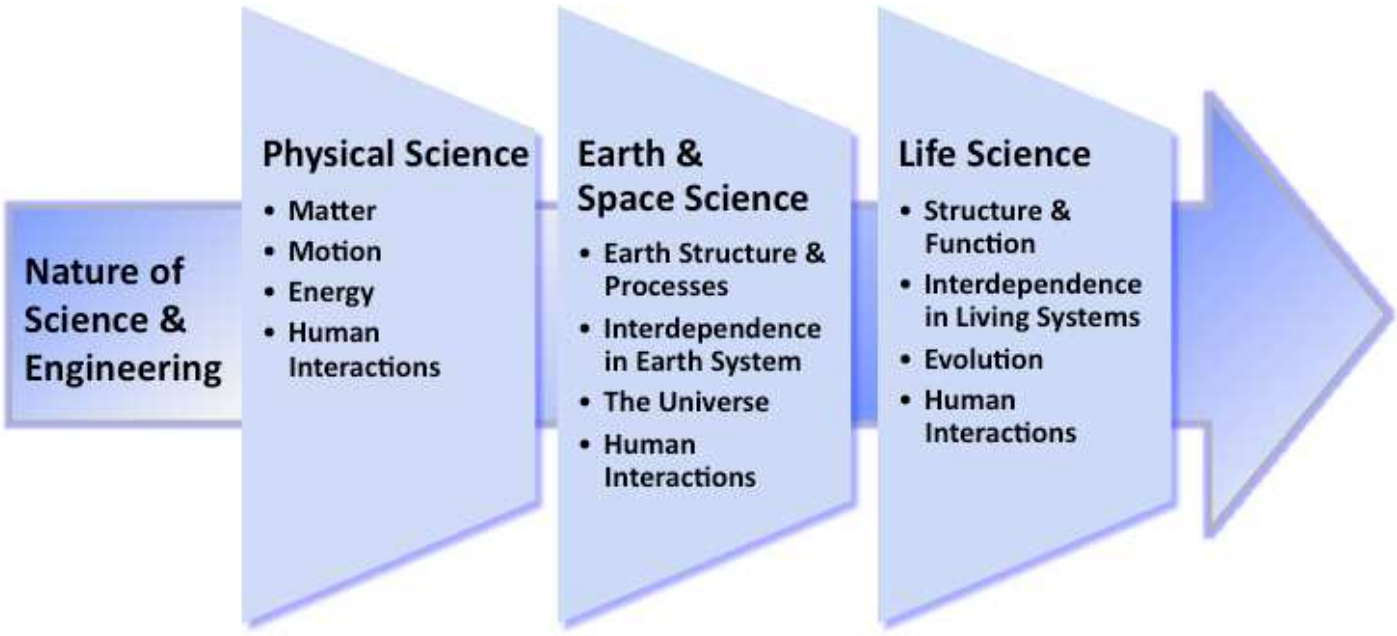
Minnesota Academic Standards

Science K-12

2009 version



This official standards document contains the science standards revised in 2009 and put into rule effective May 24, 2010.

DEPARTMENT OF EDUCATION

Minnesota Academic Standards in Science
Introduction

The *2009 Minnesota Academic Standards in Science* set the expectations for achievement in science for 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). The standards and benchmarks 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 scientific inquiry and engineering design. The standards are placed at the grade level where mastery is expected with recognition that a progression of learning experiences in earlier grades builds the foundation for mastery later on.

The *Minnesota Academic Standards in Science* are organized by grade level into four content strands: 1) The Nature of Science and Engineering, 2) Physical Science, 3) Earth and Space Science, and 4) Life Science. **It is important to note that the content and skills in The Nature of Science and Engineering are not intended to be taught as a stand-alone unit or an isolated course, but embedded and used in the teaching, learning and assessment of the content in the other strands.** Each strand has three or four *substrands*. Each substrand contains two or more *standards* and one or more *benchmarks*. The benchmarks supplement the standards by specifying the academic knowledge and skills that schools must offer and students must achieve to satisfactorily complete a standard. Not all standards are found at every grade level. The strands, substrands and standards are organized as follows.

Strand 1: Nature of Science and Engineering

Substrand 1: The Practice of Science

Standard 1. Understandings about science
Standard 2. Scientific inquiry and investigation

Substrand 2: The Practice of Engineering

Standard 1. Understandings about engineering
Standard 2. Engineering design

Substrand 3: Interactions Among Science, Technology, Engineering, Mathematics and Society

Standard 1. Systems
Standard 2. Careers and contributions in science and engineering
Standard 3. Mutual influence of science, engineering and society
Standard 4. The role of mathematics and technology in science and engineering

Strand 2: Physical Science

Substrand 1: Matter

Standard 1. Properties and structure of matter
Standard 2. Changes in matter

Substrand 2: Motion

Standard 1. Describing motion
Standard 2. Forces

Substrand 3. Energy

Standard 1. Kinds of energy
Standard 2. Energy transformations

Substrand 4. Human Interactions with Physical Systems

Standard 1. Interaction with the environment

Strand 3: Earth and Space Science

Substrand 1. Earth Structure and Processes

Standard 1. Plate tectonics
Standard 2. Earth's changing surface
Standard 3. Rock sequences and Earth history

Substrand 2. Interdependence within the Earth System

Standard 1. Sources and transfer of energy
Standard 2. Weather and climate
Standard 3. Materials cycles

Substrand 3. The Universe

Standard 1. Solar system motion
Standard 2. Formation of the solar system
Standard 3. Age, scale and origin of the universe

Substrand 4. Human Interactions with Earth Systems

Standard 1. Interaction with the environment

Strand 4: Life Science

Substrand 1. Structure and Function in Living Systems

Standard 1. Levels of organization
Standard 2. Cells

Substrand 2. Interdependence Among Living Systems

Standard 1. Ecosystems
Standard 2. Flow of energy and matter

Substrand 3. Evolution in Living Systems

Standard 1. Reproduction
Standard 2. Variation
Standard 3. Biological evolution

Substrand 4. Human Interactions with Living Systems

Standard 1. Interaction with the environment
Standard 2. Health and disease

Minnesota Academic Standards in Science
Introduction (continued)

The standards are written as statements of content, and the benchmarks are written as learning outcomes. Each standard should be prefaced with the statement, "The student will understand that…".

Many of the benchmarks include examples that clarify the meaning of the benchmark or indicate the level of student understanding. The examples may suggest learning activities or instructional topics. They are NOT intended to be directives for curriculum or a comprehensive fulfillment of the benchmarks.

The benchmarks for each standard are designated by five(5)-digit codes. For example, in the code 3.1.1.2.1—

- The **3** refers to *grade 3*;
- The **first 1** refers to the first strand, *The Nature of Science and Engineering*;
- The **next 1** refers to the first substrand, *The Practice of Science*;
- The **2** refers to the second standard in that substrand*, Scientific inquiry is…;*
- The **last 1** refers to the first benchmark for that standard, *Generate questions that…* .

Grade	Strand	Substrand	Standard Understand that…	Code	Benchmark
3	**1**. The Nature of Science and Engineering	**1**. The Practice of Science	**2**. Scientific inquiry is a set of interrelated processes incorporating multiple approaches that are used to pose questions about the natural world and investigate phenomena.	**3.1.1.2.1**	Generate questions that can be answered when scientific knowledge is combined with knowledge gained from one's own observations or investigations. *For example:* Investigate the sounds produced by striking various objects.
				3.1.1.2.2	Observe that when a science investigation is done the way it was done before, even in a different place, a similar result is expected.
				3.1.1.2.3	Maintain a record of observations, procedures and explanations, being careful to distinguish between actual observations and ideas about what was observed. *For example*: Make a chart comparing observations about the structures of plants and animals.
				3.1.1.2.4	Construct reasonable explanations based on evidence collected from observations or experiments.

Codes that begin with "9" indicate benchmarks that are to be mastered in grades 9-12. Benchmarks that satisfy the new one-credit requirement for chemistry or physics (effective for the graduating class of 2015 and beyond) are indicated by codes beginning with "9C," or "9P" respectively. Chemistry and physics have additional standards beyond those depicted in the chart on Page 1.

These standards are to be implemented no later than the 2011-12 school year. For further information, please refer to *Frequently Asked Questions about the 2009 Minnesota Science Standards and Benchmarks for Grades K-12* on the Minnesota Department of Education Science Academic Standards website.

National Research Council (1996). National Science Education Standards. Washington D.C.: National Academy Press.

