Code: Number = grade.strand.practice.standard.benchmark.

Strand 1: Exploring phenomena or engineering problems

- Substrand 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. (related specifically to engineering)

	Kindergarten	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grades 9-12 Chemistry	Grades 9-12 Earth and Space Sciences	Grades 9-12 Life Sciences	Grades 9-12 Physics
Standard 1	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.*	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.*	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.*	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.*	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.*	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?*	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.*	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)	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.*	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.*	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.*	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)	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.*
					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.		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 crosscutting relationships.			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.*	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.*		

	Kindergarten	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grades 9-12 Chemistry	Grades 9-12 Earth and Space Sciences	Grades 9-12 Life Sciences	Grades 9-12 Physics
Standard 1							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.*			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*			

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Standard 2					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.*			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.*				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*	

Strand 1: Exploring phenomena or engineering problems

- Substrand 2: 1.2 Planning 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.

	Kindergarten	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grades 9-12 Chemistry	Grades 9-12 Earth and Space Sciences	Grades 9-12 Life Sciences	Grades 9-12 Physics
Standard 1	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.*	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.*	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.*	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).*		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.*	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).*	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.*	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).*	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: 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 CO2*	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 limestone to create karst topography.*	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*	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) calculations of vapor pressure.*
	0.1.2.1.2 Make observations of plants and animals to		2.1.2.1.2 Plan and conduct an investigation to determine if plants			5.1.2.1.2 Plan and carry out fair tests in which variables are controlled and failure points are			8.1.2.1.2 Conduct an investigation and evaluate the experimental	9C.1.2.1.2 Plan and conduct an investigation to gather evidence to	9E.1.2.1.2 Plan and conduct an investigation to generate data and identify patterns to serve	9C.1.2.1.2 Plan and conduct an investigation to provide	

	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.*		need sunlight and water to grow. (P: 3, CC:2, CI: LS2)			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.*			design to provide qualitative evidence that electric and magnetic fields exist between objects exerting forces on each other even though the objects are not in contact(P: 3, CC: 2, CI: PS2) *Examples of this phenomenon 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.*	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.*	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 specific crop requirements.*	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.*	
									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 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.*				

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.

	Kindergarten	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grades 9-12 Chemistry	Grades 9-12 Earth and Space Sciences	Grades 9-12 Life Sciences	Grades 9-12 Physics
Standard 1	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.*	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*	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.*	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.*	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.*	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.*	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.*	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. Flow charts to organize and sequence the algorithm may be used to demonstrate the relationships.*	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.*	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.*	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.*	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.*	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*
	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*		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*				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*	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*	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*		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*	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)	

	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.		*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.*				*shapes of the continents (including the continental shelves), and the locations of ocean structures such as ridges and trenches.*	*anatomical structures in organisms and the chronological order of fossil appearance in the rock layers)*	*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.*		*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.*		
	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*						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*	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*			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.	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:	

	different kinds of food; plants require light; and that all living things need water.						*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 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).*	*patterns of relatedness among embryos of different organisms by comparing the macroscopic appearance of diagrams or pictures.*			(P: 4, CC: 7, ESS3, ETS1): *Examples of evidence (for both data and climate model outputs) may include precipitation and temperature and their associated impacts on sea level, glacial ice volumes, and atmosphere and ocean composition. Engineering examples may include using climate change data (rising sea levels) to design a new sewer system to handle runoff or a new plan for acquiring potable water as existing wells become unusable.*	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.*	

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

- 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.

