DEPARTMENT OF EDUCATION

Minnesota Academic Standards in Science – 2019

Second Draft, February 2019

Introduction

The Second Draft of the Minnesota Academic Standards for Science - 2019 represents the work of the Science Standards review committee. This group of 36 includes K-12 teachers, administrators, college faculty, informal educators, and community members. The committee membership, timeline and assumptions that guide their work are found on the Minnesota Department of Education (MDE) Science webpage.

This draft of the standards represents a major shift from the 2009 Science Standards in approach to standards and science learning, hence we suggest that you read the introductory material carefully, especially the foundational research.

We encourage you to provide feedback and comments about this draft of the standards via an online feedback survey from **February 14 - 28.** The survey is posted at the MDE Science webpage.

Virtual Town Hall meetings via web conference are on February 19 at 7 a.m., noon, 4 p.m. and 7 p.m. These meetings will provide background about the standards and provide an opportunity for questions and input. The connection links are also at the MDE Science webpage.

The final draft in May will be available for planning purposes and the standards become law through the Minnesota rulemaking process. More information on the standards development process is at the Science webpage linked above.

Requirements for Minnesota Science Standards

Several Minnesota statutes provide requirements for academic standards. These statutes, the procedures that have been developed for writing academic standards, and specific guidance for the science standards are in the document "Assumptions for Guiding the Standards Committee's Work" which is available at the MDE Science webpage linked above.

Minnesota statutes require that there be statements of standards and benchmarks. Standards are summary descriptions of student learning. The benchmarks identify the learning that is to be accomplished by all students by the end of each grade for K-8 and by the end of high school for the grade band 9-12.

The standards and benchmarks should be aligned with the knowledge and skills needed for college readiness (Minn. Stat. § 120B.021, subd. 4(a)).

The committee "must include the contributions of Minnesota American Indian tribes and communities as they relate to the academic standards during the review and revision of the required academic standards." (Minn. Stat. § 12-B/021, subd. 1)

Standards for environmental literacy will be identified and/or developed to comply with Minnesota Statutes, section 115A.073.

Science standards should be revised with the assumption that all students will complete three credits, including a biology credit, and either a chemistry or a physics credit. The combination of courses should help students satisfactorily accomplish all the 9-12 science standards.

Concepts from the following areas should be embedded in the standards as appropriate: engineering, nature of science, computer science, and technology and information literacy.

The work of the Science Standards Review Committee

The Science Standards Review committee of 36 members was selected by the Commissioner of Education from approximately 200 applicants. The committee began its work in August with a three day retreat that studied standards requirements, research on science education, and model standards from other states. An online survey about the 2009 standards was given in September and had about 220 responses. In September the committee developed a statement of Career and College Readiness and determined the organizational structure of the standards and benchmarks. In October the committee developed the first draft and it was published November 8th. The Department of Education conducted Town Hall meetings in 5 locations plus an online meeting. An online survey received comments from about 230 entities, with about one-fourth of them from groups. In December the committee reviewed the comments and established writing teams to prepare the second draft. In January the draft was finalized and the structure of the draft was approved by a unanimous vote of the committee.

Implementation of the 2019 Science Standards

The final draft of the standards will be completed in May and presented to the commissioner of education for approval. That draft will be published for use by schools and districts for planning. The standards become law through the state's rulemaking process, which also sets the date for full implementation of the standards. The period of phase-in will likely be three to five years. Other components of the educational system might be adjusted to meet these standards, including statewide assessments content, licensure standards, and licensure categories.

Foundational Research influencing the Science Standards

The Assumptions for Guiding the Science Standards Committee's Work (Assumptions) direct that "the standards will be informed by *A Framework for K-12 Science Education*[1] (Framework) and include the dimensions of the scientific and engineering practices, crosscutting concepts, and disciplinary core ideas." The *Framework* document utilizes the research on science learning and instruction that has occurred in the past fifteen years to present a new vision for science standards. The *Framework for K-12 Science Education* is available as a free download at www.nap.edu. As you read the second draft, you will notice that the standards are based on Science and Engineering Practices and the benchmark statements integrate all three dimensions. A key finding from research that influenced the Framework is that students can learn concepts and skills at an earlier age than we used to think was developmentally appropriate, especially if there is a well-planned learning progression. Hence many practices and core ideas are moved to earlier grades than in the previous science standards.

Career and College Readiness Statement

Research[1] states that the majority of jobs and careers demand a set of skills whose foundation can be developed in the science classroom. Therefore, science instruction should provide students the skills that will prepare them for post-secondary education, potential careers, knowledge and appreciation of cultural diversity, and lifelong learning. These skills include communication, collaboration, critical thinking, creativity, adaptability, resilience and problem solving, which should be learned along with the concepts and practices of science and engineering.

School systems should ensure that all students, regardless of geographic location, socioeconomic status, race, disability, gender, national origin, native language, and religion, have access to rigorous science instruction, and materials and equipment that are relevant to a student's environment and culture. Science education should cultivate broadly applicable knowledge and practices that will prepare students to be conscientious, informed, and productive members of society, able to make evidence-based decisions.

[1] Nation Research Council. (2012) *A Framework for K-12 Science Education: Practices, Crosscutting Concept, and Core Ideas*. Washington DC. The National Academies Press.

Three Dimensions Summary

From *A Framework for K-12 Science Education*

Dimension 1: Science and Engineering Practices

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

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

Dimension 2: Crosscutting Concepts

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

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

Dimension 3: Disciplinary Core ideas

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

Physical Sciences

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

Life Sciences

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

Earth and Space Sciences

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

Engineering, Technology, and the Applications of Science

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

Decisions for the second draft

1. The Career and College Readiness Statement (above) will guide the writing of standards and benchmarks. This consideration led the committee to emphasize science and engineering skills, called practices, in these standards.
2. Standards will be written as anchor standards (statements that span the K-12 grade range), and will be based on the *Framework's* Science and Engineering Practices. Where appropriate, separate anchor standards will be written for both the science and the engineering aspects of a practice.
3. Benchmarks will be written to reflect the integration of the three dimensions with the wording of each benchmark including a practice, a core idea and a cross-cutting concept. Benchmarks will include statements of emphasis and/or examples that will aid, but not limit curriculum and instruction.
4. The benchmarks for grades K-5 will include core ideas from physical science, life science, and earth and space science at each grade. The grade level assignment of benchmarks will consider the grade level placement in the 2009 standards and also place a priority on the progression of learning of the concepts.
5. Benchmarks for grades 6-8 will primarily have core ideas from earth science at grade 6, life science at grade 7, and physical science at grade 8. This is a change from the first draft. See the rationale below*
6. Benchmarks for grades 9 – 12 will be organized by chemistry, earth and space science, life science and physics. The benchmarks will be sufficient to support one credit courses. As such, chemistry benchmarks will be added.
7. The contributions of American Indian Communities and tribes will be included in standards and benchmarks.
8. Computer Science and technology skills and concepts are embedded in both the practices and the examples. They are highlighted with ** in the document.
9. The format of the benchmarks will make the progression of core ideas easier to track, which resulted in a table format.
10. Full attention to consistency of wording and grain-size will be difficult to accomplish on the second draft and will be perfected for the final draft.
11. There will need to have further work on grade level assignments in K-5 to improve the progression to middle school and there may be further adjustment between middle school and high school core ideas.

*Rationale for the middle school sequence

- The feedback from the first draft advocated for strong high school Earth and Space Standards and the desire to provide for high school earth science courses
- By moving many of the physical science core ideas from high school to eighth grade, students are prepared to take full high school level courses in chemistry, earth and space science, life science, and/or physics. (Graduation Requirements call for 1 credit of biology, 1 credit of chemistry or physics and 1 elective credit. "The combination of credits… must be sufficient to satisfy all the academic standards in chemistry or physics and all other academic standards in science.")
- Providing physical science at 8th grade aligns with algebra oriented 8th grade mathematics standards.
- This sequence provides smoother learning progressions in core ideas from elementary through middle to high school.

- This sequence recognizes the lack of availability of laboratory equipment, facilities, and safety equipment for chemical and physics experimentation in many 6th grade classrooms.

It is important to note that the standards and benchmarks do not direct or imply a particular combination of Practices, Crosscutting Concepts and Core Ideas that should be taught together. Instruction and curriculum about a core idea should utilize multiple practices and crosscutting concepts, which are woven together to help students understand the core idea and gain proficiency in engaging in practices and using the crosscutting concepts. It is likely that coherent curriculum units will target combinations of benchmarks, rather than single benchmarks.

Reviewing the Second Draft

In reviewing and providing feedback, the following questions should be kept in mind:

1. How well will the standards and benchmarks encourage improved science and engineering teaching and learning?

2. How well does the sequence of practices and core ideas from grade to grade provide student learning?

3. How well do the standards and benchmarks balance broadness and specificity, particularly in light of the Framework's goal to shift science education to greater coherence?

Note: The committee's primary goals for the second draft are to attend to learning progressions in practices and core ideas, incorporate the required components of standards and benchmarks, and develop a good sequence between middle school and high school, and begin the inclusion of examples. The committee recognized that there are issues of consistency of grain size and wording of benchmarks and examples that need to be improved for the third draft.

Standards

The standards and benchmarks are organized into four strands. Each substrand is a practice, which has one to three anchor standards. When the practice has a strong component of engineering, the second standard conveys the engineering idea.

* = related explicitly to engineering

Strand 1: Exploring phenomena or engineering problems

Substrand 1: 1.1 Asking questions and defining problems (Practice 1)

Standard 1: 1.1.1 Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's' ideas, and the information they read.

Standard 2: 1.1.2 Students will be able to ask questions to define a problem to be solved and to generate ideas that lead to the constraints and specifications of its solution.*

Substrand 2: 1.2Planning and carrying out investigations (Practice 3)

Standard 1: 1.2.1 Students will design and conduct investigations to test their ideas and questions and they'll organize and collect data to provide evidence to support claims they make about phenomena. Student investigations may occur in the classroom, laboratory or field.

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

Substrand 1: 1.3 Analyzing and interpreting data (Practice 4)

Standard 1: 2.1.1 Students will be able to represent observations and data in meaningful ways, including graphically and with mathematics, which emphasize patterns in the data and relationships among variables to communicate their evidence and their interpretations.

Substrand 2: 2.2 Using mathematics and computational thinking (Practice 5)

Standard 1: 2.2.1 Students will be able to use symbolic representations to represent data, to predict outcomes, and eventually derive further mathematical or algorithmic relationships that describe phenomena.

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

Substrand 1: 3.1 Developing and using models (Practice 2)

Standard 1: 3.1.1 Students will be able to develop, revise and use models to represent their understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate their ideas and findings to others.

Standard 2: 3.1.2. Students will be able to use engineering models to identify problems, design and test solutions, and communicate design features and effectiveness to others.*

Substrand 2: 3.2 Constructing explanations and designing solutions (Practice 6).

Standard 1: 3.2.1 Students will be able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.

Standard 2: 3.2.2 Students will be able to use their understanding of scientific principles and the engineering design process to either construct a device or implement a design solution that meets agreed-on criteria and constraints.*

Standard 3: 3.2.3 Students will be able to use and apply historical and current examples of Minnesota Anishinaabe and Dakota/Lakota knowledge systems to construct explanations of phenomena.

Note: Benchmarks associated with standard 3 are duplicates of benchmarks from other standards and carry the code of that standard.

Strand 4: Communicating reasons, arguments and ideas to others

Substrand 1: 4.1 Arguing from evidence (Practice 7)

Standard 1: 4.1.1. Students will be able to use evidence to compare and evaluate competing ideas and methods, answer questions, and engage in argumentation.

Standard 2: 4.1.2 Students will be able to use evidence to construct an argument and engage in argumentation to advance and define a design solution.

Substrand 2: 4.2 Obtaining, evaluating and communicating information (Practice 8):

Standard 1: 4.2.1 Students will be able to read, interpret and produce scientific text, use multiple sources to obtain information in order to evaluate the merit and validity of claims, and communicate information, ideas and evidence in a variety of formats.

