reproduce. (P: 7, CC: 2, CI: LS2) *Emphasis of the practice is on identifying evidence supporting the outcomes of group behavior, and developing logical and reasonable arguments based on evidence. Emphasis of the core idea is on distinguishing between group and individual behavior. Examples of group behavior may include herding, migratory behaviors, or various symbioses .*
9-12 Life Science	4 Communicating reasons, arguments and ideas to others	4.1 Arguing from evidence	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.	LS: Heredity: Inheritance and Variation of Traits	9L.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. (P: 7, CC: 2, CI: LS3) *Emphasis is on using data to support arguments for the ways variation occurs.*
9-12 Life Science	4 Communicating reasons, arguments and ideas to others	4.1 Arguing from evidence	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.	LS: Evolution: Unity and Diversity	9L.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 (P: 7, CC: 2, CI: LS4) *Emphasis is on determining cause and effect relationships for (1) how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and (2) the rate of change of the environment affect distribution or disappearance of traits in species.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
9-12 Life Science	4 Communicating reasons, arguments and ideas to others	4.1 Arguing from evidence	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.	LS: Evolution: Unity and Diversity	9L.4.2.1.1 Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (P: 8, CC: 1, CI: LS4) *Emphasis is on conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence may include similarities in DNA sequences, the fossil record, artificial selection, anatomical structures, and the order of appearance of structures in embryological development.*
9-12 Life Science	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	LS: Ecosystems: Interactions, Energy, and Dynamics	9L.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.* (P: 8, CC: 7, CI: LS2, ETS1) *Examples of cultures may include those within the local context of the learning community and within the context of Minnesota . Examples of threats to biodiversity may include climate change, deforestation, urbanization, dam construction or removal, invasive species, human population growth, threatening/endangering species, agricultural practices , extraction, and the use of fossil fuels.*
9-12 Chemistry	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	Chem: Energy and Chemical Processes in Everyday Life	9C.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 (P: 1, CC: 5, CI: PS1) *Emphasis should include natural and human-made sources. Structures should include molecular shape.*
9-12 Chemistry	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	Chem: Structure and Properties of Matter	9C.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. (P: 3, CC: 1, CI: PS1) *Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles may include ions, atoms, molecules, and networked materials (such as graphite). Examples of collected evidence may include the melting point and boiling point, vapor pressure, and surface tension.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
9-12 Chemistry	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	Chem: Chemical and Nuclear Reactions	9C.1.2.1.2 Plan and conduct an investigation of acid-base reactions to test ideas about the concentrations of the hydronium ion in an aqueous solution (pH). (P:3, CC: 3, CI: PS1) *Emphasis is on developing an understanding of pH scales and various ways to measure pH. Also included is understanding the relative strength of acidity based on periodic properties of elements, the electronegativity model of electron distribution, empirical dipole moments, and molecular geometry. Examples of investigations may include household chemicals and ocean acidification analogs.*
9-12 Chemistry	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	Chem: Energy and Chemical Processes in Everyday Life	9C.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. (P: 4, CC :2, CI: PS3) *Emphasis is on the scale of the problem and appropriate use of concentration units. Examples of pollutant data may include ozone, lead, particulates, nitrates, or microorganisms. Examples of remediation may include physical, chemical or biological processes.*
9-12 Chemistry	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	Chem: Structure and Properties of Matter	9C.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.** (P: 5, CC: 2, CI: PS1) *Emphasis is on applying the kinetic molecular theory of gases to develop gas laws. Example systems may include balloons, tires, or syringes.*
9-12 Chemistry	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Using mathematics and computational thinking	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.	Chem: Chemical and Nuclear Reactions	9C.2.2.1.2 Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. (P: 5, CC: 5, CI: PS1) *Emphasis of the practice is on using mathematical ideas to communicate the proportional relationships between the masses of atoms in the reactants and products. Emphasis of the core idea is on the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
9-12 Chemistry	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	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.	Chem: Structure and Properties of Matter	9C.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. (P: 2, CC: 1, CI: PS1) *Emphasis is on properties that could be predicted from patterns may include reactivity of metals, types of bonds formed (ionic versus covalent), and numbers of bonds formed.*