Science Standards K-5

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
K	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry is a set of interrelated processes used to pose questions about the natural world and investigate phenomena.	0.1.1.2.1	Use observations to develop an accurate description of a natural phenomenon and compare one's observations and descriptions with those of others.
K	1. The Nature of Science and Engineering	2. The Practice of Engineering	1. Some objects occur in nature; others have been designed and processed by people	0.1.2.1.1	Sort objects in to two groups: those that are found in nature and those that are human made. *For example*: Cars, pencils, trees, rocks.
K	2. Physical Science	1. Matter	1. Objects can be described in terms of the materials they are made of and their physical properties.	0.2.1.1.1	Sort objects in terms of color, size, shape, and texture, and communicate reasoning for the sorting system.
K	3. Earth Science	2. Interdependence Within the Earth System	2. Weather can be described in measurable quantities and changes from day to day and with the seasons.	0.3.2.2.1	Monitor daily and seasonal changes in weather and summarize the changes. *For example*: Recording cloudiness, rain, snow and temperature.
K	3. Earth Science	2. Interdependence Within the Earth System	2. Weather can be described in measurable quantities and changes from day to day and with the seasons.	0.3.2.2.2	Identify the sun as a source of heat and light. *For example*: Record the time of day when the sun shines into different locations of the school and note patterns.
K	4. Life Science	1. Structure and Function of Living Systems	1. Living things are diverse with many different observable characteristics.	0.4.1.1.1	Observe and compare plants and animals.
K	4. Life Science	2. Structure and Function of Living Systems	1. Living things are diverse with many different observable characteristics.	0.4.1.1.2	Identify the external parts of a variety of plants and animals including humans. *For example*: Heads, legs, eyes and ears on humans and animals, flowers, stems and roots on many plants.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
K	4. Life Science	1. Structure and Function of Living Systems	1. Living things are diverse with many different observable characteristics.	0.4.1.1.3	Differentiate between living and nonliving things. *For example*: Sort organisms and objects (or pictures of these) into groups of those that grow, and reproduce, and need air, food, and water; and those that don't.
K	4. Life Science	2. Interdependence Among Living Systems	1. Natural systems have many components that interact to maintain the system.	0.4.2.1.1	Observe a natural system or its model, and identify living and nonliving components in that system. *For example*: A wetland, prairie, garden or aquarium.
1	1. The Nature of Science and Engineering	1. The Practice of Science	1. Scientists work as individuals and in groups to investigate the natural world, emphasizing evidence and communicating with others.	1.1.1.1.1	When asked "How do You Know?" students support their answer with observations. *For example*: Use observations to tell why a squirrel is a living thing.
1	1. The Nature of Science and Engineering	1. The Practice of Science	1. Scientists work as individuals and in groups to investigate the natural world, emphasizing evidence and communicating with others.	1.1.1.1.2	Recognize that describing things as accurately as possible is important in science because it enables people to compare their observations with those of others.
1	1. The Nature of Science and Engineering	3. Interactions Among Science, Engineering, Technology and Society	1. Designed and natural systems exist in the world. These systems are made up of components that act within a system and interact with other systems.	1.1.3.1.1	Observe that many living and nonliving things are made of parts and that if a part is missing or broken, they may not function properly.
1	1. The Nature of Science and Engineering	3. Interactions Among Science, Engineering, Technology and Society	2. Men and women throughout the history of all cultures, including Minnesota American Indian tribes and communities, have been involved in engineering design and scientific inquiry.	1.1.3.2.1	Recognize that tools are used by people, including scientists and engineers, to gather information and solve problems. *For example*: Magnifier, snowplow, calculator.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
1	3. Earth Science	1. Earth Structure and Processes	3. Earth materials include solid rocks, sand, soil and water. These materials have different observable physical properties that make them useful.	1.3.1.3.1	Group or classify rocks in terms of color, shape and size.
1	3. Earth Science	1. Earth Structure and Processes	3. Earth materials include solid rocks, sand, soil and water. These materials have different observable physical properties that make them useful.	1.3.1.3.2	Describe similarities and differences between soil and rocks. *For example*: Use screens to separate components of soil and observe the samples using a magnifier.
1	3. Earth Science	1. Earth Structure and Processes	3. Earth materials include solid rocks, sand, soil and water. These materials have different observable physical properties that make them useful.	1.3.1.3.3	Identify and describe large and small objects made of Earth materials.
1	4. Life Science	1. Structure and Function of Living Systems	1. Living things are diverse with many different observable characteristics.	1.4.1.1.1	Describe and sort animals into groups in many ways, according to their physical characteristics and behaviors.
1	4. Life Science	2. Interdependence Among Living Systems	1. Natural systems have many components that interact to maintain the system.	1.4.2.1.1	Recognize that animals need space, water, food, shelter and air.
1	4. Life Science	2. Interdependence Among Living Systems	1. Natural systems have many components that interact to maintain the system.	1.4.2.1.2	Describe ways in which an animal's habitat provides for its basic needs. *For example*: Compare students' houses with animal habitats.
1	4. Life Science	3. Evolution in Living Systems	1. Plants and animals undergo a series of orderly changes during their life cycles.	1.4.3.1.1	Demonstrate an understanding that animals pass through life cycles that include a beginning, development into adults, reproduction and eventually death. *For example*: Use live organisms or pictures to observe the changes that occur during the life cycle of butterflies, meal worms or frogs.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
1	4. Life Science	3. Evolution in Living Systems	1. Plants and animals undergo a series of orderly changes during their life cycles.	1.4.3.1.2	Recognize that animals pass through the same life cycle stages as their parents.
2	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry is a set of interrelated processes incorporating multiple approaches that are used to pose questions about the natural world and investigate phenomena.	2.1.1.2.1	Raise questions about the natural world and seek answers by making careful observations, noting what happens when you interact with an object, and sharing the answers with others.
2	1. The Nature of Science and Engineering	2. The Practice of Engineering	2. Engineering design is the process of identifying a problem and devising a product or process to solve the problem.	2.1.2.2.1	Identify a need or problem and construct an object that helps to meet the need or solve the problem. *For example*: Design and build a tool to show wind direction. *Another example*: Design a kite and identify the materials to use.
2	1. The Nature of Science and Engineering	2. The Practice of Engineering	2. Engineering design is the process of identifying a problem and devising a product or process to solve the problem.	2.1.2.2.2	Describe why some materials are better than others for making a particular object and how materials that are better in some ways may be worse in other ways. *For example*: Objects made of plastic or glass.
2	1. The Nature of Science and Engineering	2. The Practice of Engineering	2. Engineering design is the process of identifying a problem and devising a product or process to solve the problem.	2.1.2.2.3	Explain how engineered or designed items from everyday life benefit people.
2	2. Physical Science	1. Matter	1. Objects can be described in terms of the materials they are made of and their physical properties.	2.2.1.1.1	Describe objects in terms of color, size, shape, weight, texture, flexibility, strength and the types of materials in the object.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
2	2. Physical Science	1. Matter	2. The physical properties of materials can be changed, but not all materials respond the same way to what is done to them.	2.2.1.2.1	Observe, record, and recognize that water can be a solid or a liquid and can change from one state to another.
2	2. Physical Science	2. Motion	1. The motion of an object can be described by a change in its position over time.	2.2.2.1.1	Describe an object's change in position relative to other objects or a background. *For example*: Forward, backward, going up, going down.
2	2. Physical Science	2. Motion	1. The motion of an object can be described by a change in its position over time.	2.2.2.1.2	Demonstrate that objects move in a variety of ways, including a straight line, a curve, a circle, back and forth, and at different speeds. *For example*: Spinning toy and rocking toy. *Another example*: Construct objects that will move in a straight line or a curve such as a marble or toy car on a track.
2	2. Physical Science	2. Motion	2. The motion of an object can be changed by a push or a pull forces.	2.2.2.2.1	Describe how push and pull forces can make objects move. *For example*: Push and pull objects on smooth and rough surfaces.
2	2. Physical Science	2. Motion	2. The motion of an object can be changed by a push or a pull forces.	2.2.2.2.2	Describe how things near Earth fall to the ground unless something holds them up.
2	3. Earth Science	2. Interdependence within the Earth system	2. Weather can be described in measurable quantities and changes from day to day and with the seasons.	2.3.2.2.1	Measure, record and describe weather conditions using common tools. *For example*: Temperature, precipitation, sunrise/sunset, and wind speed/direction.
2	4. Life Science	1. Structure and Function of Living Systems	1. Living things are diverse with many different observable characteristics.	2.4.1.1.1	Describe and sort plants into groups in many ways, according to their physical characteristics and behaviors.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
2	4. Life Science	2. Interdependence Among Living Systems	1. Natural systems have many components that interact to maintain the system	2.4.2.1.1	Recognize that plants need space, water, nutrients and air, and that they fulfill these needs in different ways.
2	4. Life Science	3. Evolution in Living Systems	1. Plants and animals undergo a series of orderly changes during their life cycles.	2.4.3.1.1	Describe the characteristics of plants at different stages of their life cycles. *For example*: Use live organisms or pictures to observe the changes that occur during the life cycle of bean plants or marigolds.
3	1. The Nature of Science and Engineering	1. The Practice of Science	1. Scientists work as individuals and in groups; emphasizing evidence, open communication and skepticism.	3.1.1.1.1	Provide evidence to support claims, other than saying "Everyone knows that," or "I just know," and question such reasons when given by others.
3	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry is a set of interrelated processes incorporating multiple approaches that are used to pose questions about the natural world and investigate phenomena.	3.1.1.2.1	Generate questions that can be answered when scientific knowledge is combined with knowledge gained from one's own observations or investigations. *For example*: Investigate the sounds produced by striking various objects.
3	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry is a set of interrelated processes incorporating multiple approaches that are used to pose questions about the natural world and investigate phenomena.	3.1.1.2.2	Recognize that when a science investigation is done the way it was done before, even in a different place, a similar result is expected.
3	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry is a set of interrelated processes incorporating multiple approaches that are used to pose questions about the natural world and investigate phenomena.	3.1.1.2.3	Maintain a record of observations, procedures and explanations, being careful to distinguish between actual observations and ideas about what was observed. *For example*: Make a chart comparing observations about the structures of plants and animals.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
3	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry is a set of interrelated processes incorporating multiple approaches that are used to pose questions about the natural world and investigate phenomena.	3.1.1.2.4	Construct reasonable explanations based on evidence collected from observations or experiments.
3	1. The Nature of Science and Engineering	3. Interactions Among Science, Engineering, Technology and Society	2. Men and women throughout the history of all cultures, including Minnesota American Indian tribes and communities, have been involved in engineering design and scientific inquiry.	3.1.3.2.1	Understand that everybody can use evidence to learn about the natural world, identify patterns in nature, and develop tools. *For example*: Ojibwe and Dakota knowledge and use of patterns in the stars to predict and plan.
3	1. The Nature of Science and Engineering	3. Interactions Among Science, Engineering, Technology and Society	2. Men and women throughout the history of all cultures, including Minnesota American Indian tribes and communities, have been involved in engineering design and scientific inquiry.	3.1.3.2.2	Recognize that the practice of science and/or engineering involves many different kinds of work and engages men and women of all ages and backgrounds.
3	1. The Nature of Science and Engineering	3. Interactions Among Science, Engineering, Technology and Society	4. Tools and mathematics help scientists and engineers see more, measure more accurately, and do things that they could not otherwise accomplish.	3.1.3.4.1	Use tools, including rulers, thermometers, magnifiers and simple balance, to improve observations and keep a record of the observations made.
3	2. Physical Science	3. Energy	1. Energy appears in different forms, including sound and light.	3.2.3.1.1	Explain the relationship between the pitch of a sound, the rate of vibration of the source, and factors that affect pitch. *For example*: Changing the length of a string that is plucked changes the pitch.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
3	2. Physical Science	3. Energy	1. Energy appears in different forms, including sound and light.	3.2.3.1.2	Explain how shadows form and can change in various ways.
3	2. Physical Science	3. Energy	1. Energy appears in different forms, including sound and light.	3.2.3.1.3	Describe how light travels in a straight line until it is absorbed, redirected, reflected or allowed to pass through an object. *For example*: Use a flashlight, mirrors and water to demonstrate reflection and bending of light.
3	3. Earth Science	3. The Universe	1. The sun and moon have locations and movements that can be observed and described.	3.3.3.1.1	Observe and describe the daily and seasonal changes in the position of the sun and compare observations.
3	3. Earth Science	3. The Universe	1. The sun and moon have locations and movements that can be observed and described.	3.3.3.1.2	Recognize the pattern of apparent changes in the moon's shape and position.