Standard 2: 4.2.2 Students will be able to evaluate proposed engineering design solutions and communicate their critiques by using appropriate combinations of sketches, models, and language.*

Benchmarks

Code: Number = grade.strand.practice.standard.benchmark
For example 5.4.3.2.1 = grade 5, strand 4, substrand 3, standard 2, benchmark 1

The references in parentheses at the end of the benchmark refers to the dimensions on page 3. P = Practice, CC = Crosscutting Concept, CI = Core Idea,

* = a standard or benchmark related to engineering
** = a standard or benchmark related to computer science

Elementary

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
K	1.1. Asking questions and defining problems (Practice 1)	1.1.1 Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's ideas, and the information they read.		0.1.1.1.1 Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.* (P: 1, CC: 2, CI: ESS3, ETS2) *Emphasis is on local forms of severe weather and should include examples of engineered solutions to severe weather.*	
K	1.2 Planning and carrying out investigation s (Practice 3)	1.2.1. Students will design and conduct investigations to test their ideas and questions and they'll organize and collect data to provide evidence to support claims they make about phenomena. Student investigations may occur in the classroom, laboratory or field.	0.1.2.1.1 Collect and organize observational data to determine the effect of sunlight on Earth's surface. (P: 3, CC 2, CI: PS3, ETS2) *Examples of Earth's surface could include sand, soil, rocks, and water. Data could be organized in pictographs or bar graphs.*		0.1.2.1.2 Make observations of plants and animals to compare the diversity of life in different habitats. (P: 3, CC:-, CI: LS4) *Emphasis is on the diversity of living things in each of a variety of different habitats and patterns across habitats.*

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
K	2.1 Analyzing and interpreting data (Practice 4)	2.1.1 Students will be able to represent observations and data in meaningful ways, including graphically and with mathematics, which emphasize patterns in the data and relationships among variables to communicate their evidence and their interpretations.	0.2.1.1.1 Analyze data to identify patterns and determine if a design solution works as intended to change the speed or direction of an object with a push or a pull. **(P: 4, CC: 2, CI: PS2) *Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object or a structure that would cause an object such as a marble or ball to turn.*	0.2.1.1.2 Use and share observations of local weather conditions to describe patterns over time. **(P: 4, CC: 1, CI: ESS2) *Examples of qualitative observations could include descriptions of the weather (such as sunny, cloudy, rainy, and warm); examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month. Examples of patterns could include that it is usually cooler in the morning than in the afternoon and that different months have different number of sunny days versus cloudy days in different months.*	0.2.1.1.3 Record and use observations to describe patterns of what plants and animals (including humans) need to survive.** (P: 4, CC: 1, CI: LS1) *Examples of patterns could include that animals need to take in food, but plants do not; different animals need different kinds of food; plants require light; and that all living things need water.*
K	2.2 Using mathematics and computational thinking (Practice 5)	2.2.1 Students will be able to use symbolic representations that can be used to represent data, to predict outcomes, and eventually derive further mathematical or algorithmic relationships that describe or model phenomena.	0.2.1.1 Use counting and numbers to identify and describe patterns that emerge from the effects of different strengths or different directions of pushes and pulls on the motion of an object. **(P: 5, CC: 2, CI: PS2) *Examples could include an unbalanced force on one side of a ball can make it start moving; and balanced forces pushing on a box from both sides will not produce any motion at all.*		

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
K	3.1 Developing and using models (Practice 2)	3.1.1 Students will be able to develop, revise and use models to represent their understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate their ideas and findings to others.		0.3.2.1.1 Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live. (P: 2, CC: 4, CI: ESS3) *Examples of relationships could include that deer eat buds and leaves, therefore, they usually live in forested areas; and grasses need sunlight, so they often grow in meadows. Examples of models may include food chains, collages, and/or sorting.*	
K	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.2 Students will be able to use their understanding of scientific principles and the engineering design process to either construct a device or implement a design solution that meets agreed-on criteria and constraints.*	0.3.2.2.1 Use tools and materials provided to develop plans, design, and build a structure to reduce the warming effect of sunlight on Earth's surface.* (P: 6, CC: 2, CI: PS3, ETS1) *Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the sun.*		

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
K	4.1 Engaging in Arguing from evidence (Practice 7)	4.1.1 Students will be able to use evidence to engage in argumentation to compare and evaluate competing ideas and methods, and to answer questions.	0.4.1.1.1 Use evidence to support an argument that the gravitational force exerted by Earth on objects is directed down. (P: 7, CC: 2, CI: PS2) Emphasis is on *"down" as a local description of the direction that points toward the center of the spherical Earth.*		
K	4.2 Obtaining, evaluating and communicating information (Practice 8)	4.2.2 Students will be able to evaluate proposed engineering design solutions and communicate their critiques by using appropriate combinations of sketches, models, and language.*	0.4.2.2.1 Communicate design ideas for a structure that reduces the warming effect of sunlight on Earth's surface using oral and/or written forms.* (P: 8, CC: 2, CI: PS3, ETS1) *Examples of written forms include models, drawings, writing, or numbers.*		
1	1.1 Asking questions and defining problems (Practice 1)	1.1.1 Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's ideas, and the information they read.			1.1.1.1.1 Ask questions based on observations to find more information about the similarities and differences between young plants and animals and their parents (P: 1, CC: 2, CI: LS3) *Examples of observations could include leaves from the same kind of plant are the same shape but can differ in size; and a particular breed of dog looks like its parents but is not exactly the same.*

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
1	1.2 Planning and carrying out investigations (Practice 3)	1.2.1 Students will design and conduct investigations to test their ideas and questions and they'll organize and collect data to provide evidence to support claims they make about phenomena. Student investigations may occur in the classroom, laboratory or field.	1.1.2.1.1 Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate. (P: 3, CC: 2, CI: PS4) *Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.*		
1	2.1 Analyzing and interpreting data (Practice 4)	2.1.1 Students will be able to represent observations and data in meaningful ways, including graphically and with mathematics, which emphasize patterns in the data and relationships among variables to communicate their evidence and their interpretations.	1.2.1.1.1 Identify and describe patterns in data obtained from testing different materials and determine which materials have the properties that are best suited for the intended purpose.* (P: 4, CC: 2, CI: PS1, ETS2) *Examples of properties could include, strength, flexibility, hardness, texture, and absorbency.*		

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1	2.2 Using mathematics and computation al thinking (Practice 5)	2.2.1 Students will be able to use symbolic representations to represent data, to predict outcomes, and eventually derive further mathematical or algorithmic relationships that describe or model phenomena.		1.2.2.1.1 Use counting and numbers presented in various visual formats to identify and describe patterns in Earth events and determine whether they occur quickly or slowly. ** (P: 5, CC: 7, CI: ESS1) *Examples of events include volcanic explosions and earthquakes, which happen quickly, and erosion of rocks, which occurs slowly. Various visual formats can include pictographs, bar graphs, and pie charts.*	
1	3.1 Developing and using models (Practice 2)	3.1.1 Students will be able to develop, revise and use models to represent their understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate their ideas and findings to others.			1.3.1.1.1 Develop a simple model based on evidence to represent how plants and/or animals use their external parts to help them survive, grow, and meet their needs. (P: 2, CC: 6, CI: LS1) *Examples of external parts could include acorn shells, plant roots, and thorns on branches, turtle shells, animal scales, animal tails, and animal quills.*

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
1	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.2 Students will be able to use their understanding of scientific principles and the engineering design process to either construct a device or implement a design solution that meets agreed-on criteria and constraints.*	1.3.2.2.1 Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.* (P: 6, CC: -, CI: PS4, ETS1, ETS2) *Examples of devices could include paper cup and string "telephones" and a pattern of drum beats.*		1.3.2.2.2 Use materials to plan and design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.* (P: 6, CC: 6, CI: LS1, ETS2) *Examples of human problems that can be solved by mimicking plant or animal solutions could include designing clothing or equipment to protect bicyclists by mimicking turtle shells, acorn shells, and animal scales; stabilizing structures by mimicking animal tails and roots on plants; keeping out intruders by mimicking thorns on branches and animal quills; and detecting intruders by mimicking eyes and ears.*

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
1	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.3 Students will be able to use and apply historical and current examples of Minnesota Anishinaabe and Dakota/Lakota knowledge systems to construct explanations of phenomena. Note: these benchmarks are duplicates of other locations and carry that code.	1.4.2.1.1 Communicate solutions that use materials to meet a human want or need that were developed and used by Minnesota American Indian tribes and communities. (P: 8, CC: 2, CI: PS1, ETS2) *Examples could include birch bark baskets, moss used for insulation, and tools used for ricing.*		
1	4.1 Engaging in Arguing from evidence (Practice 7)	4.1.1. Students will be able to use evidence to compare and evaluate competing ideas and methods, answer questions, and engage in argumentation.		1.4.1.1.1 Construct an argument based on observational evidence for how plants and animals (including humans) can change the non-living aspects of the environment to meet their needs. (P: 7, CC: 4, CI: ESS2) *Examples of plants and animals changing their environment could include a squirrel digging in the ground to hide its food and tree roots breaking concrete.*	

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
1	4.1 Engaging in Arguing from evidence (Practice 7)	4.1.2 Students will be able to use evidence to construct an argument and engage in argumentation to advance and define a design solution.*		1.4.1.2.1 Construct an argument with evidence to evaluate multiple solutions designed to slow or prevent wind or water from changing the shape of the land. (P: 7, CC: 7, CI: ESS2, ETS2) *Examples of solutions could include different designs of dikes and windbreaks to hold back wind and water; and different designs for using shrubs, grass, and trees to hold back the land.*	
1	4.2 Obtaining, evaluating and communicating information (Practice 8)	4.2.1 Students will be able to read, interpret and produce scientific text, use multiple sources to obtain information in order to evaluate the merit and validity of claims, and communicate information, ideas and evidence in a variety of formats.	1.4.2.1.1 Communicate solutions that use materials to meet a human want or need that were developed and used by Minnesota American Indian tribes and communities. (P: 8, CC: 2, CI: PS1, ETS2) *Examples could include birch bark baskets, moss used for insulation, and tools used for ricing.*	1.4.2.1.2 Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.* (P: 8, CC: 2, CI: ESS3) *Examples of human impact on the land could include cutting trees to produce paper, using resources to produce bottles, and using water for bathing and brushing teeth. Examples of solutions could include reusing paper and recycling cans and bottles.*	1.4.2.1.3 Read texts and use media to determine patterns in the behavior of parents and offspring that help offspring survive. (P: 8, CC: 1, CI: LS1) *Examples of behavior patterns could include the signals that offspring make (such as crying, chirping, and other vocalizations) and the responses of the parents (such as feeding, comforting, and protecting the offspring).*

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
2	1.1 Asking questions and defining problems (Practice 1)	1.1.1 Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's ideas, and the information they read.	2.1.1.1.1 Ask and/or identify questions about an object's motion that can be answered by an investigation. (P: 1, CC:1, CI: PS2) *Examples could include an unbalanced force on one side of a ball can make it start moving; and balanced forces pushing on a box from both sides will not produce any motion at all.*		
2	1.2 Planning and carrying out investigation s (Practice 3)	1.2.1 Students will design and conduct investigations to test their ideas and questions and they'll organize and collect data to provide evidence to support claims they make about phenomena. Student investigations may occur in the classroom, laboratory or field.	2.1.2.1.1 Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties. (P: 3, CC:1, CI: PS1) *Observations could include color, texture, hardness, and flexibility.*		2.1.2.1.2 Plan and conduct an investigation to determine if plants need sunlight and water to grow. (P: 3, CC:2, CI: LS2)

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
2	2.1 Analyzing and interpreting data (Practice 4)	2.1.1 Students will be able to represent observations and data in meaningful ways, including graphically and with mathematics, which emphasize patterns in the data and relationships among variables to communicate their evidence and their interpretations.		2.2.1.1.1 Represent data in tables and various visual formats to describe typical weather conditions expected during a particular season. **(P: 4, CC: 1, CI: ESS2) *Examples of data could include temperature, precipitation, and wind direction. Various visual formats can include pictographs, bar graphs, and pie charts.* -- 2.2.1.1.2 Analyze data from tests of two objects designed to reduce the impacts of a weather-related hazard and compare the strengths and weaknesses of how each performs.* (P: 4, CC: 2, CI: ESS3, ETS2) *Examples of design solutions to weather-related hazards could include barriers to prevent flooding or snow drifting, wind resistant roofs, and buildings that are able to withstand tornadoes.*	

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
2	2.2 Using mathematics and computational thinking (Practice 5)	2.2.1 Students will be able to use symbolic representations to represent data, to predict outcomes, and eventually derive further mathematical or algorithmic relationships that describe phenomena.	2.2.2.1.1 Use counting and numbers presented in various visual formats to identify and predict patterns of the effects of balanced and unbalanced forces on the motion of an object. ** (P: 5, CC:2, CI: PS2) *Examples could include an unbalanced force on one side of a ball can make it start moving; and balanced forces pushing on a box from both sides will not produce any motion at all. Various visual formats could include pictographs, bar graphs, and pie charts.*		
2	3.1 Developing and using models (Practice 2)	3.1.1 Students will be able to develop, revise and use models to represent their understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate their ideas and findings to others.	2.3.1.1.1 Develop a simple diagram or physical model to illustrate how some changes caused by heating or cooling can be reversed and some cannot. ** (P: 2, CC: 2, CI: PS1) *Examples of reversible changes could include materials such as water and butter at different temperatures. Examples of irreversible changes could include cooking an egg, freezing a plant leaf, and heating paper. Examples of diagrams could include a flow chart.*		

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
2	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.2 Students will be able to use their understanding of scientific principles and the engineering design process to either construct a device or implement a design solution that meets agreed-on criteria and constraints.*			2.3.2.2.1 Use tools and/or materials to design and/or build a device that mimics the function of a natural process.* (P: 6, CC: 6, CI: LS2, ETS1) *Examples could include seed dispersal by animals and pollination of plants.*
2	4.1 Engaging in Arguing from evidence (Practice 7)	4.1.1. Students will be able to use evidence to compare and evaluate competing ideas and methods, answer questions, and engage in argumentation.			2.4.1.1.1 Construct an argument with evidence that evaluates how in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all. (P: 7, CC: 2, CI: LS4, ETS2) *Habitats should include those found in Minnesota, such as a wetland, prairie, or garden. Examples of evidence could include needs and characteristics of the organisms and habitats involved. Emphasis is on the interdependence of parts of a system (organisms and their habitat).*

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
2	4.2 Obtaining, evaluating and communicating information (Practice 8)	4.2.1 Students will be able to read, interpret and produce scientific text, use multiple sources to obtain information in order to evaluate the merit and validity of claims, and communicate information, ideas and evidence in a variety of formats.		2.4.2.1.1 Obtain and synthesize information from multiple sources to identify where water is found on Earth and that it can be solid or liquid. (P: 8, CC: 2, CI: ESS2) *Examples could include liquid water in oceans, lakes, rivers, and ponds; and solid water in glaciers and polar ice caps.* --- 2.4.2.1.2 Obtain and synthesize information from multiple sources, including electronic sources, to describe climates in different regions of the world. ** (P: 8, CC: 1, CI: ESS2) *Emphasis is on the ranges of an area's typical weather conditions and the extent to which those conditions vary over years to centuries.*	