9-12 Chemistry	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	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.	Chem: Structure and Properties of Matter	9C.3.1.1.2 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. (P: 2, CC: 5, CI: PS1) *Emphasis of the practice is on illustrating the relationships between components of the system. Emphasis of the core idea is on how a chemical reaction is a system that affects the energy change. Examples of models may include molecular level drawings, diagrams, graphs showing the relative energies of reactants and products, and representations showing energy is conserved. Not included is the calculation of the total bond energy change during a chemical reaction from the bond energies of reactants and products.*
9-12 Chemistry	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	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.	Chem: Chemical and Nuclear Reactions	9C.3.1.1.3 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. (P: 2, CC: 5, CI: PS1) *Emphasis is on simple qualitative models and on the scale of energy released in nuclear processes relative to other kinds of transformations. Not included is quantitative calculations of the energy released.*
9-12 Chemistry	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.	Chem: Chemical and Nuclear Reactions	9C.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. (P: 6, CC: 1, CI: PS1) *Examples of chemical reactions may include synthesis, decomposition, or combustion.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
9-12 Chemistry	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.	Chem: Chemical and Nuclear Reactions	9C.3.2.1.2 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. (P: 6, CC: 1, CI: PS1) *Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules and on simple reactions in which there are only two reactants. Examples of evidence may include temperature, concentration, and rate data; and qualitative relationships between rate and temperature.*
9-12 Chemistry	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	3.2.1 Students will be able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.	Chem: Energy and Chemical Processes in Everyday Life	9C.3.2.1.3 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. (P: 6, CC: 1, CI: PS1) *Emphasis is on polarity, solubility, boiling point elevation, freezing point depression, and osmosis. Examples may include salts dissolving to make water hard, road salt, antifreeze, oil spills, reverse osmosis water systems.*
9-12 Chemistry	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.*	Chem: Energy and Chemical Processes in Everyday Life	9C.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.* (P: 6, CC: 6,CI: PS1, ETS1) *Examples of desired needs are having flexible but durable materials made up of long-chained molecules (polymers and plastics), and having pharmaceuticals designed to interact with specific receptors.*
9-12 Chemistry	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Chem: Structure and Properties of Matter	9C.4.2.1.1 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* (P: 8, CC: 6, CI: PS1) *Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples may include why electrically conductive materials are often made of metal.*

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9-12 Chemistry	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Chem: Energy and Chemical Processes in Everyday Life	9C.4.2.1.2 Review text and online sources to develop a series of questions regarding the chemistry, utility, and safety of nuclear fission. (P: 8, CC: 7,CI: PS1) *Emphasis is on evaluating the argument and specific claims in the text including the validity of reasoning as well as the relevance and sufficiency of the evidence. Examples may include fission (nuclear power generation, nuclear weapons) and the use of fission by-products (nuclear medicine, food irradiation).*
9-12 Chemistry	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Chem: Energy and Chemical Processes in Everyday Life	9C.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. (P: 8, CC: 2, CI: PS1) *Examples of cultures may include those within the local context of the learning community and within the context of Minnesota. Examples of natural resources may include wild rice harvesting, mining of minerals, and access to clean air and water. Examples of chemical processes may include sulfate in water/soil, acid mine drainage, and air and water pollution.*
9-12 Physics	1 Exploring phenomena or engineering problems	1.1 Asking questions and defining problems	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.	Phys: Waves and their Applications	9P.1.1.1.1 Evaluate questions about the advantages and disadvantages of using digital transmission and storage of information.* ** (P: 1, CC: 7, CI: PS4, ETS1) *Emphasis is on the tradeoffs involved in the transmission and storage of data elements. Examples of advantages may include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Examples of disadvantages may include issues of easy deletion, security, and theft.*
9-12 Physics	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	Phys: Motion and Stability: Forces and Interactions	9P.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. (P: 3, CC: 2, CI: PS2) *Examples of contexts for investigations may include coils, motors, generators, and transformers.*