3	3. Earth Science	3. The Universe	2. Objects in the solar system as seen from Earth have various sizes and distinctive patterns of motion.	3.3.3.2.1	Demonstrate how a large light source at a great distance looks like a small light that is much closer. *For example*: Car headlights at a distance look small compared to when they are close.
3	3. Earth Science	3. The Universe	2. Objects in the solar system as seen from Earth have various sizes and distinctive patterns of motion.	3.3.3.2.2	Recognize that the Earth is one of several planets that orbit the sun, and that the moon orbits the Earth.
3	4. Life Science	1. Structure and Function of Living Systems	1. Living things are diverse with many different characteristics that enable them to grow, reproduce and survive.	3.4.1.1.1	Compare how the different structures of plants and animals serve various functions of growth, survival and reproduction. *For example*: Skeletons in animals and stems in plants provide strength and stability.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
3	4. Life Science	1. Structure and Function of Living Systems	1. Living things are diverse with many different characteristics that enable them to grow, reproduce and survive.	3.4.1.1.2	Identify common groups of plants and animals using observable physical characteristics, structures and behaviors. *For example*: Sort animals into groups such as mammals and amphibians based on physical characteristics. *Another example*: Sort and identify common Minnesota trees based on leaf/needle characteristics.
3	4. Life Science	3. Evolution in Living Systems	2. Offspring are generally similar to their parents, but may have variations that can be advantageous or disadvantageous in a particular environment.	3.4.3.2.1	Give examples of likenesses between adults and offspring in plants and animals that can be inherited or acquired. *For example*: Collect samples or pictures that show similarities between adults and their young offspring.
3	4. Life Science	3. Evolution in Living Systems	2. Offspring are generally similar to their parents, but may have variations that can be advantageous or disadvantageous in a particular environment.	3.4.3.2.2	Give examples of differences among individuals that can sometimes give an individual an advantage in survival and reproduction.
4	1. The Nature of Science and Engineering	2. The Practice of Engineering	1. Engineers design, create, and develop structures, processes, and systems that are intended to improve society and may make humans more productive.	4.1.2.1.1	Describe the positive and negative impacts that the designed world has on the natural world as more and more engineered products and services are created and used.
4	1. The Nature of Science and Engineering	2. The Practice of Engineering	2. Engineering design is the process of identifying problems, developing multiple solutions, selecting the best possible solution, and building the product.	4.1.2.2.1	Identify and investigate a design solution and describe how it was used to solve an everyday problem. *For example*: Investigate different varieties of construction tools.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
4	1. The Nature of Science and Engineering	2. The Practice of Engineering	2. Engineering design is the process of identifying problems, developing multiple solutions, selecting the best possible solution, and building the product.	4.1.2.2.2	Generate ideas and possible constraints for solving a problem through engineering design. *For example*: Design and build an electromagnet to sort steel and aluminum materials for recycling.
4	1. The Nature of Science and Engineering	2. The Practice of Engineering	2. Engineering design is the process of identifying problems, developing multiple solutions, selecting the best possible solution, and building the product.	4.1.2.2.3	Test and evaluate solutions, considering advantages and disadvantages for the engineering solution, and communicate the results effectively.
4	1. The Nature of Science and Engineering	3. Interactions Among Science, Engineering, Technology and Society	3. The needs of any society influence the technologies that are developed and how they are used.	4.1.3.3.1	Describe a situation in which one invention led to other inventions.
4	2. Physical Science	1. Matter	1. Objects have observable properties that can be measured.	4.2.1.1.1	Measure temperature, volume, weight and length using appropriate tools and units.
4	2. Physical Science	1. Matter	2. Solids, liquids and gases are states of matter that each have unique properties.	4.2.1.2.1	Distinguish between solids, liquids and gases in terms of shape and volume. *For example*: Liquid water changes shape depending on the shape of its container.
4	2. Physical Science	1. Matter	2. Solids, liquids and gases are states of matter that each have unique properties.	4.2.1.2.2	Describe how the states of matter change as a result of heating and cooling.
4	2. Physical Science	3. Energy	1. Energy appears in different forms, including heat and electromagnetism.	4.2.3.1.1	Describe the transfer of heat energy when a warm and a cool object are touching or placed near each other.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
4	2. Physical Science	3. Energy	1. Energy appears in different forms, including heat and electromagnetism.	4.2.3.1.2	Describe how magnets can repel or attract each other and how they attract certain metal objects.
4	2. Physical Science	3. Energy	1. Energy appears in different forms, including heat and electromagnetism.	4.2.3.1.3	Compare materials that are conductors and insulators of heat and/or electricity. *For example*: Glass conducts heat well, but is a poor conductor of electricity.
4	2. Physical Science	3. Energy	2. Energy can be transformed within a system or transferred to other systems or the environment.	4.2.3.2.1	Identify several ways to generate heat energy. *For example*: Burning a substance, rubbing hands together, or electricity flowing through wires.
4	2. Physical Science	3. Energy	2. Energy can be transformed within a system or transferred to other systems or the environment.	4.2.3.2.2	Construct a simple electrical circuit using wires, batteries, and light bulbs.
4	2. Physical Science	3. Energy	2. Energy can be transformed within a system or transferred to other systems or the environment.	4.2.3.2.3	Demonstrate how an electric current can produce a magnetic force. *For example*: Construct an electromagnet to pick up paperclips.
4	3. Earth Science	1. Earth Structure and Processes	3. Rocks are an Earth material that may vary in composition.	4.3.1.3.1	Recognize that rocks may be uniform or made of mixtures of different minerals.
4	3. Earth Science	1. Earth Structure and Processes	3. Rocks are an Earth material that may vary in composition.	4.3.1.3.2	Describe and classify minerals based on their physical properties. *For example*: Streak, luster, hardness, reaction to vinegar.
4	3. Earth Science	2. Interdependence within the Earth system	3. Water circulates through the Earth's crust, oceans and atmosphere in what is known as the water cycle.	4.3.2.3.1	Identify where water collects on Earth, including atmosphere, ground, and surface water, and describe how water moves through the Earth system using the processes of evaporation, condensation and precipitation.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
4	3. Earth Science	4. Human Interaction with Earth Systems	1. In order to maintain and improve their existence, humans interact with and influence Earth systems.	4.3.4.1.1	Describe how the methods people utilize to obtain and use water in their homes and communities can affect water supply and quality.
4	4. Life Science	4. Human Interactions with Living Systems	2. Microorganisms can get inside one's body and they may keep it from working properly.	4.4.4.2.1	Recognize that the body has defense systems against germs, including tears, saliva, skin, and blood.
4	4. Life Science	4. Human Interactions with Living Systems	2. Microorganisms can get inside one's body and they may keep it from working properly.	4.4.4.2.2	Give examples of diseases that can be prevented by vaccination.
5	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world, is done by individuals and groups, and is characterized by empirical criteria, logical argument and skeptical review.	5.1.1.1.1	Explain why evidence, clear communication, accurate record keeping, replication by others, and openness to scrutiny are essential parts of doing science.
5	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world, is done by individuals and groups, and is characterized by empirical criteria, logical argument and skeptical review.	5.1.1.1.2	Recognize that when scientific investigations are replicated they generally produce the same results, and when results differ significantly, it is important to investigate what may have caused such differences. *For example*: Measurement errors, equipment failures, or uncontrolled variables.
5	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world, is done by individuals and groups, and is characterized by empirical criteria, logical argument and skeptical review.	5.1.1.1.3	Understand that different explanations for the same observations usually lead to making more observations and trying to resolve the differences.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
5	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world, is done by individuals and groups, and is characterized by empirical criteria, logical argument and skeptical review.	5.1.1.1.4	Understand that different models can be used to represent natural phenomena and these models have limitations about what they can explain. *For example*: Different kinds of maps of a region provide different information about the land surface.
5	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.	5.1.1.2.1	Generate a scientific question and plan an appropriate scientific investigation, such as systematic observations, field studies, open-ended exploration or controlled experiments to answer the question.
5	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.	5.1.1.2.2	Identify and collect relevant evidence, make systematic observations and accurate measurements, and identify variables in a scientific investigation.
5	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations.	5.1.1.2.3	Conduct or critique an experiment, noting when the experiment might not be fair because some of the things that might change the outcome are not kept the same, or that the experiment isn't repeated enough times to provide valid results.
5	1. The Nature of Science and Engineering	3. Interactions Among Science, Engineering, Technology and Society	2. Men and women throughout the history of all cultures, including Minnesota American Indian tribes and communities, have been involved in engineering design and scientific inquiry.	5.1.3.2.1	Describe how science and engineering influence and are influenced by local traditions and beliefs. *For example*: Sustainable agriculture practices used by many cultures.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
5	1. The Nature of Science and Engineering	3. Interactions Among Science, Engineering, Technology and Society	4. Tools and mathematics help scientists and engineers see more, measure more accurately, and do things that they could not otherwise accomplish.	5.1.3.4.1	Use appropriate tools and techniques in gathering, analyzing and interpreting data. *For example*: Spring scale, metric measurements, tables, mean/median/range, spreadsheets, and appropriate graphs.
5	1. The Nature of Science and Engineering	3. Interactions Among Science, Engineering, Technology and Society	4. Tools and mathematics help scientists and engineers see more, measure more accurately, and do things that they could not otherwise accomplish.	5.1.3.4.2	Create and analyze different kinds of maps of the student's community and of Minnesota. *For example*: Weather maps, city maps, aerial photos, regional maps, or online map resources.
5	2. Physical Science	2. Motion	1. An object's motion is affected by forces and can be described by the object's speed and the direction it is moving.	5.2.2.1.1	Give examples of simple machines and demonstrate how they change the input and output of forces and motion.
5	2. Physical Science	2. Motion	1. An object's motion is affected by forces and can be described by the object's speed and the direction it is moving.	5.2.2.1.2	Identify the force that starts something moving or changes its speed or direction of motion. *For example*: Friction slows down a moving skateboard.
5	2. Physical Science	2. Motion	1. An object's motion is affected by forces and can be described by the object's speed and the direction it is moving.	5.2.2.1.3	Demonstrate that a greater force on an object can produce a greater change in motion.
5	3. Earth Science	1. Earth Structure and Processes	2. The surface of the Earth changes. Some changes are due to slow processes and some changes are due to rapid processes.	5.3.1.2.1	Explain how, over time, rocks weather and combine with organic matter to form soil.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
5	3. Earth Science	1. Earth Structure and Processes	2. The surface of the Earth changes. Some changes are due to slow processes and some changes are due to rapid processes.	5.3.1.2.2	Explain how slow processes, such as water erosion, and rapid processes, such as landslides and volcanic eruptions, form features of the Earth's surface.
5	3. Earth Science	4. Human Interactions with Earth Systems	1. In order to maintain and improve their existence humans interact with and influence Earth systems.	5.3.4.1.1	Identify renewable and non-renewable energy and material resources that are found in Minnesota and describe how they are used. *For example*: Water, iron ore, granite, sand and gravel, wind, and forests.
5	3. Earth Science	4. Human Interactions with Earth Systems	1. In order to maintain and improve their existence humans interact with and influence Earth systems.	5.3.4.1.2	Give examples of how mineral and energy resources are obtained and processed and how that processing modifies their properties to make them more useful. *For example*: Iron ore, biofuels, or coal.
5	3. Earth Science	4. Human Interactions with Earth Systems	1. In order to maintain and improve their existence humans interact with and influence Earth systems.	5.3.4.1.3	Compare the impact of individual decisions on natural systems. *For example*: Choosing paper or plastic bags impacts landfills as well as ocean life cycles.
5	4. Life Science	1. Structure and Function of Living Systems	1. Living things are diverse with many different characteristics that enable them to grow, reproduce and survive.	5.4.1.1.1	Describe how plant and animal structures and their functions provide an advantage for survival in a given natural system. *For example*: Compare the physical characteristics of plants or animals from widely different environments, such as desert verses tropical, and explore how each has adapted to its environment.
5	4. Life Science	2. Interdependence Among Living Systems	1. Natural systems have many components that interact to maintain the living system	5.4.2.1.1	Describe a natural system in Minnesota, such as a wetland, prairie, or garden, in terms of the relationships among its living and nonliving parts, as well as inputs and outputs. *For example*: Design and construct a habitat for a living organism that meets its need for food, air and water.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
5	4. Life Science	2. Interdependence Among Living Systems	1. Natural systems have many parts that interact to maintain the living system	5.4.2.1.2	Explain what would happen to a system such as a wetland, prairie or garden if one of its parts were changed. *For example*: Investigate how road salt runoff affects plants, insects and other parts of an ecosystem. *Another example*: Investigate how an invasive species changes an ecosystem.
5	4. Life Science	4. Human Interactions with Living Systems	1. Humans change environments in ways that can be either beneficial or harmful to themselves and other organisms.	5.4.4.1.1	Give examples of beneficial and harmful human interaction with natural systems. *For example*: Recreation, pollution, wildlife management.