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
3	1.1 Asking questions and defining problems (Practice 1)	1.1.1 Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's ideas, and the information they read.	3.1.1.1.1 Ask questions based on observations to find more information about why objects in darkness can be seen only when illuminated. (P: 1, CC: 2, CI: PS4) *Examples of observations could include those made in a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight. Illumination could be from an external light source or by an object giving off its own light.*		
3	1.2 Planning and carrying out investigation s (Practice 3)	1.2.1 Students will design and conduct investigations to test their ideas and questions and they'll organize and collect data to provide evidence to support claims they make about phenomena. Student investigations may occur in the classroom, laboratory or field.	3.1.2.1 1 Plan and conduct investigations to determine the effect of placing objects made with different materials in the path of a beam of light. (P: 3, CC: 2, CI: PS4) *Emphasis is on conducting fair tests by controlling variables. Examples of materials could include those that are transparent (such as clear plastic), translucent (such as wax paper), opaque (such as cardboard), and reflective (such as a mirror).*		

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
3	2.1 Analyzing and interpreting data (Practice 4)	2.1.1 Students will be able to represent observations and data in meaningful ways, including graphically and with mathematics, which emphasize patterns in the data and relationships among variables to communicate their evidence and their interpretations.		3.2.1.1.1 Record and use observations of the sun, moon, and stars to describe patterns that can be predicted. ** (P: 4, CC: 2, CI: ESS1) *Examples of patterns could include that the sun and moon appear to rise in one part of the sky, move across the sky, and set; and stars other than our sun are visible at night but not during the day.*	
3	2.2 Using mathematics and computation al thinking (Practice 5)	2.2.1 Students will be able to use symbolic representations to represent data, to predict outcomes, and eventually derive further mathematical or algorithmic relationships that describe phenomena.		3.2.2.1.1 Organize and present collected data to identify and describe patterns in the amount of daylight in the different times of the year. ** (P: 5, CC: 1, CI: ESS1) *Emphasis is on relative comparisons of the amount of daylight in the winter to the amount in the spring or fall.*	

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
3	3.1 Developing and using models (Practice 2)	3.1.1 Students will be able to develop, revise and use models to represent their understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate their ideas and findings to others.	3.3.1.1.1 Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. (P: 2, CC: 2, CI: PS4)		3.3.1.1.2 Construct multiple models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death. (P: 2, CC: 1, CI: LS1) *Emphasis is on the pattern of changes organisms go through during their life. Models could include diagrams, drawings, physical models, or computer programs.*

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
3	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.1 Students will be able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.			3.3.2.1.1 Use evidence, including evidence from electronic sources, to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing. **(P: 6, CC: 2. CI: LS4) *Examples of cause and effect relationships could include plants with large thorns that may be less likely to be eaten by predators than plants with smaller thorns; and animals that have better camouflage coloration than other animals may be more likely to survive and therefore more likely to leave offspring. Examples of electronic sources could include reliable internet sources.*

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
3	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.2 Students will be able to use their understanding of scientific principles and the engineering design process to either construct a device or implement a design solution that meets agreed-on criteria and constraints.*	3.3.2.2.1 Generate and compare multiple solutions that use patterns to transfer information.* (P: 6, CC: 1, CI: PS4, ETS1) *Examples of solutions could include drums sending coded information through sound waves, using a grid of 1's and 0's representing black and white to send information about a picture, and using Morse code to send text.*	3.3.2.2.3 Construct an explanation of Minnesota America Indian tribes and communities use of patterns in stars to make predictions and plans. (P: 7, CC: 1, CI: ESS1)	3.3.2.2.2 Use tools and/or materials to design and build a device that mimics an organism's internal or external survival structure that includes specified criteria for success.* (P: 6, CC: 6, CI: LS1, ETS1) *Examples of survival structures could include acorn shells, plant roots, thorns on branches, turtle shells, animal scales, animal tails, animal quills, and eyes or ears.*
3	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.3 Students will be able to use and apply historical and current examples of Minnesota Anishinaabe and Dakota/Lakota knowledge systems to construct explanations of phenomena. Note: these benchmarks are duplicates of other locations and carry that code.		3.3.2.2.3 Construct an explanation of Minnesota America Indian tribes and communities use of patterns in stars to make predictions and plans. (P: 7, CC: 1, CI: ESS1)	
3	4.1 Engaging in Arguing from evidence (Practice 7)	4.1.1 Students will be able to use evidence to compare and evaluate competing ideas and methods, answer questions, and engage in argumentation.			3.4.1.1.2 Construct an argument that some animals form groups that help members survive. (P: 7, CC: 2, CI: LS2)

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
3	4.2 Obtaining, evaluating and communicating information (Practice 8)	4.2.1 Students will be able to read, interpret and produce scientific text, use multiple sources to obtain information in order to evaluate the merit and validity of claims, and communicate information, ideas and evidence in a variety of formats.			3.4.2.1.1 Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media to support an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction. ** (P: 8, CC: 4, CI: LS1) *Examples of structures could include thorns, stems, roots, colored petals, heart, stomach, lungs, brain, and skin.*

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
4	1.1 Asking questions and defining problems (Practice 1)	1.1.1 Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's ideas, and the information they read.	4.1.1.1.1 Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. (P: 1, CC: 2, CI: PS2) *Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paper clips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships could include how the distance between objects affects the strength of the force and how the orientation of magnets affects the direction of the magnetic force.*	4.1.1.1.2 Ask questions to describe how water moves through the Earth system. (P: 1, CC: 5, CI: ESS2) *Emphasis is on the processes of evaporation, condensation, and precipitation.*	

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
4	1.1 Asking questions and defining problems (Practice 1)	1.1.2 Students will be able to ask questions to define a problem to be solved and to generate ideas that lead to the constraints and specifications of its solution.*	4.1.1.2.1 Define a simple design problem that can be solved by applying scientific ideas about magnets.* (P: 1, CC: -, CI: PS2, ETS2) *Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other.*		
4	2.1 Analyzing and interpreting data (Practice 4)	2.1.1 Students will be able to represent observations and data in meaningful ways, including graphically and with mathematics, which emphasize patterns in the data and relationships among variables to communicate their evidence and their interpretations.			4.2.1.1.1 Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago. **(P: 4, CC: 3, CI: LS4) *Examples of data could include type, size, and distributions of fossil organisms. Examples of fossils and environments could include marine fossils found on dry land, tropical plant fossils found in Arctic areas, and fossils of extinct organisms.*

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
4	2.2 Using mathematics and computational thinking (Practice 5)	2.2.1 Students will be able to use symbolic representations to represent data, to predict outcomes, and eventually derive further mathematical or algorithmic relationships that describe phenomena.	4.2.2.1.1 Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved. (P: 5, CC: 3, CI: PS1) *Examples of reactions or changes could include phase changes, dissolving, and mixing to form new substances.*	4.2.2.1.2 Interpret charts and/or graphs of the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. ** (P: 5, CC: 3, CI: ESS2) *Emphasis is on oceans, lakes, rivers, glaciers, ground water, and polar ice caps. Not included is water in the atmosphere.*	

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
4	3.1 Developing and using models (Practice 2)	3.1.1 Students will be able to develop, revise and use models to represent their understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate their ideas and findings to others.	4.3.1.1 1 Construct and refine a model to describe that matter is made of particles too small to be seen. (P: 2, CC: 3, CI: PS1) *Examples of evidence supporting a model could include adding air to expand a basketball, compressing air in a syringe, dissolving sugar in water, and evaporating salt water.* --- 4.3.1.1.2 Use models to describe that energy in animals' food (used for body repair, growth, and motion and to maintain body warmth) was once energy from the sun. (P: 2, CC: 5, CI: PS3) *Examples of models could include diagrams, and flow charts.*	4.3.1.1.3 Develop a model to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact. (P: 2, CC: 4, CI: ESS2) *Emphasis is on how rock, living things, water, and/or air are individual systems that make up the larger Earth system and interact with each other.*	

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
4	3.1 Developing and using models (Practice 2)	3.1.2 Students will be able to use engineering models to identify problems, design and test solutions, and communicate design features and effectiveness to others.*	4.3.1.2.1 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. (P: 3, CC: 5, CI: PS3) -- 4.3.1.2.2 Make observations and measurements to identify materials based on their properties. (P: 3, CC: 3, CI: PS1) *Examples of materials to be identified could include baking soda and other powders, metals, minerals, and liquids. Examples of properties could include color, hardness, reflectivity, electrical conductivity, thermal conductivity, response to magnetic forces, and solubility; density is not intended as an identifiable property.* -- 4.3.1.2.3 Conduct an investigation to determine whether the mixing of two or more substances results in new substances. (P: 3, CC: 2, CI: PS1) *Emphasis is on conducting fair tests by controlling variables.*		

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
4	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.1 Students will be able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.		3.2.1.1 1 Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time. **(P: 6, CC: 1, CI: ESS1) *Examples of evidence from patterns could include rock layers with marine shell fossils above rock layers with plant fossils and no shells, indicating a change from land to water over time; and a canyon with different rock layers in the walls and a river in the bottom, indicating that over time a river cut through the rock.*	
4	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.2 Students will be able to use their understanding of scientific principles and the engineering design process to either construct a device or implement a design solution that meets agreed-on criteria and constraints.*	4.3.2.2 1 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.* (P: 6, CC: 5, CI: PS3, ETS1, ETS2) *Examples of devices could include electric circuits that convert electrical energy into kinetic energy of a moving vehicle, light, or sound; and a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.*		

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
4	4.1 Engaging in Arguing from evidence (Practice 7)	4.1.1. Students will be able to use evidence to compare and evaluate competing ideas and methods, answer questions, and engage in argumentation.			4.4.1.1.1 Use evidence to support an argument that traits can be influenced by different environments. (P: 7, CC: 2, CI: LS3) *Examples of the environment affecting a trait could include the stunted growth of a typically tall plant grown with insufficient water; and an overweight dog that has access to too much food and little exercise.*
4	4.2 Obtaining, evaluating and communicating information (Practice 8)	4.2.1 Students will be able to read, interpret and produce scientific text, use multiple sources to obtain information in order to evaluate the merit and validity of claims, and communicate information, ideas and evidence in a variety of formats.			4.4.2.1.1 Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media to determine that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms. ** (P: 8, CC: 1, CI: LS3) *Emphasis is on organisms other than humans and the patterns in traits between offspring and their parents or among siblings.*

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
5	1.1 Asking questions and defining problems (Practice 1)	1.1.1 Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's ideas, and the information they read.	5.1.1.1.1 Ask questions and predict outcomes about the changes in energy, related to speed, that occur when objects interact. (P: 1, CC: 5, CI: PS3) *Emphasis is on the change in energy due to a change in speed, not on the forces, as objects interact. Example: Where and how do marbles move after a collision?*		

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
5	1.2 Planning and carrying out investigations (Practice 3)	1.2.1 Students will design and conduct investigations to test their ideas and questions and they'll organize and collect data to provide evidence to support claims they make about phenomena. Student investigations may occur in the classroom, laboratory or field.		5.1.2.1.1 Create a computing program or investigation to provide evidence of the effects of weathering or the rate of erosion by the forces of water, ice, wind, or vegetation. **(P: 3, CC: 2, CI: ESS2) *Emphasis is on predicting the rate of change when variables are changed. Examples of variables to test could include angle of slope in the downhill movement of water, amount of vegetation, speed of wind, relative rate of deposition, cycles of freezing and thawing of water, cycles of heating and cooling, and volume of water flow.* --- 5.1.2.1.2 Plan and carry out fair tests in which variables are controlled and failure points are considered and used to improve a model or prototype to prevent erosion.* (P: 3, CC: -, CI: ESS2, ETS1; ETS2) *Examples of prototypes to prevent erosion include retaining walls, wind breaks, use of shrubs or other vegetation, and drainage systems.*	

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
5	2.1 Analyzing and interpreting data (Practice 4)	2.1.1 Students will be able to represent observations and data in meaningful ways, including graphically and with mathematics, which emphasize patterns in the data and relationships among variables to communicate their evidence and their interpretations.		5.2.1.1.1 Analyze and interpret data from maps to describe patterns of Earth's features. **(P: 4, CC: 1, CI: ESS2) *Examples of maps can include topographic maps of Earth's land (including Minnesota) and ocean floor, as well as maps of the locations of mountains, continental boundaries, volcanoes, and earthquakes.*	
5	2.2 Using mathematics and computational thinking (Practice 5)	2.2.1 Students will be able to use symbolic representations to represent data, to predict outcomes, and eventually derive further mathematical or algorithmic relationships that describe phenomena.		5.2.2.1.1 Use data to describe patterns in the daily changes in length and direction of shadows, day and night and the seasonal appearance of some stars in the night sky. ** (P: 5, CC: 1, CI: ESS1) *Examples of patterns could include the position and motion of Earth with respect to the sun, and selected stars that are visible only in particular months.*	

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
5	3.1 Developing and using models (Practice 2)	3.1.1 Students will be able to develop, revise and use models to represent their understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate their ideas and findings to others.			5.3.1.1.1 Construct a model to predict the movement of matter among plants, animals, decomposers, and the environment. (P: 2, CC: 4, CI: LS2) *Emphasis is on the idea that matter that is not food (air, water, decomposed materials in soil) is changed by plants into matter that is food. Examples of systems could include organisms, ecosystems, and the Earth.*
5	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.1 Students will be able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.	5.3.2.1.1 Use evidence to construct an explanation relating the speed of an object to the energy of that object. (P: 6, CC: 5, CI: PS3).		