	Kindergarten	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grades 9-12 Chemistry	Grades 9-12 Earth and Space Sciences	Grades 9-12 Life Sciences	Grades 9-12 Physics
Standard 1	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.*	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.*	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.*	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.*	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.*	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.*		7.2.2.1 1 Develop an algorithm to visually support explanations of how natural selection that may lead to increases and decreases of specific traits in populations, including human cultural or ethnic groups, such as MN American Indian tribes, over time.** (P: 5, CC: 2, CI: LS4) *Emphasis is on using mathematical models, probability statements, and proportional reasoning to support explanations of trends in changes to populations over time.*	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.*	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 thinking and not on memorization and rote application of problem-solving techniques*	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.	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)	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.*
					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.*					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*	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*	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)	9P.2.2.1.2 Use algorithmic representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. ** (P: 5, CC: 1, CI: PS2) *Emphasis is on both quantitative and conceptual descriptions*

										included is the ideal gas law. Examples could include weather, hot air balloons, filling tires hot vs cold, airbags	*organisms). Emphasis is also on algorithmic thinking.*		*of gravitational and electric fields.*
											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.*		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*
											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 biodiversity may include conservation limits for hunting and fishing.*		

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.*

	Kindergarten	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grades 9-12 Chemistry	Grades 9-12 Earth and Space Sciences	Grades 9-12 Life Sciences	Grades 9-12 Physics
Standard 1	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.*	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.*	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.*	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)	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.*	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.*	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.*	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.*	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.*	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).*	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.*	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.*	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.*
				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,	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*		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	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	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*	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*	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*	9L.3.1.1.2 Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms. (P: 2, CC: 2, CI: LS1)	9P.3.1.1.2 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between two objects and the changes in energy of the two

				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.*	*models could include diagrams, and flow charts.*		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 or state). Not included are Kepler's Laws and retrograde motion of planets.*	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.*	*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.*	*from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.*	*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.*		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.*
					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.*		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*	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.*	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*	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*	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,	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.*	

							minerals and rocks as Earth's materials have been recycled throughout geologic time.		*storyboard/diagram that uses MN American Indian style of teaching through storytelling. Examples of particles could include molecules or inert atoms.*	*relative to other kinds of transformations.*	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.		
							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 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.*	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.*	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*		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 - 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.*	9L.3.1.1.4 Use a model to illustrate that cellular 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.*	

									storyboard/diagram that uses MN American Indian style of teaching through storytelling.				
									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.*			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 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.	

	Kindergarten	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grades 9-12 Chemistry	Grades 9-12 Earth and Space Sciences	Grades 9-12 Life Sciences	Grades 9-12 Physics
Standard 2					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)							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.*	
					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*								

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

- 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.

	Kindergarten	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grades 9-12 Chemistry	Grades 9-12 Earth and Space Sciences	Grades 9-12 Life Sciences	Grades 9-12 Physics
Standard 1				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.*	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.*	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).	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.*	7.3.2.1.1 Construct a scientific explanation based on evidence for how environmental and genetic factors including those influenced by various human populations, like MN American Indian tribes, influence the growth of organisms. (P: 6, CC: 2, CI: LS1, EST2) *Examples may include agricultural practices, phosphorus and nitrogen loading in lakes, hybridization and breeding practices Examples of environmental factors may include local environmental conditions such as availability of food, light, space, and water - probes could be used to collect evidence Examples of genetic factors may include large breed cattle and species of grass affecting growth of organisms. Examples of evidence may include drought decreasing plant growth, fertilizer increasing plant growth, different varieties of plant seeds growing at different rates in different conditions, And fish growing larger in large ponds than they do in small ponds.*		9C.3.2.1.1 Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties. (P: 6, CC: 1, CI: PS1) *Examples of chemical reactions 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.*	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.*	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).	
							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*	7.3.2.1.2 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*		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 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*	9E.3.2.1.2 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. (P: 6, CC: 7, CI: ESS1) *Emphasis 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*	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.*	

							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.			*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 a*	*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.*		
							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 nonrenewable 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 (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.*	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. Examples may include types of interactions such as competitive, predatory and mutually beneficial.*		9C.3.2.1.3 Construct an explanation for 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.*	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. Examples may include the water cycle and how precipitation change over time impacts cultural practices related to nibi ("water" in the Ojibwe language); or the decline/species loss of wiigwaas ("paper birch" in the Ojibwe language and an important tree in Anishinaabe culture) due to climate stressors like drought or changes in snow cover.*	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*	
							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*	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.*			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	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	