Science Standards 6-8

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
6	1. The Nature of Science and Engineering	2. The Practice of Engineering	1. Engineers create, develop and manufacture machines, structures, processes and systems that impact society and may make humans more productive.	6.1.2.1.1	Identify a common engineered system and evaluate its impact on the daily life of humans. *For example*: Refrigeration, cell phone, or automobile.
6	1. The Nature of Science and Engineering	2. The Practice of Engineering	1. Engineers create, develop and manufacture machines, structures, processes and systems that impact society and may make humans more productive.	6.1.2.1.2	Recognize that there is no perfect design and that new technologies have consequences that may increase some risks and decrease others. *For example*: Seat belts and airbags.
6	1. The Nature of Science and Engineering	2. The Practice of Engineering	1. Engineers create, develop and manufacture machines, structures, processes and systems that impact society and may make humans more productive.	6.1.2.1.3	Describe the trade-offs in using manufactured products in terms of features, performance, durability and cost.
6	1. The Nature of Science and Engineering	2. The Practice of Engineering	1. Engineers create, develop and manufacture machines, structures, processes and systems that impact society and may make humans more productive.	6.1.2.1.4	Explain the importance of learning from past failures, in order to inform future designs of similar products or systems. *For example*: Space shuttle or bridge design.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
6	1. The Nature of Science and Engineering	2. The Practice of Engineering	2. Engineering design is the process of devising products, processes and systems that address a need, capitalize on an opportunity, or solve a specific problem.	6.1.2.2.1	Apply and document an engineering design process that includes identifying criteria and constraints, making representations, testing and evaluation, and refining the design as needed to construct a product or system to solve a problem. *For example*: Investigate how energy changes from one form to another by designing and constructing a simple roller coaster for a marble.
6	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics and Society	1. Designed and natural systems exist in the world. These systems consist of components that act within the system and interact with other systems.	6.1.3.1.1	Describe a system in terms of its subsystems and parts, as well as its inputs, processes and outputs.
6	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics and Society	1. Designed and natural systems exist in the world. These systems consist of components that act within the system and interact with other systems.	6.1.3.1.2	Distinguish between open and closed systems. *For example*: Compare mass before and after a chemical reaction that releases a gas in sealed and open plastic bags.
6	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics and Society	4. Current and emerging technologies have enabled humans to develop and use models to understand and communicate how natural and designed systems work and interact.	6.1.3.4.1	Determine and use appropriate safe procedures, tools, measurements, graphs, and mathematical analyses to describe and investigate natural and designed systems in a physical science context.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
6	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics and Society	4. Current and emerging technologies have enabled humans to develop and use models to understand and communicate how natural and designed systems work and interact.	6.1.3.4.2	Demonstrate the conversion of units within the International System of Units (S.I. or metric) and estimate the magnitude of common objects and quantities using metric units.
6	2. Physical Science	1. Matter	1. Pure substances can be identified by properties which are independent of the sample of the substance and the properties can be explained by a model of matter that is composed of small particles.	6.2.1.1.1	Explain density, dissolving, compression, diffusion and thermal expansion using the particle model of matter.
6	2. Physical Science	1. Matter	2. Substances can undergo physical changes which do not change the composition or the total mass of the substance in a closed system.	6.2.1.2.1	Identify evidence of physical changes, including changing phase or shape, and dissolving in other materials.
6	2. Physical Science	1. Matter	2. Substances can undergo physical changes which do not change the composition or the total mass of the substance in a closed system.	6.2.1.2.2	Describe how mass is conserved during a physical change in a closed system. *For example*: The mass of an ice cube does not change when it melts.
6	2. Physical Science	1. Matter	2. Substances can undergo physical changes which do not change the composition or the total mass of the substance in a closed system.	6.2.1.2.3	Use the relationship between heat and the motion and arrangement of particles in solids, liquids and gases to explain melting, freezing, condensation and evaporation.
6	2. Physical Science	2. Motion	1. The motion of an object can be described in terms of speed, direction and change of position.	6.2.2.1.1	Measure and calculate the speed of an object that is traveling in a straight line.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
6	2. Physical Science	2. Motion	1. The motion of an object can be described in terms of speed, direction and change of position.	6.2.2.1.2	For an object traveling in a straight line, graph the object's position as a function of time, and its speed as a function of time. Explain how these graphs describe the object's motion.
6	2. Physical Science	2. Motion	2. Forces have magnitude and direction and affect the motion of objects.	6.2.2.2.1	Recognize that when the forces acting on an object are balanced, the object remains at rest or continues to move at a constant speed in a straight line, and that unbalanced forces cause a change in the speed or direction of the motion of an object.
6	2. Physical Science	2. Motion	2. Forces have magnitude and direction and affect the motion of objects.	6.2.2.2.2	Identify the forces acting on an object and describe how the sum of the forces affects the motion of the object. *For example*: Forces acting on a book on a table or a car on the road.
6	2. Physical Science	2. Motion	2. Forces have magnitude and direction and affect the motion of objects.	6.2.2.2.3	Recognize that some forces between objects act when the objects are in direct contact and others, such as magnetic, electrical, and gravitational forces can act from a distance.
6	2. Physical Science	2. Motion	2. Forces have magnitude and direction and affect the motion of objects.	6.2.2.2.4	Distinguish between mass and weight.
6	2. Physical Science	3. Energy	1. Waves involve the transfer of energy without the transfer of matter.	6.2.3.1.1	Describe properties of waves, including speed, wavelength, frequency and amplitude.
6	2. Physical Science	3. Energy	1. Waves involve the transfer of energy without the transfer of matter.	6.2.3.1.2	Explain how the vibration of particles in air and other materials results in the transfer of energy through sound waves.
6	2. Physical Science	3. Energy	1. Waves involve the transfer of energy without the transfer of matter.	6.2.3.1.3	Use wave properties of light to explain reflection, refraction and the color spectrum.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
6	2. Physical Science	3. Energy	2. Energy can be transformed within a system or transferred to other systems or the environment.	6.2.3.2.1	Differentiate between kinetic and potential energy and analyze situations where kinetic energy is converted to potential energy and vice versa.
6	2. Physical Science	3. Energy	2. Energy can be transformed within a system or transferred to other systems or the environment.	6.2.3.2.2	Trace the changes of energy forms, including thermal, electrical, chemical, mechanical or others as energy is used in devices. *For example*: A bicycle, light bulb or automobile.
6	2. Physical Science	3. Energy	2. Energy can be transformed within a system or transferred to other systems or the environment.	6.2.3.2.3	Describe how heat energy is transferred in conduction, convection and radiation.
7	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.	7.1.1.1.1	Understand that prior expectations can create bias when conducting scientific investigations. *For example*: Students often continue to think that air is not matter, even though they have contrary evidence from investigations.
7	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.	7.1.1.1.2	Understand that when similar investigations give different results, the challenge is to judge whether the differences are significant, and if further studies are required. *For example*: Use mean and range to analyze the reliability of experimental results.
7	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry uses multiple interrelated processes to investigate questions and propose explanations about the natural world.	7.1.1.2.1	Generate and refine a variety of scientific questions and match them with appropriate methods of investigation, such as field studies, controlled experiments, review of existing work, and development of models.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
7	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry uses multiple interrelated processes to investigate questions and propose explanations about the natural world.	7.1.1.2.2	Plan and conduct a controlled experiment to test a hypothesis about a relationship between two variables, ensuring that one variable is systematically manipulated, the other is measured and recorded, and any other variables are kept the same (controlled). *For example*: The effect of various factors on the production of carbon dioxide by plants.
7	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry uses multiple interrelated processes to investigate questions and propose explanations about the natural world.	7.1.1.2.3	Generate a scientific conclusion from an investigation, clearly distinguishing between results (evidence) and conclusions (explanation).
7	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry uses multiple interrelated processes to investigate questions and propose explanations about the natural world.	7.1.1.2.4	Evaluate explanations proposed by others by examining and comparing evidence, identifying faulty reasoning, and suggesting alternative explanations.
7	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics and Society	3. Current and emerging technologies have enabled humans to develop and use models to understand and communicate how natural and designed systems work and interact.	7.1.3.4.1	Use maps, satellite images and other data sets to describe patterns and make predictions about natural systems in a life science context. *For example*: Use online data sets to compare wildlife populations or water quality in regions of Minnesota.
7	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics and Society	3. Current and emerging technologies have enabled humans to develop and use models to understand and communicate how natural and designed systems work and interact.	7.1.3.4.2	Determine and use appropriate safety procedures, tools, measurements, graphs and mathematical analyses to describe and investigate natural and designed systems in a life science context.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
7	2. Physical Science	1. Matter	1. The idea that matter is made up of atoms and molecules provides the basis for understanding the properties of matter.	7.2.1.1.1	Recognize that all substances are composed of one or more of approximately one hundred elements and that the periodic table organizes the elements into groups with similar properties.
7	2. Physical Science	1. Matter	1. The idea that matter is made up of atoms and molecules provides the basis for understanding the properties of matter.	7.2.1.1.2	Describe the differences between elements and compounds in terms of atoms and molecules.
7	2. Physical Science	1. Matter	1. The idea that matter is made up of atoms and molecules provides the basis for understanding the properties of matter.	7.2.1.1.3	Recognize that a chemical equation describes a reaction where pure substances change to produce one or more pure substances whose properties are different from the original substance(s).
7	4. Life Science	1. Structure and Function of Living Systems	1. Tissues, organs and organ systems are composed of cells and function to serve the needs of all cells for food, air and waste removal.	7.4.1.1.1	Recognize that all cells do not look alike and that specialized cells in multicellular organisms are organized into tissues and organs that perform specialized functions. *For example*: Nerve cells and skin cells do not look the same because they are part of different organs and have different functions.
7	4. Life Science	1. Structure and Function of Living Systems	1. Tissues, organs and organ systems are composed of cells and function to serve the needs of all cells for food, air and waste removal.	7.4.1.1.2	Describe how the organs in the respiratory, circulatory, digestive, nervous, skin and urinary systems interact to serve the needs of vertebrate organisms.
7	4. Life Science	1. Structure and Function of Living Systems	2. All living organisms are composed of one or more cells which carry on the many functions needed to sustain life.	7.4.1.2.1	Recognize that cells carry out life functions, and that these functions are carried out in a similar way in all organisms, including, animals, plants, fungi, bacteria and protists.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
7	4. Life Science	1. Structure and Function of Living Systems	2. All living organisms are composed of one or more cells which carry on the many functions needed to sustain life.	7.4.1.2.2	Recognize that cells repeatedly divide to make more cells for growth and repair.
7	4. Life Science	1. Structure and Function of Living Systems	2. All living organisms are composed of one or more cells which carry on the many functions needed to sustain life.	7.4.1.2.3	Use the presence of the cell wall and chloroplasts to distinguish between plant and animal cells. *For example*: Compare microscopic views of plant cells and animal cells.
7	4. Life Science	2. Interdependence Among Living Systems	1. Natural systems include a variety of organisms that interact with one another in several ways.	7.4.2.1.1	Identify a variety of populations and communities in an ecosystem and describe the relationships among the populations and communities in a stable ecosystem.
7	4. Life Science	2. Interdependence Among Living Systems	1. Natural systems include a variety of organisms that interact with one another in several ways.	7.4.2.1.2	Compare and contrast the roles of organisms within the following relationships: predator/prey, parasite/host, and producer/consumer/decomposer.
7	4. Life Science	2. Interdependence Among Living Systems	1. Natural systems include a variety of organisms that interact with one another in several ways.	7.4.2.1.3	Explain how the number of populations an ecosystem can support depends on the biotic resources available as well as abiotic factors such as amount of light and water, temperature range and soil composition.
7	4. Life Science	2. Interdependence Among Living Systems	2. The flow of energy and the recycling of matter are essential to a stable ecosystem.	7.4.2.2.1	Recognize that producers use the energy from sunlight to make sugars from carbon dioxide and water through a process called photosynthesis. This food can be used immediately, stored for later use, or used by other organisms.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
7	4. Life Science	2. Interdependence Among Living Systems	2. The flow of energy and the recycling of matter are essential to a stable ecosystem.	7.4.2.2.2	Describe the roles and relationships among producers, consumers, and decomposers in changing energy from one form to another in a food web within an ecosystem.
7	4. Life Science	2. Interdependence Among Living Systems	2. The flow of energy and the recycling of matter are essential to a stable ecosystem.	7.4.2.2.3	Explain that the total amount of matter in an ecosystem remains the same as it is transferred between organisms and their physical environment, even though its form and location change. *For example:* Construct a food web to trace the flow of matter in an ecosystem.