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
5	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.2 Students will be able to use their understanding of scientific principles and the engineering design process to either construct a device or implement a design solution that meets agreed-on criteria and constraints.*		5.3.2.2.1 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.* (P: 6, CC: 2, CI: ESS3, ETS2) *Examples of solutions could include designing an earthquake resistant building and improving monitoring of volcanic activity.*	
5	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.3 Students will be able to use and apply historical and current examples of Minnesota Anishinaabe and Dakota/Lakota knowledge systems to construct explanations of phenomena. Note: these benchmarks are duplicates of other locations and carry that code.		5.4.2.1.2 Obtain and combine multiple sources of information about ways individual communities, including Minnesota American Indian tribes and communities, use science ideas to protect the Earth's resources and environment. (P: 8, CC: 4, CI: ESS3)	
5	4.1 Engaging in Arguing from evidence (Practice 7)	4.1.1. Students will be able to use evidence to compare and evaluate competing ideas and methods, answer questions, and engage in argumentation.		5.4.1.1.1 Use evidence to support an argument that the apparent brightness of the sun and stars is due to their relative distances from Earth. (P: 7, CC: 3, CI: ESS1)	5.4.1.1.2 Use observational evidence to support an argument that plants get the materials they need for growth chiefly from air and water. (P: 7, CC: 5, CI: LS1)

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
5	4.1 Engaging in Arguing from evidence (Practice 7)	4.1.2 Students will be able to use evidence to construct an argument and engage in argumentation to advance and define a design solution.*			5.4.1.2.1 Using evidence and considering design criteria and constraints, make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.* (P: 7, CC: 4, CI: LS2, ETS1) *Examples of environmental changes could include changes in land characteristics, water distribution, temperature, food, and other organisms.*

Grade	Substrand	Anchor Standard	Physical Science Benchmarks	Earth and Space Science Benchmarks	Life Science Benchmarks
5	4.2 Obtaining, evaluating and communicating information (Practice 8)	4.2.1 Students will be able to read, interpret and produce scientific text, use multiple sources to obtain information in order to evaluate the merit and validity of claims, and communicate information, ideas and evidence in a variety of formats.		5.4.2.1.1 Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment. (P: 8, CC: 2, CI: ESS3, ETS2) *Information about natural resources should include details about those found in Minnesota. Examples of renewable energy resources could include wind, water behind dams, and sunlight; non-renewable energy resources include fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning fossil fuels.* -- 5.4.2.1.2 Obtain and combine multiple sources of information about ways individual communities, including Minnesota American Indian tribes and communities, use science ideas to protect the Earth's resources and environment. (P: 8, CC: 4, CI: ESS3)	

6th Grade

Grade	Substrand	Anchor Standard	Earth's Place in the Universe	Earth's Systems and Processes	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
6	1.1 Asking questions and defining problems (Practice 1)	1.1.1 Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's ideas, and the information they read.	6.1.1.1.1 Ask questions that arise from observations of patterns in the movement of night sky objects to test the limitation of a solar system model. (P:1, CC:1, CI:ESS1) *Emphasis is on students questioning the limitations of their own models and questioning the kinds of revisions needed to account for new data. Examples of observations may include student observations or observations made by others.* ------------------------ 6.1.1.1.2 Ask questions to challenge an interpretation about the relative ages of different rock layers within a sequence of several rock layers. (P:1, CC:1, CI: ESS1) *Emphasis is on the interpretation of rock layers using the principles of superposition and cross-cutting relationships*.		6.1.1.1.3 Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century. (P: 1, CC: 7, CI: ESS3) *Emphasis is on the major role that human activities play in causing the rise in global temperatures. Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities.*	

Grade	Substrand	Anchor Standard	Earth's Place in the Universe	Earth's Systems and Processes	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
6	1.2 Planning and carrying out investigations (Practice 3)	1.2.1 Students will design and conduct investigations to test their ideas and questions and they'll organize and collect data to provide evidence to support claims they make about phenomena. Student investigations may occur in the classroom, laboratory or field.			6.1.2.1.1 Collect data and use digital data analysis tools to identify patterns to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions. **(P: 3, CC: 2, CI: ESS2) *Emphasis is on how weather at a fixed location changes in response to moving air masses and to interactions at frontal boundaries between air masses. Examples of weather data may include temperature, air pressure, precipitation, and wind. Examples of data may include weather maps, diagrams, and visualizations or may be obtained through laboratory experiments (such as with condensation).*	

Grade	Substrand	Anchor Standard	Earth's Place in the Universe	Earth's Systems and Processes	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
6	2.1 Analyzing and interpreting data (Practice 4)	2.1.1 Students will be able to represent observations and data in meaningful ways, including graphically and with mathematics, which emphasize patterns in the data and relationships among variables to communicate their evidence and their interpretations.	6.2.1.1.1 Analyze and interpret data to determine similarities and differences of features and processes occurring on solar system objects. (P: 4, CC: 3, CI: ESS1) *Emphasis is on data from Earth-based instruments, space-based telescopes, or spacecraft. Example features may include characteristics of an object's atmosphere, surface or interior. Example processes may include erosion, deposition, cratering, or volcanism.* ----------------------------------- 6.2.1.1.2 Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions. (P: 4, CC: 1, CI: ESS2) *Examples of data may include similarities of rock and fossil types on different continents, the shapes of the continents (including the continental shelves), and the locations of ocean structures such as ridges and trenches.*			6.2.1.1.3 Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. (P: 4, CC: 1, CI: ESS3, ETS2) *Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards may be taken from interior processes (such as earthquakes and*

Grade	Substrand	Anchor Standard	Earth's Place in the Universe	Earth's Systems and Processes	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
						volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data may include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies may be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).

Grade	Substrand	Anchor Standard	Earth's Place in the Universe	Earth's Systems and Processes	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
6	3.1 Developing and using models (Practice 2)	3.1.1 Students will be able to develop, revise and use models to represent their understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate their ideas and findings to others.	6.3.1.1.1 Develop and revise a series of models, including those used by Minnesota American Indian tribes and communities, to explain how motion in the Earth-sun-Moon system causes the cyclic patterns of lunar phases, eclipses and seasons. (P: 2, CC: 1, CI: ESS1) *Emphasis is on physical, graphical or conceptual models that are revised over time to account for new observations.* ----------------------------------- 6.3.1.1.2 Create a scale model of solar system objects to describe sizes and locations of the objects as well as the role that gravity and inertia play in their orbital motion. (P: 2, CC: 4, CI: ESS1) *Emphasis is on the regularity of the motion and accounting for Earth-based visual observations of the motion of these objects in our sky. Examples may include physical models (such as the analogy of distance along a football field or computer visualizations of orbits) or conceptual models (such as mathematical proportions relative to the size of familiar objects such as students' school*	6.3.1.1.3 Develop a model to describe the cycling and movement of Earth's rock material and the energy that drives these processes. (P: 2, CC: 7, CI: ESS2) *Emphasis is on the processes of melting, crystallization, weathering, erosion, deposition and deformation, which act together to form minerals and rocks as Earth's materials have been recycled throughout geologic time.* ------------------------- 6.3.1.1.4 Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force		

Grade	Substrand	Anchor Standard	Earth's Place in the Universe	Earth's Systems and Processes	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
			or state). Not included are Kepler's Laws and retrograde motion of planets.	of gravity. (P: 2, CC: 5, CI: ESS2) *Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Modeling emphasis is on representing unobservable mechanisms of water changing state. Examples of models can be conceptual or physical.*		

Grade	Substrand	Anchor Standard	Earth's Place in the Universe	Earth's Systems and Processes	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
6	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.1 Students will be able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.	6.3.2.1.1 Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. (P: 6, CC: 3, CI: ESS1) *Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of major events may include the evolution or extinction of particular organisms, the formation of mountain chains and the formation of ocean basins.* ------------------------ 6.3.2.1.2 Construct explanatory flow charts based on evidence to show how the interactions among geoscience processes have changed Earth's surface at varying time and spatial scales. (P: 6, CC: 3, CI: ESS2) *Emphasis is on how processes like erosion, deposition, mountain building, and volcanism affect the surface of Earth. Some processes, like mountain building take a long time. Others happen quickly like a landslide. Examples may include how weathering, erosion and glacial activity have shaped the surface of Minnesota.*	6.3.2.1.3 Construct a scientific explanation based on evidence for how the uneven distribution of Earth's mineral, energy, or groundwater resources are the result of past geological processes. (P: 6, CC: 2, CI: ESS3) *Emphasis is on how these resources are limited and typically non-renewable on a human timeframe. Emphasis is also on how the distribution of these resources are changing significantly as a result of removal by humans. Examples of uneven distribution of resources may include petroleum*		6.3.2.1.4 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* (P: 6, CC: 2, CI: ESS3, ETS1) *Emphasis is on the iterative nature of the engineering design process. Examples of the design process may include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce those impacts. Examples of human impacts may include water usage (such as the withdrawal of water from streams and aquifers), land*

Grade	Substrand	Anchor Standard	Earth's Place in the Universe	Earth's Systems and Processes	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
				(like in the North Dakota Bakken Shale), metal ores (like iron in the rocks of Minnesota's Iron Range), or groundwater in the different regions of Minnesota.		*usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).*
6	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.3 Students will be able to use and apply historical and current examples of Minnesota Anishinaabe and Dakota/Lakota knowledge systems to construct explanations of phenomena. Note: these benchmarks are duplicates of other locations and carry that code.	6.3.1.1.1 Develop and revise a series of models, including those used by Minnesota American Indian tribes and communities, to explain how motion in the Earth-sun-Moon system causes the cyclic patterns of lunar phases, eclipses and seasons. (P: 2, CC: 1, CI: ESS1) *Emphasis is on physical, graphical or conceptual models that are revised over time to account for new observations.*			

7th Grade

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
7	1.1 Asking questions and defining problems (Practice 1)	1.1.1 Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's ideas, and the information they read.			7.1.1.1.1 Asking questions that arise from careful observations of phenomena, or models to clarify and or seek additional information about how changes in genes can affect proteins; Examples of changes may include neutral, harmful, or beneficial effects to the structure and function of the organism. P: 1, CC: 6, CI: LS3)	
7	1.1 Asking questions and defining problems (Practice 1)	1.1.2 Students will be able to ask questions to define a problem to be solved and to generate ideas that lead to the constraints and specifications of its solution.*	7.1.1.2.1 Construct a device that simulates how the sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. (P: 8, CC: 2, CI: LS1, ETS2) *Examples may include disorders caused by dysfunctional sensory receptors: Alzheimer's, autism, paralysis- nervous systems disorders.*			

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
7	1.2 Planning and carrying out investigations (Practice 3)	1.2.1 Students will design and conduct investigations to test their ideas and questions and they'll organize and collect data to provide evidence to support claims they make about phenomena. Student investigations may occur in the classroom, laboratory or field.	7.1.2.1.1 Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. (P: 3, CC: 3, CI: LS1) *Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living things, and understanding that living things may be made of one cell or many and varied cells*			

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
7	2.1 Analyzing and interpreting data (Practice 4)	2.1.1 Students will be able to represent observations and data in meaningful ways, including graphically and with mathematics, which emphasize patterns in the data and relationships among variables to communicate their evidence and their interpretations.		7.2.1.1.1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. **(P: 4, CC: 2, CI: LS2) *Examples may include populations of MN deer, moose, wolf, scavengers or aquatic populations in Lake Superior or algal blooms in lakes and ponds Emphasis is on cause and effect relationships between resources and growth of individual organisms and the number or organisms in ecosystems during periods of abundant and scarce resources.*		7.2.1.1.2 Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. **(P: 4, CC: 1, CI: LS4) *Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers)* ---------------------------------- 7.2.1.1.3 Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy. ** (P: 4, CC: 1, CI: LS4) *Emphasis is on inferring general patterns of relatedness among*

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
				Flow charts to organize and sequence the algorithm may be used to demonstrate the relationships.		*embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures*
7	2.2 Using mathematics and computational thinking (Practice 5)	2.2.1 Students will be able to use symbolic representations to represent data, to predict outcomes, and eventually derive further mathematical or algorithmic relationships that describe phenomena.				