							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 usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).				hazards may include volcanoes, earthquakes, mass wasting, flooding, tornadoes, and drought. Examples of the results of changes	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.*	
								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.*				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) *Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems contribute to a change in gene frequency over time, leading to adaptation of populations Examples may include as ranges of seasonal temperature, long-term climate change, acidity, light, geographic barriers, or evolution of other organisms.*	

	Kindergarten	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grades 9-12 Chemistry	Grades 9-12 Earth and Space Sciences	Grades 9-12 Life Sciences	Grades 9-12 Physics
Standard 2	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.*	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.*	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.*	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.*	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.*	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.*		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.*	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.*	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 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.*	9E.3.2.2.1 Analyze a real world problem 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 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).*	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*	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.*
		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;*		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)					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.*	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 and quantitative evaluations of devices. Examples of devices could include solar cells, batteries, and generators (nuclear, fossil fuel etc). Examples of constraints could include*			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*

		and detecting intruders by mimicking eyes and ears.								*use of renewable energy forms and efficiency.*			*airbag, and packaging for safe shipping.*
				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.*					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 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.*				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.

	Kindergarten	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grades 9-12 Chemistry	Grades 9-12 Earth and Space Sciences	Grades 9-12 Life Sciences	Grades 9-12 Physics
Standard 3				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)		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)	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.*	7.3.2.1.1 Construct a scientific explanation based on evidence for how environmental and genetic factors including those influenced by various human populations, like MN American Indian tribes, influence the growth of organisms. (P: 6, CC: 2, CI: LS1, EST2)	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.*	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.*	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. Examples may include the water cycle and how precipitation change over time impacts cultural practices related to nibi ("water" in the Ojibwe language); or the decline/species loss of wiigwaas ("paper birch" in the Ojibwe language and an important tree in Anishinaabe culture) due to climate stressors like drought or changes in snow cover.*	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.*	
								7.2.2.1.1 Develop an algorithm to visually support explanations of how natural selection that may lead to increases and decreases of specific traits in populations, including human cultural or ethnic groups, such as MN American Indian tribes, over time. ** (P: 5, CC: 2, CI: LS4)	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.*	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.		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)	

								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)	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.*	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.*		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)	
										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.		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)	

										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,*		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)	
												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)	

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.

	Kindergarten	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grades 9-12 Chemistry	Grades 9-12 Earth and Space Sciences	Grades 9-12 Life Sciences	Grades 9-12 Physics
Standard 1	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.*	1.4.1.1.1 Construct an argument based on observational evidence for how plants and animals (including humans) can change the nonliving 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.*	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).*	3.4.1.1.2 Construct an argument that some animals form groups that help members survive. (P: 7, CC: 2, CI: LS2)	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.*	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)		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.*	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.*	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.*	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).*	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*	9P.4.1.1.1 Evaluate the claims, evidence, and reasoning behind the argument that 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.*
						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)		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.*	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.*		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*	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.*	

									Not included are calculations of energy.		*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 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.*	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)	
											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 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 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.*		

	Kindergarten	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8	Grades 9-12 Chemistry	Grades 9-12 Earth and Space Sciences	Grades 9-12 Life Sciences	Grades 9-12 Physics
Standard 2		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.*				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.*		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.*				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 tradeoffs 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)	
Standard 2								7.4.1.2.2 Construct an argument supported by empirical evidence or a designed solution that changes 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.*					

Strand 4: Communicating reasons, arguments and ideas to others

- 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.*

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Standard 1		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*	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.*	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.*	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.*	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 poll*		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.*	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.*	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.	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.*	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*	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)

		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.*	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.*			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)			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.*	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*	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.*		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.
		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*								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*			

		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).								*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.*			

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Standard 2	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.*							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.*		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.*			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. 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.*
													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*.