7	4. Life Science	3. Evolution in Living Systems	1. Reproduction is a characteristic of all organisms and is essential for the continuation of a species. Hereditary information is contained in genes which are inherited through asexual or sexual reproduction.	7.4.3.1.1	Recognize that cells contain genes and that each gene carries a single unit of information that either alone, or with other genes, determines the inherited traits of an organism.
7	4. Life Science	3. Evolution in Living Systems	1. Reproduction is a characteristic of all organisms and is essential for the continuation of a species. Hereditary information is contained in genes which are inherited through asexual or sexual reproduction.	7.4.3.1.2	Recognize that in asexually reproducing organisms all the genes come from a single parent, and that in sexually reproducing organisms about half of the genes come from each parent.
7	4. Life Science	3. Evolution in Living Systems	1. Reproduction is a characteristic of all organisms and is essential for the continuation of a species. Hereditary information is contained in genes which are inherited through asexual or sexual reproduction.	7.4.3.1.3	Distinguish between characteristics of organisms that are inherited and those acquired through environmental influences.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
7	4. Life Science	3. Evolution in Living Systems	2. Individual organisms with certain traits in particular environments are more likely than others to survive and have offspring.	7.4.3.2.1	Explain how the fossil record documents the appearance, diversification and extinction of many life forms.
7	4. Life Science	3. Evolution in Living Systems	2. Individual organisms with certain traits in particular environments are more likely than others to survive and have offspring.	7.4.3.2.2	Use internal and external anatomical structures to compare and infer relationships between living organisms as well as those in the fossil record.
7	4. Life Science	3. Evolution in Living Systems	2. Individual organisms with certain traits in particular environments are more likely than others to survive and have offspring.	7.4.3.2.3	Recognize that variation exists in every population and describe how a variation can help or hinder an organism's ability to survive.
7	4. Life Science	3. Evolution in Living Systems	2. Individual organisms with certain traits in particular environments are more likely than others to survive and have offspring.	7.4.3.2.4	Recognize that extinction is a common event and it can occur when the environment changes and a population's ability to adapt is insufficient to allow its survival.
7	4. Life Science	4. Human Interactions with Living Systems	1. Human activity can change living organisms and ecosystems.	7.4.4.1.1	Describe examples where selective breeding has resulted in new varieties of cultivated plants and particular traits in domesticated animals.
7	4. Life Science	4. Human Interactions with Living Systems	1. Human activity can change living organisms and ecosystems.	7.4.4.1.2	Describe ways that human activities can change the populations and communities in an ecosystem.
7	4. Life Science	4. Human Interactions with Living Systems	2. Human beings are constantly interacting with other organisms that cause disease.	7.4.4.2.1	Explain how viruses, bacteria, fungi and parasites may infect the human body and interfere with normal body functions.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
7	4. Life Science	4. Human Interactions with Living Systems	2. Human beings are constantly interacting with other organisms that cause disease.	7.4.4.2.2	Recognize that a microorganism can cause specific diseases and that there are a variety of medicines available that can be used to combat a given microorganism.
7	4. Life Science	4. Human Interactions with Living Systems	2. Human beings are constantly interacting with other organisms that cause disease.	7.4.4.2.3	Recognize that vaccines induce the body to build immunity to a disease without actually causing the disease itself.
7	4. Life Science	4. Human Interactions with Living Systems	2. Human beings are constantly interacting with other organisms that cause disease.	7.4.4.2.4	Recognize that the human immune system protects against microscopic organisms and foreign substances that enter from outside the body and against some cancer cells that arise from within.
8	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.	8.1.1.1.1	Evaluate the reasoning in arguments in which fact and opinion are intermingled or when conclusions do not follow logically from the evidence given. *For example*: Evaluate the use of pH in advertising products such as body care and gardening.
8	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry is a set of interrelated processes incorporating multiple approaches that are used to pose questions about the natural and engineered world and investigate phenomena.	8.1.1.2.1	Use logical reasoning and imagination to develop descriptions, explanations, predictions and models based on evidence.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
8	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics and Society	2. Men and women throughout the history of all cultures, including Minnesota American Indian tribes and communities, have been involved in engineering design and scientific inquiry.	8.1.3.2.1	Describe examples of important contributions to the advancement of science, engineering and technology made by individuals representing different groups and cultures at different times in history.
8	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics and Society	3. Science and engineering operate in the context of society and both influence and are influenced by this context.	8.1.3.3.1	Explain how scientific laws and engineering principles, as well as economic, political, social, and ethical expectations, must be taken into account in designing engineering solutions or conducting scientific investigations.
8	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics and Society	3. Science and engineering operate in the context of society and both influence and are influenced by this context.	8.1.3.3.2	Understand that scientific knowledge is always changing as new technologies and information enhance observations and analysis of data. *For example*: Analyze how new telescopes have provided new information about the universe.
8	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics and Society	3. Science and engineering operate in the context of society and both influence and are influenced by this context.	8.1.3.3.3	Provide examples of how advances in technology have impacted how people live, work and interact.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
8	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics and Society	4. Current and emerging technologies have enabled humans to develop and use models to understand and communicate how natural and designed systems work and interact.	8.1.3.4.1	Use maps, satellite images and other data sets to describe patterns and make predictions about local and global systems in Earth science contexts. *For example*: Use data or satellite images to identify locations of earthquakes and volcanoes, ocean surface temperatures, or weather patterns.
8	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics and Society	4. Current and emerging technologies have enabled humans to develop and use models to understand and communicate how natural and designed systems work and interact.	8.1.3.4.2	Determine and use appropriate safety procedures, tools, measurements, graphs and mathematical analyses to describe and investigate natural and designed systems in Earth and physical science contexts.
8	2. Physical Science	1. Matter	1. Pure substances can be identified by properties which are independent of the sample of the substance and the properties can be explained by a model of matter that is composed of small particles.	8.2.1.1.1	Distinguish between a mixture and a pure substance and use physical properties including color, solubility, density, melting point and boiling point to separate mixtures and identify pure substances.
8	2. Physical Science	1. Matter	1. Pure substances can be identified by properties which are independent of the sample of the substance and the properties can be explained by a model of matter that is composed of small particles.	8.2.1.1.2	Use physical properties to distinguish between metals and nonmetals.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
8	2. Physical Science	1. Matter	2. Substances can undergo physical and chemical changes which may change the properties of the substance but do not change the total mass in a closed system.	8.2.1.2.1	Identify evidence of chemical changes, including color change, gas evolution, solid formation and temperature change.
8	2. Physical Science	1. Matter	2. Substances can undergo physical and chemical changes which may change the properties of the substance but do not change the total mass in a closed system.	8.2.1.2.2	Distinguish between chemical and physical changes in matter.
8	2. Physical Science	1. Matter	2. Substances can undergo physical and chemical changes which may change the properties of the substance but do not change the total mass in a closed system.	8.2.1.2.3	Use the particle model of matter to explain how mass is conserved during physical and chemical changes in a closed system.
8	2. Physical Science	1. Matter	2. Substances can undergo physical and chemical changes which may change the properties of the substance but do not change the total mass in a closed system.	8.2.1.2.4	Recognize that acids are compounds whose properties include a sour taste, characteristic color changes with litmus and other acid/base indicators, and the tendency to react with bases to produce a salt and water.
8	2. Physical Science	3. Energy	1. Waves involve the transfer of energy without the transfer of matter.	8.2.3.1.1	Explain how seismic waves transfer energy through the layers of the Earth and across its surface.
8	3. Earth Science	1. Earth Structure and Processes	1. The movement of tectonic plates results from interactions among the lithosphere, mantle, and core.	8.3.1.1.1	Recognize that the Earth is composed of layers, and describe the properties of the layers, including the lithosphere, mantle and core.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
8	3. Earth Science	1. Earth Structure and Processes	1. The movement of tectonic plates results from interactions among the lithosphere, mantle, and core.	8.3.1.1.2	Correlate the distribution of ocean trenches, mid-ocean ridges and mountain ranges to volcanic and seismic activity.
8	3. Earth Science	1. Earth Structure and Processes	1. The movement of tectonic plates results from interactions among the lithosphere, mantle, and core.	8.3.1.1.3	Recognize that major geological events, such as earthquakes, volcanic eruptions and mountain building, result from the slow movement of tectonic plates.
8	3. Earth Science	1. Earth Structure and Processes	2. Landforms are the result of the combination of constructive and destructive processes.	8.3.1.2.1	Explain how landforms result from the processes of crustal deformation, volcanic eruptions, weathering, erosion and deposition of sediment.
8	3. Earth Science	1. Earth Structure and Processes	2. Landforms are the result of the combination of constructive and destructive processes.	8.3.1.2.2	Explain the role of weathering, erosion and glacial activity in shaping Minnesota's current landscape.
8	3. Earth Science	1. Earth Structure and Processes	3. Rocks and rock formations indicate evidence of the materials and conditions that produced them.	8.3.1.3.1	Interpret successive layers of sedimentary rocks and their fossils to infer relative ages of rock sequences, past geologic events, changes in environmental conditions, and the appearance and extinction of life forms.
8	3. Earth Science	1. Earth Structure and Processes	3. Rocks and rock formations indicate evidence of the materials and conditions that produced them.	8.3.1.3.2	Classify and identify rocks and minerals using characteristics including, but not limited to, density, hardness and streak for minerals; and texture and composition for rocks.
8	3. Earth Science	1. Earth Structure and Processes	3. Rocks and rock formations indicate evidence of the materials and conditions that produced them.	8.3.1.3.3	Relate rock composition and texture to physical conditions at the time of formation of igneous, sedimentary and metamorphic rock.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
8	3. Earth Science	2. Interdependence Within the Earth system	1. The sun is the principal external energy source for the Earth.	8.3.2.1.1	Explain how the combination of the Earth's tilted axis and revolution around the sun causes the progression of seasons.
8	3. Earth Science	2. Interdependence Within the Earth system	1. The sun is the principal external energy source for the Earth.	8.3.2.1.2	Recognize that oceans have a major effect on global climate because water in the oceans holds a large amount of heat.
8	3. Earth Science	2. Interdependence Within the Earth system	1. The sun is the principal external energy source for the Earth.	8.3.2.1.3	Explain how heating of Earth's surface and atmosphere by the sun drives convection within the atmosphere and hydrosphere producing winds, ocean currents and the water cycle, as well as influencing global climate.
8	3. Earth Science	2. Interdependence Within the Earth system	2. Patterns of atmospheric movement influence global climate and local weather.	8.3.2.2.1	Describe how the composition and structure of the Earth's atmosphere affects energy absorption, climate, and the distribution of particulates and gases. *For example*: Certain gases contribute to the greenhouse effect.
8	3. Earth Science	2. Interdependence Within the Earth system	2. Patterns of atmospheric movement influence global climate and local weather.	8.3.2.2.2	Analyze changes in wind direction, temperature, humidity and air pressure and relate them to fronts and pressure systems.
8	3. Earth Science	2. Interdependence Within the Earth system	2. Patterns of atmospheric movement influence global climate and local weather.	8.3.2.2.3	Relate global weather patterns to patterns in regional and local weather.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
8	3. Earth Science	2. Interdependence Within the Earth system	3. Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle.	8.3.2.3.1	Describe the location, composition and use of major water reservoirs on the Earth, and the transfer of water among them.
8	3. Earth Science	2. Interdependence Within the Earth system	3. Water, which covers the majority of the Earth's surface, circulates through the crust, oceans and atmosphere in what is known as the water cycle.	8.3.2.3.2	Describe how the water cycle distributes materials and purifies water. *For example*: Dissolved gases can change the chemical composition of substances on Earth. *Another example*: Waterborne disease.
8	3. Earth Science	3. The Universe	1. The Earth is the third planet from the sun in a system that includes the moon, the sun seven other planets and their moons and smaller objects.	8.3.3.1.1	Recognize that the sun is a medium sized star, one of billions of stars in the Milky Way galaxy, and the closest star to Earth.
8	3. Earth Science	3. The Universe	1. The Earth is the third planet from the sun in a system that includes the moon, the sun seven other planets and their moons and smaller objects.	8.3.3.1.2	Describe how gravity and inertia keep most objects in the solar system in regular and predictable motion.
8	3. Earth Science	3. The Universe	1. The Earth is the third planet from the sun in a system that includes the moon, the sun seven other planets and their moons and smaller objects.	8.3.3.1.3	Recognize that gravitational force exists between any two objects and describe how the masses of the objects and distance between them affect the force.
8	3. Earth Science	3. The Universe	1. The Earth is the third planet from the sun in a system that includes the moon, the sun seven other planets and their moons and smaller objects.	8.3.3.1.4	Compare and contrast the sizes, locations, and compositions of the planets and moons in our solar system.