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9-12 Physics	1 Exploring phenomena or engineering problems	1.2 Planning and carrying out investigations	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.	Phys: Energy	9P.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. (P: 3, CC: 3, CI: PS3) *Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually may include mixing liquids at different initial temperatures or adding objects at different temperatures to water.*
9-12 Physics	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.1 Analyzing and interpreting data	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.	Phys: Motion and Stability: Forces and Interactions	9P.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. (P: 4, CC: 2, PS: 2) *Examples of data (including data from student investigations) may include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force.*
9-12 Physics	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Mathematics and Computational Thinking	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.	Phys: Motion and Stability: Forces and Interactions	9P.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. (P: 5, CC: 4, CI: PS2) *Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle. Examples may include investigating changes in momentum before and after collisions in closed systems.*
9-12 Physics	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Mathematics and Computational Thinking	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.	Phys: Motion and Stability: Forces and Interactions	9P.2.2.1.2 Apply mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. (P: 5, CC: 1, CI: PS2) *Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields and the forces on objects in the fields.*

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9-12 Physics	2 Looking at data and empirical evidence to understand phenomena or solve problems	2.2 Mathematics and Computational Thinking	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.	Phys: Energy	9P.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.** (P: 5, CC: 4, CI: PS3) *Emphasis is on explaining the meaning of mathematical expressions used in the model for systems of two or three components. Forms of energy may include thermal energy, kinetic energy, and elastic potential energy . Computational models may include the creation or use of a simulation or the analysis of a data set.*
9-12 Physics	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	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.	Phys: Energy	9P.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). (P: 2, CC: 5, CI: PS3) *Examples of phenomena at the macroscopic scale may include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above Earth, and the energy stored between two electrically-charged plates. Examples of models may include diagrams, drawings, descriptions, and computer simulations.*
9-12 Physics	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.1 Developing and using models	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.	Phys: Energy	9P.3.1.1.2 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between two objects and the changes in energy of the two objects due to the interaction and describe how these forces are present in phenomena. (P: 2, CC: 2, CI: PS3) *Examples of models may include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other. Examples of phenomena may include motors, electromagnetic induction, speakers, generators, wireless charging, and induction cooktops.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
9-12 Physics	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.*	Phys: Motion and Stability: Forces and Interactions	9P.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.** (P: 6, CC: 2, CI: PS2, ETS1) *Emphasis is on applying science and engineering principles and analyzing the energy conversions. Examples of a device may include a helmet, a parachute, an airbag, and packaging for safe shipping.*
9-12 Physics	3 Developing possible explanations of phenomena or designing solutions to engineering problems	3.2 Constructing explanations and designing solutions	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.*	Phys: Energy	9P.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.* (P: 6, CC: 2, CI: PS3, ETS1) *Examples of energy-related problems may be drawn from alternative energy, manufacturing , and transportation systems.*
9-12 Physics	4 Communicating reasons, arguments and ideas to others	4.1 Arguing from evidence	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.	Phys: Waves and their Applications	9P.4.1.1.1 Evaluate the claims, evidence, and reasoning behind the argument that electromagnetic radiation can be described using either by a wave model or a particle model, and that for some phenomena one model is more useful than the other. (P: 7, CC: 4, CI: PS4) *Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of phenomena may include resonance, interference, diffraction, and photoelectric effect.*
9-12 Physics	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Phys: Waves and their Applications	9P.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. (P: 8, CC: 2, CI: PS4) *Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples may include medical imaging technology and communication devices.*

Grade	Strand	Substrand	Standard	Content Area	Benchmark
9-12 Physics	4 Communicating reasons, arguments and ideas to others	4.2 Obtaining, evaluating and communicating information	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.	Phys: Waves and their Applications	9P.4.2.1.2 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.* (P: 8, CC: 2, CI: PS4) *Examples of devices may include medical imaging technologies, cell phones, GPS, Doppler radar or solar cells that capture light and convert it to electricity.*