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
7	3.1 Developing and using models (Practice 2)	3.1.1 Students will be able to develop, revise and use models to represent their understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate their ideas and findings to others.	7.3.1.1.1 Develop and use a model to describe the function of a cell as a whole and describe the way cell parts contribute to the cell's function_(P: 2, CC: 6, CI: LS1) *Emphasis is on the cell functioning as a whole system and the primary role of identified parts of the cell, specifically the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.* ---------------------------------- 7.3.1.1.2 Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. (P: 2, CC: 5, CI: LS1) *Emphasis is on describing that molecules are broken apart and put back together and that in this process, energy is released.*	7.3.1.1.3 Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem. (P: 2, CC: 5, CI: LS2) *Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems.*	7.3.1.1.4 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation. (P: 2, CC: 2, CI: LS3) *Emphasis is on using models, such as Punnett squares, diagrams, and simulations to describe the cause and effect relationship of gene transmission from parent(s) to offspring and resulting genetic variations.*	

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
7	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.1 Students will be able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.	7.3.2.1.2	7.3.2.1.3 Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. (P: 6, CC: 1, CI: LS2, EST2) Examples can include spraying for mosquitos, antibacterial soaps, and antibiotic resistance bacteria. *Emphasis is on predicting consistent patterns of interactions in different ecosystems in different ecosystems in terms of the relationships among and between organisms and abiotic components of ecosystems.*		7.3.2.1.4 Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. (P: 6, CC: 1, CI: LS4) *Emphasis is on explanations of the evolutionary relationships among organisms in terms of similarity of differences of the gross appearance of anatomical structures.* ---------------------------------- 7.3.2.1.5 Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. (P: 6, CC: 2, CI: LS4) *Emphasis is on using simple probability statements and proportional reasoning to construct explanations.*

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
			Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. (P: 6, CC: 2, CI: LS1) *Emphasis is on tracing movement of matter and flow of energy.*	*Examples may include types of interactions such as competitive, predatory and mutually beneficial.*		
7	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.2 Students will be able to use their understanding of scientific principles and the engineering design process to either construct a device or implement a design solution that meets agreed-on criteria and constraints.	7.3.2.2.1 Construct a device that simulates how the sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories. (P: 8, CC: 2, CI: LS1, ETS2) *Examples may include disorders caused by dysfunctional sensory receptors: Alzheimer's, autism, paralysis- nervous systems disorders.*			

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
7	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.3 Students will be able to use and apply historical and current examples of Minnesota Anishinaabe and Dakota/Lakota knowledge systems to construct explanations of phenomena. Note: these benchmarks are duplicates of other locations and carry that code.				-------------------------------- 7.4.2.1.1 Gather and synthesize information about the present and historical technologies used by various human groups, including MN American Indian tribes, including the collaboration and connectivity these tools provide, that have changed the way humans influence the inheritance of desired traits in organisms. (P: 8, CC: 2, CI: LS4. ETS2)

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
7	4.1 Arguing from evidence (Practice 7)	4.1.1. Students will be able to use evidence to compare and evaluate competing ideas and methods, answer questions, and engage in argumentation.	7.4.1.1.1 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells. (P: 7, CC: 4, CI: LS1) *Emphasis is on the conceptual understanding that cells form tissues and tissues form organs specialized for particular body functions. Examples may include the interaction of subsystems within a system and the normal functioning of those systems.* ----------------------------------- 7.4.1.1.2 Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. (P: 7, CC: 2, CI: LS1) *Examples of behaviors that affect the probability of animal reproduction may include nest building to protect young herding of animals to protect young from predators, and vocalization of animal s and colorful plumage to attract mates for breeding.*			

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
7	4.1 Arguing from evidence (Practice 7)	4.1.2 Students will be able to use evidence to construct an argument and engage in argumentation to advance and define a design solution.*		7.4.1.2.1 Define a problem and evaluate competing design solutions for maintaining biodiversity and ecosystem services.* (P: 7, CC: 2, CI: LS2,EST2) *Examples of ecosystem services may include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints may include scientific, economic, and social considerations*. ------------------------ 7.4.1.2.2 Construct an argument supported by empirical evidence or a designed solution that changes		

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
				physical or biological components of an ecosystem that affect populations.(P: 7, CC: 7, CI: LS2) *Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes and/or impacts to ecosystems*		

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
7	4.2 Obtaining, evaluating and communicating information (Practice 8)	4.2.1 Students will be able to read, interpret and produce scientific text, use multiple sources to obtain information in order to evaluate the merit and validity of claims, and communicate information, ideas and evidence in a variety of formats.				7.4.2.1.1 Gather and synthesize information about the present and historical technologies used by various human groups, including MN American Indian tribes, including the collaboration and connectivity these tools provide, that have changed the way humans influence the inheritance of desired traits in organisms. (P: 8, CC: 2, CI: LS4. ETS2) *Emphasis is on synthesizing information from reliable sources about the influence of humans on genetic outcomes.* *Examples may include the influence of humans on genetic outcomes in artificial selection include genetic modification, animal breeding, gene therapy, The impact of these technologies have on society as well as the technologies leading to these scientific discoveries may also be included.*

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
7	4.2 Obtaining, evaluating and communicating information (Practice 8)	4.2.2 Students will be able to evaluate proposed engineering design solutions and communicate their critiques by using appropriate combinations of sketches, models, and language.*		7.4.2.2.1 Evaluate competing design solutions for maintaining biodiversity and ecosystem services.* (P: 7, CC: 2, CI: LS2, EST2) *Examples of ecosystem services may include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.*		

8th Grade

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
8	1.1 Asking questions and defining problems (Practice 1)	1.1.1 Students will be able to ask questions about questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's' ideas, and the information they read.		8.1.1.1.1 Ask questions about variables to determine the factors that affect the strength of electric and magnetic forces. (P: 1, CC: 2, CI: PS2) *Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators.* *Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.*		

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
8	1.2 Planning and carrying out investigations (Practice 3)	1.2.1 Students will design and conduct investigations to test their ideas and questions and they'll organize and collect data to provide evidence to support claims they make about phenomena. Student investigations may occur in the classroom, laboratory or field.		8.1.2.1.1 Plan an investigation to provide evidence that the change in an object's motion depends on the qualitative comparisons of balanced and unbalanced forces on the object and the mass of the object. (P: 3, CC: 7, CI: PS2) *Emphasis is on balanced (Newton's First Law) and unbalanced forces in one dimension in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law).* ---------------------------------- 8.1.2.1.2 Conduct an investigation and evaluate the experimental design to provide qualitative evidence that electric and magnetic fields exist between objects exerting forces on each other even though the	8.1.2.1.3 Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. (P: 3, CC: 3, CI: PS3) *Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the*	

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
				objects are not in contact(P: 3, CC: 2, CI: PS2) *Examples of this phenomenon could include the interactions of magnets, electrically-charged strips of tape, and electrically-charged pith balls.* *Examples of investigations could include first-hand experiences or simulations.*	*same material with different masses when a specific amount of energy is added.* *Not included is calculating the total amount of thermal energy transferred.* *Examples may include comparing water temperatures after different masses of ice melt, temperature changes of different materials with the same mass as they head or cool, in the environment, etc.*	

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
8	2.1 Analyzing and interpreting data (Practice 4)	2.1.1 Students will be able to represent observations and data in meaningful ways, including graphically and with mathematics, which emphasize patterns in the data and relationships among variables to communicate their evidence and their interpretations.	8.2.1.1.1 Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred. (P: 4, CC: 1, CI: PS1) *Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.* *Examples of properties could include density, melting point, boiling point, solubility, flammability, and odor.*		8.2.1.1.2 Construct and interpret graphical displays of data to describe the relationship of kinetic energy to the mass of an object and to the speed of an object. (P: 4, CC: 3, CI: PS3) *Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed.* *Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a Wiffle ball versus a tennis ball.*	

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
8	2.2 Using mathematics and computational thinking (Practice 5)	2.2.1 Students will be able to use symbolic representations to represent data, to predict outcomes, and eventually derive further mathematical or algorithmic relationships that describe phenomena.				8.2.2.1.1 Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave. (P: 5, CC: 1, CI: PS4) *Emphasis is on describing waves (standard repeating waves) with both qualitative and quantitative thinking. Not included is electromagnetic waves.*

8	3.1 Developing and using models (Practice 2)	3.1.1 Students will be able to develop, revise and use models to represent their understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate their ideas and findings to others.	8.3.1.1.1 Develop models to describe the atomic composition of simple molecules and extended structures. (P: 2, CC: 3, CI: PS1) *Emphasis is on developing models of molecules that vary in complexity.* *Examples of simple molecules could include ammonia and methanol.* *Examples of extended structures could include sodium chloride or diamonds.* *Does not include valence electrons and bonding energy, discussing the ionic nature of subunits of complex structures, or a complete description of all individual atoms in a complex molecule or extended structure is not required.* ---------------------------------- 8.3.1.1.2 Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. (P: 2, CC: 5, CI: PS1) *Emphasis is on law of conservation of matter and*		8.3.1.1.3 Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. (P: 2, CC: 2, CI: PS1) *Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs.* *Examples of models could include a storyboard/diagram that uses MN American Indian style of teaching through storytelling.* *Examples of particles could*	8.3.1.1.4 Develop and compare multiple models to describe that when the arrangement of two objects interacting (electric, magnetic, and gravitational) at a distance changes, different amounts of potential energy are stored in the system. (P: 2, CC: 6, CI: PS3) *Emphasis is on relative amounts of potential energy, not on calculations of potential energy.* *Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair.* *Examples of models could include representations, diagrams, pictures, and written descriptions of systems or a storyboard/diagram that uses MN American Indian style of teaching through storytelling.* ----------------------------------

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
			on physical models or drawings or a storyboard/diagram that uses MN American Indian style of teaching through storytelling, including digital forms, which represent atoms. *Not included are atomic masses, balancing symbolic equations, or intermolecular forces.*		*include molecules or inert atoms.*	8.3.1.1.5 Develop and use a model to describe, qualitatively, that waves are reflected, absorbed, or transmitted through various materials. (P: 2, CC: 4, CI: PS4) *Emphasis is on both light and mechanical waves.* *Examples of models could include drawings, simulations, a storyboard/diagram that uses MN American Indian style of teaching through storytelling, and written descriptions.*

8	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.2 Students will be able to use their understanding of scientific principles and the engineering design process to either construct a device or implement a design solution that meets agreed-on criteria and constraints.*	8.3.2.2.1 Design and iteratively develop a program to solve a problem involving the motion of two colliding objects using Newton's 3rd Law. ** (P: 6, CC: 4, CI: PS2) *Emphasis is on vertical or horizontal interactions in one dimension.* *Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.*	8.3.2.2.2 Design, construct, and test a device that either minimizes or maximizes thermal energy transfer.* (P: 6, CC: 5, CI: PS3) *Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup.* *Not included is calculating the total amount of thermal energy transferred.* ----------------------------------- 8.3.2.2.3 Construct, test and modify a device that either releases or absorbs thermal energy by chemical processes.* (P: 6, CC: 5, CI: PS1) *Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance while measuring the criteria of amount, time, and*		

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
				temperature of substance in testing the device. *Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride in water and measuring change in temperature.*		

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
8	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.3 Students will be able to use and apply historical and current examples of Minnesota Anishinaabe and Dakota/Lakota knowledge systems to construct explanations of phenomena. Note: these benchmarks are duplicates of other locations and carry that code.	8.3.1.1.2 Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved. (P: 2, CC: 5, CI: PS1) *Emphasis is on law of conservation of matter and on physical models or drawings or a storyboard/diagram that uses MN American Indian style of teaching through storytelling, including digital forms, which represent atoms.*		8.3.1.1.3 Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. (P: 2, CC: 2, CI: PS1) *Examples of models could include a storyboard/diagram that uses MN American Indian style of teaching through storytelling.*	8.3.1.1.4 Develop and compare multiple models to describe that when the arrangement of two objects interacting (electric, magnetic, and gravitational) at a distance changes, different amounts of potential energy are stored in the system. (P: 2, CC: 6, CI: PS3) *Examples of models could include representations, diagrams, pictures, and written descriptions of systems or a storyboard/diagram that uses MN American Indian style of teaching through storytelling.*

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
8	4.1 Arguing from evidence (Practice 7)	4.1.1 Students will be able to use evidence to compare and evaluate competing ideas and methods, answer questions, and engage in argumentation.	8.4.1.1.1 Collect data using computational tools and transmit the evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.** (P: 7, CC: 3, CI: PS2) *Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.* *Not included are Newton's Law of Gravitation or Kepler's Laws.*	8.4.1.1.2 Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. (P: 7, CC: 5, CI: PS3) *Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.* *Not included are calculations of energy.*		

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
8	4.2 Obtaining, evaluating and communicating information (Practice 8)	4.2.1 Students will be able to read, interpret and produce scientific text, use multiple sources to obtain information in order to evaluate the merit and validity of claims, and communicate information, ideas and evidence in a variety of formats.	8.4.2.1.1 Gather and make sense of multiple sources of information to qualitatively describe that synthetic materials come from natural resources and impact society. (P: 8, CC: 6, CI: PS1) *Emphasis is on natural resources that undergo a chemical process to form the synthetic material.* *Examples of new materials could include new medicine, foods, and alternative fuels.*			8.4.2.1.2 Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals. ** (P: 8, CC: 6, CI: PS4) *Emphasis is on a basic understanding that waves can be used for communication purposes.* *Examples could include using fiber optic cable to transmit light pulses, radio wave pulses in wifi devices, and conversion of stored binary patterns to make sound or text on a computer screen* *Not included are binary counting or a specific mechanism of any given device.* *Examples could include digitizing analog information, fiber optic cable, radio pulses, etc.*

High School Life

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
9-12 Life Science	1.1 Asking questions and defining problems (Practice 1)	1.1.1 Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's' ideas, and the information they read.			9L.1.1.1.1 Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring. (P: 1, CC: 2, CI: LS3)	

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
9-12 Life Science	1.1 Asking questions and defining problems (Practice 1)	1.1.2 Students will be able to ask questions to define a problem to be solved and to generate ideas that lead to the constraints and specifications of its solution.*		9L.1.1.2.1 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* (P: 6, CC: 7, CI: LS2 ETS1, ETS2) *Examples may include climate change, deforestation, urbanization, building of dams, invasive species, human population growth, endangered species, and agriculture practices*		