Grade	Strand	Substrand	Standard "Understand that…"	Code	Benchmark
8	3. Earth Science	3. The Universe	1. The Earth is the third planet from the sun in a system that includes the moon, the sun seven other planets and their moons and smaller objects.	8.3.3.1.5	Use the predictable motions of the Earth around its own axis and around the sun, and of the moon around the Earth, to explain day length, the phases of the moon, and eclipses.
8	3. Earth Science	4. Human Interactions with Earth Systems	1. In order to maintain and improve their existence humans interact with and influence Earth systems.	8.3.4.1.1	Describe how mineral and fossil fuel resources have formed over millions of years, and explain why these resources are finite and non-renewable over human time frames.
8	3. Earth Science	4. Human Interactions with Earth Systems	1. In order to maintain and improve their existence humans interact with and influence Earth systems.	8.3.4.1.2	Recognize that land and water use practices affect natural processes and that natural processes interfere and interact with human systems. *For example*: Levees change the natural flooding process of a river. *Another example*: Agricultural runoff influences natural systems far from the source.

Science Standards 9-12

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.	9.1.1.1.1	Explain the implications of the assumption that the rules of the universe are the same everywhere and these rules can be discovered by careful and systematic investigation.
9-12	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.	9.1.1.1.2	Understand that scientists conduct investigations for a variety of reasons, including: to discover new aspects of the natural world, to explain observed phenomena, to test the conclusions of prior investigations, or to test the predictions of current theories.
9-12	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.	9.1.1.1.3	Explain how the traditions and norms of science define the bounds of professional scientific practice and reveal instances of scientific error or misconduct. *For example*: The use of peer review, publications and presentations.
9-12	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.	9.1.1.1.4	Explain how societal and scientific ethics impact research practices. *For example*: Research involving human subjects may be conducted only with the informed consent of the subjects.
9-12	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.	9.1.1.1.5	Identify sources of bias and explain how bias might influence the direction of research and the interpretation of data. *For example*: How funding of research can influence questions studied, procedures used, analysis of data, and communication of results.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world and is characterized by empirical criteria, logical argument and skeptical review.	9.1.1.1.6	Describe how changes in scientific knowledge generally occur in incremental steps that include and build on earlier knowledge.
9-12	1. The Nature of Science and Engineering	1. The Practice of Science	1. Science is a way of knowing about the natural world that is characterized by empirical criteria, logical argument and skeptical review.	9.1.1.1.7	Explain how scientific and technological innovations-as well as new evidence-can challenge portions of, or entire accepted theories and models including, but not limited to: cell theory, atomic theory, theory of evolution, plate tectonic theory, germ theory of disease, and the big bang theory.
9-12	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.	9.1.1.2.1	Formulate a testable hypothesis, design and conduct an experiment to test the hypothesis, analyze the data, consider alternative explanations, and draw conclusions supported by evidence from the investigation.
9-12	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.	9.1.1.2.2	Evaluate the explanations proposed by others by examining and comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the scientifically acceptable evidence, and suggesting alternative scientific explanations.
9-12	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.	9.1.1.2.3	Identify the critical assumptions and logic used in a line of reasoning to judge the validity of a claim.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	1. The Nature of Science and Engineering	1. The Practice of Science	2. Scientific inquiry uses multiple interrelated processes to pose and investigate questions about the natural world.	9.1.1.2.4	Use primary sources or scientific writings to identify and explain how different types of questions and their associated methodologies are used by scientists for investigations in different disciplines.
9-12	1. The Nature of Science and Engineering	2. The Practice of Engineering	1. Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.	9.1.2.1.1	Understand that engineering designs and products are often continually checked and critiqued for alternatives, risks, costs and benefits, so that subsequent designs are refined and improved. *For example*: If the price of an essential raw material changes, the product design may need to be changed.
9-12	1. The Nature of Science and Engineering	2. The Practice of Engineering	1. Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.	9.1.2.1.2	Recognize that risk analysis is used to determine the potential positive and negative consequences of using a new technology or design, including the evaluation of causes and effects of failures. *For example*: Risks and benefits associated with using lithium batteries.
9-12	1. The Nature of Science and Engineering	2. The Practice of Engineering	1. Engineering is a way of addressing human needs by applying science concepts and mathematical techniques to develop new products, tools, processes and systems.	9.1.2.1.3	Explain and give examples of how, in the design of a device, engineers consider how it is to be manufactured, operated, maintained, replaced and disposed of.
9-12	1. The Nature of Science and Engineering	2. The Practice of Engineering	2. Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.	9.1.2.2.1	Identify a problem and the associated constraints on possible design solutions. *For example*: Constraints can include time, money, scientific knowledge and available technology.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	1. The Nature of Science and Engineering	2. The Practice of Engineering	2. Engineering design is an analytical and creative process of devising a solution to meet a need or solve a specific problem.	9.1.2.2.2	Develop possible solutions to an engineering problem and evaluate them using conceptual, physical and mathematical models to determine the extent to which the solutions meet the design specifications. *For example*: Develop a prototype to test the quality, efficiency and productivity of a product.
9-12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	1. Natural and designed systems are made up of components that act within a system and interact with other systems.	9.1.3.1.1	Describe a system, including specifications of boundaries and subsystems, relationships to other systems, and identification of inputs and expected outputs. *For example*: A power plant or ecosystem.
9-12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	1. Natural and designed systems are made up of components that act within a system and interact with other systems.	9.1.3.1.2	Identify properties of a system that are different from those of its parts but appear because of the interaction of those parts.
9-12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	1. Natural and designed systems are made up of components that act within a system and interact with other systems.	9.1.3.1.3	Describe how positive and/or negative feedback occur in systems. *For example*: The greenhouse effect.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	2. Men and women throughout the history of all cultures, including Minnesota American Indian tribes and communities, have been involved in engineering design and scientific inquiry.	9.1.3.2.1	"Provide examples of how diverse cultures, including natives from all of the Americas, have contributed scientific and mathematical ideas and technological inventions. *For example*: Native American understanding of ecology; Lisa Meitner's contribution to understanding radioactivity; Tesla's ideas and inventions relating to electricity; Watson, Crick and Franklin's discovery of the structure of DNA; or how George Washington Carver's ideas changed land use."
9-12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	2. Men and women throughout the history of all cultures, including Minnesota American Indian tribes and communities, have been involved in engineering design and scientific inquiry.	9.1.3.2.2	Analyze possible careers in science and engineering in terms of education requirements, working practices and rewards.
9-12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	3. Science and engineering operate in the context of society and both influence and are influenced by this context.	9.1.3.3.1	"Describe how values and constraints affect science and engineering. *For example*: Economic, environmental, social, political, ethical, health, safety, and sustainability issues.
9-12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	3. Science and engineering operate in the context of society and both influence and are influenced by this context.	9.1.3.3.2	Communicate, justify, and defend the procedures and results of a scientific inquiry or engineering design project using verbal, graphic, quantitative, virtual, or written means.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	3. Science and engineering operate in the context of society and both influence and are influenced by this context.	9.1.3.3.3	Describe how scientific investigations and engineering processes require multi-disciplinary contributions and efforts. *For example*: Nanotechnology, climate change, agriculture, or biotechnology.
9-12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	4. Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.	9.1.3.4.1	Describe how technological problems and advances often create a demand for new scientific knowledge, improved mathematics, and new technologies.
9-12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	4. Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.	9.1.3.4.2	Determine and use appropriate safety procedures, tools, computers and measurement instruments in science and engineering contexts. *For example*: Consideration of chemical and biological hazards in the lab.
9-12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	4. Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.	9.1.3.4.3	Select and use appropriate numeric, symbolic, pictorial, or graphical representation to communicate scientific ideas, procedures and experimental results.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	4. Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.	9.1.3.4.4	Relate the reliability of data to consistency of results, identify sources of error, and suggest ways to improve the data collection and analysis. *For example*: Use statistical analysis or error analysis to make judgments about the validity of results.
9-12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	4. Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.	9.1.3.4.5	Demonstrate how unit consistency and dimensional analysis can guide the calculation of quantitative solutions and verification of results.
9-12	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	4. Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding.	9.1.3.4.6	Analyze the strengths and limitations of physical, conceptual, mathematical and computer models used by scientists and engineers.
9-12	2. Physical Science	1. Matter	1. The structure of the atom determines chemical properties of elements.	9.2.1.1.1	Describe the relative charges, masses, and locations of the protons, neutrons, and electrons in an atom of an element.
9-12	2. Physical Science	1. Matter	1. The structure of the atom determines chemical properties of elements.	9.2.1.1.2	Describe how experimental evidence led Dalton, Rutherford, Thompson, Chadwick and Bohr to develop increasingly accurate models of the atom.
9-12	2. Physical Science	1. Matter	1. The structure of the atom determines chemical properties of elements.	9.2.1.1.3	Explain the arrangement of the elements on the Periodic Table, including the relationships among elements in a given column or row.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	2. Physical Science	1. Matter	1. The structure of the atom determines chemical properties of elements.	9.2.1.1.4	Explain that isotopes of an element have different numbers of neutrons and that some are unstable and emit particles and/or radiation. *For example*: Some rock formations and building materials emit radioactive radon gas. *Another example*: The predictable rate of decay of radioactive isotopes makes it possible to estimate the age of some materials, and makes them useful in some medical procedures.
9-12	2. Physical Science	1. Matter	2. Chemical reactions involve the rearrangement of atoms as chemical bonds are broken and formed through transferring or sharing of electrons and the absorption or release of energy.	9.2.1.2.1	Describe the role of valence electrons in the formation of chemical bonds.
9-12	2. Physical Science	1. Matter	2. Chemical reactions involve the rearrangement of atoms as chemical bonds are broken and formed through transferring or sharing of electrons and the absorption or release of energy.	9.2.1.2.2	Explain how the rearrangement of atoms in a chemical reaction illustrates the law of conservation of mass.
9-12	2. Physical Science	1. Matter	2. Chemical reactions involve the rearrangement of atoms as chemical bonds are broken and formed through transferring or sharing of electrons and the absorption or release of energy.	9.2.1.2.3	Describe a chemical reaction using words and symbolic equations. *For example*: The reaction of hydrogen gas with oxygen gas can be written: $2H_2 + O_2 \rightarrow 2H_2O$.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	2. Physical Science	1. Matter	2. Chemical reactions involve the rearrangement of atoms as chemical bonds are broken and formed through transferring or sharing of electrons and the absorption or release of energy.	9.2.1.2.4	Relate exothermic and endothermic chemical reactions to temperature and energy changes.
9-12	2. Physical Science	2. Motion	2. An object's mass and the forces on it affect the motion of an object.	9.2.2.2.1	Recognize that inertia is the property of an object that causes it to resist changes in motion.
9-12	2. Physical Science	2. Motion	2. An object's mass and the forces on it affect the motion of an object.	9.2.2.2.2	Explain and calculate the acceleration of an object subjected to a set of forces in one dimension (F=ma).
9-12	2. Physical Science	2. Motion	2. An object's mass and the forces on it affect the motion of an object.	9.2.2.2.3	Demonstrate that whenever one object exerts force on another, a force equal in magnitude and opposite in direction is exerted by the second object back on the first object.
9-12	2. Physical Science	2. Motion	2. An object's mass and the forces on it affect the motion of an object.	9.2.2.2.4	Use Newton's universal law of gravitation to describe and calculate the attraction between massive objects based on the distance between them. *For example*: Calculate the weight of a person on different planets using data of the mass and radius of the planets.
9-12	2. Physical Science	3. Energy	2. Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.	9.2.3.2.1	Identify the energy forms and explain the transfers of energy involved in the operation of common devices. *For example*: Light bulbs, electric motors, automobiles or bicycles.
9-12	2. Physical Science	3. Energy	2. Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.	9.2.3.2.2	Calculate and explain the energy, work and power involved in energy transfers in a mechanical system. *For example*: Compare walking and running up or down steps.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	2. Physical Science	3. Energy	2. Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.	9.2.3.2.3	Describe how energy is transferred through sound waves and how pitch and loudness are related to wave properties of frequency and amplitude.
9-12	2. Physical Science	3. Energy	2. Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.	9.2.3.2.4	Explain and calculate current, voltage and resistance, and describe energy transfers in simple electric circuits.
9-12	2. Physical Science	3. Energy	2. Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.	9.2.3.2.5	Describe how an electric current produces a magnetic force, and how this interaction is used in motors and electromagnets to produce mechanical energy.
9-12	2. Physical Science	3. Energy	2. Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.	9.2.3.2.6	Compare fission and fusion in terms of the reactants, the products and the conversion from matter into energy. *For example*: The fusion of hydrogen produces energy in the sun. *Another example*: The use of chain reactions in nuclear reactors.
9-12	2. Physical Science	3. Energy	2. Energy can be transformed within a system or transferred to other systems or the environment, but is always conserved.	9.2.3.2.7	Describe the properties and uses of forms of electromagnetic radiation from radio frequencies through gamma radiation. *For example*: Compare the energy of microwaves and X-rays.
9-12	2. Physical Science	4. Human Interactions with Physical Systems	1. There are benefits, costs and risks to different means of generating and using energy.	9.2.4.1.1	Compare local and global environmental and economic advantages and disadvantages of generating electricity using various sources or energy. *For example*: Fossil fuels, nuclear fission, wind, sun or tidal energy.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	2. Physical Science	4. Human Interactions with Physical Systems	1. There are benefits, costs and risks to different means of generating and using energy.	9.2.4.1.2	Describe the trade-offs involved when technological developments impact the way we use energy, natural resources, or synthetic materials. *For example*: Fluorescent light bulbs use less energy than incandescent lights, but contain toxic mercury.
9-12	3. Earth and Space Science	1. Earth Structure and Processes	1. The relationships among earthquakes, mountains, volcanoes, fossil deposits, rock layers and ocean features provide evidence for the theory of plate tectonics.	9.3.1.1.1	Compare and contrast the interaction of tectonic plates at convergent and divergent boundaries. *For example*: Compare the kinds of magma that emerge at plate boundaries.
9-12	3. Earth and Space Science	1. Earth Structure and Processes	1. The relationships among earthquakes, mountains, volcanoes, fossil deposits, rock layers and ocean features provide evidence for the theory of plate tectonics.	9.3.1.1.2	Use modern earthquake data to explain how seismic activity is evidence for the process of subduction. *For example*: Correlate data on distribution, depth and magnitude of earthquakes with subduction zones.
9-12	3. Earth and Space Science	1. Earth Structure and Processes	1. The relationships among earthquakes, mountains, volcanoes, fossil deposits, rock layers and ocean features provide evidence for the theory of plate tectonics.	9.3.1.1.3	Describe how the pattern of magnetic reversals and rock ages on both sides of a mid-ocean ridge provides evidence of sea-floor spreading.
9-12	3. Earth and Space Science	1. Earth Structure and Processes	1. The relationships among earthquakes, mountains, volcanoes, fossil deposits, rock layers and ocean features provide evidence for the theory of plate tectonics.	9.3.1.1.4	Explain how the rock record provides evidence for plate movement. *For example*: Similarities found in fossils, certain types of rocks, or patterns of rock layers in various locations.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	3. Earth and Space Science	1. Earth Structure and Processes	1. The relationships among earthquakes, mountains, volcanoes, fossil deposits, rock layers and ocean features provide evidence for the theory of plate tectonics.	9.3.1.1.5	Describe how experimental and observational evidence led to the theory of plate tectonics.
9-12	3. Earth and Space Science	1. Earth Structure and Processes	3. By observing rock sequences and using fossils to correlate the sequences at various locations, geologic events can be inferred and geologic time can be estimated.	9.3.1.3.1	Use relative dating techniques to explain how the structures of the Earth and life on Earth have changed over short and long periods of time.
9-12	3. Earth and Space Science	1. Earth Structure and Processes	3. By observing rock sequences and using fossils to correlate the sequences at various locations, geologic events can be inferred and geologic time can be estimated.	9.3.1.3.2	Cite evidence from the rock record for changes in the composition of the global atmosphere as life evolved on Earth. *For example*: Banded iron formations as found in Minnesota's Iron Range.
9-12	3. Earth and Space Science	2. Interdependence Within the Earth System	1. The Earth system has internal and external sources of energy, which produce heat and drive the motion of material in the oceans, atmosphere and solid earth.	9.3.2.1.1	Compare and contrast the energy sources of the Earth, including the sun, the decay of radioactive isotopes and gravitational energy.
9-12	3. Earth and Space Science	2. Interdependence Within the Earth System	1. The Earth system has internal and external sources of energy, which produce heat and drive the motion of material in the oceans, atmosphere and solid earth.	9.3.2.1.2	Explain how the outward transfer of Earth’s internal heat drives the convection circulation in the mantle to move tectonic plates.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	3. Earth and Space Science	2. Interdependence Within the Earth System	2. Global climate is determined by distribution of energy from the sun at the Earth's surface.	9.3.2.2.1	Explain how Earth's rotation, ocean currents, configuration of mountain ranges, and composition of the atmosphere influence the absorption and distribution of energy, which contributes to global climatic patterns.
9-12	3. Earth and Space Science	2. Interdependence Within the Earth System	2. Global climate is determined by distribution of energy from the sun at the Earth's surface.	9.3.2.2.2	Explain how evidence from the geologic record, including ice core samples, indicates that climate changes have occurred at varying rates over geologic time and continue to occur today.
9-12	3. Earth and Space Science	2. Interdependence Within the Earth System	3. The cycling of materials through different reservoirs of the Earth's system is powered by the Earth's sources of energy.	9.3.2.3.1	Trace the cyclical movement of carbon, oxygen and nitrogen through the lithosphere, hydrosphere, atmosphere and biosphere. *For example*: The burning of fossil fuels contributes to the greenhouse effect.
9-12	3. Earth and Space Science	3. The Universe	2. The solar system, sun, and Earth formed over billions of years.	9.3.3.2.1	Describe how the solar system formed from a nebular cloud of dust and gas 4.6 billion years ago.
9-12	3. Earth and Space Science	3. The Universe	2. The solar system, sun, and Earth formed over billions of years.	9.3.3.2.2	Explain how the Earth evolved into its present habitable form through interactions among the solid earth, the oceans, the atmosphere and organisms.
9-12	3. Earth and Space Science	3. The Universe	2. The solar system, sun, and Earth formed over billions of years.	9.3.3.2.3	Compare and contrast the environmental conditions that make life possible on Earth with conditions found on the other planets and moons of our solar system.
9-12	3. Earth and Space Science	3. The Universe	3. The big bang theory states that the universe expanded from a hot, dense chaotic mass, after which chemical elements formed and clumped together to eventually form stars and galaxies.	9.3.3.3.1	Explain how evidence, including the Doppler shift of light from distant stars and cosmic background radiation, is used to understand the composition, early history and expansion of the universe.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	3. Earth and Space Science	3. The Universe	3. The big bang theory states that the universe expanded from a hot, dense chaotic mass, after which chemical elements formed and clumped together to eventually form stars and galaxies.	9.3.3.3.2	Explain how gravitational clumping leads to nuclear fusion, producing energy and the chemical elements of a star.
9-12	3. Earth and Space Science	4. Human Interactions with the Earth Systems	1. People consider potential benefits, costs and risks to make decisions on how they interact with natural systems.	9.3.4.1.1	Analyze the benefits, costs, risks and tradeoffs associated with natural hazards, including the selection of land use and engineering mitigation. *For example*: Determining land use in floodplains and areas prone to landslides.
9-12	3. Earth and Space Science	4. Human Interactions with the Earth Systems	1. People consider potential benefits, costs and risks to make decisions on how they interact with natural systems.	9.3.4.1.2	Explain how human activity and natural processes are altering the hydrosphere, biosphere, lithosphere and atmosphere, including pollution, topography and climate. *For example*: Active volcanoes and the burning of fossil fuels contribute to the greenhouse effect.
9-12	4. Life Science	1. Structure and Function of Living Systems	1. Organisms use the interaction of cellular processes to as well as tissues and organ systems to maintain homeostasis.	9.4.1.1.1	Explain how cell processes are influenced by internal and external factors, such as pH and temperature, and how cells and organisms respond to changes in their environment to maintain homeostasis.
9-12	4. Life Science	1. Structure and Function of Living Systems	1. Organisms use the interaction of cellular processes to as well as tissues and organ systems to maintain homeostasis.	9.4.1.1.2	Describe how the functions of individual organ systems are integrated to maintain homeostasis in an organism.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	4. Life Science	1. Structure and Function of Living Systems	2. Cells and cell structures have specific functions that allow an organism to grow, survive and reproduce.	9.4.1.2.1	Recognize that cells are composed primarily of a few elements (carbon, hydrogen, oxygen, nitrogen, phosphorus, and sulfur), and describe the basic molecular structures and the primary functions of carbohydrates, lipids, proteins and nucleic acids.
9-12	4. Life Science	1. Structure and Function of Living Systems	2. Cells and cell structures have specific functions that allow an organism to grow, survive and reproduce.	9.4.1.2.2	Recognize that the work of the cell is carried out primarily by proteins, most of which are enzymes, and that protein function depends on the amino acid sequence and the shape it takes as a consequence of the interactions between those amino acids.
9-12	4. Life Science	1. Structure and Function of Living Systems	2. Cells and cell structures have specific functions that allow an organism to grow, survive and reproduce.	9.4.1.2.3	Describe how viruses, prokaryotic cells, and eukaryotic cells differ in relative size, complexity and general structure.
9-12	4. Life Science	1. Structure and Function of Living Systems	2. Cells and cell structures have specific functions that allow an organism to grow, survive and reproduce.	9.4.1.2.4	Explain the function and importance of cell organelles for prokaryotic and/or eukaryotic cells as related to the basic cell processes of respiration, photosynthesis, protein synthesis and cell reproduction.
9-12	4. Life Science	1. Structure and Function of Living Systems	2. Cells and cell structures have specific functions that allow an organism to grow, survive and reproduce.	9.4.1.2.5	Compare and contrast passive transport (including osmosis and facilitated transport) with active transport such as endocytosis and exocytosis.
9-12	4. Life Science	1. Structure and Function of Living Systems	2. Cells and cell structures have specific functions that allow an organism to grow, survive and reproduce.	9.4.1.2.6	Explain the process of mitosis in the formation of identical new cells and maintaining chromosome number during asexual reproduction.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	4. Life Science	2. Interdependence Among Living Systems	1. The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems.	9.4.2.1.1	Describe factors that affect the carrying capacity of an ecosystem and relate these to population growth.
9-12	4. Life Science	2. Interdependence Among Living Systems	1. The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems.	9.4.2.1.2	Explain how ecosystems can change as a result of the introduction of one of more new species. *For example*: The effect of migration, localized evolution or disease organism.
9-12	4. Life Science	2. Interdependence Among Living Systems	2. Matter cycles and energy flows through different levels of organization of living systems and the physical environment, as chemical elements are combined in different ways.	9.4.2.2.1	Use words and equations to differentiate between the processes of photosynthesis and respiration in terms of energy flow, beginning reactants and end products.
9-12	4. Life Science	2. Interdependence Among Living Systems	2. Matter cycles and energy flows through different levels of organization of living systems and the physical environment, as chemical elements are combined in different ways.	9.4.2.2.2	Explain how matter and energy is transformed and transferred among organisms in an ecosystem, and how energy is dissipated as heat into the environment.
9-12	4. Life Science	3. Evolution in Living Systems	1. Genetic information found in the cell provides information for assembling proteins which dictate expression of traits in an individual.	9.4.3.1.1	Explain the relationships among DNA, genes and chromosomes.

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9-12	4. Life Science	3. Evolution in Living Systems	1. Genetic information found in the cell provides information for assembling proteins which dictate expression of traits in an individual.	9.4.3.1.2	In the context of a monohybrid cross, apply the terms phenotype, genotype, allele, homozygous and heterozygous.
9-12	4. Life Science	3. Evolution in Living Systems	1. Genetic information found in the cell provides information for assembling proteins which dictate expression of traits in an individual.	9.4.3.1.3	Describe the process of DNA replication and the role of DNA and RNA in assembling protein molecules.
9-12	4. Life Science	3. Evolution in Living Systems	2. Variation within a species is the natural result of new inheritable characteristics occurring from new combinations of existing genes or from mutations of genes in reproductive cells.	9.4.3.2.1	Use concepts from Mendel's laws of segregation and independent assortment to explain how sorting and recombination (crossing over) of genes during sexual reproduction (meiosis) increases the occurrence of variation in a species.
9-12	4. Life Science	3. Evolution in Living Systems	2. Variation within a species is the natural result of new inheritable characteristics occurring from new combinations of existing genes or from mutations of genes in reproductive cells.	9.4.3.2.2	Use the processes of mitosis and meiosis to explain the advantages and disadvantages of asexual and sexual reproduction.
9-12	4. Life Science	3. Evolution in Living Systems	2. Variation within a species is the natural result of new inheritable characteristics occurring from new combinations of existing genes or from mutations of genes in reproductive cells.	9.4.3.2.3	Explain how mutations like deletions, insertions, rearrangements or substitutions of DNA segments in gametes may have no effect, may harm, or rarely may be beneficial, and can result in genetic variation within a species.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	4. Life Science	3. Evolution in Living Systems	3. Evolution by natural selection is a scientific explanation for the history and diversity of life on Earth.	9.4.3.3.1	Describe how evidence led Darwin to develop the theory of natural selection and common descent to explain evolution.
9-12	4. Life Science	3. Evolution in Living Systems	3. Evolution by natural selection is a scientific explanation for the history and diversity of life on Earth.	9.4.3.3.2	Use scientific evidence, including the fossil record, homologous structures, and genetic and/or biochemical similarities, to show evolutionary relationships among species.
9-12	4. Life Science	3. Evolution in Living Systems	3. Evolution by natural selection is a scientific explanation for the history and diversity of life on Earth.	9.4.3.3.3	Recognize that artificial selection has led to offspring through successive generations that can be very different in appearance and behavior from their distant ancestors.
9-12	4. Life Science	3. Evolution in Living Systems	3. Evolution by natural selection is a scientific explanation for the history and diversity of life on Earth.	9.4.3.3.4	Explain why genetic variation within a population is essential for evolution to occur.
9-12	4. Life Science	3. Evolution in Living Systems	3. Evolution by natural selection is a scientific explanation for the history and diversity of life on Earth.	9.4.3.3.5	Explain how competition for finite resources and the changing environment promotes natural selection on offspring survival, depending on whether the offspring have characteristics that are advantageous or disadvantageous in the new environment.
9-12	4. Life Science	3. Evolution in Living Systems	3. Evolution by natural selection is a scientific explanation for the history and diversity of life on Earth.	9.4.3.3.6	Explain how genetic variation between two populations of a given species is due, in part, to different selective pressures acting independently on each population and how, over time, these differences can lead to the development of new species.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	4. Life Science	4. Human Interactions with Living Systems	1. Human activity has consequences on living organisms and ecosystems.	9.4.4.1.1	Describe the social, economic, and ecological risks and benefits of biotechnology in agriculture and medicine. *For example*: Selective breeding, genetic engineering, and antibiotic development and use.
9-12	4. Life Science	4. Human Interactions with Living Systems	1. Human activity has consequences on living organisms and ecosystems.	9.4.4.1.2	Describe the social, economic and ecological risks and benefits of changing a natural ecosystem as a result of human activity. *For example*: Changing the temperature or composition of water, air or soil; altering the populations and communities, developing artificial ecosystems; or changing the use of land or water.
9-12	4. Life Science	4. Human Interactions with Living Systems	1. Human activity has consequences on living organisms and ecosystems.	9.4.4.1.3	Describe contributions from diverse cultures, including Minnesota American Indian tribes and communities, to the understanding of interactions among humans and living systems. *For example*: American Indian understanding of sustainable land use practices.
9-12	4. Life Science	4. Human Interactions with Living Systems	2. Personal and community health can be affected by the environment, body functions and human behavior.	9.4.4.2.1	Describe how some diseases can sometimes be predicted by genetic testing and how this affects parental and community decisions.
9-12	4. Life Science	4. Human Interactions with Living Systems	2. Personal and community health can be affected by the environment, body functions and human behavior.	9.4.4.2.2	Explain how the body produces antibodies to fight disease and how vaccines assist this process.
9-12	4. Life Science	4. Human Interactions with Living Systems	2. Personal and community health can be affected by the environment, body functions and human behavior.	9.4.4.2.3	Describe how the immune system sometimes attacks some of the body’s own cells and how some allergic reactions are caused by the body's immune responses to usually harmless environmental substances.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
9-12	4. Life Science	4. Human Interactions with Living Systems	2. Personal and community health can be affected by the environment, body functions and human behavior.	9.4.4.2.4	Explain how environmental factors and personal decisions, such as water quality, air quality and smoking affect personal and community health.
9-12	4. Life Science	4. Human Interactions with Living Systems	2. Personal and community health can be affected by the environment, body functions and human behavior.	9.4.4.2.5	Recognize that a gene mutation in a cell can result in uncontrolled cell division called cancer, and how exposure of cells to certain chemicals and radiation increases mutations and thus increases the chance of cancer.
Chemistry	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	3. Developments in chemistry affect society and societal concerns affect the field of chemistry.	9C.1.3.3.1	Explain the political, societal, economic and environmental impact of chemical products and technologies. *For example*: Pollution effects, atmospheric changes, petroleum products, material use or waste disposal.
Chemistry	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	4. Physical and mathematical models are used to describe physical systems.	9C.1.3.4.1	Use significant figures and an understanding of accuracy and precision in scientific measurements to determine and express the uncertainty of a result.
Chemistry	2. Physical Science	1. Matter	1. The periodic table illustrates how patterns in the physical and chemical properties of elements are related to atomic structure.	9C.2.1.1.1	Explain the relationship of an element's position on the periodic table to its atomic number and electron configuration.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
Chemistry	2. Physical Science	1. Matter	1. The periodic table illustrates how patterns in the physical and chemical properties of elements are related to atomic structure.	9C.2.1.1.2	Identify and compare trends on the periodic table, including reactivity and relative sizes of atoms and ions; use the trends to explain the properties of subgroups, including metals, non-metals, alkali metals, alkaline earth metals, halogens and noble gases.
Chemistry	2. Physical Science	1. Matter	2. Chemical and physical properties of matter result from the ability of atoms to form bonds.	9C.2.1.2.1	Explain how elements combine to form compounds through ionic and covalent bonding.
Chemistry	2. Physical Science	1. Matter	2. Chemical and physical properties of matter result from the ability of atoms to form bonds.	9C.2.1.2.2	Compare and contrast the structure, properties and uses of organic compounds, such as hydrocarbons, alcohols, sugars, fats and proteins.
Chemistry	2. Physical Science	1. Matter	2. Chemical and physical properties of matter result from the ability of atoms to form bonds.	9C.2.1.2.3	Use IUPAC (International Union of Pure and Applied Chemistry) nomenclature to write chemical formulas and name molecular and ionic compounds, including those that contain polyatomic ions.
Chemistry	2. Physical Science	1. Matter	2. Chemical and physical properties of matter result from the ability of atoms to form bonds.	9C.2.1.2.4	Determine the molar mass of a compound from its chemical formula and a table of atomic masses; convert the mass of a molecular substance to moles, number of particles, or volume of gas at standard temperature and pressure.
Chemistry	2. Physical Science	1. Matter	2. Chemical and physical properties of matter result from the ability of atoms to form bonds.	9C.2.1.2.5	Determine percent composition, empirical formulas and molecular formulas of simple compounds.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
Chemistry	2. Physical Science	1. Matter	2. Chemical and physical properties of matter result from the ability of atoms to form bonds.	9C.2.1.2.6	Describe the dynamic process by which solutes dissolve in solvents, and calculate concentrations, including percent concentration, molarity and parts per million.
Chemistry	2. Physical Science	1. Matter	2. Chemical and physical properties of matter result from the ability of atoms to form bonds.	9C.2.1.2.7	Explain the role of solubility of solids, liquids and gases in natural and designed systems. *For example*: The presence of heavy metals in water and the atmosphere. *Another example*: Development and use of alloys.
Chemistry	2. Physical Science	1. Matter	3. Chemical reactions describe a chemical change in which one or more reactants are transformed into one or more products.	9C.2.1.3.1	Classify chemical reactions as double replacement, single replacement, synthesis, decomposition or combustion.
Chemistry	2. Physical Science	1. Matter	3. Chemical reactions describe a chemical change in which one or more reactants are transformed into one or more products.	9C.2.1.3.2	Use solubility and activity of ions to determine whether a double replacement or single replacement reaction will occur.
Chemistry	2. Physical Science	1. Matter	3. Chemical reactions describe a chemical change in which one or more reactants are transformed into one or more products.	9C.2.1.3.3	Relate the properties of acids and bases to the ions they contain and predict the products of an acid-base reaction.
Chemistry	2. Physical Science	1. Matter	3. Chemical reactions describe a chemical change in which one or more reactants are transformed into one or more products.	9C.2.1.3.4	Balance chemical equations by applying the laws of conservation of mass and constant composition.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
Chemistry	2. Physical Science	1. Matter	3. Chemical reactions describe a chemical change in which one or more reactants are transformed into one or more products.	9C.2.1.3.5	Use the law of conservation of mass to describe and calculate relationships in a chemical reaction, including molarity, mole/mass relationships, mass/volume relations, limiting reactants and percent yield.
Chemistry	2. Physical Science	1. Matter	3. Chemical reactions describe a chemical change in which one or more reactants are transformed into one or more products.	9C.2.1.3.6	Describe the factors that affect the rate of a chemical reaction, including temperature, pressure, mixing, concentration, particle size, surface area and catalyst.
Chemistry	2. Physical Science	1. Matter	3. Chemical reactions describe a chemical change in which one or more reactants are transformed into one or more products.	9C.2.1.3.7	Recognize that some chemical reactions are reversible and that not all chemical reactions go to completion.
Chemistry	2. Physical Science	1. Matter	4. States of matter can be described in terms of motion of molecules and that the properties and behavior of gases can be explained using the kinetic molecular theory.	9C.2.1.4.1	Use kinetic molecular theory to explain how changes in energy content affect the state of matter (solid, liquid and gaseous phases).
Chemistry	2. Physical Science	1. Matter	4. States of matter can be described in terms of motion of molecules and that the properties and behavior of gases can be explained using the kinetic molecular theory.	9C.2.1.4.2	Use the kinetic molecular theory to explain the behavior of gases and the relationship among temperature, pressure, volume and the number of particles.