9-12 Life Science	2.1 Analyzing and interpreting data (Practice 4)	2.1.1 Students will be able to represent observations and data in meaningful ways, including graphically and with mathematics, which emphasize patterns in the data and relationships among variables to communicate their evidence and their interpretations.		9L.2.1.1.1 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem (P: 7, CC: 7, CI: LS2 ETS2). *Examples may include historical approaches to maintaining stable conditions in an ecosystem such as Minnesota American Indian tribes have used.*	9L.2.1.1.2 Apply concepts of probability to explain and/or predict the variation and distribution of expressed traits in a population, including unique traits in various human groups, such as in MN American Indian tribes. (P: 4, CC: 3, CI: LS3)	9L.2.1.1.3 Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. (P: 4, CC: 1, CI: LS4) *Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations. Examples may include change in bacterial growth in changing environmental conditions to connect to antibiotic resistance, or biodiesel fuel source production via algae or bacteria.*

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
9-12 Life Science	2.2 Using mathematics and computational thinking (Practice 5)	2.2.1 Students will be able to use symbolic representations to represent data, to predict outcomes, and eventually derive further mathematical or algorithmic relationships that describe phenomena.		9L.2.2.1.2 Use a computational model to support or revise an evidence-based explanation for the factors affecting population dynamics in different sized ecosystems including those affected by the practices of various human groups, including MN American Indian tribes. **(P: 5, CC: 3, CI: LS2) ---------------------- 9L.2.2.1.3 Use a computational model to support claims for the cycling of matter and flow of energy among organisms in an ecosystem. ** (P: 5, CC: 5, CI: LS2)		

9-12 Life Science	3.1 Developing and using models (Practice 2)	3.1.1 Students will be able to develop, revise and use models to represent their understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate their ideas and findings to others.	9L.3.1.1.1 Develop and use a model to illustrate the levels of organization and how that translates into specific functions in multicellular organisms. ** (P: 2, CC: 6, CI: LS1) *Emphasis is on functions at the organism system level such as nutrient uptake, water delivery, and organism movement in response to neural stimuli.* *An example of an interacting system may include an artery depending on the proper function of elastic tissue and smooth muscle to regulate and deliver the proper amount of blood within the circulatory system.* ---------------------------- 9L.3.1.1.2 Use a model to illustrate the role of cellular division	9L.3.1.1.5 Create and/or revise a mathematical or a computational model or simulation to support explanations of factors, such as those caused by various human groups, including MN American Indian tribes that affect carrying capacities of ecosystems at different scales. ** (P: 5, CC: 3, CI: LS2) ----------------------- 9L.2.5.1.6 Create and revise a mathematical or a computational model for improved accuracy that demonstrates the ecological or economic impacts of various human groups, including MN American Indian tribes, on biodiversity. **(P: 5, CC: 7, CI: LS4) *Examples may include species diversity, species*		

			(mitosis) and differentiation in producing and maintaining complex organisms. (P: 2, CC: 2, CI: LS1) ---------------------------- 9L.3.1.1.3 Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy. (P: 2, CC: 2, CI: LS1) *Emphasis is on illustrating inputs and outputs of matter and the transfer and transformation of energy in photosynthesis by plants and other photosynthesizing organisms* *Examples of models may include diagrams, chemical equations, and conceptual models.* ---------------------------- 9L.3.1.1.4 Use a model to illustrate that cellular	*abundance, species distribution or allele frequency, etc.* ---------------------------- 9L.3.1.1.6 Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere (P: 2, CC: 7, CI: LS2). *Examples of models may include simulations and mathematical models.*		

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
			respiration is a chemical process where energy from food is used to create new compounds (P: 2, CC: 5, CI: LS1) *Emphasis is on the conceptual understanding of the inputs and outputs of the process of cellular respiration. .*			

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
9-12 Life Science	3.1 Developing and using models (Practice 2)	3.1.2. Students will be able to use engineering models to identify problems, design and test solutions, and communicate design features and effectiveness to others.*		9L.3.1.2.1 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.* (P: 6, CC: 7, CI: LS2 ETS1, ETS2) *Examples may include climate change, deforestation, urbanization, building of dams, invasive species, human population growth, endangered species, and agriculture practices.*		

9-12 Life Science	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.1 Students will be able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.	9L.3.2.1.1 Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of (P: 6, CC: 6, CI: LS1). ---------------------------------- 9L.3.6.1.2 Construct and revise an explanation based on evidence for how various elements combine with carbon to form molecules that form the basis for life on Earth (P: 6, CC: 5, CI: LS1) *Emphasis is on using evidence from models and simulations to support explanations.*	9L.3.2.1.3 Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions (P: 6, CC: 5, CI: LS2). *Examples can include ways to: manage ag run-off, reduce carbon emissions from the atmosphere and reducing the burning of fossil fuels.* *Emphasis is on conceptual understanding of the role of aerobic and anaerobic respiration in different environments*		9L.3.2.1.4 Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment (P: 6, CC: 2, CI: LS4) *Emphasis is on using evidence to explain the influence each of the four factors has on number of organisms, behaviors, morphology, or physiology in terms*

						of ability to compete for limited resources and subsequent survival of individuals and adaptation of species. Examples of evidence may include mathematical models such as simple distribution graphs and proportional reasoning.

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
9-12 Life Science	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.2 Students will be able to use their understanding of scientific principles and the engineering design process to either construct a device or implement a design solution that meets agreed-on criteria and constraints.*		9L.3.2.2.1 Design, evaluate, and refine a solution for reducing the impacts of human activities including those resulting from various human groups, such as MN American Indian tribes, on the environment and biodiversity.* (P: 6, CC: 7, CI: LS2 ETS1, ETS2) *Examples may include climate change, deforestation, urbanization, building of dams, invasive species, human population growth, endangered species, agriculture practices*		

9-12 Life Science	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.3 Students will be able to use and apply historical and current examples of Minnesota Anishinaabe and Dakota/Lakota knowledge systems to construct explanations of phenomena. Note: these benchmarks are duplicates of other locations and carry that code.		9L.2.1.1.1 Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem. (P: 7, CC: 7, CI: LS2 ETS2). *Examples may include historical approaches to maintaining stable conditions in an ecosystem such as Minnesota American Indian tribes have used.* ----------------------- 9L.2.2.1.2 Use a computational model to support or revise an evidence-based explanation for the factors affecting population dynamics in different sized ecosystems including those	9L.2.1.1.2 Apply concepts of probability to explain and/or predict the variation and distribution of expressed traits in a population, including unique traits in various human groups, such as in MN American Indian tribes. **(P: 4, CC: 3, CI: LS3)	9L.3.2.1.5 Construct an explanation based on evidence for how natural selection leads to adaptation of populations including the adaptations of various human groups, such as in MN American Indian tribes (P: 6, CC: 2, CI: LS4)

				affected by the practices of various human groups, including MN American Indian tribes. **(P: 5, CC: 3, CI: LS2) ----------------------- 9L.3.1.1.5 Create and/or revise a mathematical or a computational model or simulation to support explanations of factors, such as those caused by various human groups, including MN American Indian tribes that affect carrying capacities of ecosystems at different scales. **(P: 5, CC: 3, CI: LS2) ----------------------- 9L.2.5.1.6 Create and revise a mathematical or a computational model for improved accuracy that demonstrates the ecological or economic impacts of various human		

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
				groups, including MN American Indian tribes, on biodiversity. ** (P: 5, CC: 7, CI: LS4) ------------------------ 9L.3.6.2.1 Design, evaluate, and refine a solution for reducing the impacts of human activities including those resulting from various human groups, such as MN American Indian tribes, on the environment and biodiversity.* (P: 6, CC: 7, CI: LS2 ETS1, ETS2)		

9-12 Life Science	4.1 Arguing from evidence (Practice 7)	4.1.1. Students will be able to use evidence to compare and evaluate competing ideas and methods, answer questions, and engage in argumentation.			9L.4.1.1.1 Make and defend a claim based on evidence that inheritable genetic variations may result from (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors (P: 7, CC: 2, CI: LS3). *Emphasis is on using data to support arguments for the way variation occurs*	9L.4.1.1.2 Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce (P: 7, CC: 2, CI: LS2 ETS1) *Examples may include how humans might design a solution to survive extreme climate change on Earth*. ----------------------- 9L.4.1.1.3 Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species (P: 7, CC: 2, CI: LS4 EST1)

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
9-12 Life Science	4.1 Arguing from evidence (Practice 7)	4.1.2 Students will be able to use evidence to construct an argument and engage in argumentation to advance and define a design solution.		9L.4.1.2.1 Use digital collaboration tools to define a complex real world problem and evaluate a solution based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, digital privacy, and environmental impacts. ** (P: 6, CC: -, CI: ETS1)		

Grade	Substrand	Anchor Standard	From Molecules to Organisms: Structures and Processes Benchmarks	Ecosystems: Interactions, Energy, and Dynamics Benchmarks	Heredity: inheritance and variation of traits Benchmarks	Evolution: Unity and Diversity Benchmarks
9-12 Life Science	4.2 Obtaining, evaluating and communicating information (Practice 8)	4.2.1 Students will be able to read, interpret and produce scientific text, use multiple sources to obtain information in order to evaluate the merit and validity of claims, and communicate information, ideas and evidence in a variety of formats.				9L.4.2.1.1 Communicate scientific information, that common ancestry and biological evolution are supported by multiple lines of empirical evidence. (P: 8, CC: 1, CI: ESS3) *Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence may include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development*

High School Earth Space

Grade	Substrand	Anchor Standard	Earth's Place in the Universe	Earth's Systems and Processes global	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
9-12 Earth & Space Science	1.1 Asking questions and defining problems (Practice 1)	1.1.1 Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's ideas, and the information they read.	9E.1.1.1.1 Ask questions that arise from examining models of nuclear fusion to clarify how a star changes throughout its life cycle. (P:1, CC: 5, CI: ESS1) *Emphasis is on asking questions to clarify and seek additional information.*	9E.1.1.1.2 Ask questions to clarify how seismic energy traveling through Earth's interior can reveal Earth's internal structure. (P:1, CC: 5, ESS2) *Emphasis is on how wave propagation depends on the density of the medium through which the wave travels and how seismic data is used to support the idea of a layered earth.*		

9-12 Earth & Space Science	1.2 Planning and carrying out investigations (Practice 3)	1.2.1 Students will design and conduct investigations to test their ideas and questions and they'll organize and collect data to provide evidence to support claims they make about phenomena. Student investigations may occur in the classroom, laboratory or field		9E.1.2.1.1 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes .(P: 3, CC:6, CI:ESS2) *Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations may include stream transportation and deposition of various substrates and landforms using a stream table, erosion using variations in soil moisture content and/or ground cover, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations may include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids). Examples specific to Minnesota may include chemical weathering of*		9E.1.2.1.2 Plan and conduct an investigation to generate data and identify patterns to serve as evidence for developing a model to communicate the effects of human activity on soil resources. (P:3, CC:2,CI: ESS3, ETS2) *Emphasis is on identifying variables to test, developing a workable experimental design, and identifying limitations of the data. Examples of variables may include soil type and composition (particularly those found in Minnesota), erosion rate, water infiltration rates, nutrient profiles, soil conservation practices, or*

Grade	Substrand	Anchor Standard	Earth's Place in the Universe	Earth's Systems and Processes global	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
				limestone to create karst topography.		*specific crop requirements.*

9-12 Earth & Space Science	2.1 Analyzing and interpreting data (Practice 4)	2.1.1 Students will be able to represent observations and data in meaningful ways, including graphically and with mathematics, which emphasize patterns in the data and relationships among variables to communicate their evidence and their interpretations.	9E.2.1.1.1 Create interactive data visualizations using software tools to make and communicate a valid scientific claim about the way stars, over their life cycle, produce elements. **(P: 4, CC: 5, CI: ESS1) *Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.*	9E.2.1.1.2 Analyze geoscience data to make a claim that one change to the Earth's surface can create feedbacks that cause changes to other Earth systems. (P: 4, CC: 7, CI: ESS2, ETS2) *Emphasis is on using data analysis tools and techniques in order to make valid scientific claims. Examples may include climate feedback mechanisms, such as how an increase in greenhouse gases causes a rise in global temperatures that melt glaciers and sea ice, which reduces the amount of sunlight reflected from the Earth's surface (albedo), increasing surface temperatures and further reducing the amount of ice. Examples may also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent and longevity.*	9E.2.1.1.3 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems. (P: 4, CC: 7, ESS3, ETS1): *Examples of evidence (for both data and climate model outputs) may include precipitation and temperature and their associated impacts on sea level, glacial ice volumes, and atmosphere and ocean composition. Engineering examples may include using*	

Grade	Substrand	Anchor Standard	Earth's Place in the Universe	Earth's Systems and Processes global	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
					climate change data (rising sea levels) to design a new sewer system to handle runoff or a new plan for acquiring potable water as existing wells become unusable.	

9-12 Earth & Space Science	2.2 Using mathematics and computational thinking (Practice 5)	2.2.1 Students will be able to use symbolic representations to represent data, to predict outcomes, and eventually derive further mathematical or algorithmic relationships that describe phenomena.	9E.2.2.1.1 Use algorithmic representations to predict the motion of natural and human-made objects that are in orbit in the solar system. ** (P: 5, CC: 3, CI: ESS1, ETS2) *Emphasis is on using simple limit cases to test simulations to see if a model makes sense by comparing outcomes with the real world. Emphasis is also on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.*	9E.2.2.1.2 Create a computational model to represent the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. (P: 2, CC: 4, CI: ESS2) *Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (providing the foundation for living organisms). Emphasis is also on algorithmic thinking.*		9E.2.2.1.3 Develop or use an algorithmic representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity. ** (P: 5, CC: 4, CI: ESS3, ETS2) *Emphasis is on students identifying components of a system and on mathematically modeling how those factors interact. Examples may include natural and human-influenced variables that influence the amount of runoff.* 9E.2.2.1.4 Create a computational simulation or simplified spreadsheet calculations to

						show the relationships among the management of natural resources, the sustainability of human populations, and biodiversity. ** (P:5, C: 7, CI: ESS3, ETS2) *Examples of factors that affect the management of natural resources may include the costs of resource extraction, waste management and environmental remediation, per-capita consumption and the development of new technologies. Examples of factors that affect human sustainability may include agricultural efficiency, levels of conservation and urban planning. Examples of factors that affect*

Grade	Substrand	Anchor Standard	Earth's Place in the Universe	Earth's Systems and Processes global	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
						biodiversity may include conservation limits for hunting and fishing.

9-12 Earth & Space Science	3.1 Developing and using models (Practice 2)	3.1.1 Students will be able to develop, revise and use models to represent their understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate their ideas and findings to others.	9E.3.1.1.1 Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. (P: 2, CC: 1, CI: ESS1) *Emphasis is on showing the relationships among the fuel, products and the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach the Earth. Examples of evidence for student models may include the masses and life times of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares, sunspot cycles, and non-cyclic variations over the centuries.*	9E.3.1.1.2 Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features. (P: 2, CC: 7, CI: ESS2) *Emphasis is on how the appearance of land features (such as mountains, valleys, basins and plateaus), and seafloor features (such as trenches, ridges, and seamounts) are a result of both constructive mechanisms (such as volcanism, tectonic motion, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion). Examples specific to Minnesota may include features formed relatively recently during continental glaciation versus volcanic features that have long since been eroded away, but whose rocks remain as evidence of past volcanic processes.*	9E.3.1.1.3 Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates. (P: 2, CC: 4, CI: ESS2) *Emphasis is on how patterns vary by latitude, altitude, and geographic land distribution. Emphasis of atmospheric circulation is on the sunlight-driven latitudinal banding, the Coriolis effect, and resulting prevailing winds; emphasis of ocean circulation is on the transfer of heat by the global ocean*	

					currents, which is constrained by the Coriolis effect and the outlines of continents. Examples of models may be diagrams, maps and globes, or digital representations. -------------------------- 9E.3.1.1.4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate. (P: 2, CC: 5, CI: ESS2). *Emphasis is on using a model to describe the mechanism for how energy flow effects changes in climate. Examples of the causes of climate change differ by timescale and may include: 1 -*	

Grade	Substrand	Anchor Standard	Earth's Place in the Universe	Earth's Systems and Processes global	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
					10 years: large volcanic eruptions, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10 - 100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10 - 100s of millions of years: long term changes in atmospheric composition.	

9-12 Earth & Space Science	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.1 Students will be able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.	9E.3.2.1.1 Construct an explanation that links astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe to the Big Bang theory. (P: 6, CC: 5, CI: ESS1, ETS2) *Emphasis is on using evidence from a variety of sources, including student investigations and simulations. Examples of evidence, made possible by technological advances, may include the redshift of light from galaxies, the cosmic microwave background radiation, and the observed composition of ordinary matter in the universe. Examples of student investigations may include spectroscopic analyses and expansion/inflation simulations.* ------------------------------- 9E.3.2.1.2 Apply scientific reasoning and evidence		9E.3.2.1.3 Apply place-based evidence from MN Anishinaabe and Dakota/Lakota communities to construct an explanation of how a warming climate impacts the hydrosphere, geosphere, biosphere, or atmosphere. (P:6, CC: 4, CI: ESS3) *Emphasis is on understanding and using Anishinaabe knowledge systems to describe regional impacts of climate change to Minnesota. Exam ples may include the water cycle and how precipitation change over time impacts cultural practices related to nibi ("water" in the Ojibwe*	9E.3.2.1.4 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. (P: 6, CC: 2, CI: ESS3) *Examples of key natural resources include access to fresh water sources, regions of fertile soils such as river deltas and floodplains, and rich deposits of minerals and fossil fuels. Examples of natural hazards may include volcanoes, earthquakes, mass wasting, flooding, tornadoes, and drought. Examples of the results of changes*

			from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. (P: 6, CC: 7, CI: ESS1) *Emphasis is on linking the evidence to the claims about Earth's formation. Emphasis is also on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.*		*language); or the decline/species loss of wiigwaas ("paper birch" in the Ojibwe language and an important tree in Anishinaabe culture) due to climate stressors like drought or changes in snow cover.*	*in climate that can affect populations or drive mass migrations may include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised in a given region. .*
9-12	3.2 Constructing explanations	3.2.2 Students will be able to use their understanding of				9E.3.2.2.1 Analyze a real world problem

Earth & Space Science	and designing solutions (Practice 6)	scientific principles and the engineering design process to either construct a device or implement a design solution that meets agreed-on criteria and constraints.*				arising from the impacts of human activities on natural systems and evaluate or refine technological solutions to reduce the human impacts.* (P:6, CC: 7, CI:ESS3, ETS1, ETS2) *Emphasis is on prioritizing identified criteria and constraints related to social and environmental considerations. Examples of data for the impacts of human activities may include the quantities and types of pollutants released into air or groundwater, changes to biomass and species diversity, or areal changes in land surface use (for surface mining, urban development, or*

Grade	Substrand	Anchor Standard	Earth's Place in the Universe	Earth's Systems and Processes global	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
						agriculture). Examples for limiting impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).

9-12 Earth & Space Science	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.3 Students will be able to use and apply historical and current examples of Minnesota Anishinaabe and Dakota/Lakota knowledge systems to construct explanations of phenomena. Note: these benchmarks are duplicates of other locations and carry that code.			9E.3.2.1.2 Apply place-based evidence from MN Anishinaabe and Dakota/Lakota communities to construct an explanation of how a warming climate impacts the hydrosphere, geosphere, biosphere, or atmosphere. (P:6, CC: 4, CI: ESS3) *Emphasis is on understanding and using Anishinaabe knowledge systems to describe regional impacts of climate change to Minnesota. Exam ples may include the water cycle and how precipitation change over time impacts cultural practices related to nibi ("water" in the Ojibwe*	

Grade	Substrand	Anchor Standard	Earth’s Place in the Universe	Earth’s Systems and Processes global	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
					language); or the decline/species loss of wiigwaas (“paper birch” in the Ojibwe language and an important tree in Anishinaabe culture) due to climate stressors like drought or changes in snow cover.	

9-12 Earth & Space Science	4.1 Arguing from evidence (Practice 7)	4.1.1 Students will be able to use evidence to compare and evaluate competing ideas and methods, answer questions, and engage in argumentation.	9E.4.1.1.1 Evaluate the evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks (P: 7, CC: 1, CI: ESS1) *Emphasis is on evaluating the, strengths, weaknesses and reliability of the given evidence along with its ability to support logical and reasonable arguments about the motion and age of crustal plates.* *Examples may include evidence of the ages of oceanic crust increasing with distance for mid-ocean ridges, the ages of North American continental crust decreasing with distance away from a central ancient core of the continental plate (a result of past plate interactions).*	9E.4.1.1.2 Evaluate the evidence and reasoning for the explanatory model that Earth's interior is layered and that thermal convection drives the cycling of matter. (P: 7, CC: 1, CI: ESS2) *Emphasis is on mantle convection (due to the outward flow of energy from the decay of radioactive isotopes and the gravitational movement of denser materials toward the interior) and its role in plate tectonics.* ---------------------------------- 9E.4.1.1.3 Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. (P: 7, CC: 2, CI: ESS2) *Examples may include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn changed weathering reactions and allowed for the evolution of life beyond single celled prokaryotes; how microbial life on land allowed for the formation of soil, which in turn allowed for the evolution of land plants; or how*		9E.4.1.1.4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. (P: 7, CC: 2, CI: ESS3, ETS2) *Examples of evidence may include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts may include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of*

				the evolution of corals created reefs that altered the patterns of erosion and deposition along coastlines, and provided habitats for the evolution of new life forms. Examples specific to Minnesota may include the banded iron formations of the Iron Range, which formed in a narrow time band (2.6-1.8 bya) that coincides with the time period during which early photosynthetic life was oxidizing our atmosphere and oceans.		*increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.* ---------------------------------- 9E.4.1.1.5 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.* (P: 7, CC: -, CI: ESS3, ETS2) *Emphasis is on the conservation, recycling, and reuse of resources (such as minerals, metals or soils) where possible, and on minimizing impacts where it is not. Examples*

Grade	Substrand	Anchor Standard	Earth's Place in the Universe	Earth's Systems and Processes global	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
						include developing best practices for agricultural soil use, mining (for fracking sand, iron ore, and rare metals), and pumping (for oil and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen in decision-making. processes.

Grade	Substrand	Anchor Standard	Earth's Place in the Universe	Earth's Systems and Processes global	Weather and Climate	Human Impacts and Sustainability in Earth's Systems
9-12 Earth & Space Science	4.2 Obtaining, evaluating and communicating information (Practice 8)	4.2.1 Students will be able to read, interpret and produce scientific text, use multiple sources to obtain information in order to evaluate the merit and validity of claims, and communicate information, ideas and evidence in a variety of formats.	9E.4.2.1.1 Read scientific literature to obtain information to summarize and communicate evidence for the formation of our solar system from a nebular cloud of dust and gas 4.6 billion years ago. *Emphasis is on reading scientific literature that has been adapted for classroom use and on linking evidence with components of the theory.* *Examples of evidence that supports the planetary nebula theory may include motion and composition of the planets and observations of other nebulae.*	9E.4.2.1.2 Compare, integrate and evaluate sources of information in order to determine how specific factors, including human activity, impact the groundwater system of a region. (P:8, CC:2, CI:ESS2, ETS2) *Emphasis is on the making sense of technical information presented in a variety of formats (graphs, diagrams and words).* *Example sources of information may include student experimental data.* *Example factors may include porosity, permeability, sediment or rock type, recharge or discharge factors, and potential energy.* *Examples of human factors may include usage rates, run-off, agricultural practices, and loss of wetlands.*		

High School Chemistry

Grade	Substrand	Anchor Standard	Chemical Reactions	Energy and Chemical Processes in Everyday Life	Structure and Properties of Matter	Nuclear Processes
9-12 Chemistry	1.1 Asking questions and defining problems (Practice 1)	1.1.1 Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's' ideas, and the information they read.	9C.1.1.1.1 Ask questions about how redox reactions have a role in energy storage and nitrification to be able to define related possibilities and limitations. (P: 1, CC: 5, CI: PS3). *Emphasis is on battery technology and Haber Bosch process. Examples could include fuel cells, car batteries, solar cells, fertilizers and farming, wind to ammonia.*	9C.1.1.1.2 Ask questions about the chemical structures and energy absorption/release of greenhouse gases, from both natural and anthropogenic sources, and their impact on the Earth's climate. (P:1, CC: 5, CI: PS1) *Emphasis is on molecule shape, dipole moments and bond vibrations/rotations/stretches. Not to include VSEPR or quantification of dipole.*	9C.1.1.1.3 Evaluate questions about the advantages and disadvantages of various types of materials used for the storage of digital information. (P:1, CC:6 CI: PS4) *Emphasis is on materials for storage of digital information. Examples include solid state drives, and semi-conductors*	
9-12 Chemistry	1.2 Planning and carrying out investigations (Practice 3)	1.2.1 Students will design and conduct investigations to test their ideas and questions and they'll organize and collect data to provide evidence to support claims they	9C.1.2.1.1 Plan and conduct an investigation of acid-base reactions in aqueous solutions to make observations to answer questions about the source and strength of acidity.(P:3, CC: 3, CI:		9C.1.2.1.2 Plan and conduct an investigation to gather evidence to compare the structure of substances and infer the strength of electrical forces between particles. (P: 3, CC: 1, CI: PS1)	

		make about phenomena. Student investigations may occur in the classroom, laboratory or field.	PS1) *Emphasis is on developing an understanding of pH scales and various ways to measure pH. Examples could include household chemicals and ocean acidification from CO_2*		*Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of collected evidence could include the melting point and boiling point, vapor pressure, and surface tension.*	
9-12 Chemistry	2.1 Analyzing and interpreting data (Practice 4)	2.1.1 Students will be able to represent observations and data in meaningful ways, including graphically and with mathematics, which emphasize patterns in the data and relationships among variables to communicate their evidence and their interpretations.		9C.2.1.1.1 Examine data and evidence of chemical concentrations of air and drinking water quality standards, and evaluate the necessity and processes of treatments. (P:4, CC:2, CI:PS1) *Emphasis includes concentration and how it's calculated such as: molarity, parts per million, and percent by mass. Both natural and human-made sources of water/air chemicals should be considered. Examples might include ozone (troposphere vs stratosphere), lead, arsenic, particulate matter, acid rain,*		

				nitrates and E. coli. *Examples of remediation include filters, water treatment plants, plants, scrubbers.*		
9-12 Chemistry	2.2 Using mathematics and computational thinking (Practice 5)	2.2.1 Students will be able to use symbolic representations to represent data, to predict outcomes, and eventually derive further mathematical or algorithmic relationships that describe phenomena.	9C.2.2.1.1 Use mathematical representations or computational models to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. ** (P: 5, CC: 5, CI: PS1) *Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale.* *Emphasis is on assessing students' use of mathematical*		9C.2.2.1.2 Develop a data simulation to produce gas pressure, volume, temperature and gas quantity data to predict the mathematical relationships between those quantities by observing the cause and effect of changing those variables.** (P:5, CC: 2, CI: PS2) *Emphasis is applying the kinetic molecular theory of gases to developing the relationships of Boyle's Law, Charles Law, Guy-Lussac's Law and Avogadro's Hypothesis. Not included is the ideal gas law.* *Examples could include weather, hot air balloons, filling tires hot vs cold, airbags*	