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Physics	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	3. Developments in physics affect society and societal concerns affect the field of physics.	9P.1.3.3.1	Describe changes in society that have resulted from significant discoveries and advances in technology in physics. *For example*: Transistors, generators, radio/television, or microwave ovens.
Physics	1. The Nature of Science and Engineering	3. Interactions Among Science, Technology, Engineering, Mathematics, and Society	4. Physical and mathematical models are used to describe physical systems.	9P.1.3.4.1	Use significant figures and an understanding of accuracy and precision in scientific measurements to determine and express the uncertainty of a result.
Physics	2. Physical Science	2. Motion	1. Forces and inertia determine the motion of objects.	9P.2.2.1.1	Use vectors and free-body diagrams to describe force, position, velocity and acceleration of objects in two-dimensional space.
Physics	2. Physical Science	2. Motion	1. Forces and inertia determine the motion of objects.	9P.2.2.1.2	Apply Newton's three laws of motion to calculate and analyze the effect of forces and momentum on motion.
Physics	2. Physical Science	2. Motion	1. Forces and inertia determine the motion of objects.	9P.2.2.1.3	Use gravitational force to explain the motion of objects near Earth and in the universe.
Physics	2. Physical Science	2. Motion	2. When objects change their motion or interact with other objects in the absence of frictional forces, the total amount of mechanical energy remains constant.	9P.2.2.2.1	Explain and calculate the work, power, potential energy and kinetic energy involved in objects moving under the influence of gravity and other mechanical forces.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
Physics	2. Physical Science	2. Motion	2. When objects change their motion or interact with other objects in the absence of frictional forces, the total amount of mechanical energy remains constant.	9P.2.2.2.2	Describe and calculate the change in velocity for objects when forces are applied perpendicular to the direction of motion. *For example*: Objects in orbit.
Physics	2. Physical Science	2. Motion	2. When objects change their motion or interact with other objects in the absence of frictional forces, the total amount of mechanical energy remains constant.	9P.2.2.2.3	Use conservation of momentum and conservation of energy to analyze an elastic collision of two solid objects in one-dimensional motion.
Physics	2. Physical Science	3. Energy	1. Sound waves are generated from mechanical oscillations of objects and travel through a medium.	9P.2.3.1.1	Analyze the frequency, period and amplitude of an oscillatory system. *For example*: An ideal pendulum, a vibrating string, or a vibrating spring-and-mass system.
Physics	2. Physical Science	3. Energy	1. Sound waves are generated from mechanical oscillations of objects and travel through a medium.	9P.2.3.1.2	Describe how vibration of physical objects sets up transverse and/or longitudinal waves in gases, liquids and solid materials.
Physics	2. Physical Science	3. Energy	1. Sound waves are generated from mechanical oscillations of objects and travel through a medium.	9P.2.3.1.3	Explain how interference, resonance, refraction and reflection affect sound waves.
Physics	2. Physical Science	3. Energy	1. Sound waves are generated from mechanical oscillations of objects and travel through a medium.	9P.2.3.1.4	Describe the Doppler effect changes that occur in an observed sound as a result of the motion of a source of the sound relative to a receiver.
Physics	2. Physical Science	3. Energy	2. Electrons respond to electric fields and voltages by moving through electrical circuits and this motion generates magnetic fields.	9P.2.3.2.1	Explain why currents flow when free charges are placed in an electric field, and how that forms the basis for electric circuits.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
Physics	2. Physical Science	3. Energy	2. Electrons respond to electric fields and voltages by moving through electrical circuits and this motion generates magnetic fields.	9P.2.3.2.2	Explain and calculate the relationship of current, voltage, resistance and power in series and parallel circuits. *For example*: Determine the voltage between two points in a series circuit with two resistors.
Physics	2. Physical Science	3. Energy	2. Electrons respond to electric fields and voltages by moving through electrical circuits and this motion generates magnetic fields.	9P.2.3.2.3	Describe how moving electric charges produce magnetic forces and moving magnets produce electric forces.
Physics	2. Physical Science	3. Energy	2. Electrons respond to electric fields and voltages by moving through electrical circuits and this motion generates magnetic fields.	9P.2.3.2.4	Use the interplay of electric and magnetic forces to explain how motors, generators, and transformers work.
Physics	2. Physical Science	3. Energy	3. Magnetic and electric fields interact to produce electromagnetic waves.	9P.2.3.3.1	Describe the nature of the magnetic and electric fields in a propagating electromagnetic wave.
Physics	2. Physical Science	3. Energy	3. Magnetic and electric fields interact to produce electromagnetic waves.	9P.2.3.3.2	Explain and calculate how the speed of light and its wavelength change when the medium changes.
Physics	2. Physical Science	3. Energy	3. Magnetic and electric fields interact to produce electromagnetic waves.	9P.2.3.3.3	Explain the refraction and/or total internal reflection of light in transparent media, such as lenses and optical fibers.
Physics	2. Physical Science	3. Energy	3. Magnetic and electric fields interact to produce electromagnetic waves.	9P.2.3.3.4	Use properties of light, including reflection, refraction, interference, Doppler effect and the photoelectric effect, to explain phenomena and describe applications.

Grade	Strand	Substrand	Standard "Understand that ..."	Code	Benchmark
Physics	2. Physical Science	3. Energy	3. Magnetic and electric fields interact to produce electromagnetic waves.	9P.2.3.3.5	Compare the wave model and particle model in explaining properties of light.
Physics	2. Physical Science	3. Energy	3. Magnetic and electric fields interact to produce electromagnetic waves.	9P.2.3.3.6	Compare the wavelength, frequency and energy of waves in different regions of the electromagnetic spectrum and describe their applications.
Physics	2. Physical Science	3. Energy	4. Heat energy is transferred between objects or regions that are at different temperatures by the processes of convection, conduction and radiation.	9P.2.3.4.1	Describe and calculate the quantity of heat transferred between solids and/or liquids, using specific heat, mass and change in temperature.
Physics	2. Physical Science	3. Energy	4. Heat energy is transferred between objects or regions that are at different temperatures by the processes of convection, conduction and radiation.	9P.2.3.4.2	Explain the role of gravity, pressure and density in the convection of heat by a fluid.
Physics	2. Physical Science	3. Energy	4. Heat energy is transferred between objects or regions that are at different temperatures by the processes of convection, conduction and radiation.	9P.2.3.4.3	Compare the rate at which objects at different temperatures will transfer thermal energy by electromagnetic radiation.