			thinking and not on memorization and rote application of problem-solving techniques			
9-12 Chemistry	3.1 Developing and using models (Practice 2)	3.1.1 Students will be able to develop, revise and use models to represent their understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate their ideas and findings to others.		9C.3.1.1.1 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. (P: 2, CC: 5, CI: PS1) *Emphasis is on simple qualitative models, such as a storyboard/diagram that uses MN American Indian style of teaching through storytelling and on the scale of energy released in nuclear processes relative to other kinds of transformations. Not included is the calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products. Examples could include hand warmers, combustion (natural gas, gasoline, various alcohols, wax).*	9C.3.1.1.2 Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. (P: 2, CC: 1, CI: PS1) : *Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.*	9C.3.1.1.3 Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. (P: 2, CC: 5, CI: PS1) *Emphasis is on simple qualitative models, such as a storyboard/diagram that uses MN American Indian style of teaching through storytelling, and on the scale of energy released in nuclear processes relative to other kinds of transformations.*
9-12 Chemistry	3.2 Constructing	3.2.1 Students will be	9C.3.2.1.1	9C.3.2.1.3 Construct an explanation for the		

	explanations and designing solutions (Practice 6)	able to apply scientific principles and empirical evidence (primary or secondary) to construct causal explanations of phenomena or identify weaknesses in explanations developed by themselves or others.	Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. (P: 6, CC: 1, CI: PS1) *Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.* *Applications could include water quality, road salt, etc.* ---------------------- 9C.3.2.1.2 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature and concentration of the	process of solvation and identify from patterns how the properties of the resulting solution depend on the interactions between solute and solvent or on concentrations of solutes.(P:6, CC: 1, CI: PS1) *Emphasis is on polarity, solvation, boiling point elevation, freezing point depression, and osmosis* *Examples may include salts dissolving to make water hard, road salt, antifreeze, oil spills, reverse osmosis water systems.*		

			reacting particles on the rate at which the reaction occurs (P: 6, CC: 1, CI: PS1) *Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.* *Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.*			
9-12 Chemistry	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.2 Students will be able to use their understanding of scientific principles and the engineering design process to either construct a device or implement a design solution that meets agreed-on	9C.3.2.2.1 Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.* (P: 6, CC: 7, CI: PS1) *Emphasis is on the application of Le*	9C.3.2.2.2 Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. to convert one form of energy into another form of energy.* (P: 6, CC: 5, CI PS 3) *Emphasis is on both qualitative*		

		criteria and constraints.*	*Chatlier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.*	*and quantitative evaluations of devices. Examples of devices could include solar cells, batteries, and generators (nuclear, fossil fuel etc). Examples of constraints could include use of renewable energy forms and efficiency.*		
9-12 Chemistry	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.3 Students will be able to use and apply historical and current examples of Minnesota Anishinaabe and Dakota/Lakota knowledge systems to construct explanations of phenomena. Note: these benchmarks are duplicates of other	9C.4.1.1.1 Create computational models that represents the cause and effect relationships in environmental factors related to wild rice production. ** (P 7, CC 2, CI, PS 1) *Emphasis is on understanding concentration units, relationships of water and soil sulfur*	9C.3.1.1.1 Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. (P: 2, CC: 5, CI: PS1) *Emphasis is on simple qualitative models, such as a storyboard/diagram that uses MN American Indian style of teaching through storytelling.*	9C.4.2.1.2 After studying how oral histories are constructed in several cultures, including Native American, prepare a narrative to communicate the chemical value of mined materials as well as the history and process of mining. (P: 8, CC: 4, CI: PS1) *Examples could include taconite mining, acid mine drainage, uranium mining impact on Native*	9C.3.1.1.3 Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. (P: 2, CC: 5, CI: PS1) *Emphasis is on simple qualitative models, such as a storyboard/diagram*

		locations and carry that code.	*forms and content as well as the role of iron.*		*Americans, mining of rare earth metals in developing countries for batteries, copper and sulfide mining.* ---------------------- 9C.4.2.1.2 After studying various languages/styles/systems, including Native American, for naming molecules, dyes, medicines etc., evaluate and compare how each approach communicates information. (P: 8, CC:1, CI: PS1) *Emphasis is on how communicating chemical information has changed over time and place as well as how scientific communication relates to accurate and precise definitions.* *Examples could include IUPAC vs Indigenous vs 'household' vs other chemical names, synthetic vs natural vs artificial, relationship between function and name.*	*that uses MN American Indian style of teaching through storytelling,*

9-12 Chemistry	4.1 Arguing from evidence (Practice 7)	4.1.1. Students will be able to use evidence to compare and evaluate competing ideas and methods, answer questions, and engage in argumentation.	9C.4.1.1.1 Create computational models that represents the cause and effect relationships in environmental factors related to wild rice production. ** (P 7, CC 2, CI, PS 1) *Emphasis is on understanding concentration units, relationships of water and soil sulfur forms and content as well as the role of iron.*			
9-12 Chemistry	4.2 Obtaining, evaluating and communicating information (Practice 8)	4.2.1 Students will be able to read, interpret and produce scientific text, use multiple sources to obtain information in order to evaluate the merit and validity of claims, and communicate information, ideas and evidence in a variety of formats.		9C.4.2.1.1 Critique and evaluate a model that illustrates that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.	9C.4.2.1.2 After studying how oral histories are constructed in several cultures, including Native American, prepare a narrative to communicate the chemical value of mined materials as well as the history and process of mining. (P: 8, CC: 4, CI: PS1) *Examples could include taconite mining, acid mine drainage, uranium mining*	

					impact on Native Americans, mining of rare earth metals in developing countries for batteries, copper and sulfide mining --------------------------------- 9C.4.2.1.3 After studying various languages/styles/systems, including Native American, for naming molecules, dyes, medicines etc., evaluate and compare how each approach communicates information. (P: 8, CC:1, CI: PS1) *Emphasis is on how communicating chemical information has changed over time and place as well as how scientific communication relates to accurate and precise definitions.* *Examples could include IUPAC vs Indigenous vs 'household' vs other chemical names, synthetic vs natural vs artificial, relationship between function and name.*	

9-12 Chemistry	4.2 Obtaining, evaluating and communicating information (Practice 8)	4.2.2 Students will be able to evaluate proposed engineering design solutions and communicate their critiques by using appropriate combinations of sketches, models, and language.*			9C.4.2.2.1 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.** (P: 8, CC: 6, CI: PS6) *Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long-chained molecules (polymers and plastics), and pharmaceuticals are designed to interact with specific receptors, and design of digital displays, and membranes in fuel cells.*	x

High School Physics

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
9-12 Physics	1.1 Asking questions and defining problems (Practice 1)	1.1.1 Students will be able to ask questions about aspects of the phenomena they observe, the conclusions they draw from their models or scientific investigations, each other's' ideas, and the information they read.				9P.1.1.1.1 Evaluate questions about the tradeoffs in how data elements are digital transmitted and stored. ** (P: 1, CC: 7, CI: PS4) *Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.*

9-12 Physics	1.2 Planning and carrying out investigations (Practice 3)	1.2.1 Students will design and conduct investigations to test their ideas and questions and they'll organize and collect data to provide evidence to support claims they make about phenomena. Student investigations may occur in the classroom, laboratory or field.	9P.1.2.1.1 Plan and conduct an investigation to gather evidence to compare the structure of substances and infer the strength of electrical forces between particles. (P: 3, CC: 1, CI: PS1) *Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of collected evidence could include the melting point and boiling point, vapor pressure, and surface tension. Not included is Raoult's law*			

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
			calculations of vapor pressure.			
9-12 Physics	2.1 Analyzing and interpreting data (Practice 4)	2.1.1 Students will be able to represent observations and data in meaningful ways, including graphically and with mathematics, which emphasize patterns in the data and relationships among variables to communicate their evidence and their interpretations. .		9P.2.1.1.1 Use graphical representations to compare the distance, velocity, and accelerations of different objects in different frames of reference to identify relationships among variables. (P:4, CC: 4, CI: PS 2) *Examples could include describing the same motion from different points of view, one-dimensional or two-dimensional motion*		

9-12 Physics	1.2 Planning and carrying out investigations (Practice 3)	1.2.1 Students will formulate questions based on observations, design and conduct investigations, organizing and collecting data to make decisions from investigations in the classroom, school laboratory and/or field.		9C.1.2.1.1 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. (P: 3, CC: 2, CI: PS2) *Examples of electromagnetic induction could include, electromagnetic motors, speakers, generators, wireless charging, induction cooktops*	9C.1.2.1.2 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperatures are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). (P: 3, CC: 3, CI: PS3) *Examples could include keeping structures warm or cool. Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.*	

9-12 Physics	2.2 Using mathematics and computational thinking (Practice 5)	2.2.1 Students will be able to use symbolic representations to represent data, to predict outcomes, and eventually derive further mathematical or algorithmic relationships that describe phenomena.		9P.2.2.1.1 Use algorithmic representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. ** (P: 5, CC: 4, CI: PS2) *Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle. Examples could include closed systems with collisions - investigating changes in momentum before and after a collision.* ---------------------------------- 9P.2.2.1.2 Use algorithmic representations of Newton's Law of Gravitation and Coulomb's Law to	9P.2.2.1.3 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in or out of the system are known. ** (P: 5, CC: 4, CI: PS3) *Emphasis is on explaining the meaning of mathematical expressions used in the model for systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.*	

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
				describe and predict the gravitational and electrostatic forces between objects. ** (P: 5, CC: 1, CI: PS2) *Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.*		

9-12 Physics	3.1 Developing and using models (Practice 2)	3.1.1 Students will be able to develop, revise and use models to represent their understanding of a system (or parts of a system) under study, to aid in the development of questions and explanations, and to communicate their ideas and findings to others.			9P.3.1.1.1 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). (P: 2, CC: 5, CI: PS3) *Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates.* *Examples of models could include diagrams, drawings, descriptions, and computer simulations.* ------------------------ 9P.3.1.1.2	

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
					Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between two objects and the changes in energy of the two objects due to the interaction. (P: 2, CC: 2, CI: PS3) *Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other. Examples could include motors, electromagnetic induction, speakers, generators, wireless charging, induction cooktops, static charging and charge transfer.*	

9-12 Physics	3.2 Constructing explanations and designing solutions (Practice 6)	3.2.2 Students will be able to use their understanding of scientific principles and the engineering design process to either construct a device or implement a design solution that meets agreed-on criteria and constraints.*	9P.3.2.2.1 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.* (P: 6, CC: -, CI: ETS1) *Examples could include climate, energy sources, water quality, and air quality.*	9P.3.2.2.2 Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision. * (P: 6, CC: 2, CI: PS2) *Examples could include seat belts, air bags, car seats for kids, etc.* *Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it.* *Examples of a device could include a helmet, a parachute, an airbag, and packaging for safe shipping.*	9P.3.2.2.3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. * (P: 6, CC: 5, CI: PS3) *Examples could include devices to convert KE to PE and/or PE to KE to accomplish a particular task under given constraints.*	
9-12 Physics	4.1 Arguing from evidence (Practice 7)	4.1.1. Students will be able to use evidence to compare and evaluate				9P.4.1.1.1 Evaluate the claims, evidence, and reasoning behind the argument that

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
		competing ideas and methods, answer questions, and engage in argumentation.				electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. (P: 7, CC: 4, CI: PS4) *Examples could include cell phones, wave behaviors, and best ways to transmit digital signals across the state. Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.*

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
9-12 Physics	4.2 Obtaining, evaluating and communicating information (Practice 8)	4.2.1 Students will be able to read, interpret and produce scientific text, use multiple sources to obtain information in order to evaluate the merit and validity of claims, and communicate information, ideas and evidence in a variety of formats.			9P.4.2.1.1 Critique and evaluate models that illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects). (P: 2, CC: 5, CI: PS3)	9P.4.2.1.2 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. (P: 8, CC: 2, CI: PS4) *Examples could include medical imaging technology and devices.*

9-12 Physics	4.2 Obtaining, evaluating and communicating information (Practice 8)	4.2.2 Students will be able to evaluate proposed engineering design solutions and communicate their critiques by using appropriate combinations of sketches, models, and language.*		9P.4.2.2.1 Evaluate and critique ideas, designs, and devices that minimize the force on a macroscopic object during a collision ------------------------------- 9P.4.2.2.2 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* (P: 8, CC: 6, CI: PS2-6) *Examples could include material properties - dryer sheets, clothing design, building design - engineering ties, medicine, etc. Emphasis is on the attractive and repulsive forces that determine the functioning of the material.*	9P.4.2.2.3 Evaluate and critique Designs and devices that work within given constraints to convert one form of energy into another form of energy.	9P.4.2.2.4 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.** (P:8, CC: 2, CI: PS4) *Engineering Examples could include medical imaging - explore the usefulness of different types of imaging for different diagnostic purposes; effects of EM radiation from digital devices on organisms; weather forecasting - systems to remotely detect water in weather systems* *Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.*

Grade	Substrand	Anchor Standard	Matter and Its Interactions	Motion and Stability: Forces and Interactions	Energy	Waves and Their Applications in Technology and Information Transfer
				Